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Extended Summaries
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Voluntary Papers

Precision Nutrient Management
Conservation Agriculture and Smart Mechanization
Innovation Systems and Last Mile Delivery
Livelihood Security and Farmers Prosperity
Emerging Challenges for Agronomic Education
New Paradigms in Agronomic Research

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Nutrient availability and productivity of sunflower as influenced by land configurations and fertilizer levels

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Sunflower (*Helianthus annuus* L.) holds great promise and plays an important role in meeting out the shortage of edible oils in the country. There is a need to improve the productivity and sustainability of sunflower under *rainfed* conditions by improving the utilization of the received rainfall with a suitable moisture conservation practice and optimal input fertilizers (Vittal *et al.,* 2003). Nutrients play major role in crop production as the basic input and its timely availability is very crucial for agricultural production. Fertilizers need to be used rationally in order to avoid a negative ecological impact and undesirable effects on the sustainability of agricultural production systems. Excessive application of fertilizers also affects the farmer's economy (Conners and Hall, 1997). Appropriate combination of land configuration along with fertilizer levels not only meets the crop nutrient requirements and sustain productivity but also improves soil health.

METHODOLOGY

A field experiment was conducted at the farm of Oilseed Research Unit, Dr. PDKV, Akola during *Kharif* of 2014 with sunflower hybrid DRSH-1. The soil of experimental site was clayey, moderately alkaline. It was low in available nitrogen, medium in phosphorus and high in available potassium. The treatments comprising two land configurations viz., ridges and furrows and flat bed and three fertilizer levels viz., 75%, 100 % (80:60:30 N, P_2O_5, K_2O kg/ha) and 125% RDF laid out in factorial randomized block design with four replications. Fertilizers were applied as per treatment combinations. A half dose of N and full dose of P and K were applied as per treatment combinations. The sunflower crop was sown on August 22 (34th MW) with spacing of 60×30 cm and harvested on November 28 (48th MW). Monsoon rains during 34th to 48st MW amounted to 235 mm in 14 rainy days. Some of the important findings emerged from this investigation are summarized.

RESULTS

The data in the table revealed that, significant variations in nutrient uptake, nutrient availability and the yield of sunflower crop with different land configurations and the fertilizer levels. Among the land configurations, sowing on ridges and furrow was found significantly superior in increasing the uptake of Nitrogen (37.70 kg/ha), phosphorus

Table 1. Nutrient uptake, nutrient availability and yield in sunflower as influenced by land configurations and fertilizer levels.

Treatment	Nutrient uptake (kg/ha)			Nutrient availability (kg/ha)			Seed yield (t/ha)	Straw yield (t/ha)
	N	P_2O_5	K_2O	N	P_2O_5	K_2O		
Land configuration								
M_1-Flat bed	34.20	14.31	77.12	214.26	15.73	359.39	0.81	3.40
M_2-Ridges and furrows	37.70	15.35	87.24	217.17	18.05	365.40	0.93	3.70
SEm±	0.75	0.33	1.96	3.14	0.83	4.24	0.018	0.096
CD (P=0.05)	2.261	1.01	5.90	NS	NS	NS	0.053	0.289
Fertilizer levels								
F_1-75% RDF	29.96	12.33	69.25	206.28	14.23	349.44	0.70	3.07
F_2-100% RDF	37.71	15.78	85.57	218.92	17.43	365.86	0.92	3.71
F_3-125% RDF	40.19	16.38	91.70	221.95	19.01	371.89	0.99	3.87
SEm±	0.91	0.41	2.40	3.85	1.02	5.20	0.022	0.117
CD (P=0.05)	2.76	1.24	7.23	11.60	3.06	15.67	0.065	0.354
Interaction A x B								
	1.29	0.58	3.39	5.44	1.44	7.35	0.03	0.166
	NS	NS	NS	NS+	NS	NS	0.092	NS

(15.35 kg/ha) and potassium (87.24 kg/ha) over the flat bed method. Similarly, with ridges and furrow the availability of Nitrogen (217 kg/ha), phosphorus (18 kg/ha) and potassium (365 kg/ha) was found significantly superior over the flat bed method. The same trend was observed for seed and straw yield. Similar type of results with ridges and furrow method were reported by Malik et al. (2001). Among the fertilizer levels, Nitrogen (40 kg/ha), phosphorus (16 kg/ha) and potassium (92 kg/ha) uptake were significantly highest with application of 125% RDF which was superior over 75% RDF and at par with 100% RDF. The same trend was noticed in obtaining the seed and straw yield. These results are in conformation with the findings of Singh *et al*. (1999).

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Effect of integrated nitrogen management on cumin productivity

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India has been known as a land of spices and at present it is the world's largest producer, consumer and exporter of seed spices. Among the seed spices, cumin (*Cuminum cyminum* L.) is an important commercial seed spice crop of arid and semi-arid regions of India and valued for its aroma, medicinal and therapeutic properties. In India, it is mainly cultivated in Rajasthan, Gujarat, Karnataka and Orissa. The productivity of the crop is below prospective due to many reasons including nutrition. The continuous use of high levels of chemical fertilizers is adversely affecting the sustainability of agricultural production and causing environmental pollution. The use of organic fertilizers is one of the solutions for sustainable fertility and productivity. Very little information is available on the combined effect of organic and inorganic source of nitrogen on cumin. Therefore, an attempt was made to evaluate different organic and inorganic sources of nitrogen for realizing higher yield and profitability in cumin.

METHODOLOGY

A field experiment was carried out during 3 winter season of 2007-10 at Jobner, Jaipur (Rajasthan). The soil was loamy sand, low in organic carbon, available N & P and medium in available K with alkaline in reaction. The experiment was laid out in RBD with 3 replications. The experiment comprised of 14 treatments for application of recommended dose of nitrogen (RDN) to cumin through different sources *viz.* control, 100% RDN though fertilizer (30 kg N + 20 kg P_2O_5 + 0 kg K_2O/ha), 100% RDN through farmyard manure (FYM), 100% RDN through poultry manure (PM), 100% RDN through vermicompost (VC), 100% RDN through neem cake (NC), 50% RDN through FYM + 50% RDN through fertilizer, 50% RDN through PM + 50% RDN through fertilizer, 50% RDN through VC + 50% RDN through fertilizer, 50% RDN through NC + 50% RDN through fertilizer, 75% RDN through FYM + 25% RDN through fertilizer, 75% RDN through PM + 25% RDN through fertilizer, 75% RDN through VC + 25% RDN through fertilizer and 75% RDN through NC + 25% RDN through fertilizer. 'RZ 209' cumin variety was sown in rows 30 cm apart using 14 kg seed/ha in the first week of November during all the years. All improved package of practices were followed to raise the crop under irrigated conditions.

RESULTS

The nitrogen management through organic sources and fertilizer alone or in combination brought significant improvement in yield attributes *viz.* umbels/plant, umbellates/umbel except100% RDN through FYM, seeds/umbellate and test weight over absolute control (Table 1). The integrated application of 50% RDN through VC + 50% RDN through fertilizer gave higher values of all the yield attributes *viz.* umbels/plant (21.3), umbellates/umbel (4.7), seeds/umbellate (27.3) and test weight (4.72 g) to the magnitude of 34.8, 23.7, 40.7 and 11.3% over absolute control, respectively and closely followed by 100% RDN through fertilizer as well as 75% RDN through organic manures + 25% RDN through fertilizer. The 100% RDN through fertilizer significantly increased seed yield (442 kg/ha) to the tune of 63.7% over absolute control. The seed yield of cumin were also significantly improved with organic manures registering 53.3% with 100% RDN through FYM; 64.1% with 100% RDN through PM; 67.8% with 100% RDN through VC and 55.9% with 100% RDN through NC over control, respectively. Among the different nitrogen management, highest mean seed yield (474 kg/ha) was obtained with conjunctive use of 50% RDN through VC + 50% RDN through fertilizer. The positive response to combined application of organic manures and fertilizer might be attributed to the better nitrogen availability and its favourable effect on soil physical and biological properties resulting in increased yield attributes and finally higher yields (Godara *et al.*, 2014). Application of 50% RDN through VC + 50% RDN through fertilizer recorded highest net monetary returns (Rs 57,861/ha) which was significantly superior to control (Rs 27,400/ha) by 111.2%, 100% RDN through fertilizer (Rs 53,778/ha) by 7.6%, 100% RDN through FYM (Rs 48,942/ha) by 18.2%, 100% RDN through PM (Rs 53,315/ha) by 8.5%, 100% RDN through VC (Rs 53,465/ha) by 8.2%,100% RDN through NC (Rs 47,150/ha) by 22.7% and 75% RDN through NC + 25% RDN through fertilizer (Rs 47,167/ha) by 22.7%, however it remained at par to rest of the treatments of integration of organic and inorganic sources of nitrogen. Results were also supported by the findings of Patel *et al.* (2013).

Table 1. Effect of integrated nitrogen management on cumin (mean data of 3 years)

Treatment	Umbels/ plant	Umbellates /umbel	Seeds/ umbellate	Test weight(g)	Seedyield (kg/ha)	Net returns (Rs/ha)
Control	15.8	3.8	19.4	4.24	270	27400
100% RDN[1] through fertilizer	20.5	4.6	26.6	4.77	442	53778
100% RDN through FYM[2]	18.0	4.0	22.9	4.51	414	48942
100% RDN through PM[3]	18.7	4.1	22.2	4.59	443	53315
100% RDN through VC[4]	19.0	4.4	24.9	4.66	453	53465
100% RDN through NC[5]	18.2	4.2	24.6	4.60	421	47150
50% RDN through FYM +50% RDN through fertilizer	18.8	4.1	25.5	4.85	449	54719
50% RDN through PM + 50% RDN through fertilizer	19.0	4.5	25.4	4.62	463	56827
50% RDN through VC + 50% RDN through fertilizer	21.3	4.7	27.3	4.72	474	57861
50% RDN through NC + 50% RDN through fertilizer	18.9	4.3	25.9	4.58	449	53264
75% RDN through FYM + 25% RDN through fertilizer	18.2	4.2	25.7	4.59	453	55270
75% RDN through PM + 25% RDN through fertilizer	18.2	4.4	24.8	4.71	460	56190
75% RDN through VC + 25% RDN through fertilizer	19.4	4.5	26.0	4.71	466	56064
75% RDN through NC + 25% RDN through fertilizer	18.3	4.2	24.2	4.52	416	47167
SEm $\pm$	0.4	0.1	0.5	0.08	15	1214
CD (P=0.05)	1.1	0.3	1.5	0.23	42	3470

Where [1]Recommended dose of fertilizer, [2]Farm yard manure, [3]Poultry manure, [4]Vermicompost, [5]Neem cake

CONCLUSION

The nitrogen play an important role in the crop production but under intensive use of chemical fertilizer alone for long period could result in deterioration of soil fertility and quality of produce. The use of organic manure in combination with fertilizer helps in balancing soil fertility, environment and reduce the cost of inputs as reported by several workers. Therefore, from present study it is recommended to apply 50% RDN through VC + 50% RDN through fertilizer for realizing higher productivity and net monetary returns from cumin along with improvement in soil health.

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Integrated nutrient management in field pea (*Pisum sativum*)

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Pea is an annual plant belongs to the family leguminoceae. It is a cool season crop grown in many parts of the world. The field pea (*Pisum sativum* L. var. *arvense*) is used as vegetable, fresh, frozen or canned and is also grown to produce dry peas like the split pea. Mature seeds of this type are also used as '*dal*' and green seeds are also canned for the use in the off season. This type is also used for green manuring. Pea is an important pulse crop grown in India and it is the fifth largest producer in the world. Apart from India, other major producers of pea are USA, China, France, UK etc. The major pea growing states in India are Uttar Pradesh, Bihar, Haryana, Punjab, Himachal Pradesh, Orissa and Karnataka. Integrated nutrient management effect was found to increase crop yield by Mishra *et al.* (2010) and Singh and Sharma (2011). To find out response of integrated nutrient management to field pea a field study was conducted at Sardarkrushinagar, Gujarat.

METHODOLOGY

A field experiment was conducted during *rabi* season of the year 2011 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to study the "Integrated nutrient management in field pea." Twenty treatment combinations consisting of five levels of organic manures viz. treatments O_1 (vermicompost @ 1 t/ha), O_2 (vermicompost @ 2 t/ha), O_3 (FYM @ 2.5 t/ha), O_4 (FYM @ 5 t/ha) and O_5 (20+40 NP kg/ha) with four levels of biofertilizer viz. treatment B_1 (no biofertilizer), B_2 (*Rhizobium* inoculation), B_3 (PSB inoculation) and B_4 (*Rhizobium* + PSB inoculation) were tested under factorial randomized block resign with three replications.

RESULTS

The result of experiment revealed that application of 20+40 NP kg/ha (O_5) showed significantly higher vine length. The yield attributes viz. 100-seed weight, seed yield and stover yield were significantly higher under the treatment 20+40 NP kg/ha (O_5) while the harvest index, protein content and available nitrogen were non significantly influenced due to organic manure treatments. Significantly higher available phosphorus in soil and uptake of nitrogen and phosphorus by seed and stover were also recorded with the same treatment. Application of *Rhizobium* + PSB inoculation (B_4) showed significantly higher vine length. The yield attributes and yield viz. seeds per pod, 100-seed weight, seed yield and stover yield where significantly higher under the treatment of *Rhizobium* + PSB inoculation (B_4). Significantly higher protein content, available nitrogen and phosphorus in soil and uptake of nitrogen and phosphorus by seed and stover were recorded with treatment *Rhizobium + PSB i*noculation (B_4).

CONCLUSION

For securing higher seed yield from field pea (cv. Dantiwada Field pea 1), it should be fertilized with 20-40 NP kg/ha and seeds should be inoculated with *Rhizobium* + PSB culture (@ 250 g per 8 kg seed).

Table 1. Effect of organic manures and bio-fertilizers on growth and yield attributes and yield of field pea

Treatment	Plant height at harvest	Number of seeds per pod	100-seed weight (g)	Seed yield (kg /ha)	Stover yield (kg /ha)
Organic manure (O)					
O_1 : Vermicompost @ 1 t/ha	67.1	6.3	15.85	1431	2103
O_2 : Vermicompost @ 2 t/ha	70.9	6.7	16.61	1609	2240
O_3 : FYM @ 2.5 t/ha	65.2	6.1	15.79	1327	2027
O_4 : FYM @ 5 t/ha	68.4	6.5	16.08	1532	2165
O_5 : 20 + 40 NP kg/ha	71.8	6.9	17.12	1629	2286
SEm $\pm$	1.59	0.11	0.29	34.2	53.4
CD (P=0.05)	4.6	0.3	0.83	98	153
Bio-fertilizers (B)					
B_1 : No bio-fertilizers	61.7	6	15.53	1265	1922
B_2 : *Rhizobium* inoculation	66.9	6.5	16.02	1449	2144
B_3 : PSB inoculation	70.9	6.6	16.53	1565	2214
B_4 : *Rhizobium* + PSB incoculation	75.3	6.9	17.09	1743	2377
SEm $\pm$	1.43	0.1	0.26	30.6	47.7
CD (P=0.05)	4.1	0.3	0.75	88	137

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Seed production potentiality of oats with reference to zinc and boron in red and lateritic soil

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Oats is an important winter cereal fodder crop. It is becoming a promising good quality forage crop due to its excellent growth habit, better regeneration capacity, palatability and nutritive value.Non- availability of forage seed in right time results in less area under green forage and seed production. The farmers have to depend on other sources like private organization and other states. Seed production of oats will mitigate the deficiency of green fodder production.The discovery of the cholesterol lowering properties has led to wider appreciation of oats as human food and possibly reduces the risk of heart disease. Oatprotein is nearly equivalent in quality to soy protein, which World Health Organization research has shown to be equal to meat, milk, and egg protein. Application of various micro-nutrients like Zn, B on seed production of oats not only improve the quality of oats seed but also reduce the deficiency of micro-nutrients in animals in absence of which the animals may suffer from malnutrition and various disorders. Singh (2009) mentioned that, nutritionally micronutrient enriched (dense) seeds are good for improving health of both livestock and human. Through better germination and vigorous seedlings, enriched seed helps in better establishment of crops at early growth stage, so give high yield with good micronutrient content in fodder grain. Crop yield even when sown in micronutrient deficit soils and agronomically it reduces seed rates, resulting in substantial economic saving on input cost. Micronutrients enriched fodders and grain concentrate are beneficial in livestock production. Keeping all these ideas in view the present experiment was carried out with the objectives of to study the productivity andeconomics of oats seeds as influenced by Zn and B application.

METHODOLOGY

The experiment was conducted during *rabi* season of 2011-2012 at Agricultural Farm, Institute of Agriculture, Visva-Bharati, Sriniketan,West Bengal in red and lateritic soil. The farm was situated at 23^{f} 39A N latitude and 87^{f} 42A E longitude with an average altitude of $58^{y}90$ m above mean sea level under sub-humid, semi-arid region of West Bengal. The soil of the experimental field was sandy loam in texture, well drained with low level of organic carbon (0.36%) available nitrogen (188.26 kg/ha) and potassium (110.25kg/ha) and medium in available phosphorus (22.64kg/ha). The soil is slightly acidic (pH 5·78) in reaction. The experiment, consisting of twelve treatments waslaid out in randomized block design (RBD) with each treatment replicated thrice. The fodder crop, oat var. JHO-822, a multi-cut fodder variety was sown with a seed rate of 100kg/ha on19November, 2011 with row to row spacing of 25cmand raised following the recommended package of practices.The net return and return/ rupee invested were calculated on the basis of prevailing market price of different inputs and outputs. The experimental data were analysed following thestandard statistical methods.

RESULTS

The treatments under investigation had nosignificant influence on number of filled grains/panicle and test weight of oats seeds except number ofpanicles/m^2. Application of 100% NPK + FYM @ 10t/ha in combination with $ZnSO_4$ and Borax at 20kg and 10 kg, respectively produced highestnumber of panicles/m^{2}which was significantly higher than all other treatments. Grain yield and straw yield of oats were influencedsignificantly by the treatments. The highest grain yield and straw yield were achieved from treatment with 100% NPK+FYM@ 10 t/ha+ $ZnSO_4$ @ 20 kg/ha+ Borax @ 10 kg/ha. This was at par with the treatment where combined application of $ZnSO_4$ and Borax at 10kg and 5kg /ha, respectively along with 100% NPK and FYM @ 10 t/ha was done. The use of 100% NPK+FYM@ 10 t haproduced significantly higher grain yield andstraw yield than100% NPK alone.Combined application of $ZnSO_4$ and Borax at 20Kg and 10kg /ha, respectively exhibited the highest gross return and net return from oats cultivation. This was at par with combined application of $ZnSO_4$ and Borax at 10 kg and 5kg/ ha, respectively along with 100% NPK+FYM@10t/ha. Though , the highest return per rupee investment was found at 100% NPK+ Borax @10kg/ ha followed by 100% NPK+ Borax @ 5kg/ha, these were at par with combined application of ZnSO4 and Borax both at their higher and lower levels (10kg/ha and 5 kg/ha, respectively).

Table 1. Effect of zinc and boron on yield components, seed yield and economics of oats

Treatment	Panicles/ m^2	Grain yield (t/ha)	Straw yield (t/ha)	Net return (Rs./ha)	Return per rupee investment (Rs.)
T_1 100% NPK (80:40:20; $N:P_2O_5:K_2O$ in kg/ha	216.0	1.82	6.12	28410	3.01
T_2 100% NPK + FYM @ 10 t/ha	256.0	2.55	6.80	33690	2.40
T_3 100% NPK +$ZnSO_4$@ 10 kg/ha	245.3	1.98	6.23	31470	3.19
T_4 100% NPK + $ZnSO_4$@ 20 kg/ha	257.3	2.16	6.73	35320	3.42
T_5 100% NPK+ FYM @ 10 t/ha + $ZnSO_4$@ 10 kg/ha	250.6	2.58	6.35	33590	2.38
T_6 100% NPK+ FYM @ 10 t/ha + $ZnSO_4$@ 20 kg/ha	264.8	2.70	6.54	35930	2.46
T_7 100% NPK + Borax@ 5 kg/ha	248.3	2.13	6.62	34893	3.45
T_8 100% NPK +Borax@10 kg/ha	262.6	2.36	6.83	39620	3.75
T_9 100% NPK+ FYM @ 10 t/ha + Borax@ 5 kg/ha	256.3	2.87	6.95	40090	2.65
T_{10} 100% NPK+ FYM @ 10 t/ha + Borax@10 kg/ha	275.2	3.02	7.12	43110	2.77
T_{11} 100% NPK+ FYM @ 10 t/ha +$ZnSO_4$@ 10 kg/ha + Borax@ 5 kg/ha	288.5	3.38	7.76	50850	3.07
T_{12} 100% NPK+ FYM @ 10 t/ha + $ZnSO_4$@ 20 kg/ha + Borax@10 kg/ha	320.0	3.52	7.93	53420	3.14
CD (P= 0.05)	21.00	0.54	0.55	10892.2	0.68

CONCLUSION

Combined application of $ZnSO_4$ and Borax at 20Kg and 10kg/ha, respectively along with 100% NPK+FYM@ 10 t/ha, exhibited higher yield components, grain yield and straw yield as well as gross return and net return from oats seed production. This treatment was comparable with combined application of $ZnSO_4$ and Borax at 10 kg and 5kg/ha, respectively along with FYM@ 10t/ha and 100% NPK. However the use of 100% NPK+ Borax @ 10 kg/ha achieved the highest return/rupee invested.

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Response of mustard varieties (*Brassica juncea*) to different nutrient combinations under late sown condition

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Indian mustard (*Brassica juncea* L.) belongs to the family cruciferae is one of the most important winter oilseed crop. Oil seed crops generally cultivated under energy starvation condition, moisture stress condition particularly rainfed areas under deficient nutrient supply these are the main cause of low productivity in oil seeds. Improved plant types play an important role in raising the seed yield of the crop. Development of high yielding varieties of mustard has been one of the major concern of the scientists because use of the improved varieties alone accounts for 15-20% increase in productivity. This is probably because of their altered morphology which results into efficient utilization of water, nutrients and radiation. The fertilizers have played a prominent role in increasing the oil seed production, balanced fertilizer is the key to achieve higher production and increase nutrient use-efficiency. The use of chemical fertilizers would remain the mainstay of agricultural production in future. Use of optimal dose of primary, secondary and micronutrients ensure better and sustainable yield, while correcting some of the nutrients deficiencies.

METHODOLOGY

The field experiment was conducted at Agronomy Research Farm, N.D. University of Agriculture & Technology, Kumarganj, Faizabad during the *rabi* season of 2011-12 consisting of 15 treatment combinations laid out in randomized block design with three replications, comprised of three varieties i.e. Vardan, Narendra Rai-1 and Narendra Ageti Rai-4 and five nutrient combinations (kg/ha) i.e. 120 kg N + 60 kg P_2O_5 + 40 kg K_2O, 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg sulphur, 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 5 kg zinc, 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg sulphur + 5 kg zinc and 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg sulphur + 5 kg zinc + 0.2% Boron spray before flowering. The experiment was sown on 15 November 2011 in the field, having the soil texture silty loam, pH 7.9, OC 0.32%, EC 0.33% and available N, available P, available K, available S and available Zn were 180.4 kg/ha, 18.4 kg/ha, 290 kg/ha, 7.3 (ppm) and 0.59 (ppm), respectively.

RESULTS

Application of 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S + 5 kg Zn + 0.2% Boron spray before flowering increased almost all the growth, yield attributes and biological, seed and stover yield of mustard significantly over rest of the nutrient combinations but at par with 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S + 5 kg Zn. However, significantly higher oil content was recorded with 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S + 5 kg Zn + 0.2% Boron spray before flowering over rest of the treatments but at par with 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S and 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S + 5 kg Zn. Among the different mustard varieties, Narendra Rai-1 being at par with Vardan recorded significantly higher growth and yield attributes as well as yield and oil content as compared to Narendra Ageti Rai- 4. Similar results also were observed by Singh *et al.* (2012), Rana *et al.* (2008) and Chaplot *et al.* (2012). The interaction effect of treatments was found to be non significant at all the growth stages, yield contributing characters and yield. With respect to economics, variety Narendra Rai-1 along with 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S + 5 kg Zn + 0.2% Boron spray before flowering recorded substantially highest value of net return (Rs. 51535/ ha) and B:C ratio.(1.87) followed by Vardan along with same nutrient combinations. Considering the growth, yield and economics, it can be concluded that Narendra Rai-1 with the application of 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S + 5 kg Zn + 0.2% Boron spray before flowering , proved superior over rest of the treatment combinations. Mustard variety Narendra Rai-1 was found suitable in late sown condition for eastern U.P. Nutrient combinations of 120 kg N/ha + 60 kg P_2O_5/ ha+ 40 kg K_2O/ha+ 40 kg S/ha+ 5 kg Zn/ha+ 0.2% Boron spray before flowering was found to be best as compared to the other nutrient combinations.

CONCLUSION

The performance of various varieties of mustard at varying nutrient combinations was found non-significant but on economics basis, Narendra Rai-1 with the application of 120 kg N/ha+ 60 kg P_2O_5/ha+ 40 kg K_2O/ha + 40 kg S/ha + 5 kg Zn/ ha+ 0.2% Boron spray before flowering better than other treatments.

Table 1. Growth, Yield attributes yields and oil content of mustard varieties as influenced by nutrient combinations under late condition

Treatment	Primary branches /plant	Secondary branches /plant	Dry matter atharvest (g/plant)	Siliquas /plant	Length of siliqua (cm)	Seeds /siliqua	Seed yield (t/ha)	Oil content (%)
Nutrient combinations								
F_1	6.57	12.00	34.62	190.58	5.33	10.27	1.41	34.67
F_2	7.39	13.52	37.48	215.46	6.10	11.00	1.58	40.67
F_3	7.10	12.82	36.44	207.29	6.07	10.90	1.53	36.33
F_4	7.90	14.41	42.67	260.46	7.69	12.14	1.81	40.67
F_5	8.30	15.14	44.26	273.63	8.24	12.50	1.96	41.33
SEm±	0.30	0.54	1.58	7.57	0.22	0.38	0.05	1.55
CD (P=0.05)	0.86	1.58	4.58	21.92	0.63	1.09	0.16	4.48
Varieties								
V_1	7.54	13.76	39.49	234.27	6.80	11.26	1.69	39.40
V_2	8.05	14.70	42.00	250.67	7.07	12.06	1.78	40.80
V_3	6.77	12.37	35.79	203.52	6.20	10.77	1.50	36.01
SEm±	0.23	0.42	1.22	5.86	0.17	0.29	0.04	1.20
CD (P=0.05)	0.67	1.22	3.54	16.98	0.49	0.84	0.12	3.47
F x V	NS	NS	NS	NS	NS	NS	NS	

V_1 =Vardan; V_2=Narendra Rai-1; V_3=Narendra Ageti Rai-4; F_1=20 kg N + 60 kg P_2O_5 + 40 kg K_2O; $F_2$1=20 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg sulphur; F_3=120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 5 kg zinc; F_4=120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg sulphur + 5 kg zinc; F_5=120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg sulphur + 5 kg zinc + 0.2% Boron spray before flowering.

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Impact of cultivation methods and nutrient management on crop growth, physiology and yield of rice

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Rice (*Oryza sativa* L.) is the foremost staple food in Asia, providing 35–60% of the dietary calories consumed by more than 3 billion people. Today, major challenge in agriculture is to feed the growing population under declining arable land per capita, declining soil health/fertility and water, and this has to be achieved under changing climate in a sustainable way. The system of rice intensification (SRI) is a rice crop management system developed in the 1980s in Madagascar (Stoop *et al*., 2002), reportedly enhances yield through synergy among several agronomic management practices with less water requirement (Thakur *et al*., 2010 & 2011). This study was carried outto investigate the effects of rice cultivation methods and nutrient management on growth, physiology and grain yield of rice.

METHODOLOGY

Field experiments were conducted for three years (2012-14) during the *kharif* season at the ICAR-IIWM Research Farm, Mendhasal, Bhubaneswar using randomized complete block designs with three replication.The systems of rice cultivation comprised SRI method and conventional transplanting method (TP) with two different nutrient managements *viz.*, organic and integrated nutrient management (INM). Experimental treatments were as: SRI-Organic, SRI-INM, TP-Organic,TP-INM.Seeds were sown in a nursery, and then transplanted for SRI plots at 12-days as single seedlings at a spacing of 20×20 cm (25 plants/m) within 30 min after removal from the nursery, and for TP plots at 25-days using three seedlings/hill at a spacing of 20×10 cm (150 plant/m^2). The SRI plots were weeded by cono-weeder at 10, 20 and 30 days after transplanting, while the TP plots had three hand weedings at the same interval. TP plots were kept continuously flooded with 5-8 cm depth of water while SRI plots were kept without stagnant water during entire vegetative stage. After panicle initiation, all plots were kept flooded with a thin layer of water 1-2 cm, and all were drained at 15 days before harvest. Under INM treatments with both cultivation practices, FYM was applied at the rate of 5 t/ha along with chemical fertilizer: N(80 kg N/ha), P (40 kg P_2O_5/ha), and K (40 kg K_2O/ha). However, for organic fertilization treatments, FYM @20 t/ha, green manure (*Sesbania aculeate*) @ 2 t/hafresh weight and vermi-compost @ 350 kg/ha were applied. Ten leaves were randomly selected from each plot to measure chlorophyll content (SPAD value), and leaf photosynthesis rate at tillering and grain-filling stages. Light interception by canopy was measured with a line quantum sensor. All plants in an area of 3×3 m for each plot were harvested (excluding the border rows) for determination of yield per unit area. Grain yield was adjusted to about 14.5% seed moisture content.Data were statistically analyzed using the analysis of variance (ANOVA) technique as applicable to randomized completeblock design. Duncan's multiple range test (DMRT) was employed to assess differences between the treatment means at the 5% probability level.

RESULTS

Light interception by the canopy showed that canopy of SRI intercepted more solar radiation than the TP canopy (Table 1). During tillering stage, SRI crop were greener than the TP crop as also evident from the measurement of SPAD value. Organically grown rice under both cultivation systems had higher SPAD value than INMcrop. However, at grain-filling stage, SPAD value was higher in INMfertilized crop than organically grown rice. With greater SPAD value in SRI organic crop, highest leaf photosynthetic rate was observed in SRI-organic plots, followed by SRI-INM, TP-organic and least in TP-INM. However, greater photosynthesis rate was observed during grain-filling stage in SRI-INM plots. Overall, results indicate that rice crop grown under SRI had significant improvement in crop physiology. The improvement in plant functions resulted into significant gain in grain production. In our earlier efforts (Thakur *et al*., 2011), it was also observed improvement in phenotype and physiological functions under SRI compared to conventional method of transplanted rice. In spite of less number of hills under SRI, number of panicles per unit area was significantly higher in SRI plots than TP (Table 2). Highest number of panicle was found under SRI-INM, followed by SRI-organic and TP-INM, and least in TP-organic plots. Highest grain yield was obtained in SRI with inorganic fertilization. As

Table 1. Rice cultivation system and nutrient management on SPAD value, light interception and photosynthetic rate during tillering and grain-filling stages (pooled data of 3 years)

Cultivation system	Light interception (%)		SPAD chlorophyll meter reading		Rate of leaf photosynthesis rate (μmol/m^2/s)	
	TS	GFS	TS	GFS	TS	GFS
SRI-Organic	64.7a	73.2b	43.1a	36.1b	25.9a	19.7b
SRI-INM	67.7a	81.4a	40.7b	38.2a	20.7b	21.3a
TP-Organic	45.4b	69.1c	36.2c	27.4d	16.9c	13.6c
TP-INM	48.4b	75.2b	31.2d	29.7c	14.5d	14.7c

TS, tillering stage and GFS, grain-filling stage

Table 2. Effect of cultivation system and nutrient management on yield attributes and grain yield of rice (pooled data of 3 years)

Cultivation system	Panicle number/m^2	Grains/ panicle	Filled grains (%)	1000-grain weight (g)	Grain yield (t/ha)
SRI-Organic	378.2bc	121.3b	79.7a	24.22a	4.98b
SRI-INM	417.0a	130.7a	78.3a	24.17a	6.04a
TP-Organic	362.3c	98.3d	71.4b	23.07b	3.99d
TP-INM	394.1b	104.7c	71.0b	23.24b	4.20c

compared to TP-INM treatment, grain yield under SRI-INM enhanced by 43% while, in case of organic fertilization grain yield under SRI method enhanced by 25% than TP. Overall, 34% higher grain yield was produced with SRI method. The enhancement in grain yield under SRI was mainly due to significant improvement in number of grains/panicle, grain filling % and 1000-grain weight (Table 2).

CONCLUSION

Overall, grain yield was increased by 34% with SRI practices due to significant improvement in morphology (tillering and light interception) and physiology (chlorophyll content and photosynthesis rate) of crop than crops grown with conventional method. This was plausible reason for improvement in yield contributing characteristics and ultimately higher grain yield under SRI than from conventional transplanting method. Lower grain yield was obtained with organic fertilization than INM crop, but it would be of more significance in improving soil health and reduction in environmental hazards. It is also important to note here that organically fertilized SRI crop gave significantly higher yield than both organically and INM crops under conventional transplanted method.

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Response of castor to phosphorus levels and biophos under north Gujarat condition

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Castor is an important non-edible oilseed crop of the arid and semi arid regions. Its yield is most useful and economically important plant oil having vast and varied industrial applications such as lubricants, surfactants, surface coating, cosmetics, plasticizers, resins, paints, pharmaceuticals, adhesives, waxes, polishes, varnishes, perfumes, flavours, textile dyes, textile finishing agents, nylon etc. India, Brazil and China are the most important castor growing countries in the World. Castor cake is considered to be excellent organic manure. At present, India is the World leader in castor production and sole exporter of castor oil, seed and some of its derivatives. Currently, the total castor production is 17.33 lakh tonnes obtained from 10.40 lakh ha with a productivity of 1666 kg/ha (2014-15) in India. Gujarat is the largest castor growing state of India. Where, it's grown over an area of 7.15 lakh ha with the annual production of 14.56 lakh tonne with average productivity of about 2036 kg/ha and its shares about 68.75% of the total area and 84% of the total castor production of the country (FAOSTAT, 2015). Integrated nutrient management holds a great promise in maintaining yield stability and quality of produce through correction of marginal deficiencies of nutrient, enhancing efficiency of applied nutrient and providing favourable soil physical condition. The balanced nutrition is needed which could be achieved through chemical as well as organic manner. Since, castor crops respond favourably to applied phosphorus alone and in conjunction with biophos. Therefore, present field experiment was planned to study the effect of biophos on performance of castor for north Gujarat agro-climatic region.

METHODOLOGY

A field experiment was carried out during 2011-12 to 2013-14 at Castor-Mustard Research Station, SDAU, Sardarkrushinagar, Gujarat to study the effect of biophos (*Chaetomium globosum*) on performance of castor (*Ricinus communis* L.) on sandy loam soil. The treatments consisted i.e. Control (No phosphorus), seed treatments with biophos @ 30 g inoculants/50 g seeds, 20 kg P_2O_5/ha, 20 kg P_2O_5/ha + Seed treatments with biophos @ 30 g inoculants/50 g seeds, 40 kg P_2O_5/ha, 40 kg P_2O_5/ha + Seed treatments with biophos @ 30 g inoculants/50 g seeds, 60 kg P_2O_5/ha, 60 kg P_2O_5/ha + Seed treatments with biophos @ 30 g inoculants/50 g seeds. The experiment was laid out in randomized block design with four replications. Castor hybrid 'GCH 7' was sown in rows 150 cm apart with keeping plant to plant distance 120 cm. Recommended dose of fertilizer (RDF) i.e. 180-37.5-20 kg N-P-S/ha. Full dose of phosphorus has been applied as per treatments and full dose of sulphur and 1/4th part of nitrogen were made to all the plots as basal. Remaining 3/4th dose of nitrogen applied in 3 equal instalments at 30-35, 60-65 and 90-95 DAS. Nitrogen, phosphorus and sulphur were supplied through urea, diammonium phosphate and elemental sulphur, respectively. Weed management was done manually as well as interculturing by tractor operated cultivator. Other management practices were adopted as per recommendations of crops under irrigation situation. All the data were statistically analysed to draw a valid conclusion.

RESULTS

The increasing level of phosphorus alone and in conjunction with biophos seed treatment observed increasing trends in plant height, number of nodes and primary branches/plant on three years pooled basis (Table 1). Application of 60 kg P_2O_5/ha alone recorded significantly tallest plant over control and added phosphorus up to 20 kg/ha along with biophos while it was statistically at par with added phosphorus from 40 kg/ha to 60 kg P_2O_5/ha along with biophos, respectively. In regards to no. of primary branches/plant which was significantly higher under application of 60 kg/ha P_2O_5 along with biophos over control and increasing level of phosphorus up to 40 kg P_2O_5/ha but at par to application of 40 kg P_2O_5/ha along with biophos and rest of higher dose of phosphorus. Length of main spike, no. of capsules on main spike, 100-seed weight and seed yield of castor and it were found statistically at par to 60 kg P_2O_5 and 40 kg P_2O_5 alone and its integration with biophos but it were significantly superior over rest of the treatments on pooled basis. However, the final plant stand and no. of nodes/plant were not influenced significantly due to increasing level of

Table 1. Effect of phosphorus levels and biophos on the growth of castor (pooled data of 3 years)

Treatment	Plant height (cm)	Nodes/plant (no.)	No. of primary branches /plant
Control (no phosphorus)	95.60	19.75	6.90
Seed treatment with biophos @ 30 g inoculants / 50 g seeds	94.28	19.48	6.43
20 kg P_2O_5/ha	98.25	20.35	7.22
20 kg P_2O_5/ha + Seed treatment with biophos	101.40	19.92	7.60
40 kg P_2O_5/ha	101.13	19.77	8.15
40 kg P_2O_5/ha + Seed treatment with biophos	105.65	20.15	8.05
60 kg P_2O_5/ha	105.87	20.15	8.25
60 kg P_2O_5/ha + Seed treatment with biophos	102.38	19.87	8.67
SEm±	1.81	0.23	0.23
CD (P=0.05)	5.12	NS	0.66

Table 2. Effect of phosphorus levels and biophos on the yield attributes and yield of castor

Treatment	Length of main spike (cm)	No. of capsules on main Spike	100-seed weight (g)	Seed yield (kg/ha)
Control (no phosphorus)	56.42	46.73	32.47	2299
Seed treatment with biophos @ 30 g inoculants/50 g seeds	56.07	48.35	32.54	2305
20 kg P_2O_5 /ha	58.77	50.28	33.11	2568
20 kg P_2O_5 /ha + Seed treatment with biophos	59.57	53.63	32.55	2585
40 kg P_2O_5 /ha	62.15	54.00	33.50	2784
40 kg P_2O_5 /ha + Seed treatment with biophos	61.62	54.40	32.72	2808
60 kg P_2O_5 /ha	62.03	54.88	32.88	2729
60 kg P_2O_5 /ha + Seed treatment with biophos	63.05	55.13	33.68	2818
SEm±	0.91	0.70	0.31	60.38
CD (P=0.05)	2.58	1.97	0.87	170.65

phosphorus with and without biophos treatments. Yield attributes *viz*. length of main spike, no. of capsules on main spike and 100-seed weight of castor were significantly influenced due to increasing level of phosphorus with and without biophos treatment and their increasing trends were observed with added level of phosphorus on three years pooled data basis (Table 2). Seed yield of castor was recorded higher with crop received 60 kg P_2O_5/ha along with biophos seed treatment closely followed by 40 kg P_2O_5/ha + biophos both the treatments were significantly higher over phosphorus application up to 20 kg/ha with biophos. Application of 60 kg P_2O_5/ha along with biophos tended to increase seed yield by the margin of 22.57% and 22.25% higher over control and seed treatment with biophos alone, respectively.

CONCLUSION

Thus, it can be concluded that application of 60 kg P_2O_5/ha along with biophos (*Chaetomium globosum*) seed treatment produced higher yield of castor in north Gujarat agro-climatic condition.

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Effect of integrated nutrient management and levels of sulphur on growth and yield of mustard (*Brassica juncea*)

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Productivity of mustard is very low in Vidarbha region of Maharashtra as it is mainly grown under rainfed condition with inadequate supply of nutrients. Deficiency of essential nutrients like nitrogen cause significant reduction in yield and oil content. Also, the cost of chemical fertilizer is increasing along with deterioration of soil health which necessitates the combine use of organic, inorganic and biological sources of nutrients for sustainable crop production and better soil health. Besides the supply of major nutrients NPK, Sulphur is now becoming major nutrient for most of the crops specially oil seed and pulse crops as it is a constituent of amino acids and of fatty acids as well as essential for synthesis of chlorophyll. Looking to the above fact, an investigation was undertaken to study the effect of integrated nutrient management and levels of sulphur on growth and yield of mustard.

METHODOLOGY

A field experiment was conducted during Rabi season of 2014-15 at College of Agriculture, Nagpur, Maharashtra. The soil was clayey in texture, slightly alkaline in reaction with 7.8 pH. Soil was medium in organic carbon, low in nitrogen (246.94 kg /ha) and phosphorus (19.82 kg /ha) content however, very high in potash (414.42 kg /ha) content. The experiment was laid out in split plot design replicated four times consisting three treatments of nutrient management viz., RDF (50:40:0 NPK kg /ha), 75 % RDF + biofertilizers (*Azotobacter* + PSB @ 2.5 kg/ha each as soil application) and 125% RDF under main plot and three levels of sulphur applications viz., 20 kg/ha, 30 kg /ha and 40 kg /ha as a sub plot treatments. Seed yield of mustard was recorded after harvest from respective treatment and the various economic parameters such as, gross monetory returns; net monetory returns and benefit cost ratio were estimated considering the prevailing market value of produce and input during 2015.

RESULTS

Seed yield/ plant, seed and stover yield /ha was significantly influenced due to the nutrient management treatments and were recorded significantly higher with the application of 75 % RDF + biofertilizers (*Azotobacter* + PSB). However, the application of 125% RDF was found at par with the application of 75 % RDF + biofertilizers. The increase in yield might be due to greater availability of nutrients to the crop that is reflected through increase in dry matter and yield attributes. Similar findings were also reported by Meena *et.al.* (2013). Oil content (%) remained unchanged due to nutrient management however, numerically highest oil content was found with the application of 75 % RDF + biofertilizers whereas, oil yield (kg /ha)was significantly influenced and was maximum with the application of 75 % RDF + biofertilizers over RDF. As regards economic returns, gross monetory returns and net monetory returns were significantly higher due to application of 75 % RDF + biofertilizers over RDF. The

Table 1. Seed and stover yield, oil content & oil yield and economics of mustard as influenced by various treatments

Treatment	Seed yield/ plant (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Oil content (%)	Oil yield kg/ha	GMR Rs. /ha	NMR Rs. /ha	B:C ratio
Fertilizer application in association with biofertilizers								
RDF 50:40:0 NPK kg/ha	4.00	479	1011	35.50	150	14844	1333	1.09
75% RDF+ Biofertilizers	4.48	578	1201	36.17	178	17909	5142	1.40
125% RDF	4.11	501	1073	35.50	194	15542	971	1.06
SEm±	0.11	22	27	0.64	5	692	692	-
CD (P=0.05)	0.38	77	92	NS	18	2395	2395	-
Sulphur application								
20 kg /ha	4.01	471	992	34.33	133	14596	1360	1.10
30 kg /ha	4.10	515	1094	36.35	176	15953	2326	1.17
40 kg /ha	4.46	573	1189	36.58	213	17748	3735	1.26
SEm±	0.11	21	24	0.54	5	667	667	-
CD (P=0.05)	0.38	64	70	1.62	16	1984	1984	-

highest B:C ratio was also registered by application of 75 % RDF + biofertilizers. Yield and yield attributes viz., seed yield/ plant, seed yield /ha and stover yield /ha were significantly maximum with the application of sulphur @ 40 kg /ha and was found at par with sulphur @ 30 kg /ha. The increase in yield might be attributed due to role of sulphur in biosynthesis of chlorophyll that increased the photosynthesis activity contributing to higher yield and yield attributes. Similar results were found in accordance with the findings of Singh *et.al*. (2013). Quality parameters such as, oil content (%) registered significantly higher values with 30 & 40 kg /ha sulphur application and significantly higher oil yield (kg /ha) was recorded with application of sulphur @ 40 kg /ha. The influence in oil content and oil yield of mustard might be due to significant role of sulphur in synthesis of fatty acids. Regarding economics, significantly maximum gross monetory returns and net monetory returns were registered with the application of sulphur @ 40 kg /ha. The maximum B:C ratio was also registered by the same treatment.

CONCLUSION

It can be concluded that, application of 75 % RDF + biofertilizers (*Azotobacter* + PSB) in mustard had significantly increased the seed & stover yield as well as oil yield (kg /ha) and economic returns. Similarly, application of sulphur @ 40 kg /ha significantly increased seed & stover yield as well as oil content & oil yield and economic returns of mustard.

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Decision support tools for nutrient recommendations for maize (*Zea mays* L.)

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Maize is an exhaustive crop, the nutrient requirement cannot be supplied only through native nutrient reserves, and hence the additional nutrient requirements have to be met from fertilizers. Further, In Northern Karnataka maize yield is low due to imbalanced application of fertilizers. Among the several soil test based fertilizer application techniques, site specific nutrient management (SSNM) and soil test crop response (STCR) are cost effective and plant need based approaches with specific yield target. The SPAD chlorophyll meter and LCC is useful in diagnosing the N status of crops and determination of the right time of N application. Nutrient Expert is a decision support tool for nutrient management in hybrid maize. This will help to increase yield and profit by target enabled fertilizer management strategy.

METHODOLOGY

A Field experiment was conducted during the *Kharif* 2014 and 2015 at Siruguppa, University of Agricultural Sciences, Raichur, situated on the latitude 15^0 38' N, longitude 76^0 54 E, 380 MSL. The soil of the experimental site was medium black and clay loam in texture, neutral pH (7.24) and low in electrical conductivity (0.36 dS/m). The soil organic carbon content was 0.41% and soil was low in available N (229 kg/ha), medium in available phosphorus (23 kg/ha) and high potassium (381 kg/ ha). The experiment was tested in RCBD with three replications. The equations used to recommend fertilizers for STCR approach was developed by AICRP on STCR, Bangalore were used in the study and are as follows (Anon., 2007). To work out SSNM based recommendation, the data on quantity of NPK uptake per tonne considered was 26.3, 13.9 and 35.8 kg respectively based on several years of field studies. Further, the quantity of fertilizers required for a target yield of 8 and 10 t/ha was worked out. For nutrient expert based fertilizer recommendation ready recknor software developed by IPNI, 2014 was used. For treatment of LCC threshold 4 and 5 intermittent N application as guided by LCC threshold 4 and 5 respectively was used. For SPAD threshold based nutrient application N was applied based on SPAD readings.

Table 1. Grain yield, stover yield, crude protein content, net returns and B: C ratio of maize as influenced by different nutrient recommendation techniques

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Crude protein (%)	Net returns (₹/ha)	B:C ratio
Nutrient Expert based target 8 t/ha (NE_8)	7.19	9.18	10.6	65,843	2.49
Nutrient Expert based target 10 t/ha (NE_{10})	7.99	9.54	10.6	75,360	2.63
SSNM target 8 t/ha ($SSNM_8$)	8.21	10.22	11.1	70,871	2.30
SSNM target 10 t/ha ($SSNM_{10}$)	9.53	11.49	11.6	86,727	2.48
STCR target 8 t/ha ($STCR_8$)	8.05	10.18	10.9	70,030	2.32
STCR target 10 t/ha ($STCR_{10}$)	9.24	11.92	11.3	84,601	2.49
SPAD threshold 40 (SPAD 40)	5.50	9.76	10.8	42,096	1.94
SPAD threshold 50 (SPAD 50)	6.78	8.93	10.6	58,735	2.30
LCC threshold 4 (LCC 4)	6.87	10.15	10.7	61,149	2.35
LCC threshold 5 (LCC 5)	7.66	9.71	10.9	71,416	2.57
Recommended dose of fertilizers (RDF)	6.12	8.37	10.5	48,018	2.04
Farmers practice (187:107:150 kg NPK/ha)	6.46	9.38	10.5	48,424	1.94
Absolute Control	3.06	5.49	9.3	9,767	1.25
SEm±	0.251	0.579	0.1	3,593	0.07
CD (P=0.05)	0.732	1.692	0.2	10,488	0.22

DAS – Days after sowing; SSNM – Site Specific Nutrient Management; STCR – Soil Test Crop Response; SPAD – Soil Plant Analysis Development; LCC –Leaf Colour Chart

RESULTS

The higher grain and stover yield of maize was recorded with application of fertilizers based on SSNM and STCR for a target yield of 10 t/ha. Among other recommendation methods nutrient expert based target 10 t/ha (7998 kg/ha) and LCC threshold 5 were statistically on par. Significantly higher stover yield was recorded with application of nutrients based on STCR for a target yield of 10 t/ha and SSNM target yield 10 t/ha which was lower in absolute control. The higher grain and stover yields of maize was mainly due to better translocation of photosynthates from source to sink and higher growth attributing and some yield attributing characters. This was evidenced through these findings of Jayaprakash *et al*. (2006) and Arun Kumar *et al*. (2007). Significantly higher crude protein content was recorded with application of nutrients based on SSNM and STCR for target yield 10 t/ha (11.6% and 11.3%). This is because of grain protein content is a nitrogen dependent quality parameter directly related to N content of maize grain. Higher net income obtained from corn production under SSNM and STCR approach for a target yield of 10 t/ha. The higher fertilizer cost in SSNM practice though slightly reduced net returns, the improvement in soil fertility over years may reduce the input costs and thereby production under SSNM approach might become profitable and sustainable. The B:C ratio was higher in NE target 10t/ha and LCC threshold 5. Umesh *et al.* (2014) also reported profitability of maize under SSNM based fertilizers application over blanket recommended fertilizers.

CONCLUSION

It is clear from the study that, SSNM, STCR and Nutrient Expert approach based target yield 10 t/ha or LCC threshold 5 can be recommended for maize production under protective irrigation in *Vertisols* of Northern Karnataka.

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Yield maximization of soybean under high fertility levels

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Globally soybean (*Glycine max* L. Merril) is the most important seed legume, contributes about 25 % of the edible oil, two-thirds of protein concentrate for livestock feeding worldwide. Soybean meal is a valuable ingredient for poultry and fish in formulated feeds. The soybean cultivation and use could be traced back to the beginning of China's agricultural age. Chinese medical compilations, dating back 6,000 years, mention its utilization for human consumption (Krishnamurthy and Shivashankar). Presently, after USA, Brazil, Argentina, and China are the lead producers of soybean in the world. India ranks fifth in the area and production of soybean in the world. In India, Soybean was introduced from China in tenth century AD through the Himalayan routes, and also brought in via Burma (now Myanmar) by traders from Indonesia. As a result, soybean has been traditionally grown on a small scale in Himachal Pradesh, the Kumaon Hills of Uttar Pradesh (now Uttaranchal), eastern Bengal, the Khasi Hills, Manipur, the Naga Hills, and parts of central India covering Madhya Pradesh. Currently, India is divided into five agro-climatic zones for soybean cultivation. These are northern hill zone, northern plain zone, north eastern zone, central zone, and southern zone. The major soybean growing states are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh, and Chattisgarh. But, the contribution of India in the world soybean area is 10 % (approximately 10-million ha), but the contribution in total world soybean production is only 4 % indicating the lower levels of productivity in India (1.1 t/ha) as compared to other courtiers (world average 2.2 t/ha). So, there is a urgent need of yield enhancement of soybean and keeping these facts in mind we have conducted a study for soybean yield maximization under high fertility levels.

METHODOLOGY

The experiment was planned on medium deep vertisol soil of Agriculture College Farm, V.N.M.K.V., Parbhani during 2015 with the object to maximize the yield of soybean under high fertility levels and to study the economics of soybean production. The experiment was laid out in randomized block design (RBD) with three replications, which has 8 treatments including Control, RDF, 150 and 200% RDF in combination with Sulphur and Zinc @ 20kg/ha. The soybean was sown on 25th June, 2015 during *kharif* season with a spacing of 45 x 5cm and variety used was MAUS-71. The gross and net plot size was 5.4m x 6.0m and 3.6m x 5.0m, respectively. The Recommended dose of fertilizer used was 30:60:30: kg NPK/ha. The sources of N, P_2O_5 and K_2O were through mixed fertilizer (10:26:26), Urea, Bensulf and Zinc sulphate was used. The biometric observations on growth and yield attributes were recorded as per the standard procedure. Data on seed yield and economics of soybean as influenced by various treatments are presented in table 1.

Table 1. Seed, straw and biological yields and harvest index of soybean as influenced by fertility levels.

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
T_1 Control	1023	1576	2599	39
T_2 RDF	1511	2312	3823	40
T_3 RDF + Sulphur @ 20 kg/ha	1602	2403	4004	40
T_4 RDF + Sulphur + Zinc each @ 20 kg/ha	1706	2525	4232	40
T_5 150% RDF + Sulphur @ 20 kg/ha	1957	2857	4814	41
T_6 150% RDF + Sulphur + Zinc each @ 20 kg/ha	2033	2928	4961	41
T_7 200% RDF + Sulphur @ 20 kg/ha	2151	3011	5162	42
T_8 200% RDF + Sulphur + Zinc each @ 20 kg/ha	2209	3048	5257	42
SEm±	155	228	283	-
CD (P=0.05)	331	487	819	-

Table 2. Economics of soybean production under high fertility levels.

Treatments	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio
T_1 Control	38651	13531	1.54
T_2 RDF	57067	28947	2.03
T_3 RDF + Sulphur @ 20 kg/ha	60463	31643	2.10
T_4 RDF + Sulphur + Zinc each @ 20 kg/ha	64397	34477	2.15
T_5 150% RDF + Sulphur @ 20 kg/ha	73838	43518	2.44
T_6 150% RDF + Sulphur + Zinc each @ 20 kg/ha	76685	45265	2.44
T_7 200% RDF + Sulphur @ 20 kg/ha	81093	49273	2.55
T_8 200% RDF + Sulphur + Zinc each @20 kg/ha	83245	50325	2.53
SEM ±	4142	4142	0.14
CD (P=0.05)	12506	12506	0.42

RESULTS

Data on seed, straw, and biological yields and harvest index as influenced by various treatments are presented in the table. The differences in seed, straw and biological yields due to various treatments were significant and the mean seed, straw, biological yields and harvest index were 1774 kg/ha, 2582 kg/ha, 4357 kg/ha and 41% respectively. Data on seed yield revealed that application of 200% RDF i.e. 60:120:60 kg NPK/ha along with Sulphur and Zinc @ 20kg/ha recorded highest seed yield (2209 kg/ha), straw yield (3048 kg/ha), biological yield (5257 kg/ha) and harvest index (42%) than rest of the fertility levels. But it was found at par with T_5, T_6 and T_7 treatments. Lowest seed yield, straw, biological yield and harvest index was recorded by control.

Data on economics of soybean revealed that the application of 200% RDF i.e. 60:120:60 kg NPK/ha along with Sulphur and Zinc @ 20kg/ha recorded highest gross monetary returns (Rs.83245/ha), net returns (Rs.50325/ha) and B:C ratio (2.53), But it was found at par with T_5 , T_6 and T_7 treatments. Lowest gross monetary returns (Rs.38651/ha), net returns (Rs.13531 / ha) and B:C ratio (1.54) was recorded by control.

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Impact of integrated application of organic and inorganic in improving soil health and sugarcane productivity

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Sugarcane crop produces a heavy ‘tonnage and tends to remove substantial quantum of plant nutrients from the soil. For achieving the higher cane yield, most balanced use of fertilizer nutrients, is the important management factor of cultivation. Fertilizer management plays an important role in the growth and development, yield and yield attributes and finally quality characters of sugarcane compared to other management factors. Use of inorganic fertilizer alone cannot maintain the soil fertility and use of organic and inorganic fertilizer in proper proportion is inevitable. A field experiment with objective of developing nutrient management strategy for sustaining soil health and sugarcane production was laid out at research farm of ICAR- Sugarcane Breeding Institute, Coimbatore Tamil Nadu, India during the year 2015 in randomized block design with different 15 nutrient management treatments replicated three times. The experimental field was low in available nitrogen (216.38 N kg/ha) and high in available P and K. The germination and initial crop growth is satisfactory and recorded average germination of 58.83 and 65.64% at 30 and 45 DAP, respectively. The Integrated application of organics and inorganics i.e. application of 10 t FYM + STCR 150 + Biofertilizer recorded significantly higher NMC and cane yield of 186.46 t/ha over the control (no fertilizer application), 20 t/ha FYM and 10 t/ha FYM application alone. Sugarcane juice analysis done at 12 months revealed that Brix, Sucrose %, Purity % and CCS % were not influenced significantly by application of organics and inorganics.

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Nutrient management in cumin based cropping sequence

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Crop rotation is the practice of growing a series of dissimilar or different types of crops in the same area in sequenced seasons. It helps in reducing soil erosion and increases soil fertility and crop yield. Crop rotation gives various nutrients to the soil. A traditional element of crop rotation is the replenishment of nitrogen through the use of green manure in sequence with cereals and other crops. North Gujarat Agro climatic Zone is characterized by erratic monsoon with extreme cold winter, hot and dry windy summer. Sesamum, pearl millet, green gram and forage jowar are the important *kharif* crops, whereas, cumin, fennel, mustard, wheat *etc*. are vital *rabi* crops, which fulfill the needs of farmer. Wide adoptability of seed spices under arid and semiarid regions, increasing demand in national and international market @10-12 percent and higher profitability as compared to other *rabi* crops. Cumin is an important short duration and cash but risky crop of these regions and requires less inputs i.e. fertilizer, irrigation, labour *etc*. as compared to other *rabi* crops. Escalating demand-supply gap of fertilizers and harmful effect on soil health necessitate to reduce the use of fertilizer. Application of manures with fertilizers to *kharif* pulses, cereals and oilseeds not only improve the soil health but reduced fertilizer requirement of succeeding *rabi* crops also.

METHODOLOGY

In order to evaluate the nutrient requirement of cumin on cumin based cropping sequence an experiment was conducted for three consecutive years from 2011-12 to 2013-14 at Seed Spice Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan (Gujarat). The soil was loamy sand in texture, neutral in soil reaction, with low in organic carbon, medium in available phosphorus and potash. An experiment was laid out in SPD by comprising three levels each of cropping sequence (Green gram-cumin, Sesame-cumin and Sorghum (forage)-cumin) as in main plot and fertility level (100% RDF + 100% RDF, 100% RDF + 50% RDF and 50% RDF + 100% RDF for each sequence in *kharif* and *rabi* crop, respectively) as in sub-plot treatments with four replications. All the recommended cultural operations were adopted as per needs of crops during crop period.

RESULTS

Effect of different cropping sequences on growth and quality attributes of cumin were non-significant however, effect of yield attributes of cumin were significant only in case of number of umbels per plant and umbellate/umbel (Table 1). In general, the maximum growth, yield and quality

Table 1. Growth and yield attributes, quality, yield (kg/ha) and economics of cumin crop as influenced by different cropping sequence and fertility levels (Mean data of three years)

Treatments	Plant height (cm)	Branches/ plant	Umbels/ plant	Umbellates/ umbel	Seeds / umbellate	Test weight (g)	Volatile oil (%)	Equivalent seed yield (kg/ha)	Net realization (Rs./ha)	BCR
Main plot : Cropping sequence										
C1 : Greengram - cumin	26.69	5.30	17.43	5.59	5.98	4.68	4.68	822	47997	1.9
C2 : Sesamum - cumin	26.17	4.97	14.98	5.22	5.85	4.55	4.64	624	25682	1.5
C3 : Sorghum - cumin	26.11	4.89	13.52	5.27	5.91	4.48	4.73	638	28329	1.5
SEm±	0.26	0.08	0.60	0.11	0.07	0.08	0.08	21.0	—	—
CD (P=0.05)	NS	NS	1.77	0.34	NS	NS	NS	62.0	—	—
Sub plot : Fertility (N:P) levels										
F1 :100 % RDF + 100 % RDF	25.83	5.03	15.09	5.34	5.93	4.62	4.71	709	34576	1.6
F2 :100 % RDF + 50 % RDF	27.39	5.29	16.49	5.37	6.06	4.64	4.69	712	36745	1.7
F3 : 50 % RDF+ 100 % RDF	25.75	4.83	14.73	5.37	5.75	4.44	4.65	662	30686	1.6
SEm±	0.64	0.10	0.31	0.07	0.12	0.06	0.06	9.5	—	—
CD (P=0.05)	NS	0.28	0.87	NS	NS	0.16	NS	27.0	—	—
Interaction										
Y x C	NS	NS	NS	NS	NS	NS	NS	16.0	—	—
Y x F	NS	NS	NS	NS	NS	NS	NS	48.0	—	—
C x F	NS	NS	NS	NS	NS	NS	NS	NS	—	—
Y x C x F	NS	NS	S	NS	NS	S	NS	NS	—	—

attributes were recorded when cumin grown after greengram and these were the minimum under sorghum (F) – cumin crop sequence. Among the different attributes, only number of branches and umbels per plant as well as test weight were influenced significantly due to different fertility levels applied to *kharif* and *rabi* crops. All the attributes were the maximum and minimum when *kharif* and *rabi* crops received 100% RDF + 50% RDF (F1) and 50% RDF+ 100% RDF (F3), respectively. The maximum numbers of branches and umbels per plant as well as test weight were recorded when 100% RDF given to *kharif* and 50% RDF given to *rabi* crop (F2) and were at par with the treatment F1 (100% RDF + 100% RDF), but significantly higher than under treatment F3 (50% RDF+ 100% RDF). This might be due to cultivation of green gram during *kharif* season improve the fertility status of soil. Effect of different cropping sequences influenced the cumin equivalent yield significantly (Table 1). The significantly maximum cumin equivalent yield was obtained in green gram – cumin crop sequence. Application of 100% RDF to *kharif* crop and 50% to *rabi* crop (F2) recorded the maximum cumin equivalent yield and was statistically near to equal when *kharif* and *rabi* crops received 100% RDF (F1) but statistically superior than treatment F3 (50% RDF + 100% RDF). The similar trend was observed at SSRS, Jagudan, when cumin grown successfully after harvesting different *kharif* crops viz; Groundnut, Sesamum, Forage Jowar, Green gram, Cowpea and Maize for cumin (SDAU,2006) and fennel (SDAU,2007) crops. Improvement in soil fertility by inclusion of greengram as *kharif* crop in cropping sequence might be reduced fertilizer requirement of cumin during *rabi* season without affecting yield. The maximum net realizations and BCR values (Table 1) were achieved higher in the greengram – cumin crop sequence and was closely followed by sorghum-cumin sequence. Whereas, these values were the highest when crop was fertilized with 100 per cent RDF to *kharif* and 50 per cent RDF to *rabi* crops followed by the treatment 100% RDF to both the crops in sequence.

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Effect of nutrient management in potato preceded by green manure crops

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Potato (*Solanum tubersum* L.) is one of the most important vegetable crops after wheat, maize and rice, contributing to food and nutritional security in the world. Fertilization and green manuaring plays a crucial role in potato production. The experiment was conducted to study the effect of nutrient management in potato preceded by green manure crops, with the objectives of (i) To study the effect of nutrient management on growth and yield attributes of potato preceded by green manure crops. (ii) To study the effect of nutrient management on yield of potato preceded by green manure crops.

METHODOLOGY

A field experiment was conducted at Post Graduate Institute Research Farm, MPKV, Rahuri (M.S.) during 2013-2014 and 2014- 2015. It lies between 19^0 48' N and 19^0 57' N latitude and 74^0 19' E and 74^0 32' E longitude. The altitude varies from 495 to 569 meters above mean sea level. Climatologically, this area falls in the semi-arid tropics with annual rainfall ranged from 307-619 mm.(average 520 mm) The experiment was carried out in split-plot design with three replication. The net plot size was 2.40 m x 3.60 m. The green manuring crops were in main plots (*kharif* season) and nutrient management levels in sub plots (*rabi* season).The main plot treatments comprised of four green manuring crop *viz.*, sunnhemp, dhaincha, cowpea, greengram, while the sub-plot treatments consisted of four nutrient management levels *viz.*, 100 % GRDF (120:60:120 N, $P_2O_5,$ K_2O kg/ ha + 20 FYM t/ ha), 100% RDF (120:60:120 N, $P_2O_5,$ K_2O kg/ ha), 75 % RDF (90:45:90 N, $P_2O_5,$ K_2O kg / ha), 50 % RDF (60:30:60 N, $P_2O_5,$ K_2O kg/ ha). Incorporation of green manure crops at 50% flowering satge as per treatment wise.

Table 1. Pooled mean of growth and yield of potato as influenced by different treatments at harvest.

Treatments	Plant height (cm)	Number of shoot/ plant	Number of potato tubers/ plant	Fresh weight of potato tubers/plant (g)	Potato tuber yield (t/ha)	Dry haulm yield (t/ ha)
A. Green manuring crops						
Sunhemp	51.38	6.28	11.54	344.30	28.52	1.76
Dhaincha	51.67	6.48	11.63	366.20	30.44	1.85
Cowpea	48.88	5.95	11.05	344.40	26.80	1.58
Greengram	49.42	5.70	10.50	336.80	27.48	1.87
SEm $\pm$	0.56	0.11	0.16	5.32	0.56	0.014
CD (P=0.05)	1.93	0.39	0.56	18.39	1.94	0.048
B. Nutrient management level						
100 % GRDF	53.05	7.30	11.96	366.20	31.77	2.101
100 % RDF	51.53	5.98	11.58	346.40	29.94	1.872
75% RDF	48.92	5.85	10.92	344.30	26.31	1.624
50% RDF	48.85	5.28	10.46	336.80	25.22	1.472
SEm $\pm$	0.80	0.13	0.15	5.32	0.39	0.024
CD (P=0.05)	2.32	0.39	0.43	18.39	1.13	0.069

RESULTS

The results stated that the growth and yield attributes of potato *viz.,* plant height (51.67 cm), number of shoots/plant (6.48), number of potato tubers/ plant (11.63), fresh weight of potato tubers/plant (366.20) were influenced maximum due to green manuring crops. Ultimately beneficial effect of incorporation of dhaincha at 50% flowering stage as a green manuring crops in *kharif* season and its residual effect on growth and development of potato crops were more as compared to other green manure crops. The tuber (30.44 t/ha) and haulm (1.85 q/ha) yield of potato was significantly higher with residual effect of dhaincha over rest of all the treatments (Table 1). Similar results reported by Pawan and Mwaja (2005). The potato yield was significantly influenced due to different nutrient management treatments in Table 1. The application of 100% GRDF (120:60:120 N, $P_2O_5,$ K_2O kg/ ha + 20 t FYM/ ha) recorded significantly higher potato yield over rest of all treatments. The availability of maximum nutrients under 100% GRDF and recorded significantly higher growth and yield attributes *viz.,* plant height (cm), number of shoots/ plant, number of potato tubers/ plant, fresh weight of potato tubers/ plant than rest of all nutrient management treatments during pooled mean. The higher growth and yield attributes resulted in higher potato tubers. Similar results reported by Patel *et al.* (2008) and Carter *et al.* (2009).

CONCLUSION

The incorporation of dhaincha at 50% flowering stage as a green manuaring crop in *kharif* season followed by growing of potato in *rabi* season with 100% GRDF (120:60:120 N, $P_2O_5,$ K_2O kg/ ha + 20 t/ha of FYM) recorded significantly higher growth and yield of potato.

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Productivity and profitability of potato cultivars as influenced by varying row proportions and organic and inorganic nutrient sources

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A field experiment was conducted during the *rabi* seasons of 2014-15 and 2015-16 to assess the effect of row proportion, organic and inorganic sources of nutrients on productivity and profitability of promising potato (*Solanum tuberosum* L.) cultivars under western Uttar Pradesh. Three potato cultivars (Kufri Pukhraj, Kufri Anand and Chipsona-3), 3 row proportions (2:1 and 4:1 potato: mustard and sole potato/sole mustard) and 3 nutrient sources *i.e* 100% organic (FYM), 100% inorganic (150+80+120 kg NPK /ha) and 50% organic + 50% through inorganic were compared. Among the elite cultivars of potato, Kufri Pukhraj recorded highest tuber yield (40.72 t /ha), maximum net returns (Rs. 164710 /ha), B:C ratio (2.07). Among row proportions pure potato/sole mustard recorded maximum grade wise and total tuber potato yield (44.83 t/ha), economics of potato, seed yield and economics of mustard, however, 4:1 row proportion recorded maximum potato equivalent yield (52.22 t/ha), gross and net returns and B:C ratio. Sowing of crops in 4:1 row proportion recorded 15.04, 16.47 and 282.57 and 20.78, 18.40 and 252.13 percent higher potato equivalent yield and net monetary returns than 2:1, pure potato and pure mustard, respectively. With regards to nutrient sources, total yield and economics of potato/ mustard recorded maximumunder100 % inorganic sources, whereas 100 % organic sources recorded maximum seed yield and economics of mustard (2.17t /ha, Rs. 54150 and Rs. 41230 /ha and 3.13:1, gross returns, net returns and B:C ratio, respectively).

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Sulphur and potassium fertilization for improved productivity and quality of jute seed

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Forest resources are diminishing not only in India but also in the whole world, while consumption of paper, bio-fuel (Demirbas, 2009) and allied materials is continuously increasing. So, it is important to seek strategies that will compensate the diminishing forest resources and also provide local economic value. It is therefore crucial to explore nonwoods as potential bioresources for production of paper, bio-fuel and allied materials (Jahan *et al.,* 2008). Jute

Table 1. Effect of sulphur and potassium levels on yield and quality of jute seed

Treatment	Seed yield (t/ha)	1,000 seed weight (g)
Potassium levels (kg K_2O / ha)		
0 (Control)	0.50	1.99
25	0.65	2.07
50	0.75	2.11
75	0.73	2.14
SEm±	0.034	0.055
CD(P= 0.05)	0.104	NS
Sulphur levels (kg S / ha)		
0 (control)	0.47	1.92
15	0.63	2.07
30	0.74	2.14
45	0.80	2.17
SEm±	0.015	0.030
CD(P= 0.05)	0.045	0.088
Interaction (Main x Sub)		
SEm±	0.031	0.072
CD (P= 0.05)	NS	NS

(*Corchorus olitorius* L.) has high biomass production potential (Jahan *et al.,* 2008). Jute can be highly economical, renewable natural resource for bio-energy and important crop for environmental cleaning. The scientific community across the world is striving hard to combat the ill effects of climate change due to greenhouse gases like CO_2. Jute has tremendous potential to sequester atmospheric CO_2. The CO_2 sequestering capacity of jute is several times higher than that of tree crops. Seed is the basic input for crop production (Jahan *et al.,* 2008). The conservative estimate of requirement of jute seed in the country is around five thousand tonnes annually. To ensure higher seed yield in any crop, effective nutrient management strategy is imperative.

METHODOLOGY

The field experiment was conducted on a Gangatic alluvial soil of ICAR-CRIJAF, Barrackpore in North 24 Parganas district of West Bengal during September, 2015 to January, 2016 using jute variety IRA. The aim of this study was to determine the effects of sulphur and potassium application on yield and quality of jute seed. The field experiment was conducted in split plot design, keeping four potassium levels (0, 25, 50 and 75 kg K_2O/ha) in main plots and four sulphur levels (0, 15, 30 and 45 kg S/ha) in sub-plots and was replicated thrice. Other standard packages of practices were followed to raise the jute seed crop.

RESULTS

The perusal of the data (Table 1) revealed that the application of 25 kg K_2O/ha resulted in significantly higher jute seed yield (0.65 t/ha) as compared to control (0.50 t/ha) but was at par with 50 kg K_2O/ha (0.75 t/ha) and 75 kg K_2O/ha application (0.73 t/ha). No significant improvement in 1,000-seed weight of jute was observed with potassium application. The application of sulphur significantly improved the seed yield and 1,000-seed weight of jute. Significantly higher seed yield (0.80 t/ha) was recorded with the application of 45 kg S/ha over all other sulphur doses. Significantly higher 1,000-seed weight of jute was recorded up to the application of 30 kg S/ha over all other sulphur doses but was on par with application of 45 kg S/ha. However, all the interactions were non-significant.

CONCLUSION

The results of the present study showed that the sulphur and potassium fertilization improved the productivity of jute seed. Significantly higher jute seed yield was recorded with the application of 45 kg S/ha along with 25 kg K_2O/ha over all other S & K combinations. The application of sulphur significantly improved the 1,000-seed weight of jute but potassium application could not affect it significantly. Thus, application of 45 kg S/ha along with 25 kg K_2O/ha can be a better combination for improved productivity and quality of jute seed in North 24 Parganas district of West Bengal.

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Effect of nutrient levels on yield and economics of Indian mustard

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The requirement of vegetable oils and fats will be much higher in coming years in view of ever increasing population. India would need 58 million tonnes of oilseeds by 2020 for maintaining minimum edible oil requirement (Mittal, 2008). To produce an additional quantity of oilseeds, the only option is to enhance productivity under the limited land resource condition. The inadequate supply of inputs often leads to limit the yield potential of rapeseed and mustard. Identification of the critical inputs to enhance the mustard production is the need of hour. Apart from improved varieties and irrigation, balanced fertilization is critical for realizing higher seed yield. Indian soils are becoming highly deficient in nitrogen (N), medium in phosphorus (P) and low in potassium (K) due to intensive cultivation and use of high analysis fertilizers. The rapeseed-mustard (*Brassica juncea* L.) requires relatively large amount of these nutrients for realization of yield potential but inadequate supply often leads to low productivity. Under such situation, balanced fertilizer can be exploited to boost the production and also to improve nutrient uptake.

METHODOLOGY

The field experiment was conducted during *rabi* season of 2014-15 at the N.E. Borlaug Crop Research Centre of the G.B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand situated at 29°N latitude, 79.3°E longitude and at an altitude of 243.24meters.The soil of experimental field was silty clay loam having pH 7.76, electrical conductivity 0.24 dS/m, medium in organic carbon (0.71%) and low in available nitrogen (203 kg/ha), medium in available phosphorus (18 kg/ha) and medium in available potassium (283 kg/ha). The experiment comprised of 12 treatments, *viz*. T_1 (60-20-0), T_2 (60-20-30), T_3 (60-40-0), T_4 (60-40-30), T_5 (80-20-0), T_6 (80-20-30), T_7 (80-40-0), T_8 (80-40-30), T_9 (100-20-0), T_{10} (100-20-30), T_{11} (100-40-0), and T_{12} (100-40-30) with 3 replications were tested under randomized block design. The fertilizer nutrients were supplied through urea, single super phosphate and muriate of potash. Full dose of phosphorus, potassium and half of nitrogen (as per treatment) were applied at sowing. Remaining half of nitrogen was applied after first irrigation. Mustard cultivar 'RGN-73' was sown in rows 30 cm apart on 22 October with a seed rate of 5 kg/ha. Pre-sowing irrigation was applied for land preparation and germination of seed. Thinning was done 10-15 days after sowing to maintain plant to plant distance of 10 cm.

RESULTS & DISCUSSION

Data revealed that the seed, stover and biological yields of Indian mustard were affected significantly due to different fertility levels (Table 1). Higher seed yield (1.92 t/ha) was recorded in application of 100 : 40 : 30 treatment. The lowest seed yield (1.07 t/ha) was recorded in 60 : 20 : 0 treatment. The treatment T_{12} which was at par with T_{10} and T_{11} produced significantly higher seed yield over remaining fertility levels. Balanced supply of essential nutrients to Indian mustard increased their availability, acquisition, mobilization and influx into the plant tissues increased and finally improved growth attributes and yield components and finally the yield. Among the different treatments higher stover yield (7.64 t/ha) was recorded with the application of 100 : 40 : 30 treatment which was statistically at par with all the treatments except 60 : 20 : 0 and 60 : 20 : 30 treatments. However, the lowest stover yield (6.92 t/ha) was recorded under 60 : 20 : 0 treatments which was statistically at par with 60 : 20 : 30, 60 : 40 : 0, 60 : 40 : 30 and 80 : 20 : 0 treatments but significantly lower than remaining treatments. Maximum biological yield (9.52 t/ha) was recorded in 100 : 40 : 30 treatment and it was statistically at par with all the treatments except 60 : 40 : 0, 60 : 20 : 30 and 60 : 20 : 0 treatments. However, lowest biological yield per hectare (7.98 t/ha) was recorded under 60 : 20 : 0 treatment which was statistically at par with 60 : 20 : 30, 60 : 40 : 0, 60 : 40 : 30, 80 : 20 : 0 and 80 : 20 : 30 treatments, but was significantly lower than rest of the treatments. The cost of cultivation and gross returns was lowest 21.54×10^3 Rs/ha and 33.83×10^3 Rs/ha respectively with application of 60 : 20 :0 treatment whereas, it was highest 24.08×10^3 Rs/ha and 60.45×10^3 Rs/ha respectively with application of 100 : 40 : 30 treatment. Highest net returns (33.83×10^3 Rs /ha) was noted with 100 : 40 : 30 treatment despite of its highest cost of cultivation. The lowest net return (12.98×10^3 Rs /ha) was noted with 60 : 20 : 0 treatment.

Table 1. Yield and economics of Indian mustard as influenced by different nutrients levels

Treatments $N:P_2O_5:K_2O$ (kg/ha)	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Cost of cultivation ($\times 10^3$ Rs/ha)	Gross returns ($\times 10^3$ Rs/ha)	Net returns ($\times 10^3$ Rs/ha)
T_1 (60:20:0)	1.07	6.92	7.99	21.54	33.83	12.98
T_2 (60:20:30)	1.12	7.16	8.32	22.36	35.46	13.81
T_3 (60:40:0)	1.17	7.23	8.49	22.59	36.92	15.05
T_4 (60:40:30)	1.27	7.30	8.55	23.41	39.99	17.31
T_5 (80:20:0)	1.34	7.32	8.64	21.87	42.22	21.08
T_6 (80:20:30)	1.38	7.37	8.87	22.69	43.61	21.65
T_7 (80:40:0)	1.47	7.47	9.07	22.92	46.18	24.01
T_8 (80:40:30)	1.60	7.58	9.18	23.74	50.23	27.25
T_9 (100:20:0)	1.63	7.59	9.23	22.21	51.35	29.90
T_{10} (100:20:30)	1.74	7.60	9.34	23.03	54.61	32.34
T_{11} (100:40:0)	1.80	7.62	9.45	23.26	56.45	33.95
T_{12} (100:40:30)	1.93	7.64	9.53	24.08	60.45	37.13
SEm$\pm$	0.09	0.15	0.32	-	-	-
CD (P=0.05)	0.27	0.44	0.95	-	-	-

Thus, on the basis of above study it can be concluded that Indian mustard cultivar RGN-73 fertilized with 100 kg N, 40 kg $P_2O_5$and 30 kg K_2O/ha sustained higher seed, stover and biological yields, and net returns under tarai condition of Uttarakhand.

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Achieving target yield through site-specific nutrient management in soybean

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Soybean is the one of the important pulse cum oil seed crop. It has been termed as miracle bean because of higher protein (40%) and oil (20%) content. It is richest, cheapest and easiest source of best quality protein, fats and having a multiplicity of uses as food and industrial products therefore it is called “Wonder crop”. In India, it is cultivated in 12.2 m ha area with annual production of 11.9 million tonnes and productivity of 983 kg/ha. The SSNM (site specific nutrient management) approach does not aim to either reduce or increase fertilizer use. Instead, it aims to apply nutrients at optimal rates and times in order to achieve high yield and high nutrient use efficiency of crop. SSNM aims for efficient nutrient use by crop and hence, help the farmer obtain high crop yields, translating to high cash value of the harvest per unit of fertilizer applied. We need SSNM mainly for increasing nutrient use efficiency and profitability.

METHODOLOGY

The experiment was conduct at Agricultural Research Station, Janawada, Bidar during *kharif* 2014 and 2015. Based on local nutrient management practices, average quantity of fertilizers for farmer’s practice treatment was worked out. The amount of fertilizer for SSNM treatments was calculated by using the formulae (IPNI web site). FA = Nutrient uptake by crop per tonne grain yield × T; Where, T = Targeted yield (t/ha). The composite soil samples from each treatment at 0-15 cm depth was collected and analyzed before the initiation of experiment. The nutrient statuses of soils were analyzed separately for each target yield**.** Nutrient removal by soybean crop per tonne seed yield was 75, 16.4, 39.0 NPK kg/ha (IPNI website). The nutrient ratings for soil available nutrient status, if medium, apply exactly removal quantity, if low apply 30 % more and if high apply 30 % less. The calculated fertilizer

Table 1. Yield parameters of soybean as influenced by site specific nutrient management in soybean

Treatment	Number of pods/ plant	Pod weight (g/plant)	Seed yield (g/plant)	Seed yield (kg /ha)	Haulm yield (kg/ha)	Harvest index (%)
JS 335 + Target yield 2.0 t /ha	47.23	36.22	33.19	2450	5279	31.70
JS 335 + Target yield 2.5 t /ha	51.92	40.04	36.48	2708	5580	32.67
JS 335 + Target yield 3.0 t /ha	62.61	47.24	44.00	3195	5903	35.12
JS 335 + Target yield 3.5 t /ha	53.64	41.80	37.69	2827	5703	33.14
JS 335 + Farmer's practice	33.02	25.59	23.20	1731	4919	26.03
JS 335 + RDF	44.85	35.03	31.52	2369	5099	31.72
DSB 21 + Target yield 2.0 t /ha	44.75	34.91	31.45	2361	5079	31.73
DSB 21 + Target yield 2.5 t /ha	49.78	38.64	34.98	2613	5389	32.65
DSB 21 + Target yield 3.0 t /ha	58.56	45.09	41.15	3049	5680	34.93
DSB 21 + Target yield 3.5 t /ha	50.45	38.64	35.45	2613	5228	33.32
DSB 21 + RDF	43.82	33.69	30.79	2279	4910	31.70
SEm±	1.54	1.23	1.08	83	54	0.31
CD (P=0.05)	4.53	11.21	3.20	246	160	0.93

doses for target yield of 2 t /ha (195:33:55 NPK kg/ha), 2.5 t / ha (244:41:68 NPK kg/ha), 3.0 t /ha (293:49:82 NPK kg /ha), 3.5 t/ha (341: 57:96 NPK kg/ha) and farmers practice (18: 46:0 NPK kg/ha). The experiment was laid out in randomized block design with the eleven treatment and three replications.

RESULTS

The JS 335 with target yield of 3.0 t/ha (62.61) recorded significantly higher number of pods/plant as compared to rest of the target yield treatments but was on par with DSB 21 with target yield of 3.0 t/ha (58.56). Significantly lower numbers of pods were recorded with JS 335 with farmer's practice (33.02) among all the treatments. The pod weight/plant and seed yield/plant varied significantly due to different target yield and follows the similar trend as that of number of pods per plant (Table 1). The data indicated that the target yield treatment JS 335 with target yield of 3.0 t/ha recorded significantly higher seed yield (3195 kg /ha and 5903 kg /ha, respectively) over rest of the treatments, but was found to be on par with that of DSB 21 with target yield of 3.0 t/ha (3049 kg /ha and 5680 kg /ha, respectively).Significantly lower seed yield (1731 kg /ha and 5079 kg/ha, respectively) was noticed with JS 335 under farmer's practice. Significantly lower haulm yield was recorded with DSB 21 in recommended dose of fertilizers (4910 kg/ha). The targeted yield of 3.5 t /ha has not been achieved which might be due to abnormal weather condition during first year of the experimentation, maximum production potential of crop was achieved only up to 3.0 t/ ha, also due to lower growth and yield parameters, lower uptake of nutrient and finally lower dry matter production. The highest grain yield of soybean in case of the achieved targeted yield was mainly due to the fact that higher total dry matter accumulation. This in turn might be due to the availability of balanced and higher nutrition. The harvest index also followed the similar trend as that of as that of growth parameters.

CONCLUSION

These results clearly indicated that the target yield based on SSNM not only optimizes the crop yield to the desired level but maintains the better soil health which is a prime factor for sustainable crop production.

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Effect of alley cropping with subabool and fertilizer application on yield of *rabi* crops

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A field experiment was conducted during *rabi* 2011-12 and 2012-13 to investigate the effect of alley cropping with Subabool (*Leucaena Leucocephala*) and fertilizer application on yield of different field crops in sandy loam soils in Jharkhand in randomized block design at Zonal Research Station Chianki, Palamau for the suitability for western plateau region of Jharkhand. Five field crops *viz.* chickpea, mustard, linseed, safflower and sesame were grown in five meter wide established alley of Subabool hedgerow with 50% N and 100% P and K RDF as mineral fertilizer in respective crops. *Leucaena* pruning yielded large biomass and nutrients in both the years. Yield of five different crops responded more to 50% N and 100% P and K as RDF respective crops than the control than to alley cropped with Subabool leaves incorporated plots. As the chickpea is the main *rabi* crops of this area therefore chickpea equivalent yield was calculated. Significantly maximum equivalent yield was observed in safflower followed by chickpea and lentil. After two years of experimentation, soils were analyzed and N content was found on higher side where as P and K content observed averagely. Besides this wood biomass was obtained by cuttings before *rabi* season.

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Enrichment of grain protein and nutrient content through zinc fortification in maize

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Maize (*Zea mays* L.) is an important cereal crop of the world and has great economic value in livestock and poultry production. Deficiencies of various micronutrients, including vitamin A, zinc and iron are common in the developing world and affect billions of people. Zinc deficiencies have equally serious consequences for health. Biofortification is a process in which plants are allowed to take up the minerals from the soils and immobilize them in the grains so as to produce nutritionally rich grains that support dietary requirement of humans. To overcome the problem of nutrient deficiency the experiment was conducted with the following objectives, to enrich the protein content in maize grain through zinc fortification and to enrich the nutrient concentration of maize grain.

METHODOLOGY

An experiment was conducted at Agronomy Research Farm, Department of Agronomy, Dr. PDKV, Akola during *kharif* season of 2015. The experiment was laid out in randomized block design with 8 treatments and 3 replications. The treatment consist of (100% RDF, 125% RDF, 75% RDF + FYM 5 t/ha, 100% RDF+ $ZnSO_4$ 20 kg/ha, 125% RDF + $ZnSO_4$ 40 kg/ha, 125% RDF + $ZnSO_4$ 20 kg/ha, 125% RDF + 40 kg/ha, 100% RDF + seed priming with $ZnSO_4$ 1% w/v). Application of zinc fertilizer was done at the time of sowing along with basal dose of fertilizer. The nutrient content was analysed as per standard methods (Jackson, 1973). Grain protein content was analysed by Folin- Lowry method.

RESULTS

Significantly higher grain protein (13.10%) was observed with 40 kg $ZnSO_4$ along with 125% RDF as Zn is responsible for protein synthesis. Significantly higher nitrogen (1.76%) and zinc content (42.09 mg/kg) in grain was recorded with of 40 kg $ZnSO_4$ along with 125% RDF. It is well known that zinc is actively involved in protein synthesis of plants, as zinc is an important structural component of the protein synthesis machinery. Early stage zinc application has positive effect on the uptake of nitrogen during the milking and grain formation stage. Addition of Zn 20 and 40 kg/ha was responsible for enrich Zn in maize grain. Zinc content in maize grain was 41-42 mg/kg with the application of $ZnSO_4$ as against 36.79 mg/kg without Zinc. Similar enrichment was also noted by (Rashid and Fox, 1992). Zinc addition did not show any significant variation in phosphorous and potassium content of maize grain.

CONCLUSION

It can be concluded from the experiment that application of $ZnSO_4$ 20/40 kg/haalong with 125% RDF increased the protein

Table 1. Protein and nutrient content of maize grain as influenced by nutrient management

Treatment	Protein content (%)	N content (%)	P content (%)	K content (%)	Zn content (mg/kg)
T_1 (*RDF 100%)	10.80	1.72	0.42	0.56	36.79
T_2 (RDF 125%)	11.90	1.73	0.44	0.60	37.67
T_3 (RDF 75% + FYM 5 t/ha)	8.93	1.71	0.43	0.53	33.99
T_4 (RDF 100% + $ZnSO_4$20 kg/ha)	10.76	1.73	0.43	0.63	38.32
T_5(RDF 100% + $ZnSO_4$ 40 kg/ha)	12.10	1.74	0.41	0.62	41.22
T_6 (RDF 125% + $ZnSO_4$ 20 kg/ha)	13.06	1.75	0.42	0.63	41.75
T_7 (RDF 125% + $ZnSO_4$ 40 kg/ha)	13.10	1.76	0.41	0.63	42.09
T_8 (RDF 100% + seed priming with $ZnSO_4$)	11.23	1.73	0.42	0.66	36.49
SEm±	0.26	0.004	0.005	0.03	0.38
CD (P= 0.05)	079	0.012	NS	NS	1.15

*RDF 120-60-30 NPK kg/ha

content as well as nitrogen and zinc content in maize grain. Thus maize grain was fortified with zinc and protein.

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Effect of integrated nutrient management on productivity of soybean varieties in vertisols of Jharkhand

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Soybean is world's as well as India's first ranking crop as a source of vegetable oil. It is the richest, cheapest and easiest source of protein and fats contains about 43.2% protein and 20% oil. India's rank fifth in global soybean production and in acreage fourth, occupying 12.22 million ha area with production of 11.86 million tons and productivity of 1041 kg/ha. It is quite low as compared to the productivity of other leading producers like USA, Brazil, Argentina and China (Anonymous, 2012-13). Soybean being a high protein and energy crop has high nutrient requirements and its productivity is often limited by the low availability of essential nutrients or imbalanced nutrition forming one of the important constraints to soybean productivity in North India. Application of organic material along with inorganic fertilizers into the soil leads to increase in productivity of soybean and sustain the soil health for longer period. Hence and experiment was conducted to study the performance of soybean varieties with different doses of organic and inorganic nutrients in terms of productivity and nutrient uptake.

METHODOLOGY

A field experiment was conducted during *kharif* seasons of 2011 and 2012 at Birsa Agricultural University, Ranchi to assess the optimum nutritional levels for newly released soybean (*Glycine max* L.Merril) varieties in vertisols of Jharkhand. The soil of the experimental field was coarse texture, acidic in reaction (pH-6.0), low in organic carbon (0.37%), Available nitrogen (213.24 kg/ha), phosphorus (14.54 kg/ha) available S (6.8 mg/kg) and medium in available potassium (180 kg/ha). The experiment was laid out in factorial RBD with 3 replications, having 2 varieties of soybean JS 97-52 and BSS 2 and 8 nutrient management treatments viz. 75% RDF, 75% RDF + FYM@5 t/ha, 100% RDF, 100% RDF + FYM@5 t/ha, 125% RDF, 125% RDF + FYM@5 t/ha, FYM @10 t/ha and absolute control. The recommended dose of NPKS for soybean was 20 kg N, 80 kg P_2O_5 and 40 kg K_2O. Soybean seed were inoculated with *Bradyrhizobium japonicum* culture @ 5 g per kg seed just before sowing. Plant samples were dried in an oven at 60^0 C, for 72 hours and then dry weight were recorded. Grain and straw from all samples were analyzed for Nitrogen phosphorus and potassium as per standard procedure. Since data followed the homogeneity test, pooling of data was done over the seasons and mean data was statistically analyzed and presented here under.

RESULTS

The grain yield was increased with increasing nutrient levels and maximum grain yield (1962 kg/ha) was obtained with application of 125% RDF (20:80:40:40 kg NPKS) with 5 t FYM however it was at par with 100% RDF with 5 t FYM and the lowest yield was obtained with control (1185 kg/ha). Similarly straw yield and harvest index was also recorded with 125% RDF with 5 t FYM Optimum quantity of NPK and organic manures promotes the bio- physical activities of crop plants that converts protein and carbohydrate in the form of grain. Significantly higher nitrogen (167.56 kg N/ha), phosphorus (22.14 kg P/ha) and potassium (115.03 kg K/ha) of soybean were recorded under 125% RDF + 5 t FYM during both the years. It might be due to addition of FYM, which played an important role in solublization of insoluble phosphorus and potash, leading to higher availability of plant nutrients. Further, integrated fertilizer management might have ensured higher uptake of NPK because of increased cation

Table1. Effect of nutrient levels and varieties on yield, net returns and nutrient uptake of soybean

Treatment	Grain Yield (kg/ha)	Net returns (Rs./ha)	Oil content (%)	Nutrient uptake (kg /ha) N	P	K
Nutrient management						
75 % RDF-FYM	1490	20537	18.67	114.93	13.56	74.18
75 % RDF+FYM@5t/ha	1611	20723	19.50	124.51	15.01	78.99
100%RDF-FYM	1785	25081	19.83	140.87	18.41	95.97
100 % RDF+FYM@5t/ha	1904	25227	20.00	152.23	20.01	102.47
125 % RDF-FYM	1916	26683	20.33	159.20	21.42	111.38
125% RDF+FYM@5t/ha	1962	25510	20.75	167.56	22.14	115.03
FYM@10t/ha	1281	15073	18.50	93.16	11.60	62.71
Absolute control	1185	17335	17.50	85.99	9.64	52.39
CD (P=0.05)	111	2005	1.41	7.48	1.30	5.71
Variety						
JS 97-52	1610	21447	19.21	126.35	15.80	83.43
RKS 18	1674	22596	19.56	133.27	17.15	89.85
CD (P=0.05)	55	1002	NS	3.74	0.65	2.86

exchange capacity of roots. Net monetary returns (Rs. 25510/ha) was found superior due to application of 125% RDF + 5 t FYM. The higher values of economic returns are directly related to higher grain and straw yield under this treatment. Soybean variety showed significant difference for grain and straw yield as well as economics and variety RKS 18 recorded maximum grain yield (1674 kg/ha) straw yield (2052 kg/ha) nutrient uptake (133.27 kg N/ha), (17.15 kg P/ha) and (89. kg K/ha) respectively and net returns (Rs 22596/ha) which was significantly superior to variety JS 97-52.

CONCLUSION

It was concluded that application of 125% RFD through fertilizer supplemented with FYM @ 5 t/ha was found most appropriate nutrient combination for improving productivity of soybean in vertisols of Jharkhand.

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Performances of wheat (*Triticum aestivum)* under rice residue management and nitrogen doses

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Rice-wheat is the major cropping system of India having the maximum acreage stands ûrst in coverage. The system covers 23% of rice and 40% of wheat, and both crops together contribute 85% of the total cereal production contributing substantially to national food basket. The major challenge facing the IGP's rice-wheat cropping system is to sustain long-term productivity. The system's productivity and economic gains have been consistently decreasing, mainly because of the delayed sowing of wheat after the rice harvest and the fatigued soil condition. The adoption of resource conservation technologies, such as zero tilled wheat sowing, is considered essential to maintain the productivity of the rice-wheat cropping system (Singh *et al*., 2010). Zero till wheat cultivation after rice is the most productive and resource-conserving technology. It significantly decreases farming costs, soil erosion and improves ecosystem than conventional plowing (Sundermeier *et al*., 2011). Zero tillage in cereal systems have helped in saving fuel, water, reduce cost of production, improved system productivity and soil health. Improved soil physical properties and root growth under ZT, the significant increase in mass of grains and consequently increased the wheat yield (Singh *et al.*, 2014). Rice residue management is important in rice-wheat cropping system. Several management options available to farmers for the management of rice residues are burning, incorporation, surface retention, mulching and removing the straw. Nitrogen is the most limiting nutrient in crop production and its efficient use to increase food production is more than any other input.

METHODOLOGY

The experiment on wheat was conducted on sandy loam soil having pH of 7.1 at the Research Farm of the Janta Vedic (P.G.) College, Baraut, District–Baghpat (U.P.). The experimental layout accommodated 24 treatments combinations imposed to wheat crop, comprising 6 tillage methods (Residue burned-Conventional tillage, Residue removed-Conventional tillage, Residue incorporated-Conventional tillage, Residue burned–Zero tillage, Residue removed–Zero tillage and Residue retained – Zero tillage) in main plots and four nitrogen levels (0, 50 kg, 100 kg and 150 kg N/ha) in sub plots, replicated thrice. The wheat variety 'PBW 343' was sown at a distance of 20 cm raw spacing using seed rate of 100 kg/ha and rice variety Pusa-1121 was transplanted for residue treatments. Conventional plots were prepared for sowing wheat after giving pre sowing irrigation and sowing was accomplished, whereas, sowing in zero tilled plots was done directly after harvesting Rice variety Residue of rice was removed and burned after harvesting of rice according by treatments. Full dose of P and K was applied basal, whereas, N as per treatments was applied in their splits at basal, crown root initiation (CRI) and earing stage of the wheat crop. Data on various yield attributes, grain and straw yields of wheat and economic return were calculated as per the standard procedures.

RESULTS

Results showed that the Highest grain and straw yields were recorded under residue retained with zero tillage followed by residue burned with zero tillage over residue incorporated with conventional tillage at all the N levels (Table 1). The increase in grains and straw yield may be attributed mainly to grain weight/spike which was highly favored under residue retained with zero tillage. However, harvest index was not found any significant differences among tillage management practices in any of the years. The higher rates of nitrogen application @ 150 kg N/ha showed significantly better grain and straw yield as compared to 100 and 50 kg N/ha level of nitrogen application at each tillage practice. The response to nitrogen application was almost identical in both the years of experimentation. Application of nitrogen 100 kg N/ha registered significantly higher grain and straw yield over 50 kg N/ha and no nitrogen. The application of higher dose of nitrogen recorded higher harvest index compared with low level of nitrogen during both the years. Significant differences in net return and BC ratio were noticed due to tillage and residue management treatments. The net income and BC ratio was minimum with residue incorporated-conventional tillage in both the years. The maximum net return of Rs 30996 and BC ratio of 1.85 were found with residue retained with zero tillage treatments followed by residue burned–zero tillage and residue removed–zero tillage. Residue retained and zero tillage with 150 kg N/ha was the best practice in wheat in terms of productivity and profitability.

CONCLUSION

It can be concluded that residue retained with zero tillage recorded significantly higher yield as well as straw yield over other residue and tillage management. The increasing rate of

Table 1. Yields, harvest index and economics of wheat as influenced by rice residue, tillage and nitrogen management

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Net return (Rs./ha)	B:C ratio
Residue and tillage management					
Residue burned-Con. tillage	3.90	4.72	44.85	23781	1.30
Residue removed-Con. tillage	4.03	5.13	43.70	24725	1.31
Residue incorporated-Con. tillage	3.67	4.47	44.70	21230	1.15
Residue burned-Zero tillage	4.24	5.32	44.10	29179	1.76
Residue removed-Zero tillage	4.22	5.19	44.60	28245	1.64
Residue retained-Zero tillage	4.40	5.74	43.30	30996	1.85
SEm±	0.04	0.05	0.55	264	0.02
CD (P=0.05)	0.13	0.16	NS	830	0.06
Nitrogen levels (kg/ha)					
0 kg/ha	2.85	3.87	42.30	15688	1.05
50 kg/ha	3.66	4.88	42.85	22913	1.39
100 kg/ha	4.75	5.67	45.75	32399	1.78
150 kg/ha	5.06	5.96	46.00	34438	1.78
SEm±	0.05	0.07	0.60	328	0.02
CD (P=0.05)	0.13	0.19	1.65	940	0.06

nitrogen at higher dose (150 kg N/ha and 100 kg N/ha) produced significantly higher grain yield and gave higher net profit and highest B:C ratio.

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Production potential of single cut fodder sorghum varieties as influenced by different fertility levels under rainfed conditions

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In Indian agriculture, livestock plays a vital role in the development and progress of mankind with crop production program as a complementary enterprise. India supports nearly 20 percent of the world's livestock and 16.8 percent human population with only 2.3 percent of the world's geographical area. Yet, the production of milk per unit milch animal and other livestock products is about the lowest in the world because of huge gap between demand and supply of all kind of feed and fodders. The projected shortages of dry and green fodder are 23.4 and 62.7 per cent compared with the requirement of 589 and 1061 million tonnes for the current livestock population respectively (Hand book of Agriculture, 2012). The available fodder can meet the demand of only 47 per cent total livestock population. Hence, all our efforts should be focused for achieving higher fodder yield.

METHODOLOGY

Field experiment was conducted during *Kharif,* 2014 at Instructional farm, Rajasthan College of Agriculture, Udaipur which is situated at 24º 34¢ N latitude and 73º 42¢ E longitude and altitude of 579.5 m above mean sea level. The

Table 1. Effect of genotypes and fertility levels on growth, fodder yield and fodder quality parameters

Treatment	Dry matter accumulation (g/plant) at harvest	Fodder yield (t/ha)		Fodder quality parameters (%)			
		Green	Dry	Crude protein	Crude fiber	Ether extract	Mineral ash
Genotype							
SPV 2185	94.87	42.32	15.16	6.70	31.54	1.68	6.89
SPV 2191	89.27	35.61	11.63	6.56	31.25	1.66	6.87
HC 308	83.12	29.42	10.34	6.07	30.42	1.66	6.70
CSV 21F	84.42	27.26	9.69	6.49	29.85	1.67	6.84
PC 1080	82.99	29.53	10.44	6.51	31.48	1.67	6.79
CSV 30F	81.33	29.65	10.56	6.53	30.95	1.65	6.67
CD (P=0.05)	5.95	2.76	0.69	0.17	0.37	0.02	0.08
*Fertility level (% RDF)**							
50	74.24	24.89	9.63	4.77	27.82	1.54	5.60
75	87.37	27.05	10.47	6.11	31.57	1.64	7.09
100	89.43	36.11	11.96	7.49	32.07	1.72	7.23
125	92.96	41.14	13.16	7.54	32.19	1.75	7.25
CD (P=0.05)	4.86	2.25	0.57	0.14	0.30	0.05	0.06

**RDF (80 kg N+40 kg P_2O_5+40 kg K_2O/ha)* soil of the experimental field was clay loam in texture, slightly alkaline in reaction (pH 7.8), medium in available nitrogen (272 kg/ha), phosphorus (21.69 kg/ha) and potassium (284.6 kg/ha).The experiment consisted of 24 treatment combinations comprises of six single cut sorghum genotypes (SPV 2185, SPV 2191, HC 308, CSV 21F, CSV 30F and PC 1080) and four fertility levels (50, 75,100% RDF (80 kg N + 40 kg P_2O_5 + 40 kg K_2O) and 125% RDF).These treatments were tested in a factorial randomised block design with three replications.

RESULTS

Fodder sorghum genotype 'SPV 2185' recorded maximum plant height at harvest, dry matter accumulation at harvest, green as well as dry fodder production, and higher crude protein, crude fiber, ether extract, mineral ash content than rest of the genotypes. Genotype 'SPV 2185' resulted in 55.2 and 56.5% higher in green as well as dry fodder over CSV21F. With respect to nutrient management, application of 125% RDF significantly recorded highest plant height, dry matter accumulation at harvest, and higher crude protein, crude fiber, ether extract and mineral ash content than 50, 75 and 100% RDF. Application of 125% RDF recorded 20.44 and 9.12 percent higher in green and dry fodder over 100% RDF.

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Effect of sulphur on nutrient uptake, yields and quality of aerobic rice grown under rice-wheat cropping system in Inceptisols

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The aerobic rice can save 50-60% water requirement when compared with transplanted rice. However, several challenges have emerged against sustainable production of rice like imbalance nutrients in soil is one of them.In India sulphur (S) deficiency in various states varied from 5 to 83% with an overall mean of 44%. Sulphur deficiency is increasing with each passing year, restricting crops yield, quality of produce and economic returns. Nowadays, S is a strategic element in a balanced fertilization program. Two sources of sulphur *i.e.* gypsum and phosphogypsum were taken for study for cheaper prices and ease in availability for the farmers. Therefore, a field experiment was conducted with the objective of improving nutrient uptake, rice yields and grain quality with application of sulphur through various sources at different levels.

METHEDOLOGY

A field study was conducted during 2010-11 and 2011-12 at research farm of IARI, New Delhi. The experimental soil was sandy clay loam in texture with 7.5 pH and medium in organic carbon (0.54%); low in available N (176 kg/ha); medium in available P (14.6 kg/ha); medium in available K (275 kg/ha)and low in available S (16.5 kg/ha).The experiment was laid out in RBD with five treatments comprising of combinations of two S sources [Gypsum (G) & phosphogypsum (PG)] with two levels *i.e.* 30 & 60 kg/ha, and control (no S) with three replications. In the subsequent wheat season, each main plot was split into three sub plots and 0, 15 and 30 kg S/hawas applied through elemental sulphur. N, P, and K concentration in plant samples and quality parameters of rice grain (hulling, milling, protein content, high density grains and amylose content, rice grain length before and after the cooking) were scored using standard procedures. S/ha applied through gypsum (Table 1) followed by with 60 kg S/ha applied through phosphogypsum.

RESULTS

Significant response of S application on total nutrient uptake was found only up to 30 kg S/ha applied through gypsum. The application of S source in soil mediated the soil rhizospheric environment, which enhanced the nutrient concentration and uptake (Dotaniya *et al.,* 2014). Averaged across two years, application of S through gypsum @ 30 and 60 kg S/ha, and phosphogypsum @ 30 and 60 kg S/haincreased the S uptake in rice by 25.7, 34.1, 24.3 and 32.7%, respectively over control. Sulphur applied to wheat did not show any residual effect on nutrient uptake by rice crop. The increase in N, P, K and S uptake with S application could be ascribed to increase in concentration in grain and straw as well as yield of crop (Dixit *et al.,* 2012). Grain yield of rice increased from 4.01 t/hain the control to 4.47 t/ha with 60 kg S/haapplied through gypsum. However, response of S was only up to 30 kg S/ha. Almost similar results were observed in straw yield (Table 1). No significant residual effects of sulphur

Table 1. Effect of sulphur on total (grain+straw) uptake of N, P, K, S and yields of rice (Pooled data of two years)

Treatment	Nutrient uptake (kg/ha)				Yields (t/ha)	
	N	P	K	S	Grain	Straw
Direct effect						
Control	90.8	11.3	120.5	11.30	4.01	7.03
Gypsum @ S30	103.0	14.0	135.5	14.20	4.40	7.68
Gypsum @ S60	106.5	14.9	138.0	15.15	4.47	7.74
Phosphogypsum @ S30	101.1	13.5	134.5	14.05	4.36	7.62
Phosphogypsum @ S60	105.3	14.7	137.0	15.00	4.45	7.73
SEm±	1.7	0.3	2.0	0.30	0.07	0.10
CD (*P=0.05*)	5.3	1.0	6.7	1.00	0.23	0.28
Residual effect						
Sulphur@0	103.5	14.3	134.0	13.90	4.43	7.73
Sulphur@15	105.4	14.6	136.0	14.40	4.47	7.80
Sulphur@30	106.3	15.0	137.0	15.00	4.50	7.83
SEm±	2.1	0.4	3.0	0.30	0.05	0.11
CD (*P=0.05*)	NS	NS	NS	NS	NS	NS

Table 2. Effect of sulphur on quality of aerobic rice grain (Pooled data of two years)

Treatment	Hulling (%)	Milling (%)	Protein content (%)	High density grain (%)	Amylose (%)	Rice grain length	
						before cooking (mm)	after cooking (mm)
Direct effect							
Control	72.95	65.05	7.81	72.8	23.40	6.91	11.7
Gypsum @ S30	76.15	67.80	8.00	76.4	24.40	7.23	12.3
Gypsum @ S60	77.50	69.65	8.11	76.3	24.80	7.33	12.5
Phosphogypsum @ S30	75.15	67.50	7.98	74.8	24.15	7.24	12.2
Phosphogypsum @ S60	77.05	69.00	8.06	75.6	24.80	7.29	12.5
SEm±	0.90	0.90	0.06	0.9	0.15	0.05	0.2
CD (*P=0.05*)	2.86	2.94	0.18	2.4	0.53	0.15	0.3
Residual effect							
Sulphur@0	75.30	67.90	7.99	74.3	24.20	7.21	12.2

applied to wheat were observed on yields of rice. As evident from the Table 1 that S application significantly and positively increased the nutrients uptake, which might have resulted in better crop growth and ultimately yields. Sulphur application significantly improved the hulling, milling, protein content, high density grain, amylose content, rice grain length before and after the cooking over the control. However, the significant response of sulphur application on rice grain quality parameters were observed only upto 30 kg S/ha (Table 2). As S is a vital constituent of essential amino acids, hence S application improved the protein content (Dixit *et al*., 2012), hulling, milling and head rice recovery (Yang *et al.,* 2012).

CONCLUSION

Based on the two years of field study, it can be concluded that application of S through gypsum or phosphogypsm improved the nutrient uptake, and rice grain quality. Application of 30 kg S/ha with gypsum or phosphogypsum can be a better option for enhancing rice yield for sustainable crop production.

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Effect of graded levels of N, P & K on growth, yield and quality of fine rice Cultivar (*Oryza sativa* L.) under subtropical conditions

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Rice (*Oryza sativa* L.*)* is one of the most important cereal crops. In India, rice ranks first among all the crops occupying 43.95 mha and production of 106.54 mt of rice with average productivity of 24.24 q/ha (Anonymous, 2015). Increasing productivity and production are essential to meet the food requirement of the burgeoning population. Fine rice occupies a pivotal position in India because of its high quality. Due to its excellent quality characters, it is popular in the international market. India is one of the major producers and exporters of Basmati rice in the international market. The area under scented rice varieties is also increasing day by day with the opening of world market as well as domestic consumption (Singh *et al.,* 2008). Out of many aromatic rice varieties cultivated in India, traditional tall varieties of Basmati constitute a sizable proportion of export, but their productivity is very low as compared to non-aromatic rice varieties (Gangaiah and Prasad 1999). Efforts are required to increase the yield of aromatic rice for enhancing the quantum of exports to improve foreign exchange reserves. In this regard, a number of aromatic rice varieties have been developed through a systematic genetic improvement programme.

METHODOLOGY

A field experiment was conducted to study the effect of graded levels of N, P & K on growth, yield and quality of fine rice at research farm of Division of Agronomy, SKUAST-Jammu (J&K) during the *kharif* season of 2015. The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction, low in organic carbon, available nitrogen and zinc and medium in available phosphorous and potassium. The experiment was laid out in split plot design, replicated thrice with 24 treatments (Table 1). The source of fertilizers was urea, DAP and MOP. Full dose of phosphorus, potassium with 1/2 dose of nitrogen fertilizers were applied as per treatments after the puddling and remaining dose of nitrogen fertilizer was broadcasted in one split at 30 DAT. The rice variety 'Pusa-1121' was used in the experiment. All recommended agronomic practices were followed throughout the crop period. The grain yield was recorded from the net plot area and expressed as t/ha.

Table 1. Effect of N, P & K on plant height, dry matter and grain yield of Pusa-1121 rice.

Treatment	Plant height at harvest (cm)	Dry matter at harvest (g/m^2)	Grain yield (t/ha)
P_2O_5 & K_2O kg/ha			
P_1K_1 - 25:15	102.29	652.69	3.79
P_1K_2 - 25:20	103.87	706.47	3.89
P_2K_1 - 30:15	104.07	701.89	4.02
P_2K_2 - 30:20	105.01	717.31	4.01
P_3K_1 - 35:15	106.78	724.42	4.09
P_3K_2 - 35:20	107.54	745.15	4.06
SEm±	1.60	12.88	1.07
CD (P= 0.05)	NS	NS	NS
N kg/ha			
N_1 - 30	100.11	648.78	3.64
N_2 - 40	103.37	700.91	3.92
N_3 - 50	106.39	739.83	4.13
N_4 - 60	107.83	755.77	4.22
SEm±	1.20	9.45	0.88
CD (P= 0.05)	3.44	27.11	2.52

RESULTS

All the graded levels of N, P & K treatments significantly influenced the growth parameters and yield of basmati rice. Amongst the N treatments, significantly highest plant height of 107.83 cm was recorded where application of N_4 (60 kg/ha) was applied which was at par with N_3. Whereas, with P & K application highest plant height of 107.54 cm was recorded with P_3K_2 (35:20 kg/ha of $P_2O_5$and K_2O) which was followed by P_3K_1 (35:15 kg/ha of $P_2O_5$and K_2O) though the difference was non- significant. Almost a similar trend was also observed with respect to dry matter accumulation and yield in Pusa-1121 rice. Highest Pusa-1121 grain yield was observed to the tune of 4.22 t/ha with N_4 application of 60 kg/ha of N and 4.06 t/ha with the application of P_2O_5 and K_2O kg/ha.

CONCLUSION

It was concluded that among the different graded levels N_4 (60 kg/ha) and P_3K_1 (35:15 kg/ha of P_2O_5 & K_2O) was the most suitable dose of fertilizer for achieving economic yield advantage from other fertility levels as it improved growth and yield of Pusa-1121.

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Productivity and nitrogen use efficiency of maize-wheat cropping system as influenced by varying sources and concentrations of nitrification inhibitors

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Maize and wheat both are highly responsive to the nutrient application particularly nitrogen and require higher N dose i.e. 120-180 kg/ha. The excessive use of nitrogen fertilizers has raised various concerns mainly due to the low efficiency (20-50%) of nitrogenous fertilizers (Prasad *et al.*, 1998), resulting in low yield and environmental hazardous. Urea is the major source of nitrogen, which suffers from low nitrogen use efficiency due to its tendency to lose a substantial portion of the nitrogen values by ammonia volatilization and rapid nitrification leading to nitrate leaching followed by de-nitrification. This rapid nitrification is one of the key factors of inefficient nitrogen use, particularly in warmer climate such as India. Under these circumstances, increasing crop yield per unit area through the use of appropriate nitrogen management practices has become an essential component of modern crop production (Fageria and Barbosa Filho, 2001). Worldwide, many nitrification inhibitors have been useful in increasing the growth, development and crop yields. However, most of the nitrification inhibitors such as nitrapyrin, A.M. (2-amino-4-chloro-6- methylpyridine), dicyandiamide and ammonium thio-sulphate remain still unpopular with most Asian farmers due to their higher costs and limited availability. Hence, a need is being increasingly felt to identify and use some new indigenous nitrification inhibitors for increased growth, development and crop yields of maize and wheat. Meagre information is available on the use of nitrification inhibitors in maize-wheat cropping system and there is a need to identify and evaluate some new indigenous nitrification inhibitor for improving growth, development and yield of these crops.

METHODOLOGY

The field experiment was conducted in sandy-loam soil of New Delhi having low organic carbon and available N contents; and medium available P and K with pH 7.7. The field experiment consisted of fourteen treatments with three nitrification inhibitors (Dicyandiamide, neem oil and meliacin) each with two different concentration and two levels of nitrogen (135 and 180 kg/ha) was laid out in randomized block design having three replications. The maize was planted on ridges made at 75 cm and intra row spacing of 20 cm and wheat was planted on flat beds with 25 cm row spacing. The nitrogen as per treatments and recommended dose of P_2O_5 and K_2O were applied to both the crops as basal. In maize, zinc sulphate @ 25 kg/ha application was also made as basal uniformly in all the plots. The other agronomic practices were followed as per recommendations uniformly in each plot.

RESULTS

Neem Oil Coated Urea (NOCU) in 700 ppm concentration recorded the highest grain yields of both maize (7.33 t/ha) and wheat (6.7 t/ha), when applied at 100% nitrogen level, which were significantly higher over remaining treatments including 100% N application by urea (Table 1). It is now evident that the nitrification inhibitors benefited the crop most, perhaps by delaying the nitrification of urea and synchronizing N release with the crop demand. Similar response was also reported by Kumar *et al.* (2011) in rice. Meliacin Coated Urea (MCU) in 350 ppm and Dicyandiamide (DCD) in 5% concentration recorded the maize yield similar to NOCU 700 ppm treatment at 100 % nitrogen level, while in case of wheat DCD at 5% concentration only remained at par to NOCU. It is important to note that increasing concentration of MCU from 350 to 750 ppm and DCD from 5 to 10% reduced yield of both maize and wheat, however significant differences were noticed with DCD only in maize and both MCU and DCD in wheat. Agronomic nitrogen use efficiency (ANUE) was also the highest with application of NOCU in 700 ppm at 100 % nitrogen level and between two levels of nitrogen no marked differences were noticed in case of all nitrogen inhibitors. However, increasing concentration in MCU and DCD reduced the ANUE considerably. The maize equivalents of maize-wheat cropping system also resulted in similar trend both in terms of productivity and ANUE (Fig. 1).

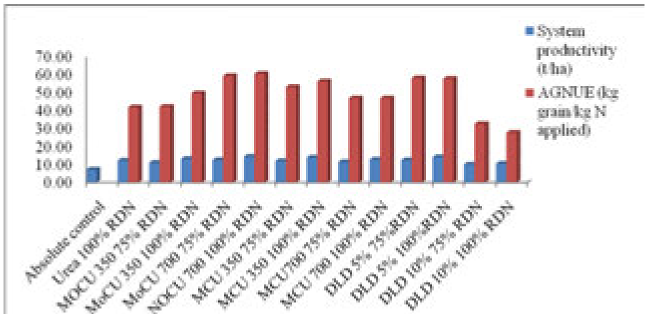

Figure 1. Productivity and agronomic nitrogen use efficiency of maize-wheat cropping system

Table 1. Productivity and agronomic use efficiency of maize and wheat grown in sequence

Treatment	Maize Grain yield (t/ha)	AGNUE of maize (kg grain/ kg N applied)	Wheat grain yield (t/ha)	ANUE of wheat (kg grain/ kg N applied)
Absolute control	3.80	0	3.2	0.00
Urea (100% RDN)	6.37	14.28	5.5	19.17
NOCU 350 ppm (75% RDN)	5.68	13.93	5.0	20.00
NOCU 350 ppm (100% RDN)	6.68	16.00	6.1	24.17
NOCU 700 ppm (75% RDN)	6.15	17.41	6.0	31.11
NOCU 700 ppm (100% RDN)	7.33	19.61	6.7	29.17
MCU 350 ppm (75% RDN)	6.24	18.07	5.4	24.44
MCU 350 ppm (100% RDN)	7.25	19.17	6.3	25.83
MCU 700 ppm (75% RDN)	6.10	17.04	5.0	20.00
MCU 700 ppm (100% RDN)	6.76	16.44	5.7	20.83
DCD 5% (75%RDN)	6.47	19.78	5.6	26.67
DCD 5% (100%RDN)	7.21	18.94	6.5	27.50
DCD 10% (75% RDN)	5.46	12.30	4.4	13.33
DCD 10% (100% RDN)	5.64	10.22	4.6	11.67
CD (P=0.05)	0.6		0.27	

CONCLUSION

Based on the experimentation, it can be concluded that NOCU in 700 ppm or MCU 350 ppm with 100 % nitrogen level may be used in maize-wheat cropping system for improving yield and NUE.

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Growth and yield of spring maize as influenced by plant rectangularity, varieties and fertility levels

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Maize *(Zea mays* L.) is one of the most important staple food crops of the world and ranks third in acreage and production next to wheat and rice. Among the growing seasons maize grown in spring season under irrigated conditions is gaining momentum because of its productivity and profitability, besides has not shown any major disease infestation. Sowing of maize during spring season would provide an opportunity to utilize the fields vacated by potato, toria, peas for green pods and sugarcane, because comparatively warm conditions would provide good environment for growth of spring maize. However, the agro-climatic conditions of sub-tropical plains of Jammu division can provide an option of growing spring season maize. As no information available on spring maize in J&K state, therefore, it becomes imperative with the objective to find out suitable plant rectangularity, varieties and fertility levels for spring maize under sub-tropical Jammu conditions.

METHODOLOGY

A field experiment was conducted during *spring* season of 2013 at SKUAST-Jammu in factorial randomized block design with 3 replications. The soil of experimental field was clay loam in texture, slightly alkaline in pH, medium in organic carbon, available phosphorus and potassium and low in available nitrogen. The treatment consisted of 2 spacing (60×20 cm & 70×20 cm), 2 varieties (PMH-1 & JH-3459) and 4 fertility levels N_{80}:$P_{17.47}$:$K_{16.67}$; N_{100}:$P_{21.83}$:$K_{20.83}$; N_{120}:$P_{26.20}$:$K_{25.00}$ & N_{140}:$P_{30.57}$:$K_{29.17}$ kg/ha. The half dose of N and full dose of P and K was applied at basal as per treatments. The remaining dose of N was applied in two splits each at knee high stage and silking stage. All recommended agronomic practices were followed throughout the crop period. The grain yield was recorded from the net plot area and expressed as t/ha.

RESULTS

Wider spacing of 70×20 cm caused significantly increase in dry matter accumulation per plant as compared to closer spacing of 60×20 cm. Comparatively thicker stem in wider spacing because of better availability of space and light might have attributed to more dry matter accumulation (Kumar and Puri, 2001). Varieties differed significantly from each other with respect to plant height. Early maturing hybrid JH-3459 attained significantly higher plant height than PMH-1. A significant variation in dry matter accumulation by cultivars was noticed. Variety PMH-1 accumulated significantly higher dry matter than JH-3459. This might be because of comparatively better genetic constitution of hybrid PMH-1 which contributed favorably for dry matter accumulation. Each incremental dose of fertilizers increased plant height and dry matter accumulation, but $N_{140}P_{30.57}K_{29.17}$ kg/ha recorded maximum plant height and dry matter accumulation while being statistically at par with $N_{120}P_{26.20}K_{25}$ kg/ha. Significant increase in plant height and dry matter accumulation at higher fertility levels might be due to optimum nutrient availability, better nutrient uptake and vigorous vegetative growth (Thakur and Singh, 1990). Crop growth rate was not significantly influenced by spacing, varieties and fertility levels. Closer plant spacing of 60×20 cm resulted in significant increase in grain yield over wider spacing of 70×20 cm. This might be because of higher plant population of 83.3 thousand plants/ha in closer spacing as compared to that of 71.4 thousand plants/ha in wider spacing. Among the hybrids, PMH-1 proved superior to JH-3459 by giving significantly higher grain yield. Response in grain yield of spring maize was recorded significant upto fertility level $N_{120}P_{26.20}K_{25}$ kg/ha and highest grain was recorded with $N_{140}P_{30.57}K_{29.17}$ kg/ha. This might be due to significant improvement of yield attributes *viz.* number of grains/cob, 1000-grain weight, more number of plants/m^2 and number of cobs/plant under optimum nutrient supply (Rameshwar and Singh, 1997).

CONCLUSION

On the basis of 1 year study, it may be concluded that closer plant spacing of 60×20 cm have been found optimum for higher grain yield than wider spacing of 70×20 cm. Among the tested hybrids, PMH-1 was most promising cultivar than the hybrid JH-3459. The fertility level $N_{120}P_{26.20}K_{25}$ was the most suitable dose for achieving good yield of spring maize.

Table 1. Effect of spacing, varieties and fertility levels on growth and yield of spring maize

Treatment	Plant height at 60 DAS (cm)	Dry matter accumulation at 60 DAS (g/plant)	CGR at 45-60 DAS (g/m^2/day)	Grain Yield (t/ha)
Spacing				
60 x 20 cm	119.41	45.02	1.59	3.37
70 x 20 cm	115.88	47.73	1.60	3.17
SEm±	1.89	0.61	0.04	0.54
CD (P= 0.05)	NS	1.75	NS	1.55
Varieties				
PMH-1	114.13	47.28	1.62	3.54
JH-3459	121.17	45.48	1.57	3.01
SEm±	1.89	0.61	0.04	0.54
CD (P= 0.05)	5.45	1.75	NS	1.55
Fertility levels (*kg/ha*)				
N_{80}: $P_{17.47}$: $K_{16.67}$	110.44	43.17	1.53	2.67
N_{100}: $P_{21.83}$: $K_{20.83}$	115.56	44.71	1.54	2.90
N_{120}: $P_{26.20}$: $K_{25.00}$	120.36	47.72	1.63	3.69
N_{140}: $P_{30.57}$: $K_{29.17}$	124.23	49.91	1.67	3.73
SEm±	2.67	0.86	0.06	0.76
CD (P= 0.05)	7.71	2.47	NS	2.19

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Evaluation of nitrogen use efficiency in tossa jute varieties

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Nitrogen is the key nutrient element in improving crop yields, but its recovery efficiency is low (25-40%). To achieve higher fibre yield of jute within a short period, farmers generally use higher dose of nitrogen which not only reduce the nitrogen use efficiency through increased losses, but also affects the soil health in the long run. The efficiency with which a crop produces a harvestable or economic product per unit available nutrient varies with the crop species and variety. Therefore, exploiting genetic differences among jute varieties for increased uptake and utilization of nitrogen (both soil and applied nitrogen) can certainly improve their productivity, enhance input use efficiency and reduce the addition of chemical nitrogen to the environment. Keeping these points in view, the present study was initiated to screen the jute varieties for higher uptake and efficient utilization of nitrogen for achieving higher fibre productivity of the crop.

METHODOLOGY

Twelve *tossa* jute varieties were grown in field at two nitrogen levels, zero and 80 kg N/ha at ICAR-CRIJAF Barrackpore during 2014 and 2015. The experiment was conducted on permanently fixed plots in a randomized block design (factorial) and the treatments were replicated thrice. Prior to jute crop, maize was grown as an exhaustive crop. Soil of the experimental site was sandy loam in texture with

0.62% organic C, 251 kg/ha available N, 30.0 kg/ha Olsen P, and 110 kg/ha neutral (N) ammonium acetate extractable K. A uniform dose of 17.5 kg P and 33.3 kg K/ha was applied to all the plots as basal while nitrogen was applied to the plots as per treatment. The crop was harvested at 120 days after sowing and fibre yield was expressed in q/ha. Plant samples were analyzed for total nitrogen following standard procedure and nitrogen uptake was calculated by multiplying nitrogen content with respective dry matter yield. Nitratre reductase (NR) activity of 35 days old jute leaf was determined by the method described by Nazar *et al*. (2011).

RESULTS

The experimental data revealed that the total above ground dry biomass was highest with Tarun at 80 kg N/ha level followed by S 19, JBO 2003 H and JRO 204 while in absence of applied nitrogen, the dry matter production was found maximum with JBO 2003 H followed by Tarun, JRO 128 and S 19. In absence of added nitrogen, maximum fibre yield was recorded with JRO 204 (1.87 t/ha) which was statistically at par with that of Tarun, JRO 66, JBO 2003 H and JRO 8432 while at 80 kg N/ha dose, highest fibre yield was observed with Tarun (3.25 t/ha) followed by JRO 204 (3.05 t/ha) and S 19 (2.84 t/ha) (Table 1). The total nitrogen uptake by *olitorius* jute varieties at harvest was highest with Tarun followed by JRO 204 and JRO 128 at both nitrogen levels. The agronomic nitrogen use efficiency (ANUE) was highest with Tarun (18.1 kg fibre/kg N) followed by S 19 and JRO 204 while maximum apparent recovery (AR) was recorded with JRO 204 (44.9 %) followed by JRO 66, Tarun, JRO 524 and S 19 (37.1–38.8 %). In absence of applied nitrogen, maximum nitrate reductase (NR) activity in jute leaf was recorded with JRO 632 followed by JRO 8432, S 19 and Tarun while at 80 kg N/ha level, NR activity was highest with JRO 204 followed by S 19 and JRO 620 (Fig. 1). However, no distinct relationship was observed between fibre yield and NR activity of the test jute varieties.

Our study indicated that the jute varieties Tarun and JRO 204 recorded higher fibre yield both in presence and absence of applied nitrogen and also showed higher nitrogen use efficiency and apparent recovery of applied nitrogen.

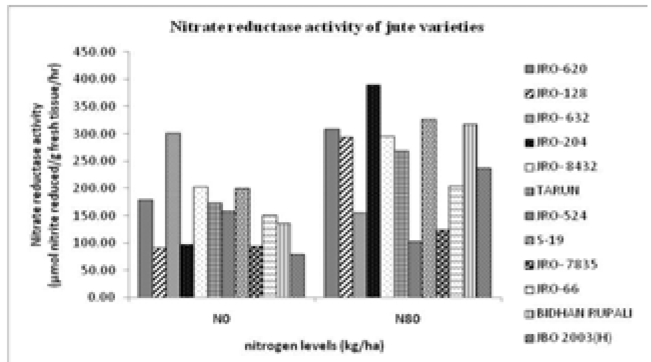

Figure 1. Effect of nitrogen on nitrate reductase (NR) activity of jute varieties.

Table 1. Effect of nitrogen on fibre yield, nitrogen uptake and nitrogen use efficiency of jute

Treatment	Fibre yield (t/ha)		Total nitrogen uptake (kg/ha)		ANUE (kg fiber /kg N applied)	Apparent recovery (%)
	Nitrogen levels					
Varieties	N_0	N_{80}	N_0	N_{80}		
JRO 620	1.28	2.35	53.22	79.28	13.4	32.6
JRO 128	1.58	2.31	75.61	101.81	9.2	32.8
JRO 632	1.38	1.85	48.43	74.26	5.9	32.3
JRO 204	1.87	3.05	70.57	106.48	14.8	44.9
JRO 8432	1.71	2.38	58.35	87.49	8.4	36.4
Tarun	1.80	3.25	77.97	109.02	18.1	38.8
JRO 524	1.69	2.68	64.21	94.60	12.3	38.0
S 19	1.54	2.84	70.61	100.30	16.3	37.1
JRO 7835	1.62	2.31	62.35	89.54	8.7	34.0
JRO 66	1.75	2.28	68.71	102.97	6.7	42.8
Bidhan Rupali	1.57	2.08	62.63	90.27	6.4	34.6
JBO 2003(H)	1.76	2.42	69.46	98.69	8.4	36.5
CD (P=0.05)	1.90	9.47	-	-		

ANUE: Agronomic nitrogen use efficiency

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Nitrogen scheduling in summer pearl millet

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Pearl millet is the world's hardiest warm season cereal crop. India has the largest area under this crop, ranking it third along with sorghum and share 42% of total world production. Nitrogen is the major nutrient required by pearl millet and has shown variable growth and yield response to nitrogen application (Gascho *et al.,* 1995).As nitrogen is mobile element, the time and rate of nitrogen application or split application of nitrogen at various times with different quantity as per requirement of crop growth stage may be an important factor which can be used for exploitation the yield potential as well as nitrogen use economy. Hence, the present investigation was undertaken to study the influence of different levels and application schedules of nitrogen on growth, yield and economics of summer pearl millet.

METHODOLODY

A field experiment was conducted during the summer season of 2015 at the Instructional farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh. The soil of experimental field was clayey in texture having pH 7.9 and EC 0.38 dS/m and organic carbon 0.62 %. The soil was low in available nitrogen (241.00 kg/ha) and phosphorus (31.60 kg/ha) and medium in available potash (245.36 kg/ha). The field experiment comprised of nine treatment combinations consisting of three nitrogen levels (90, 120 and 150 kg/ha) and three application schedules (50% as basal + 50% as top dressing, 40% as basal + 60% as top dressing and 30% as basal + 70% as top dressing) were tried in a factorial randomized block design with three replications. Nitrogen applied as basal at time of sowing and as top dressing in two equal splits at 30 & 45 DAS. Common dose of phosphorus @ 60 kg P_2O_5 was applied as basal before sowing. Gross and net plot size was 5.0 m X 3.6 m and 4.0 m X 2.4 m, respectively. Pearl millet variety GHB-732 was sown with recommended package of practice except nitrogen application schedules. Data on growth, yield performance and economic were recorded and statistically analyzed.

RESULTS

Application of nitrogen up to 120 kg/ha remarkably increased plant height, length and girth of ear head and consequently recorded significantly higher grain and stover yield as well as net return and B: C ratio as compared to 90 kg/ ha. The magnitudes of increase in plant height, length and girth of ear head, grain and stover yield and net return were to the extent of 9.80, 12.03, 13.51, 17.83, 15.77and 28.79 per cent, respectively over 90 kg N/ha. Application schedules of nitrogen 30% as basal at sowing + 70% as top dressing in two

Table 1. Growth, yield and economics of pearl millet as influenced by different levels and application schedules of nitrogen

Treatment	Plant height (cm)	Length of earhead (cm)	Girth of earhead (cm)	Grain Yield (kg/ha)	Stover Yield (kg/ha)	Netreturn (Rs/ha)	B:C ratio
Levels of nitrogen							
90 kg N /ha	153.18	21.52	7.50	3729	6918	33675	2.35
120 kg N /ha	168.33	24.11	8.51	4394	8009	43371	2.70
150 kg N /ha	161.36	22.20	7.59	3971	7587	36995	2.43
S.Em.±	3.95	0.57	0.23	149	289		
CD (P=0.05)	11.84	1.71	0.68	446	865		
Application schedules of nitrogen							
50% as basal + 50% as top dressing	152.72	21.20	7.32	3732	6887	33190	2.30
40% as basal + 60% as topdressing	162.13	22.71	8.09	4044	7656	38476	2.51
30% as basal +70% as top dressing	168.01	23.92	8.18	4317	7971	42375	2.67
S.Em.±	3.95	0.57	0.23	149	289		
CD (P=0.05)	11.84	1.71	0.68	446	865		

equal splits at 30 & 45 DAS significantly enhanced plant height, length and girth of ear head, and subsequently recorded significantly higher grain and stover yield along with higher net return and B: C ratio in comparison to 50% as basal + 50% as top dressing, but it was found statistically at par with 40% as basal + 60% as top dressing in two equal splits at 30 and 45 day after sowing. The magnitudes of increase in plant height length and girth of ear head, grain and stover yield and net return were to the extent of 9.89, 13.15, 11.78, 15.67, 15.73 and 27.67 per cent, respectively over 50% as basal + 50% as top dressing in two equal splits at 30 and 45 day after sowing. The increase in grain and stover yield under this treatments might be due to timely and adequately supply of nitrogen, which was low in soil.

CONCLUSION

On the basis of results obtained in this experiment it can concluded that application of nitrogen @120 kg/ha with its scheduling of 30% as basal at time of sowing + 70% as top dressing in two equal splits at 30 and 45 day after sowing in summer pearl millet (GHB-732) was found to be best for higher productivity and profitability in the medium black calcareous soil of South Saurashatra Agro-climatic zone.

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Effect of balance fertilization and bio-regulators on productivity and profitability of wheat (*Triticum aestivum*) on farmer's fields

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Continuous application of N and NP containing fertilizers and little or low use of multi-nutrient fertilizers lead to imbalance of nutrients in soil and hence poor utilization of applied nutrients. Among the micronutrients, zinc is the most wide spread deficient nutrients in Alwar district. In recent years, bio-regulators have offered new avenues for enhancing productivity of several crops, especially in wheat. In wheat, brassinosteroid application showed positive effect on nitrate reductase and glutamine synthetase activities, photosynthesis, chlorophyll content and total soluble protein under both irrigated and moisture stress conditions (Sairam, 1994a & b). Brassinosteroid also increases the resistance of plants against various abiotic stresses e.g. low temperature, high temperature, drought stress, salt stress (Rao *et al*., 2002). As the brassinosteroid enhances growth parameters and thiourea plays significant role in dry matter partitioning towards sink, foliar spray of brassinosteroid at tillering stage and thiourea at heading stage might be useful in improving overall productivity of wheat. Keeping in view these facts, present on-farm testing was conducted on farmer's fields of Alwar district to assess the effect of balance fertilization and bio-regulators for enhancing productivity of wheat (*Triticum aestivum* L.).

METHODOLOGY

An on-farm testing was conducted during two consecutive *rabi* seasons of 2014-15 to 2015-16 on selected farmer's fields of Babariya and Ramnagar villages of Alwar district. In present on-farm testing, technology assessed comprised of recommended dose and time of application of N P (120:35 kg/ha) along with soil application of zinc sulphate (20 kg/ha)and foliar application of brassinosteroid (0.5 ppm) at tillering stage followed by thiourea (1000 ppm) at heading

Table 1. Effect of recommended fertilization and foliar application of bio-regulators on productivity of wheat.(Mean data of 2 years)

Treatment	Mean grain yield (t /ha)		Mean grain yield (t /ha)	% Increase over FP
	2014-15	2015-16		
T_1	4.55	4.30	4.42	-
T_2	5.26	5.18	5.22	17.98
T_3	5.63	5.55	5.59	26.30

stages of wheat. The treatments were: T_1 = Farmers practice (Basal application of recommended $N_{120}P_{35}$kg /ha); T_2 = Recommended $N_{120}P_{35}$ kg /ha through basal and top dressing with basal application of $ZnSO_4$ (20 kg /ha) and T_3 = T_2 + Foliar spray of brassinosteroid (0.5 ppm) at tillering and thiourea (1000 ppm) at heading stage. In the recommended fertilization treatment, the half dose of N and full dose of P was drilled at sowing time through urea and DAP and rest half dose of N was top dressed in two equal splits at first and second irrigations. A uniform dose of 20 kg/ha of $ZnSO_4$ was applied as basal application. Foliar sprays of brassinosteroid (0.5 ppm) solution at maximum tillering (45-50 DAS) and thiourea (1000 ppm) solution at heading stage (65-70 DAS) were applied with spray volume of 600 L/ha. Wheat was sown timely under irrigated farming situation. Each treatment was replicated on five farmers fields in an area of 0.75 ha. The average prices of inputs and outputs prevailing in the market during each year were taken for calculating cost of cultivation, net return and benefit cost ratio (B:C ratio).

RESULTS

Data presented in Table 1 show that recommended NP fertilization at basal and top dressing with soil application of $ZnSO_4$ (20 kg /ha) enhanced the wheat grain yield by 18 per cent over farmer's local practice. A perusal of mean data further shows that foliar sprays of brassinosteroid (0.5 ppm) at tillering and thiourea (1000 ppm) at heading stage along with recommended fertilization practice enhanced grain yield to the magnitude of 26 per cent over farmer's practice. Data presented in Table 2 that recommended fertilization and application of brassinosteroid and thiourea proved to be economically feasible and profitable techniques over farmer's practices. On mean basis, recommended fertilization practice fetched net returns of Rs. 38,304/ha and provided additional returns of Rs. 10,225/ha with incremental B:C ratio of 8.97 compared to farmers local practice, which provided average net returns of only Rs. 28,079/ha. Foliar sprays of brassinosteroid and thiourea with recommended fertilization further raised the average net returns to Rs. 42,348/ha and on pooled basis, provided additional returns of Rs.14,269 with incremental B:C ratio of 6.10 over farmer's local practice. It clearly shows that by the additional expenditure of Rs. 2,340/ ha on foliar application of bio-regulators and recommended fertilization, a farmer could be able to earn Rs. 14,269/ha. Despite the general conception that brassinosteroid and thiourea are expensive high-tech agro-chemicals, the average B:C ratios observed in present study were found higher as 2.06 and 2.14 for T_2 and T_3; respectively as against 1.80 under farmer's local practice, this justified the feasibility of these bio-regulators.

Table 2. Economic evaluation of recommended fertilization and foliar application of bio-regulators in wheat.(Mean data of 2 years)

Treatment	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net returns (Rs/ha)	B:C ratio (Gross return/ cost of cultivation	Additional cost of treatments over FP (Rs/ha)	Additional returns over FP (Rs/ha)	Incremental B:C ratio
T_1	34960	63039	28079	1.80	-	-	-
T_2	36100	74404	38304	2.06	1140	10225	8.97
T_3	37300	79648	42348	2.14	2340	14269	6.10

CONCLUSION

In Alwar district, foliar applications of brassinosteroid (0.5 ppm) solution at tillering stage followed by thiourea (1000 ppm) solution at heading stage and soil application of zinc sulphate (20 kg /ha) in addition to recommended $N_{120}P_{40}$ kg / ha proved to be feasible technique for enhancing wheat productivity on farmers' fields.

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Effect of foliar application of ferrous sulfate and thiourea on productivity of groundnut (*Arachis hypogaea*)

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METHODOLOGY

A field experiment was conducted during Kharif 2012 at farmers' fields in different locations of Dausa district of Rajasthan, which falls in agroclimatic zone IIIa (Semi arid eastern plain zone). Soils of the experimental sites were sandy to sandy loam in texture, slight alkaline (pH 7.6) in reaction, low in nitrogen and phosphorus and medium in potassium status. The study consists four treatments namely T_1- Control (No spray), T_2- 0.5% ferrous sulfate spray at vegetative and reproductive stage, T_3- 500 ppm thiourea spray at vegetative and reproductive stage, T_4- 500 ppm thiourea+ 0.2 % ferrous sulfate (mixed solution) spray vegetative and reproductive stage. The above four treatments were replicated 20 times in the year 2012 at farmers fields of Khatwa village in Lalsot block of Dausa. The groundnut variety GG-20 was grown in the first to second week of June. The crop was irrigated at critical growth stages and as and when needed. The crop was raised with the recommended dose of major nutrients in the zone IIIa i.e. 30 kg N and 60 kg P_2O_5 per hectare. The crop was harvested in the third week of September.

RESULTS

The results of the experiment indicated that number of pods per plant, pod and haulm yield was found significantly superior in treatment T_4- 500 ppm thiourea+ 0.2 % ferrous sulfate (mixed solution) spray vegetative and reproductive stage by the tune of 14.89, 16.54 and 20.11 per cent higher over control, respectively. The yield attributes and yield of groundnut was also increased significantly in treatment T_2- 0.5% ferrous sulfate spray at vegetative and reproductive stage pod yield, haulm yield and number of pods per plant were increased by 11.82, 13.97 and 8.51 per cent higher over control or no spray that recorded 1.59 t/ha, 1.79 t/ha and 47 , respectively.

CONCLUSION

Overall study revealed that the treatment T_4- 500 ppm thiourea+ 0.2 % ferrous sulfate (mixed solution) spray vegetative and reproductive stage found significantly superior and farmer can increased their yield of groundnut by adopting this technology and gave their input in changing the scenario of green revolution to evergreen revolution.

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Wheat productivity as influenced by nutrient management and planting systems

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A field experiment was conducted at NBPGR, New Area Farm, IARI, New Delhi during rabi seasons to developed improved wheat and soil production system through integrated nutrient management (INM) and different planting system (EPS) in split plot design with 20 treatment combinations. Treatments consisted of two planting systems (conventional and FIRB) and 10 fertility treatments viz., control, RDF, 75% RDF + FYM, 75% RDF +

FYM + Zn, 75% RDF + FYM + biofertilizer (BF) , 75% RDF + FYM + BF + Zn, RDF + FYM, RDF + FYM + Zn, RDF + FYM + BF and RDF + FYM + BF + Zn. The yield contributing characters of wheat viz., number of spikes / plant and number of grains/ spike were recorded significantly higher when the crop was supplied with combined application of RDF or 75% RDF along with FYM, biofertilizer and zinc over control and treatment receiving RDF only. In case of wheat yield, 10.8 and 11.3% higher yield registered with FIRB planting system over conventional system during 2007-08 and 2008-09. The increase in grain yield with application of RDF + FYM + BF + Zn over RDF alone was 16.8 and 14.1% during 2007-08 and 2008-09, respectively. No significant difference between planting systems was recorded in respect of available nitrogen, phosphorus, potassium and organic carbon status of soil after harvest of crop. The FIRB system of planting and combined application of RDF or 75% RDF along with FYM, biofertilizers and zinc not only gave higher productivity and profitability of wheat but also have positive effect on soil physico-chemical properties which resulted into better rhizospheric environment.

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Modified urea materials for improving crop yield and nitrogen use efficiency in maize

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Nitrogen (N) fertilization assured centerstage for enhancing food grain production in developing countries especially after the introduction of high yielding and fertilizer responsive crop varieties. Almost half of the human population relies on N fertilizer for food grain production (Ladha *et al*., 2005). Urea is the major source of N because of its high N concentration, low cost, and ease of handling. However, N use efficiency (NUE) of urea is very low under field condition. The NUE, especially through chemical fertilizers such as urea, in India ranges from 20 to 50% for rice (Prasad *et al*., 1998).Modifications in fertilizer source can lead to reduced losses of N, high yields and increased fertilizer N-use efficiency.Therefore,the present investigations were undertaken to evaluate the relative performance of different modified urea materials to maize at different rates.

METHODOLOGY

A field experiment was conductedduring *kharif* seasons of 2015 at Research Farm, ICAR-Indian Institute of Soil Science, Bhopal with the objective to evaluate different modified urea materials for enhancing crop yield and nitrogen use efficiency (NUE). The experiment was laid out in a randomized block design (RBD) with 12 treatments and replicated thrice. The soil of experimental field was clayey in texture and slightly alkaline in reaction with pH 7.8 and low available N (206.8 kg/ha), high P (50.86 kg/ha) and high K (400.2 kg/ha). The treatments comprised of*viz*., absolute control,N control (N0), prilled urea @ 90 kg N/ha, prilled urea @ 120 kg N/ha, biochar coated urea @90 kg N/ha, biochar coated urea @120 kg N/ha, zeolite coated urea @90 kg N/ha,zeolite coated urea@120 kg N/ha, pine oleoresin coated urea @90 kg N/ha, pine oleoresin coated urea @120 kg N/ha, neem coated urea @90 kg N/ha, neem coated urea @120 kg N/ha). The Maize variety 'Pro-Agro 4212 was sown at 60cm X 25 cm spacing and all other agronomic practices were followed.

RESULTS

The study showed that maize yield and nitrogen use efficiency (NUE) were significantly variable with the application of different modified urea materials. Among the modified materials, (Table 1) neem coated urea (NCU) recorded significantly higher grain, stover, total dry matter yield and harvest index of maize and NUE. Further results revealed that application of biochar coated urea (BCU) and pine oleoresin coated urea (POR) were also found superior over the prilled urea in respect ofgrain, stover yields, harvest index and NUE in maize. The increase in grain yield of maize was 19.3, 11.8 and 10.4% under NCU, BCU and POR over the application of prilled urea, respectively particularly at higher levels of nitrogen (120kg N/ha). Similar results were also reported by Thind *et al*. (2010) in wheat crop. Data pertaining to nitrogen use efficiencies revealed that substantially higher agronomic use efficiency (AEn), partial factor productivity (PFPn) were recorded for NCU, BCU and POR as compared to normal urea (Fig.1). The increase in total dry matter yield and N use efficiencies might be due slow release of N for longer period during crop growth and reduces the N losses via volatilization and leaching losses in NCU, BCUand POR as compared to prilled urea.

CONCLUSION

Among the different modified urea materials used NCU was superior which was at par with BCU and followed by POR in enhancing the yields and NUE in maize as compared to prilled urea.

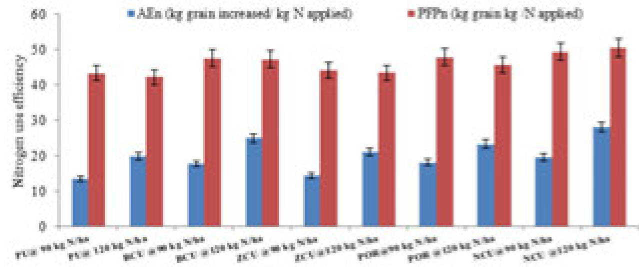

Fig.1. Nitrogen use efficiencies of maize as influenced by modified urea materials

Table1. Effect of different modified urea materials on maize yields

Treatment	Grain yield(t/ha)	Stover yield (t/ha)	Total dry matter yield (t/ha)	Harvest index
Absolute control	2.47	3.12	5.60	0.44
N control (N0)	2.68	3.44	6.11	0.44
Prilled urea @ 90 kg N/ha	3.89	5.29	9.19	0.42
Prilled urea @ 120 kg N/ha	5.07	6.24	11.31	0.45
Biochar coated urea @90 kg N/ha	4.28	5.60	9.88	0.43
Biochar coated urea @120 kg N/ha	5.67	6.67	12.35	0.46
Zeolite coated urea @90 kg N/ha	3.98	5.73	9.71	0.41
Zeolite coated urea@120 kg N/ha	5.21	6.36	11.58	0.45
Pine oleoresin coated urea @90 kg N/ha	4.31	5.50	9.81	0.44
Pine oleoresin coated urea @120 kg N/ha	5.48	6.56	12.04	0.46
Neem coated urea @90 kg N/ha	4.44	5.86	10.30	0.43
Neem coated urea @120 kg N/ha	5.85	6.78	12.83	0.47
LSD (P=0.05)	0.65	0.86	1.08	NS

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Performance of mustard as influenced by integrated nutrient management

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Mustard is a major oilseed crop and its oil is consumed mainly in north India. Currently, rapeseed-mustard is the third most important oilseed crops after groundnut and soybean in India occupying 6.70million hectaresacreage, 7.96 million tonnes production and 1188 kg/ha productivity (Anonymous,2014). Gujarat is the largest mustard growing state after Rajasthan, Madhya Pradesh, Haryana, Uttar Pradesh and West Bengal in India.Mustard is grown over an area of 0.28 million hectares with the production of 0.45 million tonnes with average productivity of about 1582kg/ha in Gujarat (Anonymous, 2014).In India mustard is grown mainly in *rabi* season and its productivity is lower than other developed nations generally due to imbalance fertilization with poor management. The rapeseed-mustard (*Brassica juncea* L.) requires relatively large amount of nutrients for realizing their yield potential but inadequate supply of nutrient often leads to lower productivity. Now, our soils are becoming deficient in sulphur, zinc, boron and other micronutrients due to following existing cropping system with intensive cultivation and use of high analysis chemical fertilizers. Under such situation, balance fertilization and farm yard manure can be exploited to boost the production and also to improve fertilizer use efficiency. However, the use of total organic or inorganic nutrient sources has some limitations, in these circumstances judicious combination of FYM with chemical fertilizers and micronutrient facilitate profitable and sustainable production.Integrated nutrient management play a great role in sustaining yield and quality of produce through correctness of marginal deficiencies of nutrient with enhancing nutrient use efficiency and providing favourable soil physical condition.Farmyard manure (FYM) improves soil quality apart from supplying all essential nutrients. Therefore, the present study was carried out to study the effect of integrated nutrient management on productivity of mustard in north Gujarat agro-climatic region.

METHODOLOGY

A field experiment was conducted during *rabi* season of 2014-15 at Castor-Mustard Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India. The soil of the experimental field was sandy loam with pH7.2, low in available nitrogen (112 kg/ha), available phosphorus (56.10 kg/ha), available potassium (268kg/ha) and organic carbon 0.27%. The experiment was laid out in randomized block design comprised of ten treatments *viz.* Control, 50% NPK, 100% NPK, 150% NPK, 100% NPK + S @ 40 kg S /ha, 100% NPK + Zn @ 25 kg ZnSo4/ha, 100% NPK + B @ 1 kg B/ha, 100% NPK + FYM @ 2.5 t/ha (dry weight basis), 100% NP and 100% Nwith replicated thrice. The mustard variety GM-3 was sown on 28.10.2014 at a spacing of 45 x 15 cm with using 3.5 kg/ha seed rate. The recommended dose of fertilizer for mustard crop was N_{50}, P_{50}, andK_{20} kg/ha. Full dose of P, K, S, micronutrient and half dose of nitrogen fertilizers were drilled just before the sowing as a basal application in the form of urea, DAP, MOP and elemental sulphur as per treatments and remaining half dose of nitrogen was applied at 25-30 DAS in earmarked plots. The thinning of experimental plot was done on 24/11/2014. Five irrigations were applied to the experiment with 20 days interval. Over all season was normal for mustard crop. However, moderate infestation of mustard aphid was observed. Various growth parameters, yield attributes and yield were recorded at harvest.

RESULTS

The fertility treatments had significant influence on plant growth. Data presented in Table 1 revealed that application of 100% NPK + 25kg $ZnSo_4$resulted in significantly higher plant height than control, 50% NPK and 100% N. These results are in accordance with the findings of Tripathi *et al*. (2010).The fertility treatments had non significant influence on yield attributes. However, seed yield influenced significantly. Data presented in Table1 revealed that application of 100% NPK resulted in non-significant influence on seed yield to control. However, the application of 100% NPK with Sulphur, Zinc, Boron and FYM were resulted in significant influence on the seed yield to control. Similarly, higher dose of NPK (150%) also had significant influence on the seed yield to control. These findings were conformity with those of Tripathi *et al*. (2010) and Dabi *et al.* (2015).The fertility treatments had non-significant influence on oil content of mustard.

Table1. Effect of fertility levels on growth, yield attributes, yield and oil content of mustard.

Treatment	Plant height (cm)	No. of Primary branches per plant	No. of siliquae/ plant	No. of Seeds/ siliqua	Length of siliqua (cm)	Oil Content (%)	Seed yield (kg/ha)
Control	96	5.00	231	13.73	4.09	38.22	920
50% NPK	160	4.67	247	13.73	4.03	40.14	1336
100% NPK	165	4.67	278	13.53	4.13	38.60	1386
150% NPK	167	4.87	274	13.53	4.30	38.72	1559
100% NPK + S @ 40 kg S /ha	172	4.67	265	12.73	4.05	39.75	1724
100% NPK + Zn @ 25 kg $ZnSo_4$/ha	184	5.60	284	13.40	3.79	38.72	1817
100% NPK + B @ 1 kg B/ha	174	4.87	262	13.67	4.47	39.38	1606
100% NPK + FYM @ 2.5 t/ha (dry weight basis)	167	5.07	258	13.27	4.23	39.75	1543
100% NP	171	4.47	254	13.33	4.02	39.83	1432
100% N	154	4.33	240	14.20	4.17	38.84	1386
CD (P=0.05)	25.69	NS	NS	NS	NS	NS	488.63

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Seed yield and economics of niger (*Guizotia abyssinica*) as influenced by varying fertility levels

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India is the prime producer of niger *Guizotia abyssinica* (L.f.) Cass] in the world. It is grown in the country on an area of about 2.77 lakh ha with a production of 0.89 lakh ton and a productivity of 319 kg/ha [IIOR, 2014]. Niger seeds contain a considerable quantity of edible oil (38 to 43%), protein (20%), sugar (12%) and minerals essential for human and animal meals. Madhya Pradesh contributes nearly 0.74 lakh ha under this crop with annual production 0.25 lakh ton and a productivity of 338 kg/ha (IIOR, 2014). Its cultivation is confined on marginal and sub marginal lands with the use of negligible agro-inputs, results into very low productivity (Sharma, 1993). This low productivity can be enhanced in sustainable manner by applying appropriate quantity of N, P and K fertilizers. The existing recommended dose of chemical fertilizers for the region / state is not enough. Hence, the present investigation was undertaken with the objectives as given below. To optimize fertilizer doses for newly developed niger varieties. To evaluate the most economic fertilizer dose for higher niger yield.

METHODOLOGY

The field experiment was conducted during semi *rabi* season of 2015 under irrigated production system at research farm of Project Coordinating Unit (Sesame & Niger), JNKVV, Jabalpur (MP). The soil of the experimental field was clay loam in texture. Six treatments consisting with different fertility levels were tested in randomized block design with three replications. Sowing of niger *cv.* JNC-6 was done on 05, October, 2015 in rows 30 cm apart by using 5 kg seeds/ha at about depth of 3 cm. A light irrigation (5 cm depth) was given immediately after sowing for germination of seeds then the subsequent irrigations were given thrice at an interval of 20 days through flood method of irrigation. Harvesting of crop was done on 25 January, 2016. Data on yield attributes were recorded during harvesting of crop. The oil content in seeds and oil yield were also determined. Finally, economics of all the treatments were statistically analysed.

RESULTS

The data presented in Table 1 indicated that the maximum seed yield of 543 kg/ha was recorded in T_1 [60:30:20 (N:P:K) kg/ha] was followed by 513 kg/ha in T_2 [50:25:15 (N:P:K) kg/ha], 474 kg/ha in T_3 [40:20:10 (N:P:K) kg/ha] all being at par. Significantly the lowest seed yield of 249 kg/ha was recorded in T_6 [Control]. The superiority in seed yield in T_1 due to higher fertility level over control and remaining some of the lower fertility levels attributed mainly due to effect of more quantity of N, P and K fertilizers by the crop. Thus, it could be concluded that the present higher fertility levels were responding to meet the nutrient requirement of niger crop under existing conditions. Several researchers have emphasized for such improved nutrient use efficiency through the application of higher fertility levels in niger crop under varying agro climatic condition (Patel, 2013). The maximum NMR of Rs 10147/ha recorded in T_1 was followed by Rs 9269/ ha in T_2 and Rs 8003/ha in T_3 with the minimum of Rs 2236/ha in T_6 [Control]. The maximum B: C ratio of 1.96 in T_1 was followed by 1.93 in T_2 and 1.83 in T_3 with the minimum of 1.07 in $T_{6.}$ Oil content of niger seed differ significantly due to effect of various fertility levels. Oil yield also significantly varied with them mainly due to variations in seed yields. The treatments producing higher seed yields in $T_{1,}$ T_2 and T_3 also produced oil yields as 196, 195 and 173 kg/ha. The lower fertility levels and control produced the lower seed yields, hence they produced significantly the minimum oil yield T_4 (163 kg/ha), T_5 (138 kg/ha) and T_5 (86 kg/ha) also among all treatments. These findings are in close conformity with the findings of Patel, 2013.

Table 1. Seed yield and economics of niger as influenced by varying fertility levels, Jabalpur

Treatment (N:P:K kg/ha)	Seed yield (kg/ha)	Net monetary returns (Rs/ha)	B:C Ratio	Oil yield (kg/ha)
T_1 - 60:30:20	543	10147	1.96	196
T_2 - 50:25:15	513	9269	1.93	195
T_3 - 40:20:10	474	8003	1.83	173
T_4 - 30:15:10	427	6386	1.69	163
T_5 - 50:10:10	383	4897	1.56	138
T_6 - Control	249	2236	1.07	86
SEm±	32.72	1310.06	0.12	14.99
CD (P=0.05)	103.11	4127.99	0.40	47.26

CONCLUSION

For obtaining increased NMR and B:C ratio and higher yield application of higher fertility levels *i.e.* 60:30:20 N:P:K kg/ ha or 50:25:15 N:P:K kg/ha were equally good. But the fertility level of 50:25:15 N: P: K kg/ha was found more remunerative for semi-rabi sown niger production in the region.

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Precision nutrient and water management in sugarcane

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Field experiment was conducted to study the precision nutrient and water management to achieve higher yield targets in sugarcane by efficient utilization of resources during 2013 to 2016 at Agricultural Research Station, Mudhol, University of Agricultural Sciences, Dharwad (Karnataka). The experiment was laid out in split plot design with three replications. The main plots consist of three methods of irrigation (I_1- Sub surface drip, I_2- Surface drip and I_3- furrow irrigation) and sub plots consists of target yield levels (S_1- 200 t/ha, S_2- 250 t/ha, S_3- 300 t/ha and S_4- recommended dose of fertilizer). The soil was clayey in texture, low in available N and P and high in available K. Before the experiment the land was laid out into grids of 20 X 20 m to know the soil spatial variability for major nutrients and based on this the nutrient application map was prepared to different target yield levels. Among the irrigation methods Sub surface drip irrigation recorded significantly higher cane yield (224 t/ha) over furrow method of irrigation (178 t/ha). However, surface drip irrigation was on par with sub surface drip irrigation (216 t/ha). Among the target yield levels, S_3 recorded significantly higher cane yield (246 t/ha) as compared to S_1 (205 t/ha), S_2 (227 t/ha) and S_4 (147 t/ha). The data on interaction effect indicated that sub-surface drip irrigation with target yield of 300 t/ha recorded the maximum yield level of 268 t/ha compared to furrow irrigation with recommended dose of fertilizers (134 t/ha). The results of irrigation water use efficiency (IWUE) shows that higher IWUE was recorded in subsurface drip irrigation with target yield level of 300 t/ha (3.71 t/ha-cm) followed by Surface drip irrigation with 300 t/ha target yield level (3.57 t/ha-cm). Among all the methods of irrigation subsurface drip has recorded higher IWUE (3.03) followed by surface drip method (3). Furrow irrigation method recorded lowest IWUE (0.96).

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Effect of solar dimming on growth and yield of wheat (*Triticum aestivum*) in Delhi NCR region

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Solar radiation is the most important factor for many plant physiological and bio-chemical processes for regulating the growth and development of plants. Apart from global warming, global dimming has received prominent attention due to climatic and environmental implications. As a consequence of increase in aerosol content and air pollutants, light dimming or reduction in global radiation (i.e. the sum of the direct solar irradiation and the diffuse or sky radiation scattered by the atmosphere) has become major challenge for crop production. Reports show that decline in solar radiation affects agricultural productivity in some parts of the world such as China (Yang *et al.*, 2013) and India (Kumari and Goswami, 2010). Keeping in view the importance of radiation dimming present study was conducted to study the growth pattern of wheat crop under reduced solar radiation.

METHODOLOGY

A field experiment was conducted with three wheat cultivars (HD 2967, WR 544 and PBW 502) under five solar radiation treatments i.e. R1 (no shading), R2 (20% shading), R3 (35% shading), R4 (50% shading) and R5 (75% shading) at the farm of ICAR-Indian Agricultural Research Institute, New Delhi during *rabi* season of 2014-15 and 2015-16. In this experiment split plot design was followed with three replications in 5 m × 3 m plots. Different plant parameters like plant height and internode distance were measured at different days after sowing (DAS) throughout the crop growth period. Plant biomass was also measured at regular intervals during entire growing seasons. At the time of harvesting final biomass and grain yield were also measured. Data were analysed using SAS software.

RESULTS

Plant height increased with the reduction in solar radiation. The highest plant height (97.67 cm) was observed in R5 at 110 DAS followed by, 96.94 cm in R4, 96.78 cm in R3, 95.23 cm in R2 and 94.78 cm in R1. In case of cultivars, HD 2967 showed the highest plant height of 102.89 cm, followed by WR 544 (97.198 cm) and PBW 502 (89.89 cm) at 110 DAS. Similar result was found for year 2015-16 that plant height was the highest (103.70 cm) in R5 compare to other treatments. Internode length (cm) of first, second, third, fourth and fifth internode from top to bottom in wheat crop was significantly influenced by the various levels of reduced radiation with maximum difference in second internode than compare to other internodes. The highest (14.50 cm), second internode distance was observed in R5 followed by R4 (13.20 cm), R3 (12.50 cm), R2 (11.40 cm) and R1 (10.60 cm) during *rabi* 2014-15. Similar results were obtained during 2015-16. In case of cultivars, the reason might be difference in their genetic makeup. During the *rabi* seasons (2014-15 and 2015-16) internode distance increased with reduced radiation level. Plant biomass was also measured at different growth stage and showed significant reduction due to reduced solar radiation in all treatments during *rabi* 2014-15 and 2015-16. Crop produced highest biomass (14.21 t/ha) in R1 followed by R2 (11.56 t/ha), R3 (8.88 t/ha), R4 (7.34 t/ha) and R5 (5.19 t/ha) at 140 DAS during *rabi* 2014- 15. Similar findings were observed during *rabi* 2015-16. The grain yield, final biomass and harvest index were significantly reduced under R5 than R4, R3, R2 and R1 conditions. During 2014-15, among the different treatments final biomass was the lowest in R5 (5.19 t/ha). Cultivars also showed significant difference in biomass. Harvest index was significantly decreased under reduced solar radiation. Harvest index was the lowest in R5 (17.61%), followed by R4 (20.35%) and R3 (28.04%) and highest under open condition (33.33%). During 2014-15, the interaction between reduced solar radiation and cultivars was non-significant. During 2015-16, similar significant result was found for final biomass, grain yield and harvest index. Final biomass was observed be the lowest under R5 (4.22 t/ha). Grain yield was also significantly reduced under R5 (0.51 t/ha) and R4 (1.14 t/ha) due to crop lodging.

CONCLUSION

Thus, the present study clearly showed significant difference in the crop growth and development of wheat crop under reduced solar radiation. Plant height and internode length were increased with the reduction in solar radiation. Both parameters were significantly higher in severe shading condition than compare to mild shading. Final biomass and grain yield were significantly decreased with shading during *rabi* seasons 2014-15 and 2015-16. Among the different parameters significant changes were observed in plant height, biomass, yield and harvest index. These difference were mainly attributed to the micro-meteorological changes within plant canopy.

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Leaf morpho-physiological and anatomical parameters of bajra napier hybrid grass as influenced by sources of nutrients

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INTRODUCTION

Mineral nutrition contributes to the structural organization of the leaf blade and more importantly nitrogen has direct influence on the morphologic and anatomic aspects, constituting many components of the vegetal cell including amino acids and nucleic acids. Of the grasses in India, Bajra Napier Hybrid Grass has the most potential as fodder for livestock. The supply of nitrogen nutrient through fertilization becomes, in many cases essential to express the genetic potential of forage production (Wilkins, 1972). Hence, the present study was conducted to evaluate the effect of levels of nitrogen fertilization in anatomic tissues, proportion on transversal sections of leaf blades of Bajra Napier Hybrid grass variety Co (CN) 4.

MATERIALS AND METHODS

The experiment was carried out at University Research Farm, Tamil Nadu Veterinary and Animal Sciences University, Madhavaram, Chennai. Bajra Napier Hybrid grass was established during December 2013 and the fertilization was started as per the schedule given in crop production guide of Tamil Nadu Agricultural University. The soil of the experimental site was sandy with a pH of 7.64, EC of 0.38 dSm^{-1}, Bulk Density of 1.52 g cc^{-1}, soil available nitrogen of 242.8 kg ha^{-1}, soil available Phosphorous of 19.6 kg ha^{-1} and soil available potassium of 182.6 kg ha^{-1}. The treatments utilized were T_1: Organic alone, T_2: 100% Recommended dose of fertilizer along with Organic nutrients, T_3: 50% of Recommended dose of fertilizers along with organic, T_4: 100% of recommended dose of fertilizer alone and T_5: Control. The design was completely randomized with four replications. As the Bajra Napier Hybrid grass is a perennial grass, fertilization was done after every harvest according to the treatment schedule. During sixth harvest, leaf blades were taken for morphological evaluation. The proportions of different leaf tissues were determined with the use of binocular optical microscope coupled to the software of Image J Analysis and the proportion of area of the cells are presented in μm^2.

RESULTS AND DISCUSSION

Leaf morpho-physiological characters are presented in Table 1. The length of the leaves, width, leaf area and specific leaf area increased with the application of 100% of recommended dose of fertilizer along with organics followed by application 100% of recommended dose of fertilizer alone. The expansion rate and the final length of leaves increased with the application of nitrogen, resulting in more increase of the leaf structure, leaf area index and leaf size (Cabral *et al,* 2012).

Leaf anatomical parameters are presented in Table 2. The results showed that application of 100 % recommended dose of fertilizers along with organic nutrients resulted in higher proportion of leaf anatomical parameters followed by application of 100% of recommended dose of fertilizer alone. The results obtained for the proportion of EPI ada and PBS in the transversal sections of the leaf blades of bajra napier hybrid grass showed no differences between the control and those that received different sources of nitrogenous fertilizers.

The outer walls of the epidermis cells, became thick lignificated and covered with a layer of cuticle and wax as they developed, being more expressive in EPI aba than in EPI ada.The leaf blades from control plot that received nitrogen had on average 57.9 % more of VT and 87.66% more of the EPI aba and VT proprtion than the blades that received the treatment with fertilization. The proportion of MES in the leaves of bajra napier hybrid grass increased linearly with different levels of nitrogen application, which is in conformity of the findings of (Basso *et al,* 2014).

CONCLUSION

The present study found consistent evidence that the application of nitrogenous fertilizers had influence on the leaf morphological and anatomical characteristics of bajra napier hybrid grass. The leaf morphological characters such as leaf length, leaf width, leaf area and specific leaf area and the anatomical parameters such as epidermis, vascular tissues, parenchymatous bundle sheath and mesophyll were influenced by the application of nitrogenous fertilizers.

Table 1. Effect of treatments on leaf parameters of Bajra Napier Hybrid Grass

Treatments	Length (cm)	Width(cm)	Leaf Area (cm ^{2})	SLA(cm^2/g)
F_1: Organic alone	98.6	4.0	356.93	31.59
F_2: 100% Recommended dose of fertilizer along with organics	107.4	5.3	515.14	43.65
F_3: 50% of Recommended dose of fertilizers along with organics	95.4	4.3	371.25	34.69
F_4: 100% of recommended dose of fertilizer alone	104.8	4.8	455.25	41.77
F_5: Control	92.5	3.9	326.48	30.22
CD(p=0.05)	8.98	NS	38.63	3.06

Table 2. Effect of treatments on leaf anatomical parameters (μm^2) of Bajra Napier Hybrid Grass

Treatments	Upper Epidermis	Lower Epidermis	Vascular Tissue	Parenchyma Bundle Sheath	Sclerenchyma Cells	Mesophyll Cells
F_1	649.3	613.0	745.4	293.4	122.7	220.3
F_2	732.8	696.7	932.9	463.1	175.6	361.7
F_3	686.3	377.9	548.1	275.4	101.4	243.6
F_4	619.8	440.9	981.0	511.9	145.7	206.9
F_5	346.0	263.4	590.7	270.9	64.4	175.4
CD(p=0.05)	55.8	48.8	74.4	34.8	10.5	22.3

Application of organic and inorganic sources of nutrients to bajra napier grass had added advantage over the production of biomass of bajra napier hybrid grass.

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Response of *rabi* castor (*Ricinus communis*) to spacing and fertility levels

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Castor (*Ricinus communis L.)* is important cash crop of arid and semi-arid regions of India due to its extensive deep root system and can be grown successfully under rainfed or irrigated conditions. In India, during last decade area, production and productivity were increased by 37, 59 and 35%, respectively. Gujarat ranks first in productivity at national and international level and contributes 58 and 74% of national castor acreages and production, respectively. Crop geometry and plant population plays important role in obtaining high yield. Castor is generally grown in *kharif* season under rainfed as well as irrigated conditions in India and being a long duration *kharif* crop, occupies the land for about 7-8 months and requires more costly and scare inputs i.e. fertilizer, labour, irrigation etc. However, semi *rabi* or *rabi* castor matures within 100 to 135 days and therefore; it is possible to take other crop during the kharif season. During recent past, area under castor cultivation during *rabi* season increased due to ever demand of castor seed, higher market price, requirement of less inputs and save the crop from diseases. Therefore, an experiment was undertaken to study the effect of spacing and fertility levels on growth, yield attributes and yields of *rabi* castor.

METHODOLOGY

A field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh-362001 (Gujarat) during *rabi* season of 2013-14. The soil was medium black and clayey in texture, slightly alkaline (7.9), having 0.69% organic carbon, 254.0 kg/ha available nitrogen, 23.0 kg/ha available P_2O_5 and 245.0 kg/ha K_2O. The experiment was laid out in split plot design comprised of four levels of spacing *viz*., S_1=120cm x 45cm, S_2=120cm x 60cm, S_3=90cm x 45cm and S_4= 90cm x 60cm were allotted to main plot and three fertility levels (F_1=50-25-25, F_2= 75-50-50 and F_3= 100-50-50 NPK kg/ha) were assigned to sub plot and replicated thrice. Sowing of castor (var. GCH-4) was done as per treatments. Full dose of phosphorus and potash was applied as basal at time of sowing. Half dose of nitrogen applied as basal and remaining quantity of nitrogen applied as top dressing in two equal splits at 30 and 70 DAS. Irrigations and other agronomic package of practices were followed as per recommendations made for the crop in region.

RESULTS

Sowing of castor at 90cm x 45cm spacing recorded significantly maximum plant population and plant height. Increase or decrease in plant population per unit area is a direct effect of the adopted plant geometry i.e. spacing between two rows and between two plants within the row. Thus, plant population per unit area was higher in closer inter and intra row spacing over wider spacing. Spacing of 120cm x 60cm recorded significantly more number of branches, dry

Table 1. Growth and yield attributes as well as yield of castor as influenced by spacing and fertility levels

Treatment	Plant population (at harvest)	Plant height (cm)	No. of branches	Dry matter (g/plant)	No.of spikes	No. of capsules /spike	100-seed weight (g)	Seedyield (kg/ha)	Stalk yield (kg/ha)	Oil (%)
Spacing : (S)										
S_1:120cm x 45cm	18303	136.4	7.7	171.6	7.0	61.8	28.8	1385	1719	47.6
S_2: 120cm x 60cm	13754	130.3	8.8	187.2	8.3	64.4	29.1	1226	1720	47.2
S_3: 90cm x 45cm	24497	153.5	7.2	156.3	6.9	53.9	28.8	1221	2016	48.0
S_4: 90cm x 60cm	18500	143.7	8.5	170.1	7.1	59.0	28.2	1444	1939	48.4
CD (P=0.05)	1680	15.2	0.8	15.6	0.8	5.7	NS	168	214	NS
Fertility levels: (F)										
F_1: 50-25-25 NPK kg/ha	18686	131.5	7.3	165.2	6.6	50.6	27.6	1256	1706	46.8
F_2: 75-50-50 NPK kg/ha	18829	139.1	8.3	169.8	7.5	61.7	28.7	1322	1892	47.9
F_3: 100-50-50 NPK kg/ha	18775	152.3	8.6	178.9	7.9	67.1	29.9	1378	1948	48.6
CD (P=0.05)	NS	8.7	0.5	8.6	0.5	3.4	1.2	74	82.1	1.2

matter accumulation, number of internodes, number of spikes, length of main spike and number of capsules/spike. Crop sown at 90cm x 60cm and 90cm x 45cm produced significantly higher seed and stalk yields of 1444 and 2016 kg/ha, respectively. The magnitude of increase in seed and stalk yields under 90cm x 60cm and 90cm x 45cm was 18.2 and17.3% over 120cm x 60cm, respectively. Significantly maximum plant height, number of branches, dry matter accumulation, number of internodes, yield attributes *viz*., number of spike, length of main spike, number of capsule/spike, test weight and oil content were recorded when crop was fertilized with 100-50-50 NPK kg/ha. Seed and stalk yields were significantly influenced by different fertility levels. Application of 100-50-50 NPK kg/ha to castor produced significantly higher seed and stalk yields of 1378 and 1948 kg/ha, respectively and which was found at par with lower fertility level of 75-50-50 NPK kg/ha. The magnitude of increase in seed and stalk yields over 50-25-25 NPK kg/ha was to the tune of 9.7 and 14.2%, respectively. Thus, increasing trend as observed in seed and stalk yields was evidently due to cumulative effects of increasing trend observed on major growth and yield attributes. Moreover, overall improvement in vegetative growth at higher fertility level, which favorably influenced flowering and fruiting which ultimately, resulted in increased number of capsules/spike.

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Soil phosphorus fractions as influenced by crop residue and phosphorus management under maize–wheat cropping system

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Phosphorus (P) is an essential element for the growth and development of plants. It plays important roles in the metabolism of plants. It is a structural element of metabolically active compounds present in plants. As its concentration and solubility in soils is low due to its reactive nature with different soil components, it has become a critical nutrient limiting plant growth. Also, the efficacy of P fertilizers is quite low, which barely exceeds15-20% in the year of its application. Rest of the applied P in soil either get fixed in different soil component or sometimes get lost through run-off. Phosphorus is kinetically available in different fractions like soluble, labile and non-labile P in soil. All these forms of soil P are always in equilibrium with each other. The equilibrium between labile and non-labile P is slower than the equilibrium between soluble and labile P. The soluble pool is the soil solution P, which represents the immediately bioavailable pool. Soils with a high proportion of P in labile pools indicate greater potential of availability to plants. When P concentration in soil solution is diminished by P removal; it is replenished by the labile P, which in turn is replenished much more slowly by non-labile P. Information on distribution of P into different fractions in the soil is of great significance in predicting bioavailability and transformation of P in soil. Now-a-days, to meet the rising demand, reduced tillage, use of cover crops and appropriate use of fertilizers are some of the conservation agriculture (CA) practices being promoted for the mitigation of soil erosion and greenhouse gases emissions, improvement in soil and water quality, and crop productivity. It is a production system involving minimum soil disturbance, providing soil cover through crop residues or other cover crops and crop rotations for achieving high productivity with most efficient resource use. Crop residues retained on the soil surface with no or minimum tillage has potential to enhance soil quality through improvement in soil organic carbon content and different physical and biological properties. Systematic information on P transformation is scanty under maize-wheat cropping system with respect to different crop residue and P fertilization practices under Indian conditions. Fractionation of P in soil treated with varying percentage of crop residue retention and P fertilization might provide the knowledge about the depletion or accumulation of P in different soil layers. Keeping this in view present investigation was undertaken to study the impact of crop residue retention and P fertilization on soil P fraction under maize - wheat cropping system.

METHODOLOGY

The field experiment on Maize (*Zea mays* L.)-Wheat (*Triticum aestivum* L.) cropping system commenced in July 2013 at Experimental Research Farm, IARI New Delhi with twenty treatments combination, which were evaluated in a split-plot design. Treatments of main-plot were varying percentage of crop residue retention *i.e.* T_1: Residue removal (No-residue), T_2: 25% crop residue, T_3: 50% crop residue, T_4: 75% crop residue and in sub-plot treatments were S_1**:** No-Phosphorus, S_2**:** 50% Recommended dose of phosphorus (RDP), S_3**:** 100% RDP, S_4:150% RDP, S_5**:** 50% RDP + PSB&AM. Rrecommended dose of N-P-K were 150-80-50 kg ha^{-1} for maize, which were applied through urea, diammonium phosphate and murate of potash, respectively. Fertilizer N and K were applied uniformly to all the plots, whereas, P was applied as per treatments. Entire amount of P and K was applied as basal dressing at the time of sowing. Fertilizer N was applied in three equal splits *i.e.* at sowing, at four leaves vegetative stage and eight leaves vegetative stage of maize. Maize (*cv.* PHM-1) was sown in first week of July and harvested during end of October, 2015. Previous wheat crop was harvested manually from ground level, and aboveground biomass/residues were retained in the plots. Maize crop was raised under assured irrigated condition, and prescribed weed and pest control measures were adopted. Plot-wise soil samples were collected at tasseling stage for determination of different P fractions from two depths (0-15 cm and 15-30 cm).

RESULTS

Results of the study indicated that crop residue retention had negative effect on Al-bound P, Fe-bound P, Ca-bound P and reductant soluble-bound P fraction, but had positive effect on soluble and loosely-bound P. Phosphorus fertilization rates had positive effect on all the phosphorus fractions with gradual increase. The Al-bound P, Fe-bound P, Ca-bound P and reluctant soluble-bound P fraction in surface soil (0-15 cm) decreases from 30.3 to 27.3 mg/kg, 44.7 to 31.3 mg/kg, 303 to 270 mg/kg, 121 to 110 mg/kg, respectively with increase in crop residue retention. Only soluble loosely-bound P was increased from 6.11 to 7.64 mg/kg with increasing rate of crop residue retention. Phosphorus fertilization rate increases the soluble loosely-bound P, Al-bound P, Fe-bound P, Ca-bound P and reluctant soluble-P fraction from 5.24 to 8.35 mg/kg, 23.1 to 33.5 mg/kg, 31.5 to 41.3 mg/kg, 231 to 335 mg/kg, 104 to 130 mg/kg, respectively. Total inorganic P has been computed as sum of all inorganic fractions *i.e.* soluble and loosely- bound P, Al-bound P, Fe-bound P, Ca-bund P and reluctant soluble-bound P fractions. The crop residue retention rate decreased total inorganic P significantly from 468 (No-CR) to 404 mg/kg (75% CR) in surface soil samples. However, organic-P fraction increased significantly with increasing rates of crop residue retention over control. The highest (329 mg/kg) and lowest (243 mg/kg) organic- P fraction was recorded in 75% CR and No-CR, respectively. The maximum (797 mg/kg) and minimum (647 mg/kg) total P was obtained in 75% CR treatment and No-CR treatments, respectively. Phosphorus fertilization rates significantly enhanced the total inorganic P, Organic P and total P in surface soil. There was increase in the organic- P fraction with increase in the phosphorus fertilization rates which varied from 244 mg/kg to 321 mg kg^{-1} in 150% RDP and 50% RDP+ PSB&AM treatment, respectively.

CONCLUSION

On the basis of results, it can be concluded that cumulative effect of repeated cropping cycles where high crop residues (more than 50%) are returned to soil may lead to a significant accumulation of organically-cycled P and reduced requirement for fertilizer P inputs by maintaining or improving functional capacity of soil. Microbial inoculation can mobilize P from bound pools to easily available pools.

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Studies on the effect of nitrogen levels and time of application on yield and economics of maize (*Zea mays* L.) under northern transition zone of Karnataka

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Maize is a considered as economically important cereal crop used as food, feed and other products. It assume as important role next to rice and wheat in the farming sector and macro-economics of the agrarian countries. Maize yield depends upon crop management especially nutrient management. It has played a crucial role in achieving self sufficiency in food grain production. The need for precise and responsive management of N fertilizer in Maize is compelling for both economic and environmental reasons. Static fertilizer recommendations based on average response lead to excessive fertilization in some years and inadequate fertilizers in years with high N losses. The uncertainty in optimum N rate poses risks for profit loses which is exacerbating by the asymmetric profit response of maize to N rates. The associated higher cost of under fertilization relative to over fertilization drives farmers to apply imbalanced rates. This uncertainty can be addressed by providing more accurate location and time specific recommendations that increase accuracy and reduce. The IRRI (International Rice Research Institute) has developed a simple and inexpensive leaf colour chart (LCC) for rice crop which can be used as a decision making tool to determine the need for N application in maize also which can promote need based variable rate of N application to the crop based on soil N supply and crop demand. Hence, there is a need to standardize the time of N application to maize crop to improve N- use efficiency and the productivity. In view of this the present investigation was undertaken in vertisols at the University of Agricultural Sciences, Dharwad.

METHODOLOGY

Field experiment was conducted at Main Agricultural Research Station, Dharwad (Karnataka) during *kharif* season of 2009 to 2015. Soil was medium black with pH 7.5, low in available nitrogen (260 kg/ha), high in available phosphorus (35 kg/ha) and available Potassium (450 kg/ha). Zinc, iron and manganese were above the critical limits. Treatments consisted four nitrogen levels (0, 80, 160 and 240 kg/ha) and three timings of N application as indicated in Table 1. Experiment was laid out in split plot design with three replications. Common nutrient doses of 90 and 80 kg/ha of P_2O_5 and K_2O respectively were applied to all the treatments

Table 1. Effect of nitrogen levels and time of application on yield and economics of hybrid maize (Pooled of 2009-15)

Treatment	Plant height (cm)	Grain weight /cob (g)	100-seed weight (g)	Grain yield (t/ha)	Harvest index	Net returns (Rs./ha)	B : C ratio
Nitrogen level							
N_1 – 00 kg/ha	106.4	36.6	23.1	1.28	0.25	2061	1.19
N_2 – 80 kg/ha	148.2	84.0	28.1	4.00	0.38	29670	2.80
N_3 – 160 kg/ha	164.7	100.9	29.9	6.38	0.44	53648	3.72
N_4 – 240 kg/ha	177.0	108.3	33.1	7.08	0.44	60084	3.84
SEm±	0.9	0.7	0.2	0.05	0.004	501	0.02
CD (P= 0.05)	3.3	2.3	0.7	0.19	0.01	1734	0.1
Time of application							
T_1 : 33% basal + 33% V4 to V6 + 33% V10	149.9	82.5	29.0	4.80	0.37	37567	2.94
T_2 : 33% basal + 33% V4 to V6 + 33% V10 (Rate as per LCC)	151.8	85.0	29.1	4.90	0.38	38588	2.98
T_3 : 50% basal + 00% V4 to V6 + 50% V10	145.5	79.8	27.5	4.35	0.37	32941	2.74
SEm±	0.6	0.5	0.3	0.03	0.003	316	0.02
CD (P= 0.05)	1.8	1.6	0.8	0.10	NS	948	0.05
Interaction	*	NS	NS	*	NS	*	*

LCC: Leaf colour chart NS: Non significant as basal application at the time of sowing and other production practices remained same for all the treatments except for the time of application of N fertilizers and maize hybrid was used Cargill 900M gold.

RESULTS

Pooled data over seven years indicated that significantly higher plant height, grain weight/cob, grain yield, harvest index, net returns (Rs. 60,084/ha) and B C ratio (3.84) were realized with N application @ 240 kg/ha as compared to application of N @ 80 kg/ha and N-application @ 160 kg/ha. No nitrogen (0 kg/ha) application resulted in significantly lowest grain and straw yield and correspondingly lower net returns (Rs 2061/ha), B: C ratio (1.19), plant height (106.4cm) and grain weight/cob (36.6 g). Time of application of nitrogen had significant effect on maize grain yield, straw yield and economics. Nitrogen application in 3-splits as per LCC *i.e.* 33% N basal + 33% V_4 to V_6 + 33% V_{10} stages (Rate as per LCC) applied resulted significantly higher plant height (151.8 cm) grain weight (85 g/cob), grain yield (4.9 t/ha), net returns (Rs. 38,588/ha) and B C ratio (2.98) as compared to application of N in 2-splits *i.e.* 50% each at basal and at 50% V_{10} stage which resulted in grain yield respectively with net returns of Rs. 32,941/ha and B C ratio of 2.74. However, application of N in 3 splits (33% basal + 33% V_4 to V_6 + 33% V_{10} stages) was statistically on par with nitrogen application in 3-splits *i.e.* 33% N basal + 33% V_4 to V_6 + 33% V_{10} stages (Rate as per LCC). Interaction of effects was found significant on yield and economics except grain weight per cob, 100-seed weight and harvest index.

CONCLUSION

Based on the results of seven years study it was concluded that nitrogen @ 240 kg/ha applied in three splits as per LCC *i.e.* 33% N each at basal, 33% at V_4-V_6 and 33% at V_{10} stage (as per LCC) can substantially improve the maize grain yield with higher economic returns as compared to the present practice of nitrogen application in 2 splits.

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Long term monitoring of nutrient management practices on productivity and their responses in rice-wheat system in IGP of India

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The rice-wheat rotation is one of largest agricultural production system in India, occupying 10.5 mha productive lands in Indo-Gangetic plains (IGPs). In India and in entire Asia, fertilizer nitrogen, mostly urea has received more attention than phosphorus and potassium fertilizer. Even after application of general recommendation of NPK have also resulted in production and soil fatigue, proving their decreased efficiency. Thus, upward refinement and proper balance among the macro and micronutrients is required to arrest higher crop productivity and any further decline in soil fertility. Therefore, it was necessary to initiate such an experiment to answer the question likely to come up in input intensive farming systems taking several aspects of crop and fertilizer management which could be better understood only through long term fertilizer experiments.

METHODOLOGY

Long term field experiments are being conducting for 30 years from 1984 to 2014 at G.B.Pant University of Agriculture & Technology, Pantnagar(Uttarakhand, India) to monitor the long term effect of nutrient management on rice (*Oryza sativa L.*) productivity under rice-wheat system. Eight treatments, *viz*. Control, N_{120}, N_{120} P_{40}, P_{40} $K_{40,}$ $N_{120}K_{40}$, N120 $P_{40}K_{40}$, $N_{120}P_{40}K_{40}$ + Zn, N120 $P_{40}K_{40}$ + farm yard manure (@5 tonnes/ha) were maintained in a fixed layout right from the inception of the experiment (1984), however another 9thtreatment *viz.*, N_{180} P_{80} + K_{40} + Zn foliar (@ 0.5%) was included in 1997 in a randomized block design with 4 replications. Crop productivity was monitored by taking grain yield of riceand nutrient responses were observed by comparing the agronomic efficiency of different nutrient sources.

RESULTS

In 1984, the year of inception of the experiment, there was no significance differences in grain yields among the treatments even in N alone except absolute control. After that the ill effect of imbalance fertilization over the years are shown. However, combined application of NPK along with farm yard manure or zinc (N_{120} P_{40} K_{40} + Zn foliar and N_{120} P_{40} K_{40} + FYM) significantly maintained higher grain yield of rice over recommended application of NPK and all other imbalanced nutrient treatments. Even after application of higher dose of nitrogen and phosphorus *i.e.* N_{180} P_{80} + K_{40} + Zn foliar could not arrest the productivity and was lower than the N_{120} P_{40} K_{40} + Zn foliar and N_{120} P_{40} K_{40} + FYM treatments. The yield gaps between balanced and fully fertility treatments containing FYM are still continued to be widening. This might be due to balanced supply of macro and micro nutrients to the rice crop along with maintaining of good soil physical and biological properties especially organic matter content of the soil. Significant nutrient responses were observed in treatments with nitrogen and its combinations. The response of nitrogen was on decline and that of phosphorus was on rise. Potassium had some response in the presence of nitrogen and phosphorus as seen in NPK over NP. However, a marked increase in yield was observed with NPK+FYM over NPK since the inception of the experiment with continuous cropping.

CONCLUSION

In Indo – Gangetic plains of India, long term studies on nutritional experiment revealed that the crop productivity mainly rice and wheat under continuous rice- wheat system which is predominantly existing system, is declining even after applying recommended doses of NPK fertilizers. Therefore, balanced use of N, P, K, Zn and FYM is to be done to arrest the decline in crop productivity. Inclusion of organics with NPK not only provides micronutrients to the crops but also provides soil physical and biological support.

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Innovative nitrogen management in maize-wheat system under conservation agriculture

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Conservation agriculture (CA), an alternative practice that involves minimum soil disturbance, crop residue retention and crop rotation, is postulated to conserve soil organic matter (SOM), energy, irrigation water and biodiversity. On the other hand, conventional tillage practices (CT) characterized by excessive tillage, residue removal and monoculture are often associated with the degradation of soil mainly in terms of depletion of SOC, sub-soil compaction and loss of biodiversity. As fertilizer nitrogen (N) is the one of key input in food production, it is typically required in larger quantities than any other nutrients by the crop for its growth and development. Therefore, proper management of N is essential to reap high yield, profit and ultimately with safe environment.

METHODOLOGY

In view of scarcity of information on N management protocols under CA, a field experiment was initiated in *kharif* 2013 at IARI farm, to evaluate different N management options i.e. basal application of 80, 50 and 33% of total fertilizer requirement followed by need-based top dressing as suggested by Green Seeker, and N sources and methods of application on crop yield, N uptake, N use efficiencies (NUE), and temporal changes in soil organic C and mineral-N in maize (*Zea mays* L.)-wheat (*Triticum aestivum* L.) cropping system under CA and CT practices.

RESULTS

Results revealed that maize grain yield was statistically similar under both cultivation practices *i.e.* CA (7.47 t /ha) and CT (7.48 t /ha), whereas grain yield of wheat was significantly higher under CA (5.0 t /ha) than that under CT (4.71 t /ha). The N top dressing requirement as assessed by using Green Seeker was relatively less under CA in both the crops, which ultimately curtailed fertilizer N application in this practice. Averaged across N management options, it was possible to curtail 62 kg fertilizer N /ha without any grain yield penalty in maize-wheatsystem. Such advantages of CA were apparently due to higher N use efficiency and better mineralization of N during the cropping period. On an average, N use efficiencies in wheat computed as agronomic efficiency (AE_N), partial factor productivity (PFP_N) and recovery efficiency (RE_N) were 23.2 kg grain /kg N, 38.4 kg grain /kg N and 52.5%, respectively under CA; the corresponding values under CT were 15.1 kg grain /kg N, 26.1 kg grain /kg N and 37.5%.The values of use efficiencies of applied N observed in the present study are well within the acceptable range reported in the literature. Among N sources and methods of application band placement of slow release modified urea materials (*i.e.* USG and IFDC-product) resulted in higher yields and NUE compared with urea broadcasting. In CA, Walkley-Black C (WBC) and mineral-N (NH_4^+-N + NO_3^-N) contents were significantly higher compared with CT in the surface layer (0–15 cm depth). Among N sources and methods of application, band placement of slow release modified urea material (i.e. USG and IFDC product) resulted in higher yield and NUE compared with urea broadcasting. These results corroborated earlier findings suggesting the superiority of slow release N fertilizers over prilled urea and also that of band placement over broadcasting.

CONCLUSION

Study revealed the possibility enhancing NUE with the adoption of CA. It was possible to curtail fertilizer N, especially in wheat, with the adoption of CA without any adverse effect on yield. Result indicated superiority of CA over CT particularly with respect toincrease in SOC and mineral-N content and enhancement in the NUE. Application of 50% N as basal and sensor-based topdressing of N was effective in reducing the applied rate of N. Further, sources like USG and IFDC-product also helped significantly in curtailing fertilizer N. The benefits associated with CA present a greater potential for its adoption to sustain soil health and crop productivity of maize–wheat cropping system.

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Nutrient management in rapeseed and mustard for yield optimization

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To meet the vegetable oil requirement of the country at optimum level, we have to increase our production from present level of 20 million tones to about 50 million tonnes by 2020 (Hedge, 2005). Indian mustard is the most important winter season *(rabi)* oilseed crop, which is nutritionally very rich and its oil content varies from 37-49 % but production of this crop need to be enhanced to meet the national short fall. Though, a suitable variety for a specific agro-ecological region is important for increasing productivity of rapeseed/ mustard, yet optimum fertility level helps in realizing the potential yield of the variety. Therefore, the present investigation was undertaken to study the impact of nutrient management in Indian mustard for yield optimization.

METHODOLOGY

A field experiment was conducted at Agricultural Research Station, Ummedganj farm, Kota during *rabi* 2015-16. The experiment consisting three levels of nitrogen (60, 80 & 100 kg N/ha), two levels of phosphorus (20 & 40 kg P_2O_5/ha) and two levels of potassium (0 & 30 kg K_2O/ha) was carried out in factorial randomized block design with replications thrice. The soil of the experimental field was clay loam, alkaline in reaction (pH 7.56), medium in organic carbon (0.52 %), nitrogen (290.0 kg/ha) and phosphorus (22.4 kg/ha) and high in potassium (312.0 kg/ha). The nitrogen and phosphorus were given through di-ammonium phosphate and remaining quantity of nitrogen was given through urea applied as basal as well as top dressing at 40-45 DAS. The potassium was applied through murate of potash. The variety of mustard (RGN 73) was used in this experiment with plot size was 5.0 m X 4.2 m.

RESULTS

The results of the investigation (Table 1) revealed that the performance of mustard variety RGN 73 differed significantly due to application of various levels of N, P and K with respect to growth, yield attributes and seed yield. Application of 80 kg N/ha registered significantly higher branches/plant, siliquae/plant, seeds/siliqua, test weight and seed yield of mustard over 60 kg N/ha but it was found on par with 100 kg N/ha. Similarly, amongst the P and K levels, the maximum branches/plant, siliquae/plant, seeds/siliqua, seed weight/ plant and test weight were noted with the application of 40 kg P_2O_5 and 30 kg K_2O/ha. Consequently, nutrient applied at 40 kg P_2O_5 and 30 kg K_2O/ha significantly enhanced seed yield of mustard by 209 kg and 182 kg/ha, respectively over 20 kg P_2O_5 and 0 kg K_2O/ha. The NPK nutrient application at higher levels resulted in significantly higher number of branches/ plant, siliquae/plant and seeds/siliqua as well as seed weight/ plant and test weight as compared to lowest levels of these nutrients which could be reason for significantly higher seed yield under better nutrient management conditions. The extent of increase was 19.3, 12.6 and 10.9 per cent over 60 kg N, 20 kg P_2O_5 and 0 kg K_2O/ha, respectively.

Table 1. Effect of nutrient management on growth, yield attributes and seed yield of mustard

Treatment	Branches / plant (Nos.)	Siliquae / plant (Nos.)	Seeds / siliqua (Nos.)	Test weight (g)	Seed weight / plant (g)	Seed yield (kg/ha)
N level						
N_1	7.47	226.28	15.70	4.48	4.76	1587
N_2	7.90	261.30	16.43	4.69	5.41	1805
N_3	8.00	278.44	16.68	4.86	5.68	1894
SEm$\pm$	0.11	6.20	0.17	0.06	0.12	47.31
CD (P=0.05)	0.33	18.17	0.48	0.18	0.35	138.75
P level						
P_1	7.62	236.08	15.68	4.50	4.97	1657
P_2	7.96	274.60	16.87	4.86	5.60	1866
SEm$\pm$	0.09	5.06	0.13	0.05	0.10	38.63
CD (P=0.05)	0.27	14.83	0.40	0.15	0.28	113.29
K level						
K_1	7.64	240.75	16.07	4.60	5.01	1671
K_2	7.93	269.93	16.48	4.75	5.56	1853
SEm$\pm$	0.09	5.06	0.13	0.05	0.10	38.63
CD (P=0.05)	0.27	14.83	0.40	0.15	0.28	113.29

CONCLUSION

From the one year investigation it is concluded that on vertisol of south eastern Rajasthan mustard variety RGN 73 should be fertilized with 80 kg n, 40 kg P_2O_5 and 30 kg K_2O / ha for higher yields and economic returns

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Performance of fodder maize (*Zea mays* L.) under varying plant geometry and fertility levels

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An increase in population growth, increasing purchasing power and better health cautious of the Indian people have lead to a sharp increase in the demand of animal product such as milk, eggs and the meat. The increase in demand for livestock products has given impetus to greater livestock population within the existing farming system and also emphasizing the need of feed and fodder security in country. The climate of the southern Rajasthan is very favourable for maize crop. In recent past development of composite fodder maize 'Pratap Makka Chari-6' by MPUAT Udaipur, has opened a new avenue for exploiting higher green fodder for livestock. Thus identification and development of production technology of fodder maize 'Pratap Makka Chari-6' as per crop growing situation is considered to be the first and foremost step for enhancing its green fodder production. Therefore considering these facts the study was conducted with objective to standardize plant density, to ascertain suitable N and P levels for fodder maize and arrive at economically viable recommendation of the treatments.

METHODOLOGY

The field experiment was conducted during 2013-14 at the Instructional farm Rajasthan College of Agriculture, Udaipur. The soil was clay loam, alkaline (pH 8.5) in reaction having medium in available nitrogen (275.1 kg/ha), phosphorus (18.1 kg/ha) and high in potassium (299.3 kg/ha). The experiment consisted four plant geometry (1,33,333 plants /ha 30 x 25 cm, 1,66,666 plants /ha 30 x 20 cm, 2,22,222 plants /ha 30 x 15 cm and 3,33,333 plants /ha 30 x 10 cm) and four fertility levels (90 + 30, 110 + 40, 130 + 50 and 150 + 60 kg N + P_2O_5 /ha) were conducted in RBD with three replications. Maize fodder variety 'Pratap Makka Chari-6' was used as test crop. For weed control atrazine 0.5 kg/ha was used as pre emergence application. Fodder maize was sown in first fort night of July and harvested at full tassels emergence during both the years. The fodder crop was raised as rainfed crop. Economics was calculated on basis of current market prices of inputs.

RESULTS

Maintenance of 2,22,222 plant population/ha by planting fodder maize at 30 x 15 cm recorded significantly higher green fodder yield and proved economically profitable over 1,66,666 (30 x 20 cm) and 1,33,333 (30 x 25 cm) plants/ha. Further increase in plant population 3,33,333 plants/ha (30 x 10) though increased green fodder yield, however failed to record statistical significance. Application of 130 kg N + 50 kg

Table 1. Effect of plant geometry and fertility levels on fodder yield and economics of 'Pratap Makka Chari-6'

Treatment	Green fodder yield (t/ha)			Net returns (₹/ ha)	B:C ratio
	2013	2014	Polled		
Plant geometry					
(1,22,222 plants/ha) 30 x 25 cm	25.36	27.45	26.40	42145	2.65
(1,22,222 plants/ha) 30 x 25 cm	29.30	28.96	19.13	44523	2.80
(1,22,222 plants/ha) 30 x 25 cm	31.53	29.95	30.74	46370	2.92
(1,22,222 plants/ha) 30 x 25 cm	31.69	30.30	30.94	46532	2.93
C.D. (P=0.05)	4.98	4.55	4.28	1013	0.64
Fertility levels					
090 kg N + 30 kg P_2O_5/ha	28.18	25.82	27.00	40961	2.58
110 kg N + 40 kg P_2O_5/ha	29.15	29.11	19.13	45208	2.84
130 kg N + 50 kg P_2O_5/ha	30.20	30.67	30.46	46971	2.95
150 kg N + 60 kg P_2O_5/ha	30.33	21.07	30.70	46429	2.92
C.D. (P=0.05)	4.98	4.55	4.28	1013	0.64

P_2O_5/ha significantly increased green fodder yield of 'Pratap Makka Chari-6' and proved economically profitable over 110 kg N + 40 kg P_2O_5/ha and 90 kg N + 30 kg P_2O_5/ha. Further increase in fertility level marginally increased green fodder yield and reduced net returns and B:C ratio, however, failed to record statistical significance.

CONCLUSION

On basis of two years study it is concluded that maintenance of 2,22,222 plant population/ha by planting fodder maize at 30 x 15 cm was found suitable for 'Pratap Makka chari-6'. Likewise application of 130 kg N + 50 kg P_2O_5/ha proved suitable dose of fertilizer for 'Pratap Makka chari-6'.

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Natural nitrification inhibitors improving the nitrogen use efficiency and yield and economics of rainfed maize (*Zea mays* L.)

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India ranks first among the rainfed agricultural countries of the world in terms of both extent and value of produce. Due to population pressure the property is concentrated in rainfed regions. With the introduction of high yielding varieties (HYVs), the use of chemical fertilizers increased. Maize (*Zea mays* L.) is varacious consumer of nitrogen fertilizer. When urea applied to soil lost by several processes like leaching, denitrification, runoff, volatilization and nitrification. Among those losses nitrification is most widely occurs under drylands. Inefficient use of nitrogen fertilizers has resulted in low nitrogen use efficiency and reduced yields, adverse ecological and environmental effects contributing to eutrophication, and N_2O emissions which is a potent green house gas. Hence arresting these losses the urea coated with several natural compounds neem cake, karanj cake and *Vitex negundo* leaf powder by using adjuvant like castor oil and coal tar are known for nitrification inhibition, to improve the availability and agronomic nitrogen use efficiency and factor productivity of the crops in terms resulted in increased crop yield and BC ratio.The increase in ANUE in different treatments was in the order of VCU (57.5%) > VCTU (57.3%) > NCTU (51.5%) > KCTU (40.6%) > NCU (28.1%) compared to uncoated urea. Factor productivity in different treatments was in the order of VCU > VCTU > NCTU > KCTU > NCU. The yield recorded in different treatments was in the order of VCU (3233 kg/ha) > VCTU (3218 kg/ ha) > NCTU (2995 kg/ha) > KCTU (2687 kg/ha) > NCU (2446 kg/ha). B:C ratio was realized with VCU (1.29) followed by VCTU (1.30). Uncoated urea recorded higher B: C ratio as compared to control.

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Effect of integrated nutrient management and potassium levels on growth quality and yield of summer soybean

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Integrated nutrient management (INM) involves the use of manures, biofertilizers and chemical fertilizers to achieve sustained crop production and maintain better soil health. INM is best approach for better utilization of resources and to produce crops with less expenditure. Integration of organic and inorganic sources of nutrients along with biofertilizers is found to give higher productivity and monetary returns in soybean (Bhattacharyya *et al*., 2008). Potassium is one of the three major essential nutrient elements required by plants. Unlike nitrogen and phosphorus, potassium does not form bonds with carbon or oxygen, so it never becomes a part of protein and other organic compounds. Keeping in view the importance of integrated nutrient management, and potassium to optimize its dose, the present investigation was undertaken on summer soybean.

METHODOLOGY

A field experiment was conducted during *summer* seasons of 2013-2014 at P. G. Research Farm, Agronomy Section, College of Agriculture, Dhule. The field experiment was laid out in a split-plot design with sixteen treatments and three replications. The main plot treatment comprises of four treatment of integrated nutrient management *viz.,* 25 % N through fertilizer + 75 % N through vermicompost, 50 % N through fertilizer + 50 % N through vermicompost, 75 % N through fertilizer + 25 % N through vermicompost, GRDF 50:75:00 kg N:P:K/ha and the subplot treatment comprises of four treatment of potassium levels *viz.,* application of potassium 0 kg/ha, 15 kg/ha, 30 kg/ha, 45 kg/ha. The recommended dose of fertilizer was applied as per treatments. The sowing was done by dibbling.

RESULTS

Different treatment of integrated nutrient management showed a significant influence on growth parameters (Table 1). Protein and oil content, protein and oil yield (Table 2) and also seed yield (Table 1) of soybean seed was affected significantly due to different treatment of integrated nutrient

Table 1. Growth attributing character of soybean as influenced by different treatments

Treatment	Plant height (cm)	Leaf area index (dS/m^2)	Dry Matter of plant (g)	No. of root nodules/ plant	Seed yield (Kg/ha)
Nitrgen Levels					
25% N through fertilizer+75% N through vermicompost	41.83	1.10	34.08	10.28	1973
50% N through fertilizer+50% N through vermicompost	45.38	1.48	37.60	14.65	2319
75% N through fertilizer+25% N through vermicompost	46.45	1.57	39.14	14.72	2353
RDF (50:75)	43.93	1.38	34.18	12.73	1986
CD (P=0.05)	2.26	0.10	3.79	0.66	97
Potassium Levels					
0 kg/ha	43.10	1.21	33.99	11.47	1990
15 kg/ha	43.44	1.27	35.23	12.18	2111
30 kg/ha	45.23	1.49	37.18	14.10	2210
45 kg/ha	45.83	1.56	38.61	14.63	2320
CD (P=0.05)	1.93	0.12	2.78	0.97	118
Interaction					
CD (P= 0.05)	NS	NS	NS	NS	238
General Mean	44.40	1.38	36.25	13.09	2158

Table 2. Oil and protein content, oil and protein yield of soybean as influenced by different treatment

Treatment	Protein content (%)	Protein yield (kg ha^{-1})	Oil content (%)	Oil yield (kg/ha)
Nitrgen Levels				
25% N through fertilizer+75% N through vermicompost	37.49	740.02	17.83	351.63
50% N through fertilizer+50% N through vermicompost	38.70	897.67	20.06	465.92
75% N through fertilizer+25% N through vermicompost	40.14	946.91	20.48	483.27
RDF (50:75)	38.47	765.91	18.95	380.42
CD (P=0.05)	1.65	50.08	1.49	43.34
Potassium Levels				
0 kg/ha	37.90	754.87	18.19	367.09
15 kg/ha	38.31	809.77	18.96	400.76
30 kg/ha	38.90	860.33	19.81	438.81
45 kg/ha	39.69	924.91	20.36	474.59
CD (P=0.05)	1.22	65.17	1.20	31.84
Interaction				
CD (P=0.05)	NS	110.35	NS	63.68
General Mean	38.70	837.47	19.33	420.31

management. However protein and oil content, was higher under application of 75 % N through fertilizer + 25 % N through vermicompost and it was being at par with 50 % N through fertilizer + 50 % N through vermicompost (F_2) but protein oil and stover yield was significantly higher under application of 75 % N through fertilizer + 25 % N through vermicompost followed by 50 % N through fertilizer + 50 % N through vermicompost. Protein and oil content in soybean seed was affected significantly due to different treatment of potassium levels. However mean protein and oil content was highest with the application of 45 kg potassium/ha and it was being at par with 30 kg potassium/ha but Protein, oil and seed yield was significantly higher under application of 45 kg potassium/ha followed by 30 kg potassium/ha.

CONCLUSION

Yield of soybean was significantly higher with 75 % N through RDF + 25 % N through vermicompost with application of 45 kg potassium/ha.

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Effect of Long term fertilizer application on yield sustainability in finger millet - maize sequence

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Inorganic fertilizers, especially N, P and K not only serve to maintain or improve crop yields, but their application directly or indirectly causes changes in chemical, physical and biological properties of the soil (Zhong and Cai, 2007). AICRP on LTFE at Bangalore Centre was started during 1986-87 with eleven treatments combinations four replications. The beneficial effect of FYM and lime is more enhancing in terms of yield and sustaining the soil and crop productivity (Tiwari, 2001). The objective of the experiment was to study the effect of continuous application of plant nutrients, singly and in combinations, in organic and inorganic forms on the yield of crops in a multiple cropping system.

METHODOLOGY

The experiment is being continued with the finger millet – maize cropping system with randomized block design and replicated four times with the following treatments and fertilizer source. The treatments comprised of 50% NPK, 100% NPK, 150% NPK, 100% NPK + HW, 100% NPK + lime, 100% NP, 100% N, 100% NPK + FYM, 100% NPK (S – free), 100% NPK + FYM + lime and Control.

RESULTS

The crops responded well with application of nutrients, however the crop response in a cropping system over the year remains sustained with application of application of balanced use of organic and inorganics (T_{10} and T_8) (Table 1). Both the crops responded well with application of super optimal dose of fertilizers (150 % NPK). Addition of manures and lime over the years sustained the crop productivity through maintaining the yields at higher levels when compared to application of inorganics alone. Though the productivity of crops is higher in super optimal dose the soil fertility has lost resulting in build up P and K in soil and organic matter depletion. Higher sustainability index for finger millet and maize over the years (Table 2) was highest in case

Table 2. Yield sustainability index of finger millet and maize as influenced by LTFE treatments (1986-87 to 2011-12)

Treatment	Finger millet	Maize
50% NPK	0.527	0.165
100% NPK	0.577	0.251
150% NPK	0.633	0.268
100% NPK+HW	0.604	0.241
NPK+lime	0.586	0.271
100% NP	0.185	0.049
100% N	0.213	-0.029
NPK+FYM	0.557	0.299
NPK (S-free)	0.582	0.180
NPK+FYM+lime	0.671	0.305
Control	0.267	0.008

Table 1. Effect of long term fertilizer addition on productivity of crops under finger millet-maize cropping system (2013-14)

Treatment	Finger millet (t/ha)				Maize (t/ha)			
	Grain	Mean over the years	Straw	Mean over the years	Grain	Mean over the years	Straw	Mean over the years
50% NPK	1.89	2.65	2.34	2.65	2.53	1.70	2.00	2.54
100% NPK	2.85	4.09	3.53	3.97	3.06	2.58	4.06	3.88
150% NPK	3.69	4.74	4.52	4.51	3.49	2.95	4.68	4.42
100% NPK+HW	3.11	4.08	3.81	3.80	3.05	2.62	3.81	3.78
NPK+lime	2.88	3.92	3.56	4.29	3.35	2.72	3.66	3.98
100% NP	0.61	0.95	0.76	1.26	0.61	0.75	1.83	1.29
100% N	0.93	0.70	1.14	0.79	0.88	0.48	1.47	0.89
NPK+FYM	3.32	4.52	4.10	4.78	3.41	3.02	4.90	4.65
NPK (S-free)	2.86	3.96	3.54	3.18	3.39	2.34	3.56	3.39
NPK+FYM+lime	3.31	4.18	4.09	4.90	4.55	3.15	5.69	4.67
Control	0.62	0.56	0.77	0.53	0.62	0.40	1.16	0.60
SEm±	0.17	-	0.20	-	0.12	-	1.06	-
CD (P= 0.05)	0.35	-	0.42	-	0.24	-	2.73	-

of treatments receiving 100% NPK + FYM+ lime followed by 150% NPK and 100% NPK+ FYM. Integrated application of NPK with organics and amendments sustained the crop and soil productivity over the long time. The results indicated highest index was recorded in T_{10} (NPK + FYM + Lime) followed by T_8 (NPK + FYM). This suggests that application of FYM would help in maintaining the soil quality over the years. Lowest SQI was recorded in T_7 (100% NP) and T_{11} (Control).

CONCLUSION

Balanced use of NPK at adequate level is essential to maintain sustainable yield and productivity over the years. Drastic reduction in yield and all the available nutrients status has been recorded in those plots not received fertilizer and FYM over the years due to continuous cropping. Yield sustainability index for maize and ragi over the years was highest in case of treatments received 100% NPK+ lime+ FYM. The crop productivity substantially improved in case of imbalanced nutrient supply (N and NP only) when superimposed with NPK and FYM.

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Nutrient management and its residual effect on yield potential and economics of groundnut based diversified cropping systems

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The experiment was conducted to study the nutrient management and its residual effect on yield potential and economics of groundnut based diversified cropping systems, with the objectives of (i) to study the effect of nutrient management on yield potential of groundnut based diversified cropping systems. (ii) To study the economics of groundnut based diversified cropping systems.

METHODOLOGY

The present investigation was conducted at Post Graduate Institute, Research Farm, MPKV, Rahuri (19° 48' N latitude and 74° 32' E longitude and 495 meter above mean sea level), in strip plot design with three replications during the year 2012-13. The available nitrogen, phosphorus and potassium were 172.11, 18.02, 427.0 kg/ ha and moderate in Fe, Mn, Zn and Cu were 6.89, 9.51, 0.62 and 3.41 µg/g of soil, respectively. The main plot treatment consists of three cropping sequences *viz.,* Groundnut – onion, Groundnut – wheat and Groundnut–chickpea and four nutrient management treatments *viz.,* recommended dose of fertilizer, fertilizer dose as per soil test, fertilizer dose as per STCR equation (2.5 t/ha) and control treatment in *kharif* season and three fertilizer levels as subplot treatments *viz*., 100 % RDF, 75% RDF and 50 % RDF in *rabi* season. The crop varieties *viz.,* groundnut 'JL-501'and chickpea 'Digvijay' were dibbled at 30 cm x 10 cm, onion 'N 2-4-1' was transplanted at 15 cm x 10 cm spacing and wheat 'Trimbak' was sown in 22.5 cm line spacing, respectively. The recommended dose of NPK (kg/ ha) for groundnut 25-50-00, onion 100-50-50, wheat 120-60-40 and chickpea 25-50-00 was applied. Groundnut was sown in third week of June and harvested at second week of October. The winter crops *viz.,* onion, durum wheat and chickpea were sown in second week of November and harvested in third and fourth week of onion.

RESULTS

Groundnut–onion cropping system recorded significantly maximum total system productivity of 6.72 t/ha and it was 115.48% higher than groundnut-wheat and 68.19 % higher than groundnut-chickpea. The nutrient management as per STCR equation proved it's superiority by recording maximum total system productivity of 6.09 t/ha and it was followed by nutrient management as per soil test. The total system productivity was significantly higher with 100% RDF to succeeding crop during *rabi* season and at par with 75% RDF. *G*roundnut–onion cropping system registered significantly higher production efficiency (30.1 kg/ha/day) and economic efficiency (Rs. 620.66/ha/day) than groundnut-wheat and

Table 1. The productivity of different cropping systems as influenced by different treatments

Treatment	Total system productivity (t/ ha)	Production efficiency (kg/ ha/ d)	Economic efficiency (Rs./ha/d)	Cost of cultivation ($X10^3$/ha)	Net monetary returns ($X10^3$ Rs/ha)	B:C ratio
Cropping system						
Groundnut-onion	6.72	30.16	620.66	93.69	138.20	2.48
Groundnut-wheat	3.12	14.34	166.09	71.15	36.46	1.51
Groundnut-chickpea	3.99	18.94	327.32	67.76	70.11	2.05
CD (P =0.5)	0.11	0.53	20.13	—	3.95	—
Nutrient management						
Recommended dose of fertilizer	5.03	23.17	422.98	81.11	92.49	2.14
Fertilizer dose as per soil test	5.37	24.60	474.61	81.22	104.21	2.29
Fertilizer dose STCR eqn (2.5 t/ha)	6.09	27.63	578.11	82.49	127.66	2.58
Control (no fertilizers)	1.95	9.18	9.74	65.33	2.02	1.03
CD (P =0.5)	0.13	0.61	23.25	—	4.57	—
Fertilizer level						
100% of RDF	4.76	21.84	391.75	78.40	86.09	2.10
75% of RDF	4.71	21.61	386.92	77.54	85.02	2.09
50% of RDF	4.36	19.99	335.41	76.68	73.67	1.96
CD (P =0.5)	0.12	0.57	19.76	—	4.32	—

groundnut-chickpea cropping systems during the period of experimentation. The nutrient management treatments as per STCR equation registered significantly higher production efficiency (27.63 kg/ha/day) and economic efficiency (Rs. 578.11 ha/day). Application of 100 % RDF to succeeding crop during *rabi* season registered significantly higher production efficiency (21.84 kg/ ha/day) and economic efficiency (Rs. 391.75/ha/day) than 50 % RDF and at par with 75 % RDF. These results are in conformity with those reported by Reddy and Suresh (2009) and Jat *et al.* (2011). Among the cropping systems, groundnut- onion cropping system obtained significantly maximum net monetary returns (Rs. 138.20 X 10^3/ ha) and B:C ratio (2.48) than groundnut-wheat and groundnut-chickpea cropping systems. Application of fertilizer as per STCR equation to *kharif* groundnut obtained significantly maximum net monetary returns (Rs.127.66 X 10^3/ ha) and B:C ratio (2.58) than rest of the nutrient management treatments. Application of 100 % RDF to succeeding crop during *rabi* season obtained significantly maximum net monetary returns (Rs. 86.09 X 10^3/ha) and B:C ratio (2.10) than 50 % RDF. However, it was at par with 75 % RDF in respect of net monetary returns and B: C ratio. These results are in confirmity with those reported by Walia *et al*. (2009) and Jat *et al*. (2011).

CONCLUSION

Application of fertilizer as per soil test crop response equation (2.5 t/ha) to *kharif* groundnut followed by 75 % RDF (75:37.5:37.5 N, P_2O_5, K_2O kg/ha) to onion during *rabi* season found most remunerative proposition to achieve maximum yield potential and monetary benefits in groundnut– *rabi* onion cropping system.

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Improved zinc efficiency in wheat (*Triticum aestivum*) through foliar application

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Wheat is the second most important staple cereal food grain in Indian diet and main source of protein & calories that contributes substantially to the national food security by providing more than 50 % of the calories for larger section of population. Improvement in its productivity has played a key role in making the country self-sufficient in food production. The productivity level of Wheat crop in the Jhunjhunu district of Rajasthan is also low-slung in comparison to potential yield of the crop, as farmers not completely follow the general recommended dose of fertilizers especially secondary plant nutrients as well as micro nutrients. The soils analysis report of the district indicates that most of the soils are deficient in Zinc. Zinc play important role in the production phenology of wheat and this crop responds well to applied nutrients (Yadav et al., 2012). The depletion of soil Zn leads low productivity & low concentration in edible grains, which causes Zn deficiency in humans also particularly in semi arid tropics (Shivay et al., 2008). Zinc is one of the most important plant micro nutrients which helps in synthesis of amino-acids, essential plant hormones, transportation of carbohydrates, regulates oxidation-reduction & photo synthesis activities in the plants. Keeping the importance Zinc, an On Farm Assessment on "Improving Zinc Efficiency in wheat (Triticum aestivum) through foliar application" was conducted on 5 farmers' field for two consecutive *rabi* season (2013-14 & 2014-15) in Chudela village. The objectives were to reveal the performance of recognised & recommended high yielding wheat varieties with full recommended package of practices along with two foliar spray of Zinc for harvesting higher crop yield; and to compare the yield levels and economics of control plots with treatment plots to assess the efficacy of foliar spray of Zinc on grain and straw yield of wheat crop at farmers field.

METHODOLOGY

To convince the farmers for adoption of foliar spray of Zinc sulphate for its higher use efficiency in Wheat crop to enhance the productivity & net return, an On Farm Testing (OFT) was carried out during two consecutive *Rabi* season of 2013-14, and 2014 -15 in Chudela village of the Jhunjhunu district of Rajasthan, which comes under *Transitional Plain of Inland drainage zone II- A* of Rajasthan. Total 5 Wheat growing farmers were selected in above selected village for On Farm Testing. Three different treatments comprising of viz. T_1- Control (N:P:K RDF), T_2- N:P:K RDF+ 25 kg basal application of Zinc & T_3- N:P:K RDF+ 10 kg basal application of Zinc + 2 foliar spray of 0.5% Zinc Sulphate at tillering and grain formation stage were evaluated in a randomized block design with 5 replications. Each farmer field was considered as a replication accommodating all the three treatments. The crop (Var. Raj-3765) was sown in mid-November under irrigated conditions and harvested in mid-April in each year. Recommended full dose of Phosphorus (60 kg/ha) was supplied through basal application of DAP and after adjusting the supplied dose of N through DAP, remaining dose of recommended N (120 kg/ha) was supplied through Urea fertilizer in two split doses. The soil of the experimental site was loamy sand having 0.15% organic carbon, 8.22 pH, low in nitrogen (140-152 kg/ha), low to medium in phosphorus (22-28 kg/ha) and medium to high in potash (215-280 kg/ha).

RESULTS

Result reveals that average grain yield under T_1, T_2, and T_3 treatments were 33.70, 36.74, and 40.82 qtl/ha. This increase in grain yield was 09.02, and 21.13 per cent higher in respective treatments over control. This increase in grain yield might be due to sufficient and readily availability of zinc micronutrient

Table 1. Effect of different treatments on yield & economics of Wheat crop (Pooled data of two years)

Treatment	Grain yield (t/ha)	% increase over control	Net return (Rs/ha)	B:C ratio
T_1- Control ((N:P:K RDF))	3.37	-	35013	1:2.12
T_2- N:P:K RDF+ 25 kg basal application of Zinc	3.67	9.02	38073	1:2.50
T_3- N:P:K RDF+10 kg basal application of Zinc+ 2 foliar spray of 0.5% Zinc Sulphate at tillering and grain formation stage	4.08	21.13	41594	1:2.80

under this treatment which might play an important role in synthesis of various enzymes, N metabolism and several oxidation-reduction reactions that improves efficiency of chloroplasts to capture solar energy through enzymic carbonic anhydrase. Hazra and Som (1999) also reported that zinc sulphate required for the activity of various enzymes including dehydrogenase, aldolase, isomerases, transphosphorylases and RNA and DNA polymerases, thereby, zinc deficiency is associated with an impairment of carbohydrate metabolism and protein synthesis. A large number of studies are available on the role of soil and foliar applied Zn fertilizers in correction of Zn deficiency and increasing plant growth and yield (Rengel et al., 1999 and Cakmak, 2008). The net return (Rs./ha.) was Rs. 35,013/-, Rs. 38,073/-, and Rs. 41,594/- under T_1,T_2, and T_3 treatments, respectively, which was Rs. 6,581/- & Rs. 3,521/- higher than T_1, & T_2 treatments, respectively. This might be due to higher grain yield achieved under T_3 treatment as compared to other treatments. The B:C ratio was also highest (2.80) under T_3 treatment as compared to control (2.10).

CONCLUSION

It can be inferred from the present investigation that wheat crop should be fertilized with N:P:K RDF+10 kg basal application of Zinc+ 2 foliar spray of 0.5% Zinc Sulphate at tillering and grain formation stage for higher seed yield and better net returns.

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Effect of seaweed saps along with inorganic fertilizers on growth and yield of drilled rice

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Rice (*Oryza sativa* L.*)* is probably the most important cereal in the world and serves as food for about 50% of the world's population. Heavy application of chemical fertilizers may cause depletion of certain nutrients in soil, due to this nutrient imbalance occurs, thus soil may show sign of fatigue, and decline in the yields of rice as well as a lower response to applied chemical fertilizers. Thus to achieve sustainability in agricultural production, organic manure and bio-fertilizer play an important and key role. Integrated nutrient management involving both the organic and inorganic source is essential to realize higher yield potential. Seaweed have effective for enhancing yield, pest and frost resistance in vegetable, fruits, flowers, cereals and pulses. Seaweed extract had beneficial effect on seed germination on plant growth.

METHODOLOGY

Field experiment was carried out at research farm of the JNKVV, Jabalpur (M.P.) during *kharif* season of 2012 to evaluate the effect of Seaweed saps along with inorganic fertilizers on growth and yield of drilled rice (*Oryza sativa* L.). Among ten treatments RDF with different doses of seaweed saps (K-sap and G-sap) *viz.*, 2.5, 5, 7.5 and 10% K-sap + RDF, 2.5, 5, 7.5 and 10% G-sap + RDF, RDF+ water spray and 10th treatment was 6.25% K-sap+50% RDF. These treatments were tested in randomized block designs in 3 replications. Rice semi-dwarf variety WGL 32100 was sown by hand drilling and fertilizer application as per treatment. A uniform dose of fertilizers 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha were applied through urea, single super phosphate and muriate of potash.

RESULTS

Plant height of drilled rice at 30 DAS was not affected by any treatment and it was almost statistically similar in all the treatments. Plant height recorded at 60, 90 DAS and at harvest were significantly affected by various treatments. Plant height increases with increasing dose of K-sap and G-sap. Maximum plant height 26.9 cm, 57.7 cm and 57.6 cm was recorded under T_4 at 60, 90 DAS and at harvest, respectively followed by T_8, whereas minimum plant height 24.2 cm, 51.2 cm and 51.2 cm was recorded under T_9 at 60, 90 DAS and at harvest, respectively. There is no any significance response has been observed on number of tillers/m^2 at 30 DAS. Further, the treatment effect shows at succeeding growth stages. Application of 10% K-sap + RDF gives highest number of tillers/m^2 i. e., 426, 503 and 507 at 60, 90 DAS and at harvest followed by T_8 (425, 502 and 500) whereas, minimum number of tillers/m^2 has been found under the application of RDF + water spray i.e. 402, 462 and 453. Grain and straw yield of drilled rice increases with increasing dose of K-sap and G-sap. It is evident from the data that grain yield significantly varied due to the effect of different treatments. The grain yield of rice among all treatments was highest under T_4 which as at par to T_8 but significantly higher than rest of the treatments. However, all treatments having RDF and different doses of seaweed sap found better to produce maximum grain yield over RDF (control) alone, except T_5 and T_1. Similarly, data on straw yield significantly varied due to different treatments. Maximum straw yield was recorded under T_4 followed by T_8 while the minimum straw yield was recorded under T_9. However, all treatments having RDF and different doses of seaweed sap found better to produce maximum straw yield over RDF + water spray, except T_5.

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Nutrient requirement of banana under different moisture regimes

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Banana is the most important fruit crop of the world with India as its largest producer and consumer. In Kerala, Nendran (AAB) is the intensively cultivated group of banana. The steady demand for banana due to its varied uses and wide adaptability to different farming situations makes it the most preferred crop. For obtaining maximum yield and income, additional supply of water and nutrients are pre-requisites. Presently farmers are dumping heavy doses of fertilisers resulting in losses or fixation, imbalances and reduced efficiency of these inputs. This has resulted in several nutritional disorders and soil degradation. In this context, trial was conducted to study the exact time and quantity of fertilizer application particularly that of major nutrients along with the maintenance of optimum soil moisture.

METHODOLOGY

An experiment was conducted in coarse textured soil at Agronomic Research Station, Chalakudy to study the nutrient dynamics of banana under varying levels of recommended dose of fertilizers (RDF) and soil moisture regimes. The fertiliser levels included combinations of 100 % nitrogen, 50, 75 and 100 % phosphorus, 100 and 125 % potassium of the recommended combination of 190 g N, 115 g P_2O_5 and 300 g K_2O/plant. Levels of N and K were applied in six splits at monthly intervals starting from one month after planting (MAP). The entire P was applied in two splits during 1 and 2 MAP. The moisture regimes included farmers' practice (basin irrigation at 100% pan evaporation) and drip irrigation at 75% pan evaporation. The experiment was laid out in factorial RBD with three replications. Observations on growth and yield parameters of banana were recorded and the data were subjected to statistical analysis.

RESULTS

Biometrical observations on growth and yield parameters showed that combined application of N at 100%, P at 75% and K at 125% (T4) of RDF resulted in better performance (8.15 kg/plant) compared to the existing recommendation of fertilisers(6.94 kg/plant) giving an yield increase of 17.5% over the present recommendation.. Lower dose of P and higher dose of K resulted in taller plants with more girth, more number of leaves resulting in better yield under basin irrigation. However under drip both 100 and 75 % P performed similarly at 125 % K . Studies on the post-harvest available P also showed that the content of P is very high (71.52-131.36 kg/ha) and higher dose of applied P increased the soil P after harvest. However higher level of K reduced P content in soil. The content of P above 24 kg/ha is considered high and hence reducing the level of P to 75% of RDF was sufficient. Further reduction in P caused yield reduction. Abraham (2014) in the survey conducted in different blocks of Thrissur district reported that the P content in the soil varied from 2.55 to 442.75 kg/ha. This showed that indiscriminate use of fertilisers especially that containing P has resulted in higher levels of available P in majority of the soil samples. The results suggest that the recommendation of P_2O_5 could be reduced to 86 gm/plant instead of the present 115 g/plant. Regarding the application of K, banana responded well to a higher level of fertiliser (125%). In banana, among the nutrients applied, potassium uptake is the highest and hence compared to nitrogen and phosphorus, the application of potassium should be more. However, the study revealed that economic response to fertilization could be expected only from the combined use of N, P and K. The study thus proved that P at 75% and K at 125% of RDF found to increase yield to an extent of 17.5% over the present recommendation. Among different methods of irrigation, basin irrigation resulted in significantly higher yield than drip irrigation. This suggests that water requirement for banana is very high and saving in water may negatively affect the yield. But water being a limited resource, its efficient use is inevitable. Drip irrigation at 75% pan evaporation could save irrigation water and increased water use efficiency.

CONCLUSION

The study proved that combined application of 100% of recommended N, 75% of recommended P and 125% of recommended K could increase the yield to an extent of 17.5% over the present recommendation.

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Efficient management of nutrients and intercrops under maize + urdbean intercropping system

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Maize (*Zea mays* L.) is mainly grown during *kharif* season in India and being a wide spaced crop, can accommodate intercrops within by adjusting the crop geometry to paired row planting method to attain a better intercrop growth without affecting its productivity. Urdbean, because of various characters can be the best intercrop with maize (Shivay, 2001). The beneficial effects of fertilizers can often be increased by the use of appropriate placement, especially when the spacing between rows is wide. Keeping all these points in view, an attempt was made to study the productivity of maize intercropped with urdbean as influenced by various planting patterns, different methods of fertilizer application and varying levels of nitrogen in maize as compared to their sole crops with recommended doses of nitrogen.

METHODOLOGY

A field experiment was carried out during *kharif*2014 at Norman E. Borloug Crop Research Centre of GovindBallabh Pant University of Agriculture and Technology, Pantnagar. The treatments consisted of two intercropping patterns of maize + urdbean viz. normal planting in 1:1 row ratio (at 67.5 cm rows) and paired row planting in 2:2 row ratio (at 45/90 cm); three methods of fertilizer application in maize viz. furrow application, side placement (5 cm away from seed) and broadcast and two levels of nitrogen fertilization in maize viz. 75 and 100 % of recommended (120 kg/ha). Sole crops of maize and urdbean were grown with 100 % of their recommended fertilizer doses (120-60-40 and 20-50-24 kg N-P-K/ha, respectively) with broadcast method for comparison. N in sole and intercropped maize was splitted in 4 equal doses and whole P and K was given as basal whereas whole NPK amounts were applied as basal in sole urdbean. The data recorded on various parameters were analyzed as per the analysis of variance technique for factorial randomized block design with an extra treatment.

RESULTS

The yield of maize and intercropped urdbean responded differentially to intercropping patterns, methods of fertilizer application in maize and levels of N in maize (Table 1). In maize, both the intercropping patterns remained on par for yield, however significantly higher yield was observed with furrow application that remained on par with side placement of fertilizers and was 13.2 % higher than yield under

Table 1. Effect of various treatments on performance of maize.

Treatment	Maize yield (t/ha)	Urdbean yield (kg/ha)	Maize grain equivalent yield (t/ha)	Land equivalent ratio
Intercropping pattern				
Normal (1+1)	3.54	450	5.03	1.28
Paired (2+2)	3.60	538	5.39	1.36
CD (P=0.05)	NS	68	0.34	NS
Method of fertilizer application				
Furrow application	3.77	473	5.35	1.36
Side placement	3.61	498	5.26	1.33
Broadcast	3.33	510	5.02	1.26
CD (P=0.05)	0.27	NS	NS	NS
Nitrogen dose (% of recommended)				
100	3.72	462	5.25	1.34
75	3.42	526	5.17	1.30
CD (P=0.05)	0.22	NS	NS	NS
Intercropping vs. sole cropping				
Intercrop	3.57	494	5.21	1.32
Sole crop	3.54	1603	3.54	1.00
CD (P=0.05)	NS	123.9	0.62	0.15

broadcast application. Similarly, Crop nourished with 100 % recommended nitrogen dose yielded significantly higher grain yield than that of 75 %. Intercropping remained on par to sole cropping with respect to grain yield of maize. Significantly more grain yield of urdbean (19.6 %) was obtained in intercropping under paired row method than normal planting. Grain yield of urdbean did not vary significantly due to fertilization in maize by different methods of fertilizer application and nitrogen doses given in maize. Significantly lower grain yield of urdbean was recorded under intercropping than sole crop that was 69.18 % lower than sole crop. Better light interception and space availability might be attributed to higher grain yields of urdbean under paired row planting and sole crop treatment. Paired row planting produced significantly higher maize grain equivalent yield (MGEY). However, differential application methods and nitrogen doses in maize did not show significant differences in MGEY. Different intercropping patterns, method of fertilizer application and nitrogen dose in maize though exhibited the value of land equivalent ratio (LER) more than 1 but did not differ significantly. Intercropping of maize resulted in significant improvement in LER over sole cropping of maize by 32 %. The combined yield of maize and urdbean under intercropping system was higher than sole crop of maize which caused more value of LER. None of the interactions among different factors found to the level of significance.

CONCLUSION

Intercropping of maize under paired row planting (45/90 cm) under Furrow placement of fertilizer along with 75 % recommended dose of nitrogen could be adopted for getting higher and stable yields.

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Response of maize hybrids to different nutrient management practices

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Maize the 'queen of cereals' is the third most important cereal crop of world and India after wheat and rice and it is a principal staple food in many countries particularly in the tropics and subtropics. In India, maize is cultivated in diverse production environments ranging from temperate hill zone of Himachal Pradesh to the semiarid region of Rajasthan. The development and recommendation of high yielding adaptable hybrids considered to be the first step to generate maximum production. Among nutrients, nitrogen, phosphorus and potassium play important role in the growth and development of crop plant. Maize is an exhaustive crop and requires high quantities of nutrients during the period of its growth. The management of nutrients for maize requires a new approach, which enables adjustments in applying N, P and K to accommodate the field specific needs of the maize crop for supplementing nutrients. The present investigation carried out during *Kharif* 2013 at Rajasthan College of Agriculture, Udaipur to access productivity of maize hybrids under different nutrient management practices.

METHODOLOGY

The experiment was laid out at the Instructional Farm, Rajasthan College of Agriculture, Udaipur which is situated at 24Ú35' N latitude and 74Ú42' E longitude and at an altitude of 579.5 meter above mean sea level. The treatment consisted combinations of five hybrids (PMH-1, PMH-3, HQPM-1, CMH-08-350, CMH-08-292) and three fertility levels SSNM (90 kg N + 60 kg P_2O_5 +30 kg K_2O /ha) RDF (90 kg N + 30 kg P_2O_5 + 30 kg K_2O /ha) 50% RDF (45 kg N + 15 kg P_2O_5 /ha + 15 kg K_2O /ha). These treatments were evaluated under factorial randomized block design with three replications. Furrows were opened at 75 cm apart and seeds were placed at depth of 3-4 cm using seed rate 25 kg/ha. The sources used for applying N, P and K were urea, di-ammonium phosphate (adjusted for its N content) and muriate of potash, respectively. Full dose of phosphorus and potassium, zinc and half dose of nitrogen were applied at the time of sowing by drilling fertilizer in crop rows about 4-5 cm below the seeds. The remaining nitrogen was given in two equal splits at knee high and tassel initiation stages as top dressing.

RESULTS

The results of present investigation revealed that amongst hybrids, 'PMH-1' attained highest plant height which was statistically at par with 'CMH-08-350' at successive growth stages. At 25 DAS and 50 DAS 'PMH-1' and 'CMH-08-292' accumulated highest dry matter plant^{-1} and proved significantly higher over 'PMH-1, HQPM-1 and CMH-08-350 but at harvest, 'PMH-1' produced highest dry matter and was significantly higher over rest of the hybrids. Similarly

Table 1. Effect of maize hybrids and fertility levels on yield (t /ha), harvest index (%) and grain protein (%)

Treatment	Grain yield	Stover yield	Biological yield	Harvest index	Grain protein (%)
Hybrid					
PMH-1	5.21	10.94	16.14	32.18	10.20
PMH-3	6.21	10.24	16.45	37.76	10.51
HQPM-1	5.56	9.64	15.21	36.82	10.68
CMH-08-350	5.43	9.71	15.14	35.86	10.41
CMH-08-292	5.83	10.70	16.53	35.39	10.34
SEm±	0.16	0.30	0.34	0.96	0.10
CD (P=0.05)	0.46	0.86	0.98	2.77	0.28
Fertility Level					
SSNM	6.10	11.07	17.16	35.51	10.79
RDF	5.69	10.22	15.91	35.92	10.48
50 % RDF	5.16	9.45	14.61	35.37	10.01
SEm±	0.12	0.23	0.26	0.74	0.08
CD (P=0.05)	0.36	0.67	0.76	NS	0.22

highest LAI at 25, 50, and 75 DAS recorded by 'PMH-1' and statistically at par with "PMH-3". The highest CGR recorded between 25-50 DAS in 'CMH-08-292', and between 50-75 DAS in 'PMH-1'. Similarly the highest RGR recorded between 25-50 DAS in 'CMH-08-292' and between 50-75 DAS in 'HQPM-1'. Among yield attributes, cobs/plant in 'HQPM-1', grain weight cob^{-1} in 'PMH-3' and 1000 grains weight recorded in 'PMH-3' were significantly higher over rest of hybrids. The next best hybrid in terms of yield attributing was "PMH-1". Consequently highest Grain yield by 'PMH-3', stover yield by 'PMH-1' and biological yields by 'CMH-08-292' were recorded followed by "CMH-08-292" in terms of grain and stover yield and highest harvest index recorded in PMH-3. Alike this, Grain protein content recorded in HQPM-1 and PMH-3. The highest N content found in grain and stover of HQPM-1, P content highest in grain and stover of PMH-3, and k content highest in grain and stover of PMH-3 and highest N uptake by grain, in 'PMH-3', stover by CMH-08-292, and total uptake was recorded by 'PMH-3'. Similar trend was observed in P uptake. But, highest K in grain, stover and total recorded by 'PMH-3'. Amongst hybrids 'PMH-3' fetched highest gross returns (₹89841 /ha), net returns (70889/ha) and B-C ratio (3.74) and proved best. HQPM-1 proved next best hybrid in terms of gross, net returns and B-C ratio. The SSNM recorded highest plant height at harvest, dry matter accumulation at 50, 75 DAS and at harvest by RDF and SSNM respectively and similar trend in CGR and RGR between 25-50 by RDF and 50-75 by SSNM but SSNM highest in LAI at successive growth stages. Similarly application of SSNM recorded significantly higher value of yield attributing parameters viz. cobs/plant, grain weight/cob consequently grain, stover and biological yield over RDF and 50% RDF. The fertility levels failed to record significant variation in plant population. The results of present investigation indicating positive response of various yield parameters to balanced and higher level of fertilization corroborates findings of several researchers (Singh *et al*., 2009 and Mehta *et al*., 2011). The highest protein content in grain, N, P and K content and uptake in grain and stover were recorded with SSNM application. Application of SSNM 90 kg N + 40 kg P_2O_5 /ha proved economically beneficial as it recorded significantly higher gross returns (89760 /ha), net returns (69270/ha) and B-C ratio (3.39). SSNM appears to be the suitable economic fertility level for maize "PMH-3" hybrid as it recorded higher grain yield (6.10 t/ha), net returns (69270 /ha) and B-C ratio (3.39).

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Evaluation of green manure crops in terms of productivity and economics of basmati rice in rice (*Oryza sativa* L.) -wheat (*Triticum aestivum* L.) cropping system

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Green manuring application in rice improve crop yield by addition of organic matter, minimize P, K fixation and produces humus, which enhances the utilization of fertilizer nutrients by plants. An application of green manures improves soil physical and biological properties and also can assist with pest, disease and weed management thus improve rice yield. Tilak (2004) reported an increase in yield of rice and wheat by the application of green manuring. Incorporation of green manure was found to be beneficial to sustain the productivity and economics of rice-wheat system.

METHODOLOGY

A field experiment was conducted at the research farm of the ICAR- Indian Agricultural Research Institute, New Delhi, India (28^{0}38'N, 77^{0}10'E, 228.6m above mean sea level) during the rainy (June–October) season of 2014 on a sandy clay-loam soil (Typic Ustochrept). The mean annual rainfall of New Delhi is 650 mm and more than 80% generally occurs during the south-west monsoon season (July-September). The soil of the experimental field had 147.3 kg/ha alkaline permanganate oxidizable nitrogen N, 13.7 kg/ha available phosphorus, 283.1 kg/ha 1 N ammonium acetate exchangeable potassium and 0.53% organic carbon. The pH of soil was 8.2 (1:2.5 soil and water ratio; Prasad et al., 2006).

Three green manures and one fallow treatments viz. *Sesbania aculeata, Vigna umbellata, Leucaena leucocephala* (15 tonnes/ha on fresh weight basis) and Fallow in main plots and five zinc fertilization treatments viz. Control (no Zn), 5 kg Zn through chelated Zn-EDTA as soil application, 2.5 kg Zn through chelated Zn-EDTA as soil application + 1 Foliar application at flowering, Foliar application of chelated Zn-EDTA at active tillering + flowering + grain filling and Foliar application of chelated Zn-EDTA at 20, 40, 60 and 80 DAT in sub plots were laid out in a split plot design with three replications.

The experimental field was disk-ploughed twice and levelled. Phosphorus and potassium @ 26.2 kg P/ha as single super phosphate and 33.3 kg K/ha as muriate of potash was broadcast at final puddling and incorporated in soil. Nitrogen was applied in three doses, 1st half at transplanting and rest two as foliar spray, one at tillering and one at flowering at the rate of 130 kg N/ha as urea. Green manures crops were incorporated in soil at the time of final puddling of soil. Rice variety grown was 'Pusa improved Basmati 1', which is a high yielding Basmati variety.

Data on leaf area index (LAI), plant height, effective tillers/hill, panicle length, grains/panicle, grain weight/panicle, 1,000-grain weight and grain and straw yields from different green manuring plots were recorded and measured separately. Data were analyzed using the F-test. Least significant difference (LSD) values at P = 0.05 were used to determine the significance of differences between treatment means.

RESULTS

Growth, yield attributes and yields

Green manures application significantly increased all the growth characters, yield attributes, grain and straw yields. Leaf area index (LAI) recorded after 40 and 60 days after transplanting was significantly increased with application of *Sesbania aculeata,* over other green manures crops. The highest LAI at both the stages was recorded with *Sesbania aculeata* which was significantly superior to *Vigna umbellata, Leucaena leucocephala* (15 tonnes/ha on fresh weight basis) and Fallow treatment. An application of *Sesbania aculeata,* significantly increased plant height, panicle length, effective tillers/hill, filled grains/panicle and grain weight/panicle. However, 1,000-grain weight was not influenced significantly due to application of *Sesbania aculeata* over others green manures crops treatment. The highest values of all the yield attributes were recorded with *Sesbania aculeata* which were significantly superior to *Vigna umbellata, Leucaena leucocephala* (15 tonnes/ha on fresh weight basis) and Fallow.

An application of *Sesbania aculeata,* produced significantly higher grain and straw yield compared to *Vigna umbellata, Leucaena leucocephala* (15 tonnes/ha on fresh weight basis) and Fallow. Similarly biological yields were also significantly influenced due to application of *Sesbania aculeata.*

Economics

The highest net and gross return was recorded with application of *Sesbania aculeata* and was higher over *Vigna umbellata, Leucaena leucocephala* (15 tonnes/ha on fresh weight basis) and Fallow treatment.

CONCLUSION

It is concluded that an application of *Sesbania aculeata* recorded higher productivity and net returns from the transplanted basmati rice over *Vigna umbellata, Leucaena leucocephala* (15 tonnes/ha on fresh weight basis) and Fallow treatment.

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Effect of various levels of nitrogen on different wheat genotype under new alluvial zone

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Wheat is the most important cereal crop sown in winter season in north eastern plain zone (NEPZ) of West Bengal. However its popularity in the famer field is very occasional and in general people of Bengal and Bihar belt avoid its cultivation, because lack of improved cultivar and suitable agronomic practices for higher productivity. Application of fertilizers is one of the critical issue and it varies from region to region as it is governed by the availability of nutrient and soil status condition (Mukherjee, 2010). Among the various agronomic practices quantity of primary nutrient application with respect to different genotype, plays a significant role in maximizing the crop yield and productivity. Rate of fertilizer application mostly nitrogen, along with genotype are the two key factors in determining the yield and grain quality of wheat particularly in alluvial zone. Keeping this in view, the present investigation has been undertaken during the winter season of 2014-15 to evaluate the effect nitrogen levels along with different genotype on growth and productivity of wheat under new alluvial zone of West Bengal.

METHODOLOGY

The field experiment was conducted at District Seed Farm (AB Block), Kalyani under Bidhan Chandra Krishi Viswavidyalaya during winter season of 2014-15 and 2015-16 in upland situation. The farm is situated at approximately 22^{o} 56´ N latitude and 88^{o} 32´ E longitude with an average altitude of 9.75 m above mean sea level (MSL). The soil of the experimental field was loamy in texture and almost neutral in reaction having pH 7.2, organic carbon 0.43%, available nitrogen (N) 238 kg, available phosphorus 23.2 and available potassium 234 kg/ha. The experiment was carried out in a split plot design with four levels of nitrogen (*viz.* 100, 125, 150 and 175 kg/ha) in main plot, and six wheat genotypes (DBW 39, HD 2733, K 0307, HD 2643, PBW 343 and HUW 234) in subplot, and experiment was replicated thrice. The length of each plot was 8 m (nine rows of wheat). The sowing of crop was done on last week of November, during both the years, using recommended seed rate of 100 kg/ha. The crop was subjected to recommended package of agronomic and plant protection practices to obtain a healty crop. Levels of phosphorus and potassium was fixed for this experiment (60 kg P_2O_5 and 40 kg K_2O/ha). Nitrogen levels apply as per the treatments. The experimental data were analyzed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test the significance of overall difference among treatments by the F test and conclusions were drawn at 5 % probability level. Benefit: cost ratio (B: C) was obtained by dividing the gross income with cost of cultivation. The effect of treatments was evaluated on pooled analysis basis on yield attributes and yields.

RESULTS

With various levels of nitrogen more growth and yield attributing characters was registered with all levels except extreme lowest rate i.e 100 kg N/ha. Effective tiller and grain/ear were more observed with the nitrogen level of 125 and 150 kg/ha, and significantly better to rest of the main plot treatment except @ 175 kg nitrogen/ha for grain/ ear.Performance of various cultivars with different levels of nitrogen, showed different pattern with respect to various ancillary data. Maximum effective tiller/m^2 registered with DBW 39, and was at par with K0307, and significantly better to other treatments. Number of grains/ear head was highest observed with DBW 39, and was at par with the HD 2733. The grain and biomass yield differences were statistically noteworthy due to different fertilizer application. Application of nitrogen @ 175 kg/ha registered utmost wheat grain yield (3.50 t/ha), and was at par with the 125 (2.99 t/ha) and 150 kg N/ha (3.43 t/ha). Higher dose of N incorporation gave significantly more grain and biomass yield than lower levels. The grain yield of wheat was decreased about 44 to 73% with lower level of fertilizer incorporation in field compared to optimum doses (i.e. 150 kg N/ha). However, excess level of nitrogen i.e. 175 kg/ha, leads to lodging problem in few genotype and reduce yield drastically particularly in HD 2643 and HUW 234. The grain yield differences due to different genotypes were statistically significant. The variety DBW 39 (3.34 t/ha) out yielded all other varieties except HD 2733 (3.11 t/ha) and K0307 (2.90 t/ha). These three cultivars were statistically superior to rest of the genotypes under alluvial plain zone of West Bengal situation. Variation in yield of wheat varieties due to heterogeneity in genetical constitution has also been reported by Rawat *et al.* (2000). Highest B: C ratio was obtained with nitrogen application @ 125 kg/ha along with cultivars DBW 39.

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Combined effect of vermicompost and NPK fertilizers on apparent recovery of nutrient in wheat (*Triticum aestivum* L.)

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In India wheat is the second most important food crop next to rice and it contributes nearly 35% to the national food basket. Among winter crops, it contributes about 49% of the food grains. India is the second largest wheat producer 86.53 million tonnes next only to China 121.72 million tonnes and covers the largest area under wheat cultivation (29.65 m ha), which is about 13.77 % of the world wheat area 217 million hectare. Enhancement of wheat production from limited land area is great challenge for Indian agriculturist. Apart from developing high yielding wheat varieties, integrated nutrient management will be required to boost wheat production. Indian soil are generally deficient in nutrient particularly nitrogen. Nitrogen fertilization always results in an increase in above ground dry matter and root biomass production which results into higher productivity as well as higher residue left in soil after the harvest of the crop which helps in improving the fertility of soil. Plant nutrient plays an important role in growth, development and productivity of crop. Wheat crop is highly responsive to applied nutrient through various sources, a proper fertility management is an important parameter for optimizing the productivity while, generally grown in intensive cropping system with higher use of inorganic especially nitrogenous fertilizers. This condition is adversely affected and therefore it is needed to supply the nutrient to the crop in combination with organic sources. The nutrient use efficiency value becomes high with combination vermicompost. Keeping this in view, an attempt was made to Effect of nutrient management option on crop yield and nutrient uptake by wheat (*Triticum aestivum* L.) in western Uttar Pradesh.

METHODOLOGY

The field experiment was conducted during the *rabi* season of 2013-14 and 2014-15 at CRC,Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, (29^0 13' N, 77^0 68' 43 E, 237 m above mean sea level) Meerut, India. Combined Application of Vermicompost and NPK Fertilizers on Wheat Production in western Uttar Pradesh. Soil of experimental field was sandy loam with pH of 7.2, Electric Conductivity (EC) 0.61.5dS/m, low in organic C (0.41%), available N (247.65 kg /ha), medium in available P (18.9 kg /ha) and K (197.7 kg /ha). The experiment was carried out in the same field during both the years. Wheat crop (PBW 550) was sown with the row spacing of 22.5 cm as per treatments. Five irrigations were applied at four critical phenological stages. In regards to fertilizer application of the crop, 150 kg N, 75 kg P_2O_5 and 60 kg K_2O were applied. Out of which, 1/2 N and full dose of P_2O_5 and K_2O were applied as basal dose at the time of sowing by broadcasting method. The remaining 1/2 dose of N were applied in two splits at CRI and late tillering stages, 2% urea spray was done at tillering, jointing stage and both stage organic manure was applied through vermicompost 2% urea spray was used from 100% NPK and 75% NPK treatment. The experiment was laid out in 3 replicates in a RBD (Randomized Block design).Studies were conducted with eleven treatments viz.,Control,100% NPK,100% NPK (2% Urea spray at tillering stage),100% NPK (2% Urea spray at jointing stage),100% NPK (2% Urea spray at tillering and jointing stage),100% NPK (2% Urea spray at the time of herbicide

Table 1. Effect of nutrient management practices on apparent recovery of N P K

Treatment	Apparent recovery (%)					
	N		P		K	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	-	-	-	-	-	-
100% NPK	32.75	32.02	25.59	21.00	63.52	62.47
100% NPK (2% Urea spray at tillering stage)	38.61	38.22	26.44	25.02	74.44	73.64
100% NPK (2% Urea spray at jointing stage)	30.72	30.02	24.76	22.64	58.79	56.75
100% NPK (2% Urea spray at tillering and jointing stage)	44.64	43.26	35.05	30.23	84.18	81.37
100% NPK (2% Urea spray at the time of herbicide application)	27.49	27.08	22.15	20.46	49.18	47.07
75% NPK + Vermicompost 2 t/ha	27.12	26.71	19.21	16.75	35.77	34.52
75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering stage)	38.41	37.66	20.01	17.32	59.61	58.11
75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage)	24.18	23.30	16.99	16.02	33.13	32.50
75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage)	42.73	41.53	22.65	21.88	68.07	67.09
75% NPK + Vermicompost 2 t/ha (2% Urea spray at the time of herbicide application)	29.90	29.12	19.93	18.40	47.88	46.85
CD (P=0.05)	3.38	4.51	2.22	2.05	5.76	6.31

application),75% NPK + Vermicompost 2 t/ha,75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering stage) ,75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage),75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage),75% NPK + Vermicompost 2 t/ha (2% Urea spray at the time of herbicide application).

RESULTS

Apparent N recovery was found to be affected significantly by different treatments. It indicates that significantly highest apparent recovery of nitrogen 44.64 and 43.26 % recorded with the 100% NPK (2% Urea spray at tillering and jointing stage) was statistically at par with 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) and significantly higher than the remaining treatments. Lowest apparent recovery of nitrogen 24.18 and 23.30% recorded with 75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage) during 2013-14 and 2014-15, respectively. Apparent recovery of phosphorus was found to vary significantly among different nutrient treatments and indicates that highest apparent recovery33.08 and 30.23% was recorded with the 100% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage)which was significantly higher than the rest of the treatments during both the years. Lowest apparent recovery of phosphorus 16.99 and 16.02% was recorded in 75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage) during 2013-14 and 2014-15 respectively. Apparent recovery of potassium was found to vary significantly among different nutrient management treatments and the highest apparent recovery efficiency of potassium 84.18 and 81.37% recorded with the 100 % NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) which was significantly higher than the rest of the treatments during both the years. However, the lowest potassium apparent recovery 33.13 and 32.50% recorded in 75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage) during 2013-14 and 2014-15 respectively.N, P and K use efficiency is directly correlated with yield. Increased yield ultimately resulted in higher fertilizer recovery. N, P and K use efficiency is directly correlated with yield. Increased yield ultimately resulted in higher fertilizer recovery. Similar results were also reported by Laxminarayana and Patiram, (2006) and Ganajax *et al.,* (2016).

CONCLUSION

Our study showed that about 60, 40 and 30% fertilized N was lost under the current NPK fertilizations, which could have potential risks to increase nitrate leaching and/or ammonia volatilization. The addition of Vermicompost and chemical N fertilization played an important role in improving both yield and NUE of wheat. For developing effective nutrient management, these finding might be helped in Western Uttar Pradesh and other place of same climate.

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On-farm response of rice-wheat cropping system to fertilizers inputs in Kumaon Himalayas

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Among the various agro-techniques, fertilizer is the single most important input in modern agriculture to raise the crop productivity. To get maximum returns, fertilizers must be applied in well balanced ratio, leading to their efficient utilization. Though information on nutrient management on individual crops is abundantly available, but the system based information is meager. Moreover, single nutrient approach has been replaced by multi nutrient so as to boost up crop productivity and nutrient use efficiency. Besides, nutrient management in cropping system is more efficient and judicious than individual crop, as succeeding crops take care of the residual effect of nutrients. The present experiment was therefore, undertaken to study the response of rice-wheat cropping system to NPK and sulphur fertilizers input in terms of yield, production efficiency as well as net monetary returns. Keeping in view the above mentioned facts, studies on response of nutrients (NPK& S) to rice-wheat cropping sequence was undertaken under on-farm conditions.

METHODOLOGY

The field experiment was conducted during *kharif* and *rabi* seasons of 2011-12 and 2012-13 on farmers' fields in six villages spread in two blocks (Bhimtal and Kotabagh) of district Nainital situated in NARP zone "Hills of Uttarakhand". In each village, four farmers' fields were selected for conducting the experiment. The experiment consisted of seven treatments *viz*; control, recommended dose of nitrogen (N), recommended dose of N and phosphorus (P), recommended dose of N and K, recommended dose of NPK, recommended dose of NPK + sulphur @ 20 kg/ha and farmers practice applied to rice (*kharif*) and wheat (*rabi*) in sequence. The experiment was conducted in randomized block design with 24 treatment combinations. The net plot size was 50 m^2 for each treatment. The recommended dose of N: P_2O_5:K_20 considered for rice and wheat was 150:60:40 kg/ha, while sulphur was applied at 20 kg/ha for both the crops. In farmers' practice 114:46:0 and 112:42:0 kg N: P_2O_5:K_2O/ha were applied to rice and wheat, respectively. Both the years' data were pooled and analyzed as per standard procedure.

RESULTS

Highest pooled grain yield of rice and wheat was recorded in the plots applied with the recommended doses of nitrogen, phosphorus and potassium along with sulphur @ 20 kg/ha (7205 and 5140 kg/ha, in rice and wheat, respectively). The increased grain yields by application of recommended doses of nutrients might be due to favorable influence on soil fertility. The highest net returns (Rs. 150147/ha), benefit: cost ratio (1.71), system productivity (12616 kg/ha) in terms of rice grain equivalent yield (SEY) and production efficiency (45.4 kg/ha/day) were obtained with the application of

Table 1. Yield, economics and production efficiency of rice-wheat cropping system

Treatment	Rice grain yield (kg/ha)	Wheat grain yield (kg/ha)	System economic yield (kg/ha)	Net returns from thesystem (Rs./ha)	B:C ratio of thesystem	Production efficiency (kg/ha/day)
Control	3607	2567	6310	37427	0.51	22.7
N	4942	3647	8785	77138	0.98	31.6
NP	6347	4422	11005	110972	1.36	39.6
NK	5864	4114	10198	99615	1.22	36.7
NPK	7013	5010	12288	150147	1.71	44.2
NPK+S	7205	5140	12616	129666	1.46	45.4
FP*	5517	3973	9703	96940	1.59	34.9
SEm±	88	50	117	9303	0.11	-
CD (P=0.05)	244	139	327	26014	0.31	-

recommended NP&K fertilization along with sulphur (20 kg/ha) to both the crops (rice and wheat) on pooled basis. This was mainly due to significant increase in grain yield of component crops in the system.

CONCLUSION

Thus, it may be concluded that application of state recommended fertilization to rice and wheat crops in sequence may be recommended for achieving higher net returns and benefit: cost ratio, while use of sulphur @ 20 kg/ha may be advocated to achieve higher system productivity and production efficiency and for better residual soil fertility in rice-wheat system.

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Baby corn, fodder and proximate yield of baby corn as influenced by crop geometry and nitrogen doses

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Baby corn refers to the whole, entirely edible cobs of immature corn, harvested just before fertilization at silk emergence stage. It is a dual purpose crop which provides green cobs for human consumption and fodder for livestock. At present, the country faces a net deficit of 63% of green fodder and 23% of dry crop residues and 64% feeds and it is expected to increase in near future (ICAR, 2010). Under this situation, baby corn can be a good option as a dual purpose food cum fodder crop. Among the different agronomic practices, optimum crop geometry and ideal nitrogen management are most important for maximising yield and quality of baby corn. So, an experiment was conducted to study the effect of crop geometry nitrogen levels on yield and quality of baby corn and its fodder.

METHODOLOGY

A field experiment was conducted at NDRI, Karnal, India(29^0 432 N latitude and 76^0 58' E longitudes) in split plot design with six treatments of planting geometry (40 cm x 15 cm, 40 cm x 20 cm, 50 cm x 15 cm, 50 cm x 20 cm, 60 cm x 15 cm and 60 cm x 20 cm) in main plots and four levels of nitrogen (0, 60, 120 and 180 kg/ha) in sub plots with four replications. Half dose of N along with 60 kg P_2O_5 and 40 kg K_2O was applied at the time of sowing. The remaining dose of N was applied equally in two splits at 30 and 45 DAS. Five pickings of baby corn (variety "HM-4") were taken at an interval of 3-4 days. Crude protein and ether extract content of baby corn and its fodder were estimated with standard procedures of AOAC, 2005. Statistical analysis was done using the two way analysis of variance with the help of statistical software IRRISTAT (IRRI, 1999) and differences among treatments were assessed with the Least Significant Difference (LSD) at 0.05 significance level.

RESULTS

Baby corn and Fodder yield:The planting geometry of 50 cm x 15 cm recorded significantly higher baby corn yield as compared to all other planting geometries. Regarding fodder yield, 50 cm x 15 cm crop geometry showed significantly higher green fodder as compared to 50 cm x 20 cm, 60 cm x 15 cm and 60 cm x 20 cm. The baby corn and fodder yield increased by 74 % and 18 % respectively when crop geometry was changed from 60 cm x 20 cm to 50 cm x 15 cm. Successive increase in the level of nitrogen application from 0 to 120 kg N /haresulted in significant increase in baby corn yield. However, 180 kg N /haremained at par in baby corn yield with 120 kg N /ha. Application of 180 kg N /ha recorded significantly higher green fodder yield than all other nitrogen levels (Table 1). Protein and ether extract:The protein and ether extract (fat) yield of baby corn as well as fodder were higher in 50 cm x 15 cm. Although the protein content as well as ether extract content (%) was significantly higher in wider crop geometry of 60 cm x 20 cm (data not shown); the dry matter yield was higher in closer geometries resulting in higher protein and fat yield. Successive increase in the level of nitrogen application from 0 to 180 kg N /ha resulted in a significant increase in crude protein of baby corn and its fodder; however the ether extract yield of baby corn increased only up to 120 kg N /ha (Table 1).

Table 1. Baby corn, fodder yield and crude protein and ether extract yield as influenced by different crop geometry and nitrogen levels

Treatment	Yield (t/ha)		Yield (kg/ha)			
			Baby corn		Fodder	
	Baby corn	Fodder	Crude Protein	Ether Extract	Crude Protein	Ether Extract
Planting geometry						
40 cm x 15 cm	1.45	22.1	9.2	4.00	501.8	70.52
40 cm x 20 cm	1.63	22.7	11.2	4.65	564.1	78.22
50 cm x 15 cm	1.88	23.7	13.5	5.70	576.7	81.00
50 cm x 20 cm	1.22	21.2	9.0	3.66	529.6	70.68
60 cm x 15 cm	1.34	20.7	9.2	3.82	514.8	71.45
60 cm x 20 cm	1.08	20.1	8.1	3.30	522.5	71.52
CD (p= 0.05)	0.15	1.6	0.7	0.25	38.4	4.6
Nitrogen (kg/ha)						
0	0.9	14.3	5.7	2.35	305.1	36.85
60	1.39	21.3	9.7	4.17	515.7	69.89
120	1.67	24.9	12.5	5.22	652.0	94.01
180	1.77	26.4	13.1	5.40	717.5	105.62
CD (p= 0.05)	0.13	0.6	0.6	0.20	36.7	4.2

CONCLUSION

Thus it was concluded that planting of baby corn at 50 cm x 15 cm resulted in higher growth and yield of baby corn. Most of the growth attributes as well as cob and baby corn yield increased with increase in the level of N application up to 120 kg N/ha. However, green fodder and proximate yieldsignificantly improved up to 180 kg N/ha.

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Economics and quality of soybean as influenced by integrated nutrient management and *in-situ* moisture conservation practices

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A sustainable increase in production can be obtained by using fertilizers. More scientific efforts are needed to increase the productivity of soybean per unit area and per unit time with optimum fertilizer dose. Therefore it is necessary to study the behavior of soybean under various fertilizer levels (Garud, 2013). Application of organic manures alone sustain the fertility of soil but are unable to fulfill increasing demand of growing population, whereas application of mineral fertilizers alone help to get higher yields but they cannot sustain the fertility of soil on a long term basis. Also the fertilizer use efficiency is low in all mineral fertilizer and organic manures when used separately or alone. So to overcome all these constraints organic and inorganic fertilizer level combination is used in the experimental treatment with the other treatments. Its success depends on how best rainwater is conserved and utilized. In shallow alfisol crop growing period is seriously affected due to scanty and erratic distribution of rainfall. Proper mechanical and vegetative structure can help to conserve the rainwater *in situ* and provide the essential moisture for crop growth. In this view, an attempt was made to study the degree of different beneficial effect of integrated nutrient management and *in situ* moisture conservation practices on Economics and quality of soybean.

METHODOLOGY

A field experiment was conducted during *kharif,* season of 2013 at Department of Agronomy, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The soil of experimental plot was clayey in texture and slightly alkaline in reaction. The soil of the experimental plot was low in available nitrogen (207.31 kg/ha), medium in available phosphorus (14.55 kg/ha), very high in available potassium (451.60 kg/ha) and low in organic carbon content (0.48 %).A field experiment was laid out in split plot design which consisted of nine treatment combinations comprising of three treatments of integrated nutrient management practices with three treatments of *in situ* moisture conservation practices replicated three times. The three integrated nutrient management consisted of rhizobium + FYM @ 5t/ha (N_1), recommended dose of fertilizer (N_2) and rhizobium + recommended dose of fertilizer + FYM @ 5t/ha (N_3) as main plot treatments with three *in situ* moisture conservation practices i.e. flat bed (M_1), opening of furrow in each row (M_2) and opening of furrow in fourth row (M_3) as sub plot treatments were included in the investigation. Soybean variety MAUS-71 was sown by hand dibbling method at the spacing of 45 cm x 05 cm. Rhizobium seed treatment was done @ 250 g per 10 kg seed before sowing and the soybean crop was fertilized at the time of sowing with recommended dose of fertilizer (RDF) applied @ 30:60:30 NPK kg/ha by using fertilizers diammonium phosphate (DAP), urea and muriate of potash (MOP). A well decomposed farm yard manure is used as per the requirement of treatment at the rate of 5 tonnes/ha.

RESULTS

Application of rhizobium + RDF + FYM @ 5t/ha (N_3) recorded significantly highest gross and net monetary returns than recommended dose of fertilizer (N_2) and rhizobium + FYM @ 5t/ha (N_1) (Table 1). This might be due to the high cost of FYM as well as its high quantity needed per hectare application. But the application of FYM improves the soil physical condition and also maintains the fertility of soil. Besides that the combine application of organic and inorganic fertilizers increased the seed yield ultimately turn to higher net monetary returns. However, application of RDF alone gave the highest B:C ratio. Among the integrated nutrient management practices used, rhizobium + RDF + FYM @ 5t/ha (N_3) recorded numerically the highest oil content (20.54 %). Effect of moisture conservation practices on economics of soybean: *In situ* moisture conservation practices had profound effect on gross and net monetary returns. Opening of furrow in each row (M_2) recorded significantly higher gross and net monetary than opening of furrow in fourth row (M_3) and flat bed (M_1). This might be due to the conservation of moisture in treatments opening of furrow in each row and opening of furrow in fourth row over flat bed sowing of soybean which resulted in higher seed yield and thus ultimately gave higher gross and net monetary returns. Opening of furrow in each row also produced highest B:C ratio. The influence of various treatments on the oil content was not turn out to be significant. However, opening of furrow in each row (M_2) recorded numerically higher oil content (20.83 %) than rest of the treatments. The interaction effect between integrated nutrient management and *in situ* moisture conservation practices did not influenced the various yield attributes, seed yield, straw yield, biological yield, gross monetary returns and net monetary returns of soybean.

CONCLUSION

The application of rhizobium + recommended dose of fertilizer + FYM @ 5t/ha significantly highest seed yield, straw yield, biological yield, gross monetary returns and net monetary returns over nutrient treatment of recommended

Table 1. Economics of soybean as influenced by various treatments

Treatment	Gross monetary returns (Rs/ha)	Net monetary returns (Rs/ha)	B:C ratio	Oil content (%)
Integrated nutrient management				
N_1 : Rhizobium + FYM @ 5t/ha	52483	29687	2.28	19.96
N_2 : Recommended dose of fertilizer	56470	36503	2.82	20.15
N_3 : Rhizobium + RDF + FYM @ 5t/ha	69624	44527	2.77	20.54
Seem$\pm$	508.63	508	-	0.26
CD (P=0.05)	1565	1565	-	NS
Moisture conservation techniques				
M_1 : Flat bed	53523	31669	2.42	20.47
M_2 : Opening of furrow in each row	67821	44467	2.92	20.83
M_3 : Opening of furrow in fourth row	57233	34580	2.52	20.32
SEm $\pm$	434.77	434	-	0.30
CD (P=0.05)	1338	1338	-	NS
Interaction (N x M)				
SEm $\pm$	753	753	-	0.52
CD (P=0.05)	NS	NS	-	NS

dose of fertilizer alone and rhizobium + FYM @ 5t/ha alone. Opening of furrow in each row is the most suitable and adaptive measure in soybean which produced seed yield, straw yield, biological yield, gross monetary returns and net monetary returns over opening of furrow in fourth row and flat bed.

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Phosphorus management in transplanted pigeon pea through VAM fungi

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Pigeonpea is commonly known in India as redgram or arhar or tur. It is a tropical crop predominantly grown in India, during the *kharif* season both as a sole crop and as an intercrop, and found in wide range of Agro-Ecological situations. In Northern Karnataka, where the rainfall is not only scanty but also erratic, soil moisture becomes the most limiting factor in production of pigeonpea. In order to ensure timely sowing due to late onset of monsoon, transplanting of pigeonpea seedlings is one of the agronomic measures to overcome delayed sowing. Inadequate and imbalanced nutrient application is another of the important factors, which is limiting the yield. As pigeonpea is a legume crop, can meet its nitrogen demand through biological nitrogen fixation. Although total P pool is high, only a part is available to plants. So, the release and mobilization of insoluble and fixed forms of P is an important aspect of increasing soil P availability. However, the supply of phosphorus becomes crucial for yield maximization. Phosphorus use efficiency can be improved by use of soil micro organisms like Vesicular – Arbuscular Mycorrhiza (VAM). Mycorrhiza is symbiotic fungus which operates in the root system of higher plants. Keeping all these aspects in view, the present investigation was planned with objectives of enhancing transplanted pigeonpea yield through phosphorus management and VA Mycorrhiza.

METHODOLOGY

A field experiment was conducted at ARS, Bheemarayanagudi during *kharif* season of 2010-11, 2011-12 and 2012-13, to evaluate the performance of transplanted pigeonpea, (Cv.TS-3R) as influenced by Mycorrhizal application at different phosphorus levels. The 14 treatments were laid out in RCBD with three replications. The treatments consists of planting methods (transplanting and dibbling) and phosphatic different grades (0, 12.5, 25, 37.5 and 50 kg P_2O_5/ha) along with VAM and without VAM. Take 1kg of VAM mixed with 100 kg of Vermicompost.Apply 15 g mixed material (VAM+VC) to each poly bag while sowing the seeds to raise seedlings. Seedlings were raised in the polythene bags in the nursery for a period of 25 days and then transplanting those seedlings to the main field, immediately after soil wetting rains. The recommended fertilizer is applied to the pigeonpea 25:50 kg N P_2O_5/ha in the form of Urea and Single super phosphate.

RESULTS

Highest pigeonpea yield was obtained with application of 50 kg P_2O_5/hawith inoculation of Vesicular-Arbuscular Mycorrhizal (VAM) fungi and adopting transplanting method of planting technique over other levels of fertilizer and planting methods. However, it was on par with application of 37.5 kg P_2O_5/ha with transplanting technique of pigeonpea over 3 years of pooled data (Table 1). With organic acids, VAM fungi can solubilize low-soluble and insoluble P sources which are a part of the crystalline structure of minerals in the soil (Anonymous, (2005). Significantly higher yield components obtained in transplanting were attributed to better root development, more uptake of nutrients and soil moisture which was coupled with greater light interception because of good canopy growth. These favourable conditions for growth caused significantly higher values of yield components as compared to dibbling (Singh*et al.,* 2006). Pigeonpea yield is governed by several factors, which have a direct or indirect impact. The factors which have much influence on seed yield are yield components like number of pods per plants and 100-seed weight. Significantly higher number of pods per plant and 100 seed weight (11.30 g) at harvest was recorded with application of 50 kg P_2O_5/ha+VAM fungi along with transplanting method(210)over other treatments and it was on par with application of 37.5 kg P_2O_5/ ha+ VAM fungi along with transplanting method(Table 1).The performance of any cultivar basically depends on growth

Table 1. Growth and yield parameters of pigeonpea as influenced by transplanting under graded P levels and mycorrhizal inoculation (pooled over 3 years).

Treatment	Plant height (cm)	No. of branches/plant	No of pods /plant	100-grain weight (g)	Seed yield (kg/ha)
Transplanted with 0 kg P_2O_5 /ha	132.1	14.97	169.6	9.13	997
Transplanted with 0 kg P_2O_5 /ha	132.1	14.97	169.6	9.13	997
Transplanted with 12.5 kg P_2O_5 /ha	137.6	15.17	177.8	9.57	1071
Transplanted with 25 kg P_2O_5 /ha	138.9	15.60	179.7	9.67	1132
Transplanted with 37.5 kg P_2O_5/ha	147.1	16.43	192.1	10.34	1231
Transplanted with 50 kg P2O5 /ha	150.7	16.87	197.5	10.63	1375
Transplanted with 0 kg P_2O_5 /ha + VAM	140.0	15.77	181.3	9.77	1079
Transplanted with 12.5 kg P_2O_5 /ha +VAM	142.2	15.93	184.8	9.94	1151
Transplanted with 25 kg P_2O_5 /ha + VAM	150.0	16.70	196.5	10.55	1258
Transplanted with 37.50 kg P_2O_5 /ha + VAM	156.9	17.37	207.0	11.14	1478
Transplanted with 50 kg P_2O_5/ha + VAM	158.9	17.57	210.0	11.30	1510
Dibbling 0 kg P_2O_5/ha	109.7	12.77	135.6	7.30	785
Dibbling 0 kg P_2O_5 /ha + VAM	114.7	13.20	142.2	7.66	850
Dibbling 50 kg P_2O_5 /ha	115.8	13.03	144.8	7.79	928
Dibbling 50 kg P_2O_5 /ha + VAM	119.0	13.70	150.7	8.12	1008
SEM ±	5.89	0.55	8.34	0.47	47
CD(P=0.05)	17.11	1.59	24.23	1.37	134

VAM: Vesicular-Arbuscular Mycorrhizal (VAM) fungi.

parameters in turn is dependent on total photosynthetic area and rate of photosynthesis. The above results are in conformity with the findings of Sarkar *et al*. (1995).From this results,application of 37.5 kg P_2O_5/ha+ mycorrhizal inoculation along with transplanting technique was found to be beneficial for pigeonpea because of higher seed yield and net returns and which will save phosphorus to the tune of 12.5 kg/ha.

CONCLUSION

Application of 50 kg P_2O_5/ha + VAM fungi along with transplanting technique produced significantly higher pigeonpea seed yield than the lower dosage of P_2O_5 along with both transplanting as well as dibbling method.

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Response of compact cotton genotypes to graded levels of fertilizer under varied planting density

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Field experiments were conducted under rainfed conditions at Main Agricultural Research Station, UAS, Dharwad for consecutive years during 2012-13 and 2013-14. Experiment consisted of three genotypes (RAH-274, SC-2028-22 and SC-7-58) as main-plot, four spacing (45x10 cm, 45x15 cm, 60x10 cm and 60x15 cm) as sub-plots and three fertilizer levels (80:40:40, 120:60:60 and 160:80:80 kg N:P_2O_5:K_2O/ha) under sub-sub-plots. Experiment was laid out in split-split plot design. Cotton genotype, RAH-274 recorded significantly higher seed cotton yield (2017 kg/ha) which was 7.5 per cent and 16.4 per cent higher over SC-2028-22 (1866 kg/ha) and SC-7-58 (1685 kg/ha), respectively. Spacing of 45x15 cm produced significantly higher seed cotton yield (2028 kg/ha) compared to 60x10 cm (1902 kg/ha), 45x10cm (1833 kg/ha) and 60x15 cm (1663 kg/ha). Application of 160:80:80 kg N:P_2O_5:K_2O/ha produced significantly higher seed cotton yield (2063 kg/ha) compared to 120:60:60 kg N:P_2O_5:K_2O/ha (1871 kg/ha) and 80:40:40 kg N:P_2O_5:K_2O/ha (1635 kg/ha). The fibre quality parameters were influenced by genotypes and values were within specified range. Interaction of RAH-274 at spacing of 45x15 cm with higher level of fertilizer (160:80:80 kg N:P_2O_5:K_2O/ha) recorded significantly higher seed cotton yield (2430 kg/ha), gross returns (₹ .109233/ha), net returns (₹ .75704/ha) and B C ratio (3.26) over other interactions.

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Standardization of potassium management practices for paddy in command areas of Karnataka

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Although Green Revolution had tremendous impact on nitrogen fertilizer use in Asia, it had much less impact on the use of phosphorous and potassium fertilizers (Ranjha *et al.,* 2001). Rice is one such crop which consumes considerable amount of potassium due to lack of distinct recommendations and methods we are left with lower potassium use efficiency. In order to standardize the potassium fertilization methods a field experiment was conducted and salient findings are discussed in this paper.

METHODOLOGY

A field experiment was conducted for two consecutive seasons of 2014 and 2015 at Agriculture and Horticulture Research Station, Honnavile, University of Agricultural and Horticultural Sciences, Navile, Shivamogga. The experiment consists of different levels, time and varied concentration of foliar applications and was planned by adopting split – split plot design with three replications. All the crop management practices are adopted as per the recommendations of the University, observations and statistical analysis was carried out by adopting standard methodology suggested.

RESULTS

Data presented in the Table 1 indicated that, significantly higher grain (5.87 t/ha) and stover (6.32 t/ha) yields of paddy was obtained with application of potassium at 100 kg/ha. Significant improvement of grain yields of paddy in the said treatment was traced back to the significant improvement in yield attributing traits such as number of productive tillersper plant (20), panicle weight (16.10 g), panicle length (10.35 cm), number of grains per panicle (51.39) and test weight (20.20). Among the different time of application, 50 per cent of recommended potassium applied at basal coupled with remaining 50 per cent as top dressing recorded significantly higher grain and stover yields of paddy. It could be due to continuous availability of the potassium in the soil nutrient pool during major part of crop growth might have favored the crop growth and was also reflected through higher values of yield attributing characters of paddy (Table 1). Among the various foliar feeding treatments tried in the study, grain yields of paddy improved as the concentration of potassium increases up to 2 per cent K_2SO_4. Present findings are in the line of Ranjha *et al.* (2001). Excellence grain yields of paddy with foliar feeding of potassium with 2 per cent K_2SO_4 at 75 DAT was traced back to the superiority of yield attributing characteristics such as number of productive tillers per plant (19.95), panicle weight (16.10 g), panicle length (19.65 cm), number of grains per panicle (51.50) and test weight (10.95 g). It could be due to direct supply of higher amount of readily available potassium to the metabolic site might have favored the crop during flowering to grain filling stage. These finding are in agreement with the findings of Ebrahimi *et al.* (2012).

Table 1. Yield attributes and yield of paddy as influenced by different potassium management treatments

Treatment	Productive tillers (No.)	Panicle weight (g)	Panicle Length (cm)	Grains perpanicle (No.)	Test Weight (g)	Grain Yield (t/ha)	Stover Yield (t/ha)
Levels of K (M)							
M1	19.00	15.40	10.05	49.46	19.40	5.65	6.11
M2	19.50	15.75	10.15	50.51	19.75	5.75	6.23
M3	20.00	16.10	10.35	51.39	20.20	5.87	6.32
SEm±	0.13	0.17	0.09	0.44	0.25	0.02	0.02
CD (P=0.05)	0.48	0.68	0.35	1.72	0.96	0.07	0.09
Time of application (S)							
S1	17.90	14.50	17.90	46.98	9.90	5.35	5.84
S2	21.30	17.05	20.75	54.41	11.75	6.21	6.62
S3	19.30	15.65	19.10	49.97	10.50	5.71	6.20
SEm±	0.15	0.18	0.23	0.37	0.11	0.03	0.03
CD (P=0.05)	0.46	0.59	0.74	1.21	0.35	0.09	1.10
Foliar spray (F)							
F1	18.80	15.20	18.70	48.80	10.40	5.57	6.02
F2	19.70	15.85	19.45	51.01	10.80	5.76	6.28
F3	19.95	16.10	19.65	51.50	10.95	5.90	6.36
SEm±	0.12	0.14	0.20	0.32	0.09	0.02	0.03
CD (P=0.05)	0.35	0.39	0.57	0.90	0.25	0.06	0.07

M_1-50 kg/ha; M_2- 75 kg/ha; M_3-100 kg/ha;S_1-100% basal;S_2- 50% basal S3-25% basal; F_1-Foliar application of 0 % K_2SO_4 at 75 DAT;F_2-Foliar application of 1 % K_2SO_4 at 75 DAT; F_3-Foliar application of 2% K_2SO_4 at 75 DAT

CONCLUSION

Paddy crop fertilized with 100 kg/ha of potassium coupled with 50 % as basal and one foliar of 2% K_2SO_4 at 75 DAT found significantly superior by recording higher grain yield of paddy in command area of Southern Transitional Zone of Karnataka.

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Nutrient management in *Bt* cotton based cropping system

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Cotton "White Gold" is an important raw material for the Indian textile industry and important cash crop of the country. India ranks first in area and second in production with an average productivity of 496 kg/ha. Optimum plant density for Bt cotton was studied for black cotton soils of Marathwada and 18,518 plants / ha were found an optimum plant density for the region (Khargkharate *et al*., 2008).

METHODOLOGY

The experiment was conducted on black cotton soil having low organic matter, low in available nitrogen, medium in available phosphorus and high in available potassium. FRBD design with three replications. Three intercropping treatments, two plant geometries and four nutrient levels.

RESULTS

The cropping system, cotton + green gram and cotton + soybean were found significant over sole cotton. Seed cotton equivalent yield (SCEY), The yield of seed cotton was significantly higher in sole cotton treatment while in case of geometry it was significantly higher in 120 cm x 45 cm. In nutrient treatments N4 was found superior over rest of treatments excluding N3 treatment. Similar trend was observed in yield attributing characters also i.e. boll weight and number of bolls per plant. The differences in monetary returns as influenced by different intercropping treatments were significant. Cotton + Green gram gave highest / hectare followed by Cotton + Soybean. Lowest monetary returns were received from Sole Cotton. Plant geometry 120 cm X 45

Table 1. Seed cotton yield (SCY in Kg/ha), seed cotton equivalent yield (SCEY in Kg/ha) and gross monetary return, net monetary returns, boll weight and no. of bolls/plant during the year 2011-12.

	SCY (kg/ha)	SCEY (kg/ha)	GMR (Rs./ha)	NMR (Rs./ha)	Boll wt. (g)	No. of bolls /plant
Plant density (Plants/ha)						
I_1 – Cotton + Green gram	1444	1949	77970	44928	3.04	42.64
I_2– Cotton + Soybean	1330	1801	72049	39563	3.06	40.02
I_3– Sole cotton	1601	1601	64045	30476	3.29	52.65
CD (P=0.05)	101.82	100.14	4005	3677	0.20	2.57
Geometry (Plants/ha)						
G_1 – 90 x 60 cm	1431	1727	69080	36191	3.09	44.40
G_2– 120 x 45 cm	1485	1840	73629	40454	3.16	45.82
CD (P=0.05)	83.13	81.76	3270	3003	N.S.	2.10
Nutrient treatment						
$N_{1=}$ 100 % RDF (N and K in 4 splits) + Foliar DAP 1.5 % + K 0.5 %	1309	1606	64256	32706	2.86	38.70
N_2 =N1 + Mg So4 (20 kg /ha soil application as basal) + Foliar spraying of DAP 1.5%, K 0.5 %, Mg SO4 (0.5 %) + Boron as solubor (0.15 %)	1398	1722	68910	35467	2.97	41.68
$N_{3=}$125 % recommended NPK (N and K in 4 equal Splits) + Foliar DAP 1.5 % + K 0.5 % and	1524	1849	73990	41529	3.30	48.66
$N_{4=}$- N3 + Foliar spraying of DAP 1.5 %, K 0.5 %, Mg SO4 (0.5 %) + Boron as solubor (0.15 %)	1602	1956	78264	43587	3.38	51.38
CD (P=0.05)	117.57	115.64	4625	4246	0.28	2.97

cm recorded significantly highest monetary returns compared to 90 cm X 60 cm. Nutrient application of 125 % RDF + $MgSO_4$ soil application + foliar spray of DAP, K and Boron recorded highest monetary returns was at par with 125 % RDF. Interactions intercrop x geometry, intercrop x nutrient levels were found significant. However crop geometry x nutrient levels and intercrop x geometry x nutrient interactions were found non-significant.

CONCLUSION

Cotton equivalent yield and GMR have been appreciably enhanced by Cotton + Green gram intercropping treatment. Geometry 120 cm x 45 cm performed significantly superior over 90 cm x 60 cm for SCEY and monetary returns. Nutrient treatment 125 % RDF with foliar application of nutrients recorded significantly superior for yield and economics over 100 % RDF along with foliar and 100 % RDF with micronutrient.

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Effect of different crop establishment methods and nitrogen levels on yield and production economics of wheat (*triticum aestivum* L.)

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Wheat (*Triticum aestivum* L.) is the most extensively grown food crop in the world, whereas second in India after rice. In India, wheat is grown in 30.97 M ha with production of 86.53 Mt and productivity of 2.79 t/ha (Anonymous, 2016). Inefficient utilization of available resources by plants, particularly solar radiation, under a wider row spacing and severe inter-row competition among plants in narrow rows have compelled researchers to optimize row spacing for attaining better production of different crops. Cultural practices like method of sowing, crop density and geometry have pronounced effect on crop-weed interference. Row spacing in wheat is an important agronomic practice to maximize the yield and quality of wheat crop. Sowing of wheat under FIRBS (furrow irrigated raised bed system) with 2 and 3 rows per bed was found to produce more yield compared to flat sowing (Kumar *et al*., 2010). Moreover, the cost of cultivation was lower and net benefit cost ratio was higher in bed planting as compared to conventional method of wheat plantation. Among essential plant nutrients, nitrogen is the one of most important nutrient for cereal crops and its availability is limited in soils. Its application in large quantities is very essential, particularly in high yielding varieties of wheat, for optimum growth and higher yields. The use of optimum dose of fertilizer and their suitable method of application are essential for improving the productivity level and finally the net income.

METHODOLOGY

A field experiment was carried out during *Rabi* season of 2013-14 at CCS Haryana Agricultural University, Hisar, Haryana to study the performance of wheat under different crop establishment methods and nitrogen levels. The treatments consists of five crop establishment methods [T_1- Conventional sowing with drill at 20 cm, T_2- Conventional sowing with drill at 18 cm, T_3- Conventional sowing with drill at 16 cm, T_4- Bed planting (3 rows) and T_5- Bed planting (2 rows)] in main plots and four fertility level [F_1- 100 % Recommended N level (150 kg N/ha), F_2- 112.5 % Recommended N level (168.75 kg N/ha), F_3- 125 % Recommended N level (187.5 kg N/ha) and F_4- Control (No Nitrogen)] in sub plots. The study was made in split plot design with three replications.

RESULTS

The data presented in Table 1 revealed that among different planting techniques, conventional drill sowing at 18 cm row spacing recorded maximum grain yield and straw yield which was statistically at par with the drill sowing at 20 cm row spacing and bed planting with three rows of wheat. These treatments produced significantly higher yields over bed planting with two rows of wheat and drill sowing at 16 cm row spacing (Table 1). With increase in nitrogen from 100 per

Table 1. Effects of crop establishment methods and nitrogen levels on yield and production economics of wheat

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Total cost (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Row spacing					
Drill sowing at 20 cm	4.97	7.59	58384	32401	1.55
Drill sowing at 18 cm	5.09	7.78	58384	34718	1.59
Drill sowing at 16 cm	4.63	7.07	58384	26211	1.45
Bed planting (3 rows)	4.97	7.58	59312	31420	1.53
Bed planting (2 rows)	4.47	6.83	59312	22360	1.38
CD (P=0.05)	0.14	0.22	-	-	-
Fertility level					
100 % RDN (150 kg/ha)	4.81	7.35	59310	28679	1.48
112.5 % RDN (168.7 kg/ha)	5.10	7.79	59528	33669	1.56
125 % RDN (187.5kg/ha)	5.18	7.91	59748	34869	1.58
Control	4.21	6.43	56433	20471	1.36
CD (P=0.05)	0.08	0.12	-	-	-

cent RDN to 112.5 per cent RDN, grain yield and straw yield of wheat increased significantly, however, they increased non-significantly with increasing N level from 112.5 per cent to 125 per cent RDN. The improvement in the grain yield and straw yield due to increasing N levels probably came through favourable influences of increasing N levels on vegetative growth and yield attributing components as accumulation and translocation of photosynthates from source to the sink were more efficiently utilized which in turn increased all the growth and yield attributes too (Table 1). Net returns (34718 Rs/ha) as well as B-C ratio (1.59) were maximum under conventional drill sowing at 18 cm row spacing because grain and straw yields were higher in this method. This was closely followed by 20 cm row spacing and bed planting with three rows which was more economical to 16 cm row spacing in spite of higher cost of production in bed planting. The net returns remained highest with drill sowing at 18 cm and lowest under bed planting system with two rows. This was also true with application of 125 per cent RDN. Benefit-cost ratio also followed the similar trend.

CONCLUSION

The highest grain yield, net returns and B-C ratio were obtained with 18 cm row spacing. With application of 125 per cent RDN, highest grain yield was obtained which was at par with yield under 112.5 per cent RDN. So, drill sowing of wheat at 18 cm will be better when fertilized with 112.5 per cent RDN for getting higher and economical wheat yield.

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Effect of different levels of boron on yield and yield attributes of cauliflower in an acid alfisol of Himachal Pradesh

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Cauliflower, *Brassica oleracea* var. *botrytis* L. (2n=2x=18) belongs to the cole group of vegetables. Today among cole crops, it occupies the pride place in India due to its delicious taste, flavour and nutritive value. Boron (B) being an important micronutrient is indispensable for the normal growth and development of plants as it plays crucial role in curd quality, curd yield, flowering and fertilization, and seed yield of cauliflower. It is unique among the other micronutrients in that the threshold between deficiency and toxicity is narrow (Shuang *et al.,* 2009). Over the years, the intensive agriculture with no addition of boron has caused its decline in the soil. The problem has been further compounded by the use of high-analysis fertilizers lacking boron and discontinuation of application of organic sources of nutrients like farmyard manure (FYM). Recently, B deficiency has been reported to the extent of 33 per cent in Indian soils (Ram *et al*., 2014). Although, boron is needed in relatively small amounts but if present in amounts appreciably greater than needed, it becomes toxic. Therefore, there is need for systematic study on the boron nutrition aiming at increasing the productivity of cauliflower.

METHODOLOGY

A field experiment was conducted at the experimental farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, during *rabi* 2013-14. The field experiment was laid out in a randomized block design with 10 treatments replicated three times with following treatment details: T_1 - 100% NPK + FYM + B_0 (Boron 0 kg/ha); T_2 - 100% NPK + FYM + B_1 (Boron 0.75 kg/ha); T_3 - 100% NPK + FYM + B_2 (Boron 1.5 kg/ha); T_4 - 100% NPK + FYM + B_3 (Boron 2.5 kg/ha); T_5 - 100% NPK + FYM + B_4 (Boron 5.0 kg/ha); T_6 - 100% NPK + FYM + B_5 (Boron 10 kg/ha); T_7 - 100% NPK + FYM + B_6 (Boron 20 kg/ha); T_8 - 100% NPK + FYM + B_7 (Boron 30 kg/ha); T_9 - FYM @ 20 t/ha and T_{10} - Absolute control (No fertilizer). Farmyard manure in T_1 to T_9 was applied at 20 t/ha on fresh weight basis. Boron was applied as per the treatment, whereas N, P_2O_5 and K_2O were applied at the recommended rate of fertilizers (125, 60 and 75 kg/ha) except in T_9 and T_{10}.

RESULTS

Data on effect of different levels of boron on yield and yield attributes of cauliflower has been presented in Table. Data revealed that different treatments exercised a marked and significant effect on curd diameter, curd depth, curd size index and curd yield. Highest value of curd diameter in treatment T_3 (1.5 kg B/ha + 100% NPK + FYM) was statistically at par with T_2 (B @ 0.75 kg/ha + 100% NPK + FYM), T_4 (B @ 2.5 kg/ha + 100% NPK + FYM) and T_5 (B @ 5 kg/ha + 100% NPK + FYM), respectively. Curd depth in cauliflower ranged from 3.8 cm in T_{10} (absolute control) to 5.8 cm in T_3 (B @ 1.5 kg/ha + 100% NPK + FYM). Curd size index showed linear increase with increasing application of boron from 0.75 kg B/ha to 5.0 kg B/ha along with 100% NPK (T_2 to T_5) as compared to

Table 1: Effect of different levels of boron on yield and yield attributes of cauliflower

Treatment	Curd diameter (cm)	Curd depth (cm)	Curd size index (cm^2)	Curd yield (t/ha)
T_1	17.9	5.4	68.2	8.53
T_2	19.4	5.7	71.3	9.84
T_3	20.2	5.8	75.5	11.03
T_4	19.5	5.7	73.1	10.51
T_5	19.2	5.6	69.6	9.45
T_6	17.5	5.2	64.1	7.71
T_7	16.6	5.1	62.1	6.54
T_8	15.7	5.0	59.5	4.82
T_9	10.5	3.9	32.5	3.01
T_{10}	9.5	3.8	31.3	2.50
CD (P=0.05)	2.17	0.43	6.56	0.66

application of 100% NPK without boron (T_1). This may be due to B deficiency in treatment T_1 which might have reduced the levels of other plant nutrients (Carpena-Artes O and Carpena-Ruiz RO 1987) which ultimately resulted in reduced growth. Curd yield of cauliflower varied from minimum of 2.5 t/ha in T_{10} (absolute control) to maximum of 11.03t/ha in T_3 (B @ 1.5 kg/ha + 100% NPK + FYM). Highest yield in this treatment was statistically at par with treatment T_4 (B @ 2.5 kg/ha along with 100% NPK + FYM) and both treatments were significantly superior to rest of the treatments. Dhakal *et al*. (2009) have also reported a similar promotive effect of B application on cauliflower yield. At higher rate of boron application i.e. 10, 20 and 30 kg/ha, due to toxic effect of boron significant reduction in all parameters were observed as compared to lower doses.

CONCLUSION

The study conclusively indicated that the maximum increase in curd diameter, curd depth, curd size index and curd yield was recorded in treatment T_3, where boron was applied @ 1.5 kg/ha along with 100% NPK and FYM.

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Integrated nutrient management in sesame (*Sesamum indicum* L.) intercropped with *kharif* pulses

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The system of intercropping not only improves the yield and returns but also reduces the risk of complete crop failure as compared to the sole cropping system (Rao and Singh, 1990). Slow and erect growing nature during initial growth period of sesame make possible to be intercropped with short duration legume crops like mungbean, cowpea, mothbean, clusterbean *etc.* Intercropping of sesame with *kharif* pulses may prove more productive and numerative under rainfed conditions as sesame utilizes the residual soil moisture and nutrient from deeper soil layers left after harvest of *kharif* pulses which are otherwise wasted. A judicious combination of organic and inorganic fertilizers can maintain long term fertility and sustain higher productivity of crops (Nambiar and Abrol, 1992). Hence, the present study was conducted to determine the compatibility of sesame for intercropping with *kharif* pulses under varying levels of fertilizer and vermicompost.

METHODOLOGY

The study was carried out under loamy sandy soil during *kharif,* 2015 at S.K.N. College of Agriculture, Jobner. The soil of the experimental field was alkaline in reaction, low in organic carbon, available nitrogen and medium in available phosphorus and potassium. The experiment comprising twenty treatment combinations replicated three times, was conducted in Randomized Block Design with five intercropping systems [sole mungbean, sole mothbean, sole sesame, mungbean + sesame (2:1) paired row and mothbean + sesame (2:1) paired row and four treatments of integrated nutrient management (100 % RDF through fertilizer, 75% RDF through fertilizer + 25% RDF through vermicompost, 50% RDF through fertilizer + 50% RDF through vermicompost and 100% RDF through vermicompost) during *Kharif* season 2015 at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan).

RESULTS

Result showed that significantly maximum plant height of mungbean and mothbean was recorded in mungbean + sesame (2:1) PR and mothbean + sesame (2:1)PR intercropping system, whereas sole mungbean and mothbean recorded significantly more dry matter accumulation of mungbean and mothbean at 40 DAS and at harvest. Mothbean + sesame (2:1) PR recorded significantly highest dry matter accumulation of sesame at 60 DAS and at harvest. Whereas, sesame grown in mothbean + sesame (2:1) PR ratio, recorded significantly highest value of yield attributes *viz*., number of capsules per plant and number of seeds per capsule and was at par to mungbean + sesame (2:1) PR ratio. All the sole crops (mungbean, mothbean and sesame) gave significantly higher seed yields (1161, 880 and 720 kg/ha, respectively) as compared to intercropping systems. The mungbean + sesame (2:1) PR ratio, recorded significantly highest mungbean equivalent yield (1316 kg/ha), while mothbean + sesame (2:1) PR ratio being at par with mungbean + sesame (2:1) PR ratio, gave significantly highest LER (1.34) as compared to sole crops. The sole mungbean and mothbean recorded significantly higher N concentration in seed, P and K concentration in seed and straw and protein content in seed. Sesame grown in Mothbean + sesame (2:1) PR ratio, recorded significantly highest concentration of N, P and K in seed and stick, except mungbean + sesame (2:1) PR ratio. All the sole crops recorded significantly higher total uptake of N, P and K. In the whole system mungbean + sesame (2:1) PR ratio gave significantly maximum net returns (¹ 78656/ha).The application of 50% RDF through fertilizer + 50% RDF through vermicompost significantly increased plant height and dry matter accumulation at different growth stages, yield attributes and yield of mungbean, mothbean and sesame and in most of cases was at par with 75% RDF through fertilizer + 25% RDF through vermicompost and significantly superior to rest of treatments. N and K concentration in seed and straw of mungbean and mothbean, P concentration in seed and straw of mungbean and seed of mothbean and protein content in seed of mungbean and mothbean, N and P concentration in seed and stick of sesame and K content in seed of sesame, oil content in seed of sesame and total uptake of N, P and K of all the crops significantly increased due to application of 50% RDF through fertilizer + 50% RDF through vermicompost over rest treatment and was at par to 75% RDF through fertilizer + 25% RDF through vermicompost. Significantly higher mungbean equivalent yield (1018 kg/ha) and net returns (¹ 55803/ha) were recorded with the application of 50% RDF through fertilizer + 50% RDF through vermicompost over remaining treatments and was at par to 75% RDF through fertilizer + 25% RDF through vermicompost.

CONCLUSION

Significantly higher mungbean equivalent yield (1018 kg/ha) and net returns (¹ 55803/ha) were recorded with the application of 50% RDF through fertilizer + 50% RDF through vermicompost over remaining treatments and was at par to 75% RDF through fertilizer + 25% RDF through vermicompost.

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Residual effect of green manuring crops on nutrient management in potato (*Solanum tubersum* L.)

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Fertilization and manuring plays a crucial role in potato production. Combined use of fertilizer with organic with inorganic sources improves the productivity and giving higher returns per unit area per unit time (Chettri *et al.,* 2002). Complete dependence on chemical fertilizers is making the soil infertile and less productive in absence of organic materials. Among the different organic manures, green manuring is the most important (Mishra *et al.,* 2001). Green manure legumes can play an important role in the soil fertility improvement, when incorporated into the soil, improves soil organic matter, moisture retention capacity and soil workability (Kiiya *et al.*2010). Incorporation of green manure in soil is known to increase the bioavailability of phosphate in succeeding crop.

METHODOLOGY

The field experiment was conducted for two consecutive years at Post Graduate Institute Research Farm of Mahatma Phule Krishi Vidyapeeth Rahuri during 2013- 2014 and 2014-2015. Climatologically, this area falls in the semi-arid tropics

Table 1. Grade wise potato yield as influenced by different treatments at harvest

Treatment	Grade wise potato yield (t/ha)								
	Small (< 25 g)			Medium (25-75 g)			Big (>75 g)		
	2013-14	2014-15	pooled	2013-14	2014-15	pooled	2013-14	2014-15	pooled
Green manuring crops									
Sannhemp	5.25	6.25	5.75	9.08	11.01	10.04	14.91	13.98	14.44
Dhaincha	5.57	6.79	6.18	9.37	11.02	10.19	15.40	14.83	15.11
Cowpea	5.10	5.54	5.32	9.00	10.71	9.85	12.97	13.21	13.09
Greengram	5.15	5.83	5.48	8.74	10.42	9.58	13.48	12.23	12.85
CD(P=0.05)	0.15	0.28	0.22	0.33	0.24	0.29	0.94	1.51	1.23
Nutrient management levels									
100% GRDF	5.58	6.45	6.01	9.63	12.00	10.82	16.82	15.05	15.94
100% RDF	5.27	6.10	5.68	9.32	11.42	10.37	14.87	13.87	14.37
75 % of RDF	5.13	5.95	5.54	8.79	9.76	9.27	12.78	13.15	12.97
50% of RDF	5.09	5.92	5.51	8.45	9.99	9.22	11.29	12.68	11.98
CD(P=0.05)	0.20	0.33	0.27	0.16	0.47	0.32	0.83	0.95	0.64

with annual rainfall ranged from 307-619 mm. The experiment was carried out in split-plot design with three replication. The green manuring crops were kept in main plots (*kharif* season) and nutrient management levels kept in sub plots (*rabi* season). The main plot treatments (*kharif* season) comprised of four green manuring crop *viz.*, G_1 : sannhemp, G_2 : dhaincha, G_3 : cowpea, G_4 : greengram while the sub-plot treatments (*rabi season*) consisted of four nutrient management levels *viz.*, F_1 : 100 % GRDF (120:60:120 N, P_2O_5, K_2O kg/ha + 20 t/ha of FYM, F_2 : 100 % RDF (120:60:120 N, P_2O_5, K_2O kg/ha), F_3 : 75 % RDF (90:45:90 N, P_2O_5, K_2O kg/ha), F_4: 50 % RDF (60:30:60 N, P_2O_5, K_2O kg/ha). The potato was planted after incorporation of green manuring crops. The total green biomass of green manuring crops will be recorded with the help of one m^2 quadrate. Chemical Quality parameters of Potato viz. Total Soluble Salts (TSS) and Protein (%) and Sensor quality parameters of chips viz. Taste, Flavor, Texture, crispiness and Overall acceptability are analyzed after of potato using standard methods. For economic evaluation, the cost of cultivation, gross monetary returns (GMR), net monetary returns (NMR) and benefit: cost ratio (B:C) were computed treatment wise.

RESULTS

It is evident from the data (Table 1) during both the years of experimentation as well as when pooled, the grade wise potato yield (t/ha) were significantly higher with residual effect of G_2. i.e dhaincha and treatment F1 i.e 100% GRDF, which was remained at par with residual effect of dhaincha (G2) and treatment F2 i.e 100% RDF. This might be because of beneficial residual effect of *kharif* dhaincha as a green manuring crop by fixing atmospheric nitrogen through biological means and which may be available to mineralization of plant residues thereby increases the growth and yield of succeeding crop.

CONCLUSION

It may be concluded from the finding of this study based on the two years experimentation incorporation of dhaincha at 50% of flowering stage as a green manuring crop in *kharif* season and application of 100% general recommended dose of fertilizers (RDF-120:60:120 N P_2O_5 K_2O kg/ha + 20 tons of farm yard manure/ha) to potato in *rabi* season was found beneficial in terms of grade wise potato tuber yield.

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Integrated use of conventional and foliar fertilizers with effective microbial consortia on nutrient uptake and nutrient status of soil in paddy crop

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Paddy is a predominant staple food crop of the World, being cultivated in more than hundred countries. About 91 %of the World's rice is being grown and consumed in Asia. Area under rice in the World is 161.4 m ha with a production of 730.2 m t and average productivity of 4480 kg /ha (Anon, 2013). Wetland rice cultivation in command area of the zone is a different scenario where farmers could achieve hardly 30-35 %use efficiency of applied chemical fertilizers. Knowing this certain problems farmers are invariably going for higher fertilizer application may be two to three times higher than the recommended dose to compensate the nutrient loss thus leading to high cost of cultivation and least economic profit. Keeping these things in mind, instead of mere soil application of nutrients at one or two stages of the crop it would be better to go for foliar application of completely Water Soluble Fertilizer (WSF) at its definite concentration looking to the need by the crop during its different growth stages. This would certainly improve the use efficiency of applied nutrients and enhance the yield level with least investment. Foliar feeding is relatively a new technique, in many cases aerial spray of nutrients is preferred which gives quicker and better results than the soil application. Considering these

Table 1. Nutrient uptake and soil nutrient status as influenced by integrated use of conventional and foliar fertilizers with effective microbial consortia in paddy crop

Treatment	Nutrient uptake(kg /ha)			Available nutrient status of soil (kg/ha)		
	N	P	K	N	P	K
$T_{1:}$ 100% Recommended NPK (Control).	59.52	25.01	38.35	284.6	32.1	209.2
T_2: 100% RDF + Bioinoculation of Effective Microbial Consortia (EMC)	73.35	28.67	46.35	293.5	34.7	215.2
T3: 100% RDF + Foliar spray of 1 % 19:19:19 at maximum tillering stage	67.85	26.59	43.76	290.2	32.2	214.8
T4: 100% RDF + Foliar spray of 1 % 13:0:45 at grain filling stage	69.46	27.14	44.11	288.8	35.1	210.5
T5: 100% RDF +Foliar sprays of 1% 19:19:19 at maximum tillering stage and 1% 13:0:45 at grain filling stage	80.27	29.88	48.86	288.0	33.6	213.3
T6: 100% RDF +Foliar sprays of 1% 19:19:19 at maximum tillering stage and 1% 13:0:45 at grain filling stage + Bioinoculation of EMC	85.82	30.51	50.58	298.1	36.0	221.5
T7: 75% RDF	55.11	24.80	35.69	286.2	30.4	208.2
T8: 75% RDF + Bioinoculation of EMC	64.83	25.99	41.68	289.5	31.1	209.5
T9: 75% RDF + Foliar spray of 1 % 19:19:19 at maximum tillering stage	60.97	25.37	39.69	286.6	32.8	211.8
T10: 75% RDF + Foliar spray of 1 % 13:0:45 at grain filling stage	62.50	25.64	40.24	283.2	30.6	213.5
T11: 75% RDF + Foliar sprays of 1% 19:19:19 at maximum tillering stage and 1 % 13:0:45 at grain filling stage	71.74	27.57	45.04	279.7	31.3	211.5
T12:75% RDF + Foliar sprays of 1% 19:19:19 at maximum tillering stage and 1 % 13:0:45 at grain filling stage+ Bioinoculation of EMC	76.48	29.08	47.99	286.1	31.2	209.0
SEm±	2.31	0.69	1.57	4.1	2.0	2.5
CD (P=0.05)	6.74	2.02	4.60	12.0	NS	7.2

points in view, an experiment was conducted with an objective, to study the nutrient uptake pattern in plant and nutrient status in soil.

METHODOLOGY

A field experiment was conducted during the *kharif* season of 2014 and 2015 by using rice variety JGL-1798 in Agronomy field unit, University of Agricultural and Horticultural Sciences, Navile, Shivamogga. The soil of the experimental site was sandy loam having pH 5.85, EC 0.09 dS/m, medium in organic carbon (0.61 %), nitrogen (282.24 kg/ha), available phosphorus (21.6 kg/ha) and potassium (209.66 kg/ha). The experiment was laid out in Randomized Complete Block Design with twelve treatments and three replications. The treatments include 100 and 75 % RDF of NPK besides, foliar spry of 1% 19:19:19 at maximum tillering and 13:0:45 at grain filling stage and bioinculation of effective microbial consortia at the time of sowing. Nutrient uptake by the crop was analysed at the time of harvest. Soil nutrient status was analysed before commencement of experiment and after the harvest of the crop.

RESULTS

Effect of integrated use of conventional and foliar fertilizers with effective microbial consortia on Nutrients uptake and nutrient status of soil. In the present investigation, there was increased uptake of nitrogen, phosphorus and potassium at harvest. Significantly higher uptake of nitrogen (85.82 kg/ha), phosphorus (30.51 kg/ha) and potassium (50.58 kg/ha) by paddy crop was recorded in the treatment which received 100% RDF with one %each foliar spray of 19:19:19 and 13:0:45 at maximum tillering and grain filling stages, respectively with bioinoculation of EMC as compared to rest of the treatments (Table 1). Higher uptake of these nutrients was due to higher grain yield and dry matter production. Significantly higher available nitrogen (298.13 kg/ha), phosphorus (35.98 kg/ha) and potassium (221.45 kg/ha) in the soils after harvest of paddy crop was recorded in the treatment which received 100% RDF with one % each foliar spray of 19:19:19 and 13:0:45 at maximum tillering and grain filling stages, respectively with bioinoculation of EMC as compared to rest of the treatments (Table 1) This was due to the application of higher doses of chemical fertilizers along with bioinoculation of EMC resulted in an increase in available nitrogen phosphorus and potassium in the soil. Effective microbial consortia inoculation resulted in greater atmospheric nitrogen fixing, increased the availability of insoluble ‘P’ and fixed K and mineralization of organic nitrogen, phosphorus and potassium.

CONCLUSION

Significantly higher uptake of nitrogen (85.82 kg/ha), phosphorus (30.51 kg/ha) and potassium (50.58 kg/ha) and available nitrogen (298.13 kg/ha), phosphorus (35.98 kg/ha) and potassium (221.45 kg/ha) by paddy crop was recorded in the treatment which received 100% RDF with 1% each foliar spray of 19:19:19 and 13:0:45 at maximum tillering and grain filling stages, respectively with bioinoculation of EM

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Interaction effect of nitrogen and phosphorus on yield attributes and quality of cowpea [*Vigna unguiculata* (L.) Walp] on medium black soil of Gujarat

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Nitrogen plays an important role in various metabolic process of plant. Nitrogen is an essential constituent of protein, chlorophyll and is present in many other compounds helps in plant metabolism, such as nucleotides, phosphatides, alkaloids, enzymes, hormones, vitamins, etc. It imparts dark-green colour of plants, produces rapid early growth, improves capacity to fix atmospheric nitrogen symbiotically and it responds to small quantity of nitrogenous fertilizers applied as starter dose. Application of 15-20 kg N/ha has been found optimum to get better production response in cowpea. Phosphorus is an essential constituent of nucleic acids and stimulates root growth as well as increase nodule activity in plant. Phosphorus is also an essential constituent of nucleic acids such as ribonucleic acid (RNA) and deoxyribonucleic acid (DNA), adenosine diphosphate (ADP) and adenosine triphosphate (ATP), nucleoproteins, amino acids, proteins, phosphotides, phytin, several co-enzymes viz., thiamine, pyrophosphate and pyrodoxyl phosphite.

METHODOLOGY

A field experiment was conducted during 2012 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh in a factorial randomized block design with three replications. The soil was medium black in texture, alkaline in reaction (pH 7.8), medium in organic carbon (0.57 %), low available nitrogen (237.0 kg/ha), medium available phosphorus (32.5 kg P_2O_5/ ha) and medium in potassium (269.0 kg K_2O/ha) content. The experiment consisted four levels of nitrogen (control, 20, 30 and 40 kg/ha) and four levels of phosphorus (control, 40, 60 and 80 kg P_2O_5/ha), thereby, making sixteen treatment combinations. Fertilizers were applied as per treatment through single super phosphate (SSP) and urea at the time of sowing as basal dose. The cowpea cv. ‘GC-5’ was sown on 27 February, 2012 using seed rate of 25 kg/ha with a row spacing of 45 cm. The crop was harvested on 9 May, 2012. The average number of pods and seeds per plants was worked out. After threshing and winnowing the weight of seeds for each net plot area was recorded in kg per plot and then converted to kg/ha.

RESULTS

The results indicated application of nitrogen @ 20 kg/ha showed significantly higher net returns and BCR in cowpea as compared to other treatments. Application of nitrogen @ 20 kg/ha recorded the maximum net returns (¹ 13270/ha) and BCR (2.64) over other treatments. The application of nitrogen @ 40 kg/ha recorded significantly increased seed yield (1022 kg/ha) and straw yield (2141 kg/ha), number of pods per plant, number of seeds per pod, test weight, biological yield, protein content in seed, chlorophyll content and being at par with 20 and 30 kg N/ha (Table 1). The application of phosphorus levels up 80 kg/ha significantly higher the number of pods per plant, number of seeds per pod, test weight, seed yield, straw yield, biological yield, protein content, chlorophyll content and remained at par with 40 and 60 kg P_2O_5/ha over control. Application of 40 kg P_2O_5/ha recorded the maximum net returns (¹ 12519/ha) and benefit cost ratio (2.34) over all other treatments. The combined application of nitrogen and phosphorus @ 20 and 40 significantly increases in term of seed and straw yield and it’s remained at par with application $N_{20}P_{60}$, $N_{20}P_{80}$, $N_{30}P_{40}$, $N_{30}P_{60}$, $N_{30}P_{80}$, $N_{40}P_{40}$, $N_{40}P_{60}$ and $N_{40}P_{80}$ over rest of treatments. Phosphorus enhances the symbiotic nitrogen (N) fixation process in legume crops and ultimately improved the uptake of nutrients.

CONCLUSION

On the basis of one year field experimentation, it seems quite logical to conclude that higher yield net returns and benefit cost ratio in term of combined application of nitrogen and phosphorus @ 20 and 40 kg/ha on medium black soil of Gujarat.

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Foliar fertilization of nutrient in chickpea (*Cicer arietinum* L.) under rainfed condition

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Chickpea is the most important pulse crop of India and grown mostly under rainfed condition. To increase the productivity of chickpea, an effort is needed to develop such a technology that may help the crop plants to with stand under drought conditions. One of the ways for it is to control undesirable vegetative growth so that reproductive growths of crop plants may not be suffer due to shortage of soil moisture. In rainfed condition, the fertilizer use efficiency is generally low because of soil moisture scarcity. Foliar application of nutrient is one of the ways to increase the fertilizer use efficiency. Foliar fertilization of rainfed chickpea grow with 2% urea solution has given encouraging results in some of the studies. It was, therefore, considered necessary to try these nutrients as foliar application in rainfed chickpea with objective to find out the appropriate dose of foliar nutrient.

METHODOLOGY

A field experiment was conducted at Agriculture Farm of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalay, Chitrakoot (25^0 10Ê N latitude and $80^0$52Ê E longitude and about 200 meter above mean sea level) Satna (M.P.) during *rabi* season of 2013-14. The rainfall received during the crop season (October to March 2014) was 370.25 mm with total rainfall of 1153.5 mm. The soil was sandy loam with slightly alkaline (p^H 7.7), low in organic carbon (0.30%), available nitrogen (152.0 kg/ha) and available phosphorus (10.5 kg/ha) and medium in available potassium (186.3 kg/ha). The treatments comprised 1 fertility levels of NPK [100% - 20 kg N+40 kg P_2O_5+20 kg K_2O/ha)] and with foliar spray of urea (2%), KNO_3 (0.5 and 1%) and Ca (NO_3) (0.5 and 1%) at 30 DAS & 30 and 45 DAS) along with one absolute control (water spray). In all, 12 treatment were tried in Randomized Block design with 3 replication. The chickpea cv. Pusa 1103 @ 100 kg/ha was sown on 12th October, 2013 at 30 cm row spacing harvested on 28th March, 2014. Water was used for spraying @ 800 l/ha in control and treatments. Seed was treated with PSB culture @40 g/kg seed. One hand weeding with khurpi was also done at 30 DAS. Economic analysis were worked out on the basis of the prevailing market price.

RESULTS

Total biomass as well as grain yield were produced highest of 5.56 and 2.06 t/ha, respectively under the application of $Ca(NO_3)_2$ @ 1.0% spray at 30 DAS which were found at par with T12, T10, T9, T8 and T7 treatments, but significantly

Table 1. Effect of foliar fertilization on yield and economics of chickpea.

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Net income (₹/ha)	B:C Ratio
T1 Water Spray	1.21	2.60	31.80	24467	2.26
T2 RDF	1.68	3.13	34.87	37445	2.67
T3 RDF+ Urea 2% 30DAS	1.71	3.26	34.41	38658	2.71
T4 RDF+ Urea 2% 30&45DAS	1.72	3.34	34.03	39099	2.73
T5 RDF+ KNO_3 0.5% 30DAS	1.72	3.08	35.85	38301	2.67
T6 RDF+ KNO_3 0.5% 30&45DAS	1.80	3.18	36.13	40493	2.74
T7 RDF+ KNO_3 1% 30DAS	1.91	3.40	35.98	44645	2.91
T8 RDF+ KNO_3 1% 30&45DAS	1.95	3.36	36.70	45031	2.87
T9 RDF+ $Ca(NO_3)$ 0.5% 30DAS	1.99	3.49	36.33	47678	3.08
T10 RDF+ $Ca(NO_3)$ 0.5% 30DAS	2.05	3.39	37.67	48845	3.07
T11 RDF+ $Ca(NO_3)$ 0.5% 30DAS	2.07	3.50	37.13	49569	3.11
T12 RDF+ $Ca(NO_3)$ 0.5% 30DAS	2.05	3.34	38.04	47817	2.96
C.D.(P=0.05)	0.24	0.40	1.85	2315	0.27

higher than other treatments. Though straw yield was also recorded highest under T11 treatment but it was significantly higher only over T5 and T1 treatments. These yields might be attributed to higher growth and yield attributes which also behaved almost similar under different treatments. Besides, grain yield may also be supported by harvest index values. It is thus proved that foliar spray of Ca $(NO_3)_2$ @ 0.5 or 1.0% solution at 30 DAS has yielded higher chickpea followed by 1.0% spray of KNO_3. These results corroborate with the findings of Kundu and Sarkar (2009). Gross income and net returns were obtained maximum of Rs. 73108 and 49569/ha, respectively under treatment T11 of Ca $(NO_3)_2$ @ 1.0% spray at 30 DAS (Table 2). It was found at par with T10, T12 and T9 treatments but significantly superior than all other treatments. Such higher gross income and net returns might be attributed to higher grain and straw yields under respective treatments. As the differences in gross income of various treatments were wider than in cost of cultivation. Net returns followed the same pattern of gross income. Benefit: Cost ratio was also maximized (3.11) under treatment T11 which being at par with T9, T10, T12, T7 and T8 and found significantly higher than all remaining treatments. It might be attributed to gross income values under different treatments. These results are in agreement with the findings of Kundu and Sarkar (2009) in rice crop.

CONCLUSION

It can be concluded that over and above soil application of recommended N,P,K fertilizers in rainfed chickpea, foliar application of $Ca(NO_3)_2$ 1% at 30 DAS was most productive and profitable. It was followed by foliar application of KNO_3 1 % spray at 30 DAS. However, urea 2% spray at 30 and 45 DAS could not prove its superiority over RDF alone.

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Effective nutrient management in pigeonpea and groundnut intercropping system

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Pulses provide the vital protein and vitamins in an average Indian diet. They form a major and cheapest source of dietary protein especially for vegetarians which form a major part of our population. In India, there is an increasing demand especially for pulses and oil seeds besides cereals to cope up with the increasing human population and to overcome malnutrition in the large section of society. Pigeonpea [*Cajanus cajan* (L). Millsp.] is the second most important pulse crop of India after chickpea, it is a late maturing, tall growing, wide spaced crop with a deep root system which makes it suitable for intercropping system. The availability of land for agriculture is shrinking every day as it is increasingly utilized for non-agricultural purposes. Under this situation, one of the important strategies to increase agricultural output is the development of new high intensity cropping systems including intercropping systems. The noted trend necessitates the generation of agricultural technologies that will allow for the optimal use of the limited arable land for increasing crop production while at the same time rejuvenating and maintaining soil fertility. One of such technologies is intercropping pigeonpea with groundnut. Nutrient management in cropping systems is an important aspect for sustainable production system in long run. Foliar application of specific nutrients is a method used to improve the efficiency of fertilizer use and increase yields. A thorough understanding of these factors and their interactions is critical in maximizing profitability of any intercropping system. Objective of the present study was to study the advantage of effective nutrient management in terms of their yield and economics.

METHODOLOGY

The field experiment was carried out at College of Agriculture, Raichur, during kharif of 2015, to study the nutrient management in pigeonpea and groundnut intercropping system. The treatments consisted of T1 - Sole pigeonpea with 100% RDF ; T2 - Sole groundnut with 100% RDF; T3 - 100% RDF to pigeonpea and no fertilizer to groundnut; T4 - 125% RDF to pigeonpea and no fertilizer to groundnut; T5 - 100% RDF to pigeonpea and 50% RDF to groundnut; T6 - 100% RDF to pigeonpea and 100% RDF to groundnut; T7 - 100 % RDF to pigeonpea and no fertilizer to

Table 1. Pigeonpea equivalent yield, Cost of cultivation, gross returns, net returns and benefit cost ratio as influenced by nutrient management practices in pigeonpea and groundnut (1:2) intercropping system

Treatment	PEY (kg/ha)	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	Benefit cost ratio
T_1: Sole pigeonpea with 100% RDF	1618	26025	111140	85115	4.27
T_2: Sole groundnut with 100% RDF	1232	33574	84603	51029	2.52
T_3: 100% RDF to pigeonpea and no fertilizer to groundnut	1942	30280	133371	103091	4.18
T_4: 125% RDF to pigeonpea and no fertilizer to groundnut	2271	31900	155988	124088	4.89
T_5: 100% RDF to pigeonpea and 50% RDF to groundnut	2189	32100	150335	118235	4.68
T_6: 100% RDF to pigeonpea and 100% RDF to groundnut	2326	32780	159749	126969	4.87
T_7:100 % RDF to pigeonpea and no fertilizer to groundnut + Foliar application of 19:19:19 @ 1 % at flowering and pod formation stage of respective crops	2152	31069	147815	116746	4.76
T_8: 125 % RDF to pigeonpea and no fertilizer to groundnut + Foliar application of 19:19:19 @ 1 % at flowering and pod formation stage of respective crops	2463	32445	169156	136711	5.21
T_9:100 % RDF to pigeonpea and 50 % RDF to groundnut + Foliar application of 13:0:45 @ 1 % at flowering and pod formation stage of respective crops	2455	34095	168609	134514	4.95
T_{10}:100 % RDF to pigeonpea and 100 % RDF to groundnut + Foliar application of 13:0:45 @ 1% at flowering and pod formation stage of respective crops	2588	34775	177747	142972	5.11
SEm.±	29	—	—	1923	0.09
CD (P=0.05)	87	—	—	5772	0.27

Price of pigeonpea seeds=68690/- per tonne;Price of groundnut pods=38880/- per tonne

groundnut + Foliar application of 19:19:19 @ 1 % at flowering and pod formation stage of respective crops; T8 - 125 % RDF to pigeonpea and no fertilizer to groundnut + Foliar application of 19:19:19 @ 1 % at flowering and pod formation stage of respective crops; T9 - 100 % RDF to pigeonpea and 50 % RDF to groundnut + Foliar application of 13:0:45 @ 1 % at flowering and pod formation stage of respective crops; T10- 100 % RDF to pigeonpea and 100 % RDF to groundnut + Foliar application of 13:0:45 @ 1% at flowering and pod formation stage of respective crops. Observations were recorded on yield and later converted to pigeonpea equivalent yield and economics was also worked out.

RESULTS

Experimental results from the study revealed that among intercropped treatments, the significantly higher pigeonpea equivalent yield was obtained under T_{10} (2588 kg/ha) over other treatments, but it was on par with T_9. The sole crop of pigeonpea with 100 per cent RDF (T_1) recorded significantly lower net returns (Rs. 85115/ha) followed by T_2 (Rs. 51,029/ ha). Among the intercropped treatments, 100 % RDF to pigeonpea and 100 % RDF to groundnut + Foliar application of 13:0:45 @ 1% at flowering and pod formation stage of respective crops (T_{10}) provided significantly higher net returns (Rs. 1, 42, 972 /ha) over other treatments. Further in intercropped treatments, the on par net returns was recorded in T_8 (Rs. 1, 36, 71 /ha) and T_9 (Rs. 1, 34, 514/ha). Among all the treatments, T_8 recorded significantly higher B: C of 5.21 and was on par with T_{10} (5.11) and T_9 (4.95). This was due to the relatively wider gap between costs of cultivation incurred and gross returns accrued, compared to other treatments. Similar results of higher B: C was reported in pigeonpea and ashwagandha intercropping system and, pigeonpea and sunflower intercropping system. The significantly higher pigeonpea equivalent yield was obtained in the intercropped treatment which received 100 % RDF to pigeonpea and 100 % RDF to groundnut along with foliar application of 13:0:45 @ 1% at flowering and pod formation stage of respective crops. Further, significantly higher net returns and benefit cost ratio was obtained in the intercropped treatment where both the crops were applied with 100 per cent RDF along with foliar application of 13:0:45 @ 1% at flowering and pod formation stage of respective crops as compared to sole crops.

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Effect of sowing time and nutrient management on yield and economics of summer sesame

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Sesame (*Sesamum indicum* L.) is known as "Queen of oilseed crops" and mainly cultivated in Gujarat on 73,608 hectares with production of 27,511 tonnes. Today, India has achieved self-sufficiency in cereal food production but still vegetable oil needs to reach at the stage of self-sufficiency. Nutrient management with appropriate sowing time seems to be a viable substitute method to obtain higher yields and economic advantages in sesame (Reddy *et al.*, 2014). However, meager information is available for middle Gujarat conditions; hence the present investigation was undertaken.

METHODOLOGY

A field experiment was carried out during summer season of 2014 at Anand Agricultural University, Anand (Gujarat) to test the effect of sowing time and nutrient management on yield and economics of sesame. The experiment was laid out in a split plot design with four replications consisting of 15 treatments, namely, main plots: 3 sowing time (10th February, 20th February and 01st March) and sub plots: five nutrient management levels (50 % RDF + 5 t FYM/ha, 50 % RDF + 5 t/FYM ha + Bio-fertilizer, 75 % RDF + 5 t FYM/ha, 75 % RDF + 5 t/FYM ha + Bio-fertilizer and 100 % RDF). FYM was incorporated in the soil before sowing of sesame crop as per the treatments. The seeds were inoculated with liquid bio-fertilizers (*Azospirillum* + Phosphorus solubilising bacteria) @ 20 ml per kg seed at the time of sowing as per treatments. The sources of fertilizers used in the experiment were urea @ 50 kg/ha and di ammonium phosphate (DAP) @ 25 kg/ha. Data on yield performance and economics were recorded.

RESULTS

Seed yield (1101 kg/ha) and stalk yield (2454 kg/ha) were found significantly higher under the sowing date D_2 (20th February) and the magnitude of increase in the seed and stalk yields of sesame under sowing date D_2 (20th February) was 43.36 % and 30.81 %, respectively over sowing on D_1 (10th February). Similarly, the treatment N_4 (75 % RDF + 5 t FYM/ha + bio-fertilizer) also produced significantly higher seed yield

Table 1. Effect of sowing time and nutrient management levels on yield and economics of sesame

Treatment	Seed yield (kg/ha)	Grain yield (kg/ha)	Gross realization (Rs./ha)	Total cost of production (Rs./ha)	Net realization (Rs./ha)	B:C ratio
Sowing dates (D)						
D_1: 10th February	768	1876	37052	15875	21177	1.33
20th February	768	2454	53093	15875	37218	2.34
01st March	1084	2337	52266	15875	-	2.29
S. Em. ±	26	57	-	-	-	-
CD (P=0.05)	90	196	-	-	-	-
Nutrient management (N)						
N_1: 50 % RDF + 5 FYM t/ha	858	2023	41386	20066	21320	1.06
N_2: 50 % RDF + 5 FYM t/ha + Bio-fertilizer	952	2158	45912	20083	25829	1.29
N_3: 75 % RDF + 5 FYM t/ha	973	2266	46931	20600	26331	1.28
N_4: 75 % RDF + 5 FYM t/ha + bio-fertilizer	1186	2440	57172	20617	36555	1.77
N_5: 100 % RDF	32	2225	46015	18484	27731	1.52
SEm ±	32	61	-	-	-	-
CD (P=0.05)	92	176	-	-	-	-

(1186 kg/ha) and stalk yield (2440 kg/ha), but was found at par with treatment N_3 (75 % RDF + 5 t FYM/ha) for stalk yield. The treatment combination D_2N_4 (sowing on 20th February + 75 % RDF + 5 t FYM/ha + Bio-fertilizer) also noted maximum net realization (Rs. 47490/ha) closely followed by treatment combination D_3N_4 (Rs. 43187/ha). However, the highest BC ratio of 2.35 was obtained under treatment combination D_2N_5 (sowing on 20th February + 100% RDF). It was concluded that sowing on 20th February with 75% RDF (37.5: 18.75: 0 kg NPK/ha) + 5 t FYM/ha + Bio-fertilizer (*Azospirillum* and PSB) was most effective for improving grain yield and profitability of sesame.

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Evaluation of American cotton genotypes under high density planting system in relation to planting geometry and nitrogen levels in south western region of Punjab

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India has a largest area of 118 lakh ha under cotton with the highest production of 268 lakh bales. However, India's average cotton lint productivity is 494 kg/ha which is lower as compared to countries like Australia, China, Brazil (Anonymous, 2016). High density planting system (HDPS) in cotton is one of option for obtaining higher yield. HDPS of cotton is the manipulation of plant density and plant geometry for getting higher productivity per unit area. Under HDPS, plant densities' ranging from 5-10 plants/m^2 has been tested commonly (Kerby *et al*, 1990). There is a need to evaluate the performance of different cotton genotypes in varying planting geometry and nutrient levels under HDPS. Compact genotypes of cotton coupled with balanced fertilizer, plant growth regulators and cotton picking machine might be adopted for HDPS in our country. Thus, an experiment was planned to evaluate cotton genotypes for optimum plant geometry and nitrogen requirement under high density planting system.

METHODOLOGY

A field study was conducted during *kharif* 2015 at Punjab Agricultural University, Regional Research Station, Bathinda. The soil of the experimental site was Loamy sand in texture, electrical conductivity of 0.15 m mhos, slightly alkaline with pH 8.1, low in available organic carbon (0.19 %), medium in available phosphorus (18.3 kg/ha) and high in available potassium (339.5 kg/ha). The experiment was laid out in a split plot design consisting three American cotton genotypes (F2381, CSH3075 & F2383) in main plot; three spacing levels (67.5 cm × 10 cm, 67.5 cm × 15 cm & 80 cm × 10 cm) in sub plot and three nitrogen levels (100%, 125% and 150 % of recommended) in the sub sub plots and were replicated thrice. The recommended dose of nitrogen (RDN) for cotton in Punjab is 75 kg N per hectare. Nitrogen was applied through Urea in two equal split applications after first irrigation and at the time of initiation of flowering. Experiment was sown on May 15, 2015. Five representative plants were selected in each treatment for recording the data of yield parameters on plant basis and seed cotton yield of whole plot was recorded from all the pickings done from the treatment plots and converted to kg/ha. The data was subjected to ANOVA to evaluate the differences between treatments and significance of interaction effects; means were compared using LSD test (p = 0.05).

RESULTS

Among the three genotypes (Table 1) under HDPS, plant stand per plot was significantly higher in F2381 and CSH3075 as compared to F2383. Boll weight did not varied significantly among the genotypes but was recorded higher in F2381 followed by CSH3075 and F2383. However, number of bolls/m^2 varied significantly among all the genotypes with highest boll weight in F2381 followed by CSH3075 and F2383. All these led to significant differences in seed cotton yield under HDPS. F 2381 recorded significantly higher seed cotton yield (1379 kg/ha) followed by CSH3075 (1292 kg/ha) and F2383 (1096 kg/ha). Among planting geometries (Table 1), significantly higher number of bolls/m^2 and plant stand was recorded in a spacing of 67.5 cm × 10 cm; while, boll weight and seed cotton yield was significantly lower. Significantly lesser number of bolls/m^2 and plant stand was recorded in a spacing of 67.5 cm × 15 cm with a second highest boll weight

Table 1. Yield and yield attributes of cotton genotypes under different planting geometries and nitrogen levels in HDPS

Treatment	Plant stand /plot	Bolls/m^2	Boll weight (g)	Seed cotton yield (Kg/ha)
Variety				
F2381	259	113.5	2.71	1379
CSH 3075	262	102.0	2.64	1291
F2383	243	90.8	2.44	1096
LSD (P=0.05)	11.7	9.4	NS	71
Spacing				
67.5 ×10 cm	301	110.7	2.33	1104
67.5 ×15 cm	202	92.1	2.52	1280
80 ×10 cm	262	103.6	2.94	1383
LSD (P=0.05)	5.6	7.2	0.19	60
N level				
100 % RD	249	91.0	2.55	1120
125 % RD	253	105.1	2.58	1294
150 % RD	263	110.2	2.67	1352
LSD (P=0.05)	8.1	8.7	NS	98

Table 2. Interaction between cotton genotypes and plating geometry for seed cotton yield (kg/ha)

Treatment	S_1-67.5 cm ×10 cm	S_2-67.5 cm ×15 cm	S_3-80 cm ×10 cm	Mean
F2381	1133	1291	1713	1379
CSH 3075	1152	1424	1297	1291
F2383	1027	1124	1138	1096
Mean	1104	1280	1383	
LSD (P=0.05)	104			

and seed cotton yield. While, planting geometry of 80 cm × 10 cm recorded the second highest number of bolls/m^2 as well as plant stand with significantly heavier bolls which resulted in a significantly higher seed cotton yield as compared to that of 67.5 cm × 10 cm and 67.5 cm × 15 cm . In case of nitrogen levels (Table 1), boll weight did not differ significantly. Plant stand was significantly highest in 150% RDN while, 100% and 125% RDN were at par with each other. 150% RDN resulted in highest number of bolls/m^2 and seed cotton yield (1352 kg/ha) though at par with 125 % (SCY 1294 kg/ha) while statistically least bolls/m^2 and seed cotton yield was recorded with 100% level of nitrogen (SCY 1120 kg/ha). Interaction among the varieties and spacing was found significant (Table 2). F2381 recorded highest seed cotton yield (1713 kg/ha) at a spacing level of 80 x 10 cm. However, CSH3075 recorded highest seed cotton yield (1424 kg/ha) at a spacing level of 67.5 cm x 15 cm.

CONCLUSION

Thus, from the above study, it is concluded that planting of F 2381 under 80 cm × 10 cm coupled with 125 % of recommended dose of nitrogen could give better yield under HDPS.

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Effect of manure and fertilizers on pearlmillet-mustard cropping system

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Pearlmillet-mustard cropping system has a great potential in arid and semiarid areas of India, comprising mainly Rajasthan, Haryana and parts of Gujarat and Madhya Pradesh. Pearlmillet-mustard cropping system is back bone of agrarian community of Rajasthan in particular. Pearlmillet – mustard cropping system is reputed to cover an area of 9.37 lakh ha and contributes about 3.5 % of national food basket (Yadav,1996). Due to prolonged cultivation of crops without inadequate and imbalanced fertilizers on hungry soils of the region, the productivity and fertility of the soil has been going downwards. Judicious combination of manures and chemical fertilizers not only maximize the crop production and improve the quality of agricultural produces but would also help in maintaining the soil fertility (Parihar *et al*.,2010) and also to sustain the system productivity (Singh and Yadav,1992). Keeping these points in consideration a field investigation was carried out to workout suitable nutrient management practices for higher sustainable productivity and fertility.

METHODOLOGY

Field experiment was carried out in three consecutive years during 2007-08 to 2009-10 at the research farm of the Agriculture Research Station, Fatehpur Shekhawati (Sikar), SKRAU-Bikaner. The soil was loamy sand, alkaline (pH 8.2) in reaction, very low in organic carbon(0.22%), low in available N (173.2 kg/ha) and P (13.9 kg/ha) and medium in K (313 kg/ ha) with DTPA –extractable Zn (0.46 ppm) and Fe (4.5 ppm). The treatment comprised of two levels of FYM (0 and 5 t/ha) with six levels of chemical fertilizers, *viz*. T_1-Recommended dose (RD) of N and P (60:30),T_2-T_1+30 kg K_2O, T_3-T_2+100 kg gypsum, T_4-T_3+10kg $ZnSO_4$,T_5-T_4+10 kg $FeSO_4$ and T6-control (without any chemical fertilizer). Twelve treatment combinations of the system were evaluated at a fixed site under factorial randomized block design with three replication. FYM and recommended dose of N and P (60:30 kg/ha) were applied to pearl millet and all the six levels of chemical fertilizers were applied to mustard crop. FYM (0.45% N, 0.21%P, 0.32% K), zinc (as $ZnSO_4.7H_2O$; 21%Zn), iron (as $FeSO_4.5H_2O$;25% Fe) and gypsum ($CaSO_4.2H_2O$;12.5% S) as per treatments were applied 20 days before sowing and incorporated through land preparation in the soil; and the whole quantity of recommended dose of P and K and half dose of N fertilizers were drilled with sowing and rest half nitrogen was applied through broadcasting in standing crop.

Table 1. Effect of manure and fertilizers on yield and harvest index of pearlmillet – mustard cropping system

Treatment	Pearlmillet			Mustard		
	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
Organic manure						
M_0-Control(without FYM)	1284	3350	33.57	1118	2794	28.41
M_1-FYM 5t/ha	1993	3866	33.98	1311	3072	29.75
SEm±	31.74	58.66	0.27	17.75	40.30	0.21
CD(P=0.05)	93.21	171.89	NS	52	118	0.62
Chemical fertilizer						
F_1-RD of N&P	1778	3458	33.94	1125	2796	28.67
F_2-F1+30kg K_2O	1847	3610	33.83	1194	2920	28.98
F_3-F2+100 kg gypsum	1911	3707	34.00	1285	3031	29.75
F_4-F3+10 kg $ZnSO_4$	2009	3863	34.21	1386	3169	30.38
F_5-F4+10 kg $FeSO_4$	2083	3934	34.62	1430	3223	30.70
F_6-Absolute control	1454	3076	32.02	867	2461	26.00
SEm±	54.66	101.76	0.47	30.72	70.3	0.37
CD(P=0.05)	160.14	298.16	1.38	90	206	1.08

Table 2. Effect of nutrient management practices on cost of cultivation and monetary returns (x10^3Rs./ha) from pearlmillet-mustard cropping system

Treatment	Pearlmillet			Mustard			System
	Cost of cultivation	Net returns	B:C ratio	Cost of cultivation	Net returns	B:C ratio	net returns
Organic manure							
M_0-control (without FYM)	9.56	9.09	0.95	13.27	21.11	1.59	30.20
M_1-FYM 5t/ha	12.42	13.19	1.06	13.27	26.98	2.03	40.17
SEm±		0.41	0.02		0.79	0.03	0.97
CD(P=0.05)		1.20	0.05		2.32	0.09	2.84
Chemical fertilizer							
F_1-RD of N&P	10.99	11.88	1.08	12.82	21.77	1.70	33.65
F_2-F1+30kg K_2O	10.99	12.81	1.17	13.40	23.30	1.74	36.11
F_3-F2+100kg gypsum	10.99	13.57	1.23	13.64	25.82	1.89	39.39
F_4-F3+10 kg $ZnSO_4$	10.99	14.74	1.34	13.89	28.64	2.06	43.38
F_5-F4+10 kg $FeSO_4$	10.99	15.51	1.41	14.26	29.61	2.08	45.12
F_6-absolute control	10.99	8.37	0.76	11.63	15.12	1.30	23.49
SEm±		0.72	0.03		1.40	0.05	1.72
CD(P=0.05)		2.12	0.09		4.10	0.16	5.03

Urea, DAP and murate of potash were used as sources of nutrients. The crops were raised with standard agronomic practices except for treatments. All the growth and yield parameters were recorded at physiological maturity (125 DAS) and the crop was manually harvested, threshed and grain yields were recorded. Net return and benefit: cost (B:C) ratio were computed using the prevailing market rates and prices for the inputs and seeds of pearlmillet and mustard. The data recorded were analyzed as per analysis of variance technique for factorial randomized plot design and presented as mean data of 3 years.

RESULTS

The result indicated that application of 5t/ha farm yard manure (FYM) to pearlmillet and recommended dose (RD) of N&P along with 30 kg potash+100 kg gypsum+10kg zinc sulphate and 10 kg ferrous sulphate to mustard recorded significantly higher growth and yield parameters and yield of pearlmillet. The succeeding crop of mustard too showed a similar trend. The net returns were higher with 5 t/ha of FYM in pearlmillet (Rs 13194) and succeeding mustard crop (Rs. 26982) as well as in pearlmillet-mustard cropping system (Rs. 40173). The highest benefit:cost (B:C) ratio of 1.41 and 2.08 was recorded with RD of N&P along from pearlmillet and mustard, respectively. 5t/ha FYM to pearlmillet also brought higher B:C ratio to both pearlmillet (1.06) and mustard (2.03).

CONCLUSION

It can be concluded that application of 5t/ha FYM to pearlmillet and RD of N&P along with 30kg potash,100 kg gypsum,10 kg zinc sulphate and 10 kg ferrous sulphate is necessary for getting higher yield and net returns from pearlmillet-mustard cropping system.

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Effect of planting density and level of nitrogen on grain and biomass yield of sweet sorghum (*Sorghum bicolor* [L.] Moench) varieties

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Sorghum (*Sorghum bicolor* [L.] Moench) is similar to grain sorghum having sugar-rich stalk, almost like sugarcane, yields high biomass and fermentable sugars. It's average grain yield 17–28 q /ha with a cane yield of about 35–50 t /ha. In India sorghum is grown over an area of 2.85 million ha in kharif and 4.18 million ha in rabi season with a 3.08 million ton and 3.06 million ton production of grain in kharif and rabi season respectively. Among the various agronomic factors, proper crop nutrition and appropriate planting geometry are of prime importance in getting higher grain and biomass yield of better quality.

METHODOLOGY

The Experiment was carried out to study the effect of planting density and levels of nitrogen on Grain production of sweet sorghum in rainy seasons of 2014 at the Instructional Farm, Indira Gandhi Krish Vishwavidyalaya, Raipur (C.G.) The experiment included two varieties (viz., V_1-SSV-84 and V_2-CSV-24SS), two planting densities (viz., P_1-111.11 plants/m with plant geometry of 50 × 15 cm and P_2-13.33 plants/m with plant geometry of 60 cm × 15 cm) and four levels of nitrogen (viz.,N_0-0, N_1-40, N_2-80 and N_3-120 kg N /ha) were tested in factorial split plot design with three replication assigning varieties x plant geometry in main plots and levels of nitrogen in sub plots. The crop was fertilized with a uniform dose of 80 kg P_2O_5, 40 kg K_2O with varied levels of nitrogen per hectare as per treatments.

RESULTS

The grain and biomass yield is attributed to the cumulative effects of various growth and yield components. Both grain and biomass as well as dry biomass (stover) yields were influenced significantly due to variety, plant density and levels of nitrogen. Crop variety SSV-84 produced the maximum grain (1.7 t/ha), green biomass (24.80 t /ha) and dry biomass (5.93 t /ha) yields, being significantly superior over that obtained with CSV-24SS with the margin of 3.91, 4.83 and 6.40 % in the respective yields. In this study also, sweet sorghum planted with narrow spacing of 50 cm x 15 cm (P1) produced significantly higher grain (1.8 t/ha), green biomass

Table 1. Grain yield, green biomass, dry biomass yield and harvest index of sweet sorghum varieties as influenced by planting density and levels of nitrogen

Treatment	Yield components			
	Grain yield (t/ha)	Green fodder (t/ha)	Stover (t /ha)	Harvest index (%)
Variety				
V1: SSV-84	1.67	24.80	5.93	17.29
V2: CSV-24SS	1.66	23.60	5.55	18.38
CD (P=0.05)	0.59	0.687	0.253	0.07
Planting density				
P1: 50 cm X 15 cm	1.43	22.64	5.33	19.38
P2: 60 cm X 15 cm	1.83	25.77	6.15	16.58
CD (P=0.05)	0.149	2.30	0.610	0.18
Level of nitrogen				
N0 : Control	1.28	20.49	4.78	21.08
N1 : 40 kg /ha	1.49	23.14	5.50	18.33
N2 : 80 kg /ha	1.74	25.26	5.97	16.87
N3 : 120/ha	2.01	27.94	6.70	15.07
CD (P=0.05)	0.06	0.696	0.185	1
Interaction	NS	NS	NS	NS

(25.77 t /ha) and dry biomass (6.15 t /ha) yields, which was significantly greater than those of found under wider spacing 60 cm x 15 cm (P2). Without N addition, the grain and biomass yield of sweet sorghum was relatively low, there was progressive increase in grain and biomass yields of sweet sorghum due to increasing levels of nitrogen application. An application of nitrogen at 120 Kg N /ha produced significantly higher grain (2.13 t/ha), green biomass (27.94 t /ha) and green biomass (6.70 t /ha) compared to lower levels of nitrogen. Though, the harvest index of sweet sorghum differed significantly due to variety and levels of nitrogen. The maximum values of 18.38 were noticed in variety CSV 24 SS which was significantly higher compared to SSV 84. The lowest plant density (11.11 plants/m^2) established at a plant geometry of 60 cm x 15 cm resulted in highest harvest index of 19.38 compared to other plant density. Compared to without nitrogen treatments, decreasing trends in HI was recorded with increased levels of N application.

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Effect of methods of tillage, land configurations and sources of nutrients on the growth, yield, quality and economics of direct seeded rice (*Orzo sativa* L.)

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Two years research experiment conducted on Effect of methods of tillage, land configurations and sources of nutrients on the performance of direct seeded rice (*Oryza sativa* L.)" was laid out in split-split plot design comprising 30 treatment combinations replicated thrice. The growth attributing characters of rice *viz*., plant height at 80 DAS in the year 2014 and 2015, number of tillers per 0.5 m length at 40 DAS in 2014 and dry matter accumulation per 0.25 m length at 40 DAS in 2014 were significantly influenced and enhanced due to various methods of tillage at initial growth stages of crop. Treatment conventional tillage (T_2) recorded higher plant height, number of tillers per 0.5 m length and dry matter accumulation per 0.25 m length of rice crop followed by conservation tillage (T_1) which were at par with each other but recorded significantly superior over treatment zero tillage (T_0) at all the stages of growth except 20 DAS during both years of study. However, treatment conventional tillage (T_2) recorded higher number of tillers per 0.5 m length at 40, 60, 80 DAS and at harvest, length of panicle, number of panicles per tiller, number of filled grains per panicle and test weight followed by treatment conservation tillage (T_1) which were at par with each other but significantly superior over treatment zero tillage (T_0). The rice crop grown by conventional method (T_2) registered significantly the higher grain yield in 2014 and 2015 (4.44 and 4.18 t/ha) and straw yield (5.21 and 4.59 t/ha) which was followed by treatment conservation tillage (T_1) (4.19 and 4.17 t/ha) which was at par with each other but found significantly superior over treatment zero tillage (T_0) (3.62 and 3.34 t/ha) grain yield and straw yield (4.94 and 4.52 t/ha) during both the years. However, in the pooled analysis treatment conventional tillage (T_2) recorded significantly the higher grain yield than the rest of treatments except conservation tillage which was on par with conventional tillage. Significantly the lower grain yield was registered under the treatment zero tillage (T_0). The plant height, number of tillers/0.5 m length and dry matter accumulation/0.25 m length of rice was recorded significantly higher in treatment flat bed (L_1) than raised bed (L_2) at all growth stages of crop growth except at 20 DAS during both the years of investigation. Treatment flat bed (L_1) recorded significantly more grain (4.30 and 4.17 t/ha and straw yield (5.15 and 4.59 t/ha) over the treatment raised beds (L_2) of grain (3.95 and 3.62 t/ha) and straw yield (4.50 and 3.95 t/ha) in both the years. These results corroborated the findings of Hussain *et al.* (2013). The treatment flat bed (L_1) gave significantly the higher net monetary returns over rest of raised bed treatment. The treatment flat bed (L_1) gave the higher benefit cost ratio which was (1.18 and 1.16 in year 2014 and 2015, respectively) followed by treatment of raised bed (1.04 and 1.02, respectively) during both years of study. Significantly more plant height, number of tillers per 0.5 m length and dry matter accumulation in plant was recorded in treatment KAB with applying micronutrients (N_3) recorded higher plant height followed by treatment Modified KAB in combination with micronutrients (N_4) which were at par with each other but significantly superior over rest of the treatments. The yield contributing characters *viz*., number of panicle per 0.5 m length, length of panicle, number of filled grain per panicle, and test weight were observed to be significantly more and significantly more number of unfilled grain per panicle in treatment KAB with applying micronutrients (N_3) recorded higher values followed by treatment of Modified KAB in

Table 1. Mean grain, straw yield of rice as influenced by different treatments during the years 2014, 2015 and in pooled data.

Treatment	Grain yield (t/ha)			Straw yield (t/ha)		
	2014	2015	Pooled mean	2014	2015	Pooled mean
Tillage methods (T)						
T_0:Zero tillage	3.63	3.34	3.48	4.33	3.70	4.02
T_1:Conservation tillage	4.19	4.17	4.18	4.94	4.52	4.72
T_2:Conventional tillage	4.44	4.18	4.31	5.21	4.59	4.90
CD (P=0.05)	0.44	0.435	0.26	0.566	0.61	0.346
Land configurations (L)						
L_1: Flat Bed	4.36	4.17	4.08	5.15	4.59	4.82
L_2: Raised Bed	3.81	3.62	3.89	4.50	3.95	4.27
CD (P=0.05)	0.263	0.265	0.150	0.412	0.403	0.231
Source of nutrient (N)						
N_0: Absolute control	2.83	2.81	2.82	3.39	3.06	3.22
N_1: RDF	3.92	3.74	3.83	4.57	4.09	4.33
N_2: RDF with applying Zinc sulphate @ 25 Kg + Copper sulphate @ 5 Kg ha^{-1})	4.16	3.97	4.06	4.87	4.33	4.60
N_3 : KAB with Zinc sulphate @ 25 Kg + Copper sulphate @ 5 kg ha^{-1})	4.85	4.59	4.72	5.75	5.02	5.38
$N_{4:}$ Modified KAB in comb. with Zn. Sul. @ 25 Kg + Cu. Su. @ 5 Kg ha^{-1} (46 :20 :8 : 8:1.5 N:P:K:Zn:Cu)	4.66	4.37	4.52	5.54	4.84	5.19
CD (P=0.05)	0.269	0.265	0.186	0.319	0.300	0.216

combination with micronutrients (N_4) which was at par with each other but significantly superior over rest of the treatments. Significantly the higher grain yield was found in treatment of KAB+ soil application of micronutrients (N_3) followed by treatment of application of modified KAB in combination with micronutrients (N_4) which were at par with each other but was observed to be significantly superior than the treatment of recommended dose of fertilizer (N_1) and recommended dose of fertilizer + soil application of micronutrients (N_2). Similar results were also obtained by Mohanty *et al.* (2014). Higher gross monetary returns were obtained by the treatment of N_3 followed by the treatment N_4 which were at par with each other but significantly superior over rest of the treatments. In the year 2014 treatment N_4 was followed by treatment N_2, N_1 and N_0 in descending order of significance while in the year 2015 treatments N_2 and N_1 were found to be at par with each other but significantly superior over treatment N_0. Net monetary returns of rice were significantly affected due to different sources of nutrient during both the years of study. The treatment N_3 gave significantly the highest net monetary returns followed by the treatment N_4, N_2, N_1 and N_0 in the descending order of significance during year 2014 but treatment N_3 was at par with treatment N_4 in the year 2015. The highest B: C ratio of 1.52 and 1.56 were recorded by the treatment combination $T_1L_1N_3$ *i.e.* conservation tillage with flat bed and supplied with KAB (56:24:10 NPK kg/ha) + along with soil application of Zinc sulphate 25 kg/ ha and Copper sulphate 5 kg/ ha over rest of treatment combinations.

CONCLUSION

Therefore, it can be concluded that direct seeded rice should be grown by adopting conservation tillage method on flat bed system along with the use of Konkan Annapurna Briquettes @175 kg/ha in combination with soil application of zinc sulphate @ 25 kg/ ha and copper sulphate @ 5 kg/ha

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Effect of nutrient management on grain yield of lentil (*Lens culinaris*), nutrient uptake and soil microbial population in winter rice (*Oryza sativa*) fallows

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Lentil (*Lens culinaris* Medik.) is an important *Rabi* pulse extensively grown in India. In Assam, it is the third important pulse crop, after blackgram (*Vigna radiata* L.) and field pea (*Pisum sativum* L.), occupying an area of 29051 ha with a production of 22524 t and a productivity of 775 kg/ha (2014-15). The requirement of pulse in the state of Assam has been estimated at 3.78 lakh t per year and annual domestic production is 1.21 lakh t, which shows a deficit of 68%. The winter rice (*Oryza sativa* L.) crop is the main crop in the state. About 6.5 lakh ha of medium textured medium rice lands remain fallow during *Rabi* season. In such lands, lentil could be a better option because it grows well both under sequential and relay cropping (Gupta and Bhowmick, 2005). However, in rice-fallows, yield of this crop is very low, and as such, there is no nutrient management recommendation. Therefore, the present study was planned to generate proper nutrient management technology for higher productivity of lentil and for sustaining or improving soil health in rice-fallows.

METHODOLOGY

The trial was conducted during *Rabi* 2011-12, 2012-13 and 2013-14 at Shillongani, Assam (20^0N, $90^0$45'E, 50.2 m above mean sea-level) to study the influence of varying combinations of organic and inorganic fertilizers along with foliar nutrition on yield, nutrient removal, soil microbial and nutrient status and economics of lentil grown in winter rice fallows. The rice variety 'Gitesh' was transplanted in second week of July and harvested in second week of November. The treatments (Table 1) were tested in a randomized block design with 3 replications in lentil. The soil was sandy loam, slightly acidic, low in available N, P_2O_5 and K_2O. The crop (var. HUL 57) was sown on November 22, 21 and 29 in respective years using a seed rate of 30 kg/ha. Nutrient's availability in soil before sowing and just after harvest and their uptake were determined by standard methods. The microbial populations (both fungi and bacteria) were determined by counting colony forming unit through serial dilution plate technique. The generated technologies were tested in farmer's fields through Krishi Vigyan Kendra in 4 districts (Nagaon, Jorhat, Darrang and Karbi Anglong) of Assam for their economic viability and acceptance.

RESULTS

In all the 3 years of study, application of 50% of recommended dose (RD) of fertilizers (i.e. 7.5 kg N, 17.5 kg P_2O_5 and 7.5 kg K_2O/ha) + 1 t vermicompost/ha and 75% of RD of fertilizer (i.e. 11.25 kg N, 26.25 kg P_2O_5 and 11.25 kg K_2O/ha + 0.5 t vermicompost/ha being at par recorded significantly higher yield as compared to other treatments.

Table 1. Effect of integrated nutrient management on grain yield (kg/ha) of lentil

Treatment	2011-12	2012-13	2013-14	Pooled
Fertilizers				
Recommended dose of fertilizer (15:35:15 kg N:P_2O_5:K_2O/ha)	1015	1129	867	1004
75% RD + FYM 2 t/ha	1088	1279	917	1094
RD of N, K_2O + Phosphate rich Organic Matter (230 kg/ha)	1093	1210	913	1072
75% RD + 0.5 t/ha vermicompost	1146	1423	947	1172
50% RD + 1 t/ha vermicompost	1157	1474	967	1202
CD (P=0.05)	73	105	18	63
2% Urea spray				
No spray	1045	1164	883	1031
Two sprays at branching and pod initiation	1155	1442	961	1187
CD (P=0.05)	46	66	11	40

The pooled analysis showed that the former treatment accrued in a productivity of 1202 kg/ha and the latter 1172 kg/ha. These two treatments resulted in significantly higher nutrient removal by the crop. This might be attributed to better soil physical conditions and soil moisture conservation due to vermicompost addition. These two treatments also left behind considerable amount of available nutrients in soil after harvest. Soil microbial population (both fungi and bacteria) was considerably increased owing to vermicompost application. Two sprays of 2% urea at branching and pod initiation stages accrued in significant increase in grain yield and N-uptake over no spray. The former two treatments in combination with 2 sprays of 2% urea proved themselves to be economically viable. During *Rabi* 2014-15, these 2 treatment combinations were tested in farmer's field through Krishi Vigyan Kendra (KVK) in 4 districts of Assam. In all the locations, considerable yield increase (15-48%) and much higher benefit-cost ratio were reported as compared to farmers practice (i.e. recommended dose of fertilizers 15:35:15 N, P_2O_5, K_2O/ha).

CONCLUSION

From the above study, it can be concluded that application of 50% of state (Assam) recommendation of fertilizers + 1 t/ha vermicompost + 2 sprays of 2% urea at branching and pod initiation stages or 75% of fertilizer recommendation + 0.5 t/ha vermicompost + 2 sprays of 2% urea at the same crop stages or both might be recommended in lentil for higher productivity and also for sustaining/improving soil health.

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Growth and yield of late sown wheat as affected by FYM and foliar nutrition

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Wheat is major staple food crop of the world and has second largest acreage and production in India among cereals of which considerable area is late sown. Late sown crop suffers from higher temperature during the grain filling, also called as terminal heat stress. It is one of the major constraints in decreasing productivity of wheat in tropical countries and India (Rane and Nagarajan, 2004). There are ways to combat heat stress selection of heat tolerant varieties are one of them. However, if management factors or growth resources are limited under heat-stress, the size of the plant organs such as leaves, tillers, heads, spikelets, florets, etc are reduced (Fisher, 1985). Irrigation and nutrition are critical inputs during terminal stage. However, farmers forego last irrigation in order to avoid lodging. Nutrition also becomeslimiting during heat stress. Use of management factors like application of FYM and beneficial effect of Ca, K, Zn and 1-MCP has been suggested in wheat against heat stress. Therefore present investigation was planned to find out effect of FYM and foliar nutrition of different compounds on wheat growth, physiology and grain yield.

METHODOLOGY

A field experiment was conducted during *Rabi* season of 2012-13 at GBPUATPantnagar (Uttarakhand) to evaluate the effect of FYM and foliar treatments on wheat growth (plant height, tiller count and dry matter at harvest stage and LAI, SPAD value, Fv/Fm (maximal efficiency of photosystem II) at 90 DAS. The soil of the experiment site was silty clay loam in texture having medium organic carbon, low in available nitrogen, medium available phosphorus and medium in available potassium. Soil reaction was neutral. The experiment consisted of 12 treatments, having two FYM levels (10 t/ha, FYM and no FYM) and six foliar nutrition (calcium chloride at 0.1% , zinc sulphate at 0.5%, potassium chloride at 2.0 %, a ethylene synthesis inhibiter 1- methyl cyclo propane at 20g/ha and water spray at post anthesis stage and no spray) was laid in split plot design with four replication. The wheat variety UP-2526 was sown on 03.01.2013 at 20 cm row spacing and with seed rate of 125 kg/ha. All the recommended package of practices except treatments was adopted in the experiment.

RESULTS

Plant height and dry matter at harvestshowed superior value in FYM treatedplots compared to no FYM plots however, tiller count was at par.Among the different nutrient spray at harvest stage, plots treated with$ZnSO_4$ and KCl recorded significantly taller plant than absolute control and

Table 1. Plant height (cm), tiller count (No/m^2), dry matter (g/m^2), LAI, SPAD value, Fv/Fm and grain yield (t/ha) as influenced by different treatments.

Treatment	Plant Height (At harvest)	Tiller count (At harvest)	Dry matter (At harvest)	LAI (90 DAS)	SPAD Value (90 DAS)	Fv/Fm (90 DAS)	Grain yield
Main Plot Without FYM	85.8	257	831	3.11	39.47	0.703	4.23
FYM	88.4	266	857	3.27	41.35	0.713	4.42
SEm±	0.3	9.6	4.5	0.18	0.24	0.006	0.099
CD (P=0.05)	1.5	NS	20.2	NS	1.07	NS	NS
SUB PLOT							
$CaCl_2$	86.8	264	846	3.28	41.10	0.718	4.30
Zn SO_4	88.7	278	857	3.39	43.34	0.729	4.51
KCl	88.6	268	853	3.34	40.45	0.720	4.43
MCP	86.8	268	843	3.32	40.63	0.708	4.39
Water spray	85.3	249	835	3.02	38.85	0.698	4.16
No Spray	86.6	241	832	2.78	38.10	0.676	4.14
SEm±	0.79	10.2	11.3	0.14	0.81	0.007	0.12
CD (P=0.05)	NS	29.4	NS	0.41	2.33	0.019	0.35

water spray.At harvest, $ZnSO_4$had significantly higher tiller count than no spray.Dry weight remained unaffected by foliar treatments at harvest stages. $ZnSO_4$ though gained maximum dry matter at harvest stage but remained statistically similar with other treatments. SPAD reading of FYM treated plots was significantly higher at 90 DAS whencompared to without FYM plots however Fv/Fm values were at par. It shows that FYM and no FYM plots had similar photosynthetic apparatus. At 90 DAS$ZnSO_4$ showed significantly higher SPAD and Fv/Fm values over control and water spray.1-MCP.KCl and $CaCl_2$ treatedplots also showed significantly higher Fv/Fm reading over water spray and control. Application of FYM and no FYM plots had statistically at par grain yield although FYM had higher grain yield. Application of Zinc Sulphate at anthesis hadsignificantly higher grain yield over control and water spray.All nutrient$CaCl_2$as well as 1-MCP had at par grain yield corroborated their role in quenching effect of heat stress.It is possible in our experiment that zinc improvedthermo-tolerance to the photosynthetic apparatus of wheat specially when heat stress actually experienced by the crop.It was reflected in Fv/Fm value. Zinc application hasbeen reported to increase thermo-tolerance of the photosynthetic apparatus of wheatGraham and McDonald (2001). Transient water unavailability exposes crop to heat stress, KCl might have averted it and possibly was the reason of better crop performance in this treatment.

CONCLUSION

It can thus be concluded that foliar nutrition has potential to offset ill effects of heat stress under late sown condition. These along with different moisture conservation practices can be used under late sown condition to improve grain yield of wheat.

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Nutrient management in pigeonpea (*Cajanus cajan*) based inter cropping system under rainfed condition

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Pigeonpea is widely grown on marginal land as mono/ mixed crop without any fertilizer under rainfed condition of Bihar. Yield of crop is unstable and at times uneconomical due to vagaries of monsoon in rainfed areas. To stabilize crop production and provide insurance mechanism against aberrant weather situation, intercropping could be viable agronomic means of risk minimizing farmers profit and subsistence oriented, energy efficient and sustainable venture (Faroda *et at.,* 2007). Although a number of factors are responsible for low productivity, imbalance fertilization is important one. Imbalanced application of fertilizer resulted in poor yields, deterioration of soil fertility and emergence of multiple nutrients deficiencies. Under present scenario where food security and soil health are under threat, it has become imperative to find out optimum dose of fertilizer in pigeonpea based intercropping system under rainfed conditions. With this background, the present investigation was under taken to achieve maximum productivity without impairing soil heath with the optimum use of fertilizer in pigeonpea based inter cropping system.

METHODOLOGY

The field experiment was conducted at research farm of Tirhut College of Agriculture, Dholi, Muzaffarpur, Bihar ($25^0 98^|$N, $85^0 76^|$E and an altitude of 51.3 mean sea level) during rainy season for two consecutive years 2011-12 and 2012-13. The soil was low in organic carbon (0.34%), available nitrogen (156.8 kg/ha), phosphorus (11.8 kg/ha) and potassium (56.1 kg/ha) with pH 8.1. The treatment comprised 5 intercropping systems i,e, pigeonpea+ maize (1:1), pigeonpea+ urdbean (1:2), pigeonpea+ moongbean (1:2), pigeonpea+ turmeric (1:2), pigeonpea+ sesamum (1:2) and 3 levels of fertilizers of inter crops i.e, 75% RDF, 100% RDF and 125% RDF with three replications. The pigeonpea variety 'Bahar' was sown in rows 60 cm apart in first week of August and harvested in third week of April in both the years. Plant to plant distance of 20 cm was maintained by thinning plants 3 weeks after sowing. The crop was fertilized with urea, diammonium phosphate and muriate of potash at the time of sowing. Net return was calculated by subtracting cost of

Table 1. Effect of intercropping systems and fertilizer levels on pigeonpea equivalent yield and economics (Pooled mean of 2 years)

Treatment	Grain yield (kg/ha)		Pigeonpea equivalent yield (kg/ha)	Net return ($x10^3$ Rs./ha)	Benefit: cost ratio
	Pigeonpea	Intercrops			
Intercropping					
Sole pigeonpea	1760.35	-	1760.35	37.11	1.74
Pigeonpea+maize (1:1)	1638.34	1090.70	1871.29	34.93	1.14
Pigeonpea+ urdbean (1:2)	1764.89	419.67	2392.72	55.43	1.96
Pigeonpea+ moongbean (1:2)	1932.42	190.30	2136.61	6.97	1.69
Pigeonpea+ turmeric (1:2)	1932.13	13503.95	4134.24	487.08	1.51
Pigeonpea+sesamum (1:2)	1797.39	376.57	2336.38	55.90	2.04
CD (P=0.05)	-	-	152.12	6.96	0.20
Fertilizer level					
75% RDF	1700.07	2539.45	2292.17	44.74	1.46
100% RDF	1855.58	3167.79	2607.43	54.80	1.73
125% RDF	1955.21	3640.88	2813.15	59.16	1.85
CD (P=0.05)	-	-	107.57	4.92	0.14

RDF- Recommended dose of fertilizer

cultivation from gross return. Benefit: cost ratio was calculated by dividing net returns with cost of cultivation.

RESULTS

All the intercropping systems recorded significantly higher pigeonpea equivalent yield and net return than sole pigeonpea except pigeonpea + maize intercropping system (Table 1). Among the intercropping systems, pigeonpea + turmeric found economically viable intercropping system as it recorded highest pigeonpea equivalent yield and net return but fail to produce significant effect on benefit: cost ratio, this might be due to higher input cost. Pigeonpea+ sesamum and pigeonpea+ urdbean recorded significantly higher benefit: cost ratio than other intercropping system as well as sole pigeonpea. The results are in close conformity with Pandey *et al.,* (2013). Pigeonpea equivalent yield increased significantly with an increase in fertilizer levels and recorded highest pigeonpea equivalent yield at 125% RDF. However, net return and benefit: cost ratio increased significantly only up to recommended dose of fertilizer, further increase in fertilizer level fail to produce significantly effect on net return and benefit: cost ratio.

CONCLUSION

Pigeonpea+ turmeric was found more remunerative as it recorded highest pigeonpea equivalent yield and net return. However, on the basis of benefit: cost ratio pigeonpea+ urdbean and pigeiopea+ sesamum proved economically viable intercropping systems. Application of recommended dose of fertilizer of intercrops together with RDF of pigeonpea was found economical over 75% RDF and 125% RDF of intercrops.

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Integrated nutrient management in grain amaranth (*Amaranthus hypochondriacus* l.) under middle Gujarat conditions

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A field experiment was conducted at the Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, during the *rabi* season of the year 2011-12 to study the effect of "Integrated nutrient management in grain amaranth (*Amaranthus hypochondriacus* L.) under middle Gujarat conditions". The soil of the experimental area was loamy sand in texture, low in available nitrogen and O. C., medium in available phosphorus and high in available potash with a pH of 7.8. The experiment was laid out in randomized block design with four replications and comprising of ten treatments including application 100% RDF (T_1), 100% RDF + NADEP Compost @ 2 t/ha (T_2), 75% RDF + NADEP Compost @ 3 t/ha mixed with *Azotobacter* & PSB (T_3), 50% RDF + NADEP Compost @ 4 t/ha mixed with *Azotobacter* & PSB (T_4), 100% RDF + Vermicompost @ 1 t/ha (T_5), 75% RDF + Vermicompost @ 1.5 t/ha mixed with *Azotobacter* & PSB (T_6), 50% RDF + Vermicompost @ 2 t/ha mixed with *Azotobacter* & PSB (T_7), 100% RDF + Vermiwash foliar spray at 30, 45 and 60 DAS (T_8), 75% RDF + Vermiwash mixed with *Azotobacter* foliar spray at 30, 45 and 60 DAS (T_9) and Vermicompost @ 2 t/ha + *Azotobacter* foliar spray at 30, 45 and 60 DAS (T_{10}). The results revealed that various treatments employed on the grain amaranth variety GA-2 showed significant influence on growth and yield attributes *viz*., plant height at 45, 60 DAS and at harvest, days to 50% flowering , lodging percentage, panicle length, number of panicles/plant, test weight of grains, grain and stover yields, respectively. Significantly superior results were shown by the treatment 50% RDF + Vermicompost @ 2 t/ha mixed with *Azotobacter* & PSB (T_7) in the case of plant height at harvest (156.40 cm), panicle length (78.09 cm) and number of panicles/ plant (6.69). Days to 50% flowering and lodging percentage of plants were also influenced significantly by various treatments with the highest value for days to 50% flowering recorded with 50% RDF + NADEP Compost @ 4 t/ha mixed with *Azotobacter* & PSB (T_4) (46.50) and 100% RDF + Vermicompost @ 1 t/ha (T_5) with respect to lodging percentage. The grain yield, stover yield and test weight were also significantly influenced by different treatments and the superior results recorded with 50% RDF + Vermicompost @ 2 t/ha mixed with *Azotobacter* & PSB (T_7) with its respective values of 2785 kg/ha, 6275 kg/ha and 0.89 gm. Protein content (%) was significantly affected by different treatments and 50% RDF + Vermicompost @ 2 t/ha mixed with *Azotobacter* & PSB (T_7) gave significantly higher protein content (18.03%) than others. Significantly higher content of available nitrogen was recorded under the treatment T_7 (126.11 kg/ha), available phosphorus under treatment T_5 (80.95 kg/ha) and available potassium under T_{10} (412.55 kg/ha), respectively. The economics calculated based on grain yield indicated that, maximum net realization of Rs. 90,903/ha was observed under treatment T_7 followed by the treatments T_3 (Rs. 89,367/ha) and T_1 (Rs. 88,975/ha).Whereas, maximum BCR was observed in treatment T_1 (6.20). Though treatment T_1 was found to be economical based on BCR, under the integrated approach, based on net realization and BCR, treatments T_7, T_3 and T_5 can be recommended. Thus based on the results of the present investigation, it can be concluded that for maximizing the production and net returns and, on the sustainability point of view, an integrated approach can be adopted in grain amaranth (GA-2). Out of the various integrated treatments, application of 50% RDF along with Vermicompost @ 2 t/ha mixed with *Azotobacter* and PSB was found to be superior for the successful raising of the crop under middle Gujarat conditions.

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Effect of soil test crop response (STCR) based fertilizer recommendations on crop productivity of wheat under acid Alfisol of Himachal Pradesh

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A field experiment was carried out during *rabi* 2014-15 on wheat crop at the experimental farm of CSK HPKV, Palampur. This study was a part of an on-going STCR long-term fertilizer experiment. The experiment consisted of eight treatments (control, general recommended dose, soil test based, farmers' practice, target 25 and 35 q/ha with FYM @ 5t/ha and without FYM) which was replicated thrice in a randomized block design. The fertilizer adjustment equations were developed based on target yield concept and accordingly nutrient doses were calculated. Wheat variety, HPW-236 was sown at the seed rate of 100 kg/ ha. The crop was raised under irrigated conditions. At maturity, the crop was harvested and grain and straw yields were recorded. Application of fertilizers based on soil test (STB) and general recommended dose resulted in 22.6 and 2.03 t/ha grain yield of wheat, respectively. The yield recorded under four treatments (pre-fixed yield targets of 2.5 and 3.5 t/ha with and without the use of FYM) resulted in a close agreement with the target yields which is signified by the per cent deviations that lie within the permissible limits of $\pm$10 per cent. The lowest grain yield of 1.25 t/ha was recorded in control followed by farmers' practice (1.62 t/ha). The net returns were higher in targeted yield treatment as compared to soil test based and general recommended dose. Also, the benefit cost ratio was found to be highest (3.11) in treatment corresponding to yield target of 3.5 t/ha without FYM followed by soil test based approach and least in farmers' practice. Overall, results clearly revealed the superiority of prescription based fertilizer application. Hence, target yield concept based fertilizer application excelled all other approaches in terms of yield and net returns than all other treatments and thus should be exploited under wheat-maize cropping system to maximise net productivity and at the same time ensuring soil health.

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Yield, nutrient removal and economics of Indian mustard varieties as influenced by levels and sources of sulphur under irrigated condition

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Rapeseed-mustard is the second most important oilseed crop of India after groundnut which is cultivated in an area of 6.7 mha with a total production of 8.0 million tonnes and productivity of 1180 kg/ha which is far below the world's average of 1400 kg/ha (Anonymous, 2015). Of the several reasons for low productivity of Indian mustard, cultivation of inappropriate genotype, deficiency of sulphur and application through its inappropriate source are some of the important reasons that need attention during present days. Sulphur deficiency in crops is gradually becoming wide spread in different soils in several states of India due to continuous use of sulphur free fertilizers, high yielding crop varieties, intensive multiple cropping system and high sulphur requiring crops (Jat and Yadav, 2006). The pivotal role of improved genotypes in increasing the productivity of mustard cannot be ignored. In recent past, some new genotypes of Indian mustard have been released.They need to be testedunder irrigated condition of Varanasi.

METHODOLOGY

A field experiment was carried out during winter season (*rabi*) of 2015 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University (25° 18¢ N, 83°31¢ E and 128.93 m above the mean sea level) under sub-tropical zone of Northern Gangetic Alluvial plains. The soil was sandy-clay loam in texture and classified as inceptisol (Typic Ustochrept). It was neutral in reaction (*p*H 7.30), low in organic carbon (0.35%), low in available nitrogen (190kg N/ha), medium in available phosphorus (19.3 P_2O_5 kg/ha) and available potassium (210 K_2O kg/ha). Eighteen treatment combinations comprising of three mustard varieties (Maya, Giriraj and NRCHB-506), 3 levels of sulphur (0, 30 and 60 kg S/ha) and two sources of sulphur (elemental sulphur (80% WDS) and bentonite sulphur (90% G) were laid out using split-split plot design replicated thrice with varieties in the main plots, level of sulphur in sub-plots and sources of sulphur in sub-sub plots. Recommended dose of fertilizer (RDF) for Varanasi region N-P_2O_5-K_2O (120-60-60 kg/ha) was applied uniformly to raise the experimental crop. Bentonite sulphur and elemental sulphur were applied at 15 days before sowing as per the treatments to their respective plots. After the final field preparation, the seeds of Indian mustard cv. 'Maya', 'Giriraj' and 'NRCHB-506' were sown at the rate of 5 kg/ haat a row spacing of 45cm with the help of *kudal* on 5th November.

RESULTS

Results revealed that plant height, dry matter accumulation (DMA) and leaf-area index (LAI)of 'Giriraj' were significantly superior over rest of the two varieties. Further, maximum plant height, DMA and LAI were recorded with application of highest levels of sulphur (60 kg S/ha)but remained at par with 30 kg S/ha in respect of the first two parameters. Application of elemental sulphur to mustard crop resulted in maximum values plant height and LAI. The maximum values for the yield attributes, seed and stover yield were found associated with the mustard variety 'Giriraj' which was significantly higher than 'NRCHB-506' and 'Maya'. The variety 'Giriraj' exhibited 12.17 and 15.13% increase in seed yield than 'NRCHB-506' and 'Maya', respectively. The highest values for siliquae on main shoot, siliquae/ plant, 1000-seed weight, seed and stover yield were found associated with application of highest sulphur level of 60 kg S/ha which were at par with application of 30 kg sulphur except siliquae on main shoot and stover yield which were significantly superior over its control. Application of 60 kg sulphur resulted in 8.20 and 7.92% increase in seed and stover yield over the control, respectively. The application of elemental sulphur resulted in significant increase in the yield attributes and seed and stover yield than bentonite sulphur and the magnitude of increase in seed and stover yield was 1.98 and 0.59% respectively. The maximum net return (Rs.

38153/ha) and benefit: cost ratio (1.74) was found with Indian mustard variety 'Giriraj' under no sulphur application.

CONCLUSION

It is concluded that Indian mustard variety 'Giriraj' with no sulphur proved that most remunerative for achieving higher monetary return in eastern Uttar Pradesh under irrigation condition.

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Effect of fertigation on the productivity of coconut in Brahmaputra valley region of Asom

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A field experiment was conducted at Assam Agricultural University during to study the effect of fertigation on the productivity of coconut. Application of 25, 50, 75 and 100% of recommended N, P and K through drip irrigation system was compared with the soil application of recommended NPK as well as control with no fertilizer. Fertilizers were given through drip irrigation system during October to April in ten equal splits at 20 days interval. Application of 75% N, P and K through drip irrigation produced significantly higher number of functional leaves, bunches per palm, number of female flowers and nut setting percentage compared to control and other fertigation treatments, except 100% NPK through drip irrigation. The mean nut and copra yield per palm was significantly higher with the application of 75% NPK through drip irrigation compared to control and other fertigation treatments, but on par with 100% NPK through drip irrigation. The net returns with 75% NPK through drip irrigation were also at par with the application of 100% NPK through drip irrigation. Application of 75% NPK through drip irrigation resulted in significantly highest benefit-cost ratio compared to rest treatments. Overall, this study indicated that the possibility of saving of 25% of the recommended fertilizers by adopting fertigation technique which also ensures higher productivity of coconut.

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Comparative performance of organic *vis-à-vis* inorganic farming on the productivity, economics and soil health in a long term legume based cropping sequence

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Organic farming has emerged as an important priority area globally in view of growing demand for safe and healthy food which provides health and environmental benefits. The long term sustainability and concerns on environmental pollution associated with indiscriminate use of agrochemicals call for use of organic farming practices in agriculture for maintaining soil health and crop productivity. Over the past few decades, increasing attention has been given to incorporate a legume crop as an intercrop or in cropping sequences as an indispensable component particularly in organic agricultural systems and the evidence suggests that this can provide production advantages over the systems without any legume crop due to atmospheric nitrogen fixation and more efficient utilization of resources. Component crops in intercropping may differ in their use of growth resources over time and space such that when grown together they make more efficient use of light, water and nutrients than when grown separately. Therefore, to study the effect of different composts on the productivity of crops and soil health in terms of nutrient and microbial status in mash/okra (*kharif*)-Gram/wheat+gram (*rabi*) cropping sequence a long term field experiment was conducted at Organic Research Farm of CSK Himachal Pradesh Himachal Pradesh Krishi Vishvavidyalaya, Palampur (H.P.), India

METHODOLOGY

The present study was conducted both in *kharif* and *rabi* seasons during 2012-15 at the experimental farm of Department of Organic Agriculture, CSK Himachal Pradesh Agricultural University, Palampur. The experiment was laid out in split plot design with three replications and eight treatment conditions. The ecosystem viz. irrigated and rainfed were kept in main plots and sources of nutrients *viz*. organic, inorganic, integrated and farmers practice were allocated to subplots. During *kharif* season mash and okra and in *rabi* season gram and wheat+gram were sown in alternate years. In the organic treatment, the seeds of pulses were treated with the biofertilizers (*Rhizobium*+PSB) and of okra and wheat with *Azospirillum* + PSB. Vermicompost 5.0 t/ha was applied as the basal dose at the time of sowing during all the years of study. Three applications of the liquid manure (vermiwash) were given at 15 days interval commencing from 20 days after sowing. In inorganic treatment, recommended doses of NPK were applied. In integrated, 50% of the recommended NPK along with 50% of vermicompost were applied. In farmers practice, 1/4th of the recommended NPK and vermicompost were applied. Recommended plant protection practices were adopted both for organic and inorganic farming. The area represents the mid hill wet temperate zone of Himachal Pradesh. The soil of the experimental field was silty clay loam in texture, acidic in reaction (pH 5.8), low in organic carbon (0.60%), low in available nitrogen (220.4 Kg/ha) and phosphorus (6.0 Kg/ha) & medium in available potassium (268.0 kg/ha).

RESULTS

Data (Table 1) revealed that though irrigated treatment recorded comparatively higher yields over the rainfed situation during the *kharif* seasons but the differences were not significant. However, during *rabi* seasons irrigated treatments resulted in significantly higher yield over the rainfed except during 2013-14 when the difference was non-significant. As a result the pooled gram equivalent yield and net returns were significantly higher in irrigated treatments to the tune of 10.4 & 9.1 %, respectively over the rainfed treatments. Among the nutrient sources, organic being at par with the integrated treatment resulted in significantly higher gram equivalent yield over other treatments during all the *rabi* seasons. Whereas, in *kharif* seasons mash equivalent yield in organic treatments was significantly higher over all other treatments during all the years of experimentation except during *kharif* 2013, where it was also at par with the integrated treatments. Application of inorganic sources of nutrients resulted in significantly lowest yield during the first year of study however, during the second and third years it was at par with that obtained in farmers practice. The pooled gram equivalent yield and net returns (2012-15) were significantly highest in organic treatment to the tune of 16.1

Table 1. Effect of different treatments on crop yield

Treatment	Mash equivalent yield (t/ha)				Gram equivalent yield (t/ha)			Pooled Gram equivalent yield of the system	Economics	
	Kharif				*Rabi*				Net return	B:C
	2012	2013	2014	2015	2012-13	2013-14	2014-15	(t/ha) 2012-15	(Rs/ha)	ratio
Eco-system										
Irrigated	1.08	0.97	1.05	1.21	1.41	1.29	1.47	2.731	162342	2.90
Rainfed	0.91	0.84	0.97	1.28	1.29	1.16	1.21	2.474	148777	3.03
LSD (P=0.05)	NS	NS	NS	NS	1.4	NS	0.22	0.254	12250	NS
Source of nutrient										
*Organic	1.25	1.14	1.28	1.45	1.65	1.48	1.62	3.186	200857	3.72
Inorganic	0.87	0.78	0.95	1.21	0.98	1.12	1.25	2.318	131368	2.43
Integrated	1.01	1.02	0.99	1.25	1.52	1.35	1.4	2.745	165570	3.06
*Farmers practice	0.85	0.68	0.81	1.08	1.25	0.94	1.08	2.156	124457	2.60
CD (P=0.05)	0.16	0.12	0.21	0.15	0.27	0.21	0.24	0.225	12070	0.25

*Organic: VC 5t/ha+Bifertilizers(Rhiz.+PSB)+Vermiwash (Liquid manure)
*Farmers practice: 1/4th of the recommended NPK alongwith 1.25 tones/ha of vermicompost

and 21.3% in integrated and 37.4 & 52.8 %, respectively over the inorganic treatment. The physical properties *viz.* bulk density and water holding capacity were not affected significantly due to the irrigated and rainfed ecosystem. Among the sources of nutrients, organic source though resulted in lower and chemical treatment the higher values of bulk density (BD) as compared to other treatments but the differences among all the treatments were non-significant. Water holding capacity of the soil in organic treatment was significantly higher, however, it was at par with integrated treatment, whereas, the water holding capacity in the inorganic treatment being at par with farmer’s practice was significantly lower. This may be attributed to the improvement in soil quality in organic treatment due to the addition of organic manures. Similar results have been reported by Bhatnagar *et.al* (1983) and Johnston *et.al* (1995) who observed that the crop yields were increased by using animal manures due to the corresponding improvement in soil quality. There was no significant effect of the treatments on soil pH. As far as organic carbon is concerned, it was significantly higher under irrigated condition as compared to the rainfed condition. Available N, P and K were not affected significantly by the irrigation of the crops. No significant effect on soil pH was noticed in different treatments of source of nutrients. The organic treatment resulted in significantly highest and the inorganic treatment significantly lowest organic carbon over the remaining treatments.

CONCLUSION

In a long term legume based cropping system the organic cultivation of crops resulted in significantly higher productivity and net returns over the inorganic farming. Similarly, physical, biological and chemical properties of the soil were significantly improved in organic farming. Water holding capacity (WHC), organic carbon (OC), dehydrogenase activity (DHA) and soil microbial biomass carbon (SMBC) were significantly higher under organic farming over the inorganic cultivation of crops. Hence, the productivity, net returns and soil health parameters under the organic farming are improved significantly after 3-4 years of cultivation.

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Production and quality of pigeon pea–oat cropping system under the different levels of phosphorus and sulphur in western UP condition

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Currently, even as production pulses was very low (18.5 mt) but demand is estimated at high (22 mt), which necessitates yearly pulse imports of around 3.5-4 million tonnes. Although area and production are increased, productivity of pigeon pea remained almost static during last 50 years. In complete both grains and stalk of legumes contain good amount of protein and minerals. Most of pulses growing soils are deficient in available P status. Application of phosphorus to pulse crops is demonstrated to be profitable, research results and on farm demonstration has clearly revealed that application of 15-20 kg N, 30-40 kg P_2O_5, 20-40 kg K_2O and 20-40 kg S/ha proved beneficial in most of the pulse crops (Hegde and Babu, 2004). Keeping in view, the importance of sulphur also, this investigation was undertaking to evaluate the effect of phosphorus and sulphur in pigeon pea and their residual effects on succeeding oats**.**

METHODOLOGY

A field experiment was conducted during two consecutive kharif and rabi seasons with cultivar of pigeon pea UPAS-120 and UPO-94 cultivar of oat at Janta Vedic College Baraut, CCS University Meerut. The experiment was laid out in the main plot- no phosphorus, phosphorus solubilizing bacteria, 40 kg phosphorus /ha, 40 kg phosphorus /ha + PSB, 80 kg phosphorus /ha. And in sub-plots: no sulphur, 30 kg, 60 with the four replications in Split Plot Design. The soil was sandy clay loam, pH 7.52, available nitrogen 238.2 kg/ha, available phosphorus 17.21 kg/ha, available potassium 296 kg/ha, available sulphur 10.21 kg/ha and medium in organic carbon 0 .55% in the experimental field. The crop was sown at the seed rate of 15 kg /ha, row spacing of 50 cm, plant spacing 10 cm with in row maintained by thinning the crop, respectively. The crude protein was obtained by multiplying the total nitrogen content of grain by 6.25. N, P, K and S uptake was worked out by multiplying the respective percentage of nutrient with corresponding grain yield and expressed as kg/ha. The statistical analysis of the data has been done as per procedure of analysis of variance using F-test.

RESULTS

The phosphorus and sulphur levels influenced the production and quality of pigeon pea. The pooled data are shown in Table 1. The maximum yield of pigeon pea in the 80 kg/ha Phosphorus, to be applied same trend in term of Stover yield and results indicate that remarkable significant variation in others treatments might be due to the adequate availability

Table 1. Production and quality of pigeon pea as influenced by P and S levels

Treatment	Seed yield (t/ha)	Stover yield (t/ha)	N % in seed	N % in stover	Protein % in seed	Protein % in stover
P level						
No Phosphorus	1.19	4.27	3.12	1.32	19.48	8.27
PSB	1.39	4.46	3.17	1.36	19.63	8.57
40 kg/ha	1.46	4.78	3.27	1.43	19.57	8.91
40 kg/ha + PSB	1.53	4.79	3.21	1.44	20.09	8.98
80 kg/ha	1.62	4.97	3.29	1.45	20.33	9.07
SEm±	0.18	0.55	0.043	0.21	0.25	0.08
CD (P=0.05)	0.46	1.59	NS	0.59	NS	0.25
S level						
No sulphur	1.18	4.30	3.12	1.35	19.51	8.46
30 kg/ha	1.50	4.78	3.18	1.41	19.90	8.84
60 kg/ha	1.60	4.82	3.26	1.44	20.67	8.98
SEm±	0.14	0.43	0.03	0.01	0.17	0.08
CD (P=0.05)	0.40	1.23	0.08	0.04	0.47	0.23

Table 2. Green, dry fodder yield and nutrients' uptake pattern of oat as influenced by residual effect of P and S levels applied to preceding crop ofpigeon pea

Treatment	Green fodder yield (t/ha)	Dry fodder yield (t/ha)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	S uptake (kg/ha)
P level						
No phosphorus	17.08	2.35	28.21	5.15	44.96	5.48
PSB	17.72	2.63	31.79	5.51	50.68	6.69
40 kg/ha	18.10	2.77	33.38	5.64	53.60	7.28
40 kg/ha + PSB	19.12	3.17	38.93	6.69	61.57	8.49
80 kg/ha	18.50	2.88	35.11	6.05	56.17	7.73
SEm±	2.46	0.34	0.46	0.08	0.66	0.05
CD (P=0.05)	7.50	0.98	1.41	0.27	2.02	0.94
S level						
No sulphur	17.52	2.43	15.89	4.63	46.33	5.30
30 kg/ha	18.40	2.81	33.99	4.96	54.44	7.49
60 kg/ha	18.64	3.28	37.92	6.59	59.43	8.45
SEm±	1.90	0.27	0.42	0.08	0.58	0.07
CD (P=0.05)	5.42	0.76	1.21	0.23	1.67	0.23

higher doses of Phosphorus than other treatments. Among the sulphur levels 60 kg/ha sulphur applied was significantly superior than control and other treatment might be owing to the positive role of sulphur in plant metabolic activity which may have led to the increased photosynthesis and thereby production. These results clearly indicate it play positive impact on production. Application of phosphorus had beneficial effect on protein percentage. There was incredible increase in protein percentage due to increasing dose of phosphorus where 80 kg P_2O_5/ha increased protein percentage in seed and Stover both Table 1. Second most beneficial effect of phosphorus and PSB inoculation also observed on nitrogen percentage and protein percentage in pigeon pea. The inoculation with PSB solubilization of native phosphorus rendering more phosphorus available for the plants leading to increased nitrogen percentage and its impact on protein percentage in both seed and Stover. The sulphur gave significant results in protein percentage than other level of sulphur and control. As per, pooled data recorded in Table 2, Green and dry fodder yield of oat was significantly higher in phosphorus level 40 kg/ha +PSB than 80 kg/ha, 40 kg/ha, PSB and No phosphorus treatment. Due to PSB played an important role in enhancement of fodder production by providing more phosphorus to plant also reported increased fodder yield to use of PSB in previous crop. Among the sulphur levels, 60 kg/ha sulphur was more beneficial to the rest of the treatments. It has given the significant results than 30 kg/ha, sulphur and No. sulphur treatment. In general, the marked improvement in productivity of oat fodder crop with residual sulphur could be ascribed to enhancement of SO_4^{-2}- sulphur content of soils (Table 2). This might have modified soil environment along with the improvement in physical parameters of the soil conducive during crop periods. Pooled mean data of two years (Table 2) noticed that nitrogen, phosphors, potassium and sulphur in oat crop differed significantly due to different treatments. The super optimum dose of phosphorus 80 kg/ha and sulphur 60 kg/ha recorded significant higher uptake of nutrients over the rest of the treatments. Contrary to comparable performance phosphorus levels 40 kg/ha + PSB and sulphur levels 40 kg/ha may be used. The results might be owing to super to nutrients supply in previous rising crop and higher biomass production may the most pertinent reasoning for higher uptake of nutrients in the treatments referred above.

CONCLUSION

Thus it may be concluded that the recommended dose of 80 kg/ha phosphorus and 60 kg/ha, sulphur should be applied in pigeon pea. It gave more production of pigeon pea and left better residual effect on succeeding oat fodder yield.

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Response of cassava (*Manihot esculenta*) to irrigation regimes and fertigation schedules

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Cassava is considered as the most prominent and highly prospective crop among all the tropical tuber crops having food, feed and industrial demand. India ranks first in the productivity of cassava worldwide. Traditionally, cassava was cultivated depending upon the rainfall availability. Cassava needs adequate moisture for sprouting and subsequent establishment of setts. Being a photo insensitive crop, cassava can be grown throughout the year irrespective of the season, provided sufficient moisture is assured. Moreover, development of short duration varieties made it possible to raise more than one crop in an year. Response of cassava to irrigation has been widely reported, however, in the present day context of climate change, when precipitation has become irregular and scanty, it is very essential to economise use of irrigation water and fertilizer application without compromising tuber yield. Drip irrigation and fertigation have proved to be a success in terms of water and nutrient use efficiency in a wide range of crops. Hence, an attempt was made to study the response of cassava to micro irrigation and to arrive at a suitable fertigation schedule through precision approaches to enhance the tuber yield of cassava under tropical conditions.

METHODOLOGY

Field experiments were carried out at ICAR- Central Tuber Crops Research Institute, Kerala, India during 2009-2010, 2010-2011 and 2011-2012 by planting cassava during summer months. The experiment was laid out in split plot design with three levels of drip irrigation in main plots and three fertigation schedules in sub plots. Treatments in main plots included: I_1- Irrigation at 100% of pan evaporation (PE), I_2- Irrigation at 80% PE and I_3-Irrigation at 60% PE. Treatments in sub plots included: F_1- Application of Nitrogen and Potassium fertilizers as 50% of N & K during 1-40 days, 30% of N & K during 40-80 days and 20% during 80-120 days after planting (50:30:20), F_2- N and K as 30% during 1-40 days,50% during 40-80 days and 20% during 80-120 days (30:50:20) and F_3- N and K as 50% during 1-40 days, 40% during 40-80 days and 10% during 80-120 days (50:40:10). The standard fertilizer dose of 100 kg N, 50 kg P_2O_5 and 100 kg K_2O per hectare was applied uniformly in all the treatments. Full dose of phosphorus was applied as basal dose prior to planting. Minisetts of cassava variety Sree Vijaya (7 months duration) were planted during December, every year at a spacing of 0.60 x 0.45m. Quantity of irrigation water was calculated based on daily pan evaporation rate and pan factor, in mm. Crop factor was taken into account at different stages of growth as suggested by Allen and Pruitt (1991). The crop was harvested after 7 months. The data collected on over the years were pooled and analysed statistically following SAS procedure.

RESULTS

Different levels of irrigation as well as the interaction effects of irrigation and fertigation schedules significantly affected the tuber yield of cassava in all the years. Mean yield performance of cassava over three years are presented in Table 1. Pooled data revealed a declining trend in tuber yield with decreasing levels of irrigation. Fertigation treatments have not significantly affected the yield performance in different years, however, pooled data showed that fertilizer application @ 50: 30: 20 resulted in higher yield. This may be due to the higher nutrient requirement during the early stages of growth and tuber bulking, rather than at tuber maturity phase when the plant would be less photosynthetically active. Interaction effects indicated that, irrigation at 100% PE along with fertigation schedule of 50:30:20 recorded maximum tuber yield (44.6 t/ha) which was at par with irrigation at 100% PE along with fertigation schedule of 50:40:10 (44.3 t/ha).

Table 1. Tuber yield of cassava under different treatments (Pooled mean of interaction effects)

Treatment	Tuber yield (t/ha)
Irriagtion @100% & fertigation @ 50:30:20	44.61
Irriagtion @100% & fertigation @ 30:50:20	41.23
Irriagtion @100% & fertigation @ 50:40:10	44.32
Irriagtion @80% & fertigation @ 50:30:20	38.99
Irriagtion @80% & fertigation @ 30:50:20	38.93
Irriagtion @80% & fertigation @ 50:40:10	36.18
Irriagtion @60% & fertigation @ 50:30:20	31.94
Irriagtion @60% & fertigation @ 30:50:20	33.02
Irriagtion @60% & fertigation @ 50:40:10	30.98
CD (P= 0.05)	3.386

Water use efficiency (WUE) was worked out based on fresh tuber yield under different irrigation levels. The data indicated a gradual reduction in WUE with decreasing quantity of irrigation. WUE was maximum under 100% irrigation level (81.5) followed by 80% (79.5) and minimum under 60% (76.9). This clearly revealed that supplementary irrigation during summer months increases cassava tuber yield, though the crop is reported to be drought tolerant. The effect of fertigation schedules was not significant; however, maximum agronomic efficiency of nutrients was recorded by application of N and K @ 50: 30: 20 (112 kg /kg). Apparent nitrogen and potassium recovery efficiency was also highest for the same treatment (54.3% and 58.8% respectively).

CONCLUSION

Drip irrigation at 100% of pan evaporation along with application of 50% N and K fertilizers during first 40 days, 30% during 40-80 days and rest 20% during 80-120 days after planting through fertigation is found optimum for achieving higher tuber yield in cassava.

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Productivity, nitrogen use efficiency and profitability of common bean as influenced by nitrogen application in cold desert region of Lahaul valley

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Lahaul valley belongs to cold desert region of Himachal Pradesh where the climate is extremely cold and heavy snowfall occurs during winter. Single cropping season prevails in the region and the population is entirely rural and economically backward. Common bean is a short duration non-traditional grain legume and is inefficient in symbiotic nitrogen fixation. It is a main source of protein and also a major source of income for the tribal people as there is a great demand of common bean in different parts of the country due to its better quality and taste. Imbalanced application of fertilizers is one of main reasons for deterioration of crop productivity in the region. Nitrogen is applied as top dressing by the farmers for enhancing the yield of common bean. Keeping in view the above said points, the present investigation was undertaken to evaluate the effect of nitrogen application on productivity, profitability and nitrogen use efficiency in common bean in cold desert region of Lahaul valley.

METHODOLOGY

A field experiment was conducted during the summer season of 2013 at the Research Farm, Highland Agricultural Research and Extension Centre, CSK Himachal Pradesh Krishi Vishvavidyalaya, Kukumseri (32° 44' 55" N latitude and 76° 41' 23" E longitude, and 2672 m above the mean sea level), Lahaul & Spiti, Himachal Pradesh. The soil of the experimental site was sandy loam in texture and acidic in reaction with 10.5 g organic carbon/kg soil, 280 kg available N/ha, 31 kg available P/ha and 300 kg available K/ha. Average annual rainfall of the region is 250 mm. The experiment was laid out in randomized block design with six treatment combinations *viz.* N_0 (control), N_{20} (basal), N_{40} (basal), N_{20+20} (split), N_{60} (basal) and N_{30+30} (split). HPR 35 (Kanchan) variety of common bean was used as test crop. Nitrogen was applied as basal and into two splits (½ N as basal and ½ N as top dressing at 30 days after sowing) as per treatments. Phosphorus and potassium were applied @ 60 kg and 30 kg/ha, respectively as basal application in all the experimental plots. Other recommended package of practices for the region was also followed in the production of common bean.

RESULTS

The highest dry matter production was noted at N_{60} whereas the lowest was in control treatment (N_0). Maximum dry matter efficiency was observed with split application of 60 kg followed by 40 kg N/ha as basal while minimum dry matter efficiency was in control treatment. Maximum unit area efficiency was noted with basal application of 60 kg N/ha while minimum was in control treatment (Table). Single pod dry weight was not affected by different treatments. However,

Table 1. Effect of levels and methods of nitrogen application on productivity, nitrogen use efficiency and profitability

Treatment	Dry matter production (kg/ha)	Seed yield (kg/ha)	Productivity (kg/ha/ day)	NUE (kg seed/ kg N)	Net returns (Rs.10^3/ha)	B:C	Profitability (Rs./ha/ day)
N_0 (control)	4310	1910	17.7	-	125.9	2.7	1166
N_{20} (basal)	5310	2660	24.6	37.5	201.7	3.7	1867
N_{40} (basal)	5620	2940	27.2	25.8	229.6	4.1	2126
N_{20+20} (split)*	5180	2620	24.3	17.8	196.9	3.6	1823
N_{60} (basal)	6430	3200	29.6	21.5	257.5	4.4	2385
N_{30+30} (split)*	5460	2870	26.6	16.0	221.8	3.9	2054
SEm ±	547	278					
CD (P= 0.05)	1220	620					

*½ N as basal and ½ N as top dressing at 30 days after sowing

numerically higher pod dry weight was recorded with basal application of 60 kg N/ha while the lowest pod dry weight was in control treatment. The highest seed yield (3200 kg/ha) was recorded with basal application of 60 kg N/ha. Basal application of 60 kg N/ha remained at par with 40 and 20 kg N/ha in respect of seed yield. Application of 20, 40, 40 (two splits), 60 and 60 (two splits) kg N/ha resulted in 39, 54, 37, 68 and 50 percent higher seed yield over control, respectively. Maximum productivity was noted with basal application of 60 kg N/ha. Basal application was found to be better than split application of nitrogen. The increased yield might be attributed due to significant influence of nitrogen on translocation of nutrients and dry matter accumulation during reproductive stage which in turn improved growth and yield attributes, and ultimately yields. Nitrogen use efficiency showed decreasing trend with an increase in nitrogen level. The highest value of nitrogen use efficiency was with basal application of 20 kg N/ha while the lowest was at N_{60} (split application). Nitrogen use efficiency observed in split application remained inferior to basal application of nitrogen (Table). Maximum net returns, B: C ratio and profitability was recorded with basal application of 60 kg N/ha. Application of 20, 40, 40 (two splits), 60 and 60 (two splits) kg N/ha resulted in 60, 82, 56,105 and 76 percent higher net returns and profitability over control. The higher net returns benefit cost ratio and profitability could be attributed due to increased yield with application of fertilizers.

CONCLUSION

On the basis of findings, it can be concluded that basal application of 60 kg N/ha will be helpful in increasing productivity and profitability of common bean in cold desert region of Lahaul valley.

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Precision nitrogen management for better production and improved nitrogen use efficiency in wheat

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Wheat (*Triticum aestivum* L.) is the premier cereal crop grown in India on 30.4 mha area with 2.99 t/ha yield and 90.8 mt production. Though current production is sufficient to meet the present wheat demand of India, but it has to be increased to 105 mt/ annum by 2025 to meet the increasing food demand which is possible by using inputs precisely and through development of proper production technologies. Nitrogen (N) is the largest agricultural input used by wheat farmers. They generally over-apply it because theywant to ensure enough N for increased crop requirements. Fields spatially differ in crop requirements but are mostly managed as homogenous units, often receiving a single excessive uniform rate of N. The excessive use of N may cause weed problems and could result in an increased risk of lodging, delayed maturity and greater susceptibility to diseases. Moreover, this practice leads togreater N loss to ammonia volatilization, denitrification, runoff and leaching. Special attention is needed to be given about use of nitrogenous fertilizers because of their low use efficiency (32-52%) due to spatial variability, inefficient splitting of fertilizer, etc. (Jat *et al.* 2012). This low nitrogen use efficiency (NUE) as well as yield enhancement is to be accomplished by using the approaches following principle of 4R nutrient stewardship i.e. right rate, right time, right source and right place. Optimized nitrogen management through different approaches *viz.* site specific nutrient management (SPAD, GreenSeeker), spectral indices (NDVI and NDRE), decision support system, for increasing yield, improving nutrient use efficiency and enhance the profitability of wheat. GreenSeeker, SPAD, LCC are the practices which help in need based fertilizer application. GreenSeeker guided fertilizer N application at 2nd or 3rd irrigation events can lead to improved fertilizer N-use efficiency with no reduction in yield through savings of 22 kg N/ha in total fertilizer N application as compared with prevalent blanket recommendations and 33.3 % higher recovery efficiency. Ratanoo *et al.* (2016) also reported higher agronomic and recovery efficiency when fertilizer was applied on need basis using optical sensor GreenSeeker. Spectral indices i.e. NDVI and NDRE are also efficient in the nitrogen management in wheat. NDRE showed a significant correlation with N application. Decision support system (Nutrient expert) in combination with GreenSeeker recorded significantly higher yield (5.17 t/ha) and partial factor recovery as compared to farmer's practice (Sapkota *et al.,* 2014). Multiple field experiments helped to conclude that Nutrient Expert for Wheat could be used as an alternative method to make précised fertilizer recommendations in China. So, it can be concluded that development of new efficient fertilizer management approaches like GreenSeeker, Nutrient Expert are beneficial to enhance production and nutrient efficiency.

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Response of maize (*Zea mays*) and chickpea (*Cicer arietinum*) to site specific nutrient management (SSNM) through targeted yield approach

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Field experiments were conducted at A. R. S. Belvatagi, University of Agricultural Sciences, Dharwad during *kharif* and *rabi* season to study the response of maize (*Zea mays* L.) and chickpea (*Cicer arietinum* L) to site specific nutrient management (SSNM) through targeted yield approach under irrigated conditions in Malaprabaha Command area of zone III of Karnataka. The treatments comprise of two hybrids/ varieties (Cargi l900 M and EH-434042 of maize hybrids and JG-11 and A-1 of chickpea varieties) with four targeted yield levels (6000, 7500, 9000 kg/ha with RDF for maize and 2000, 3000 and 4000 kg/ha with RDF for chickpea). Among the maize hybrids, Cargi 1900 M recorded significantly higher grain yield (8890 kg/ha) over EH-434042 (71260 kg/ha) in mother trial (at research station). Similar increase in yield also observed in baby trial (at farmers field). Application of higher fertilizer dose (216:216:322 NPK kg/ha) for 9000 kg/ha targeted yield level recorded significantly higher grain yield of maize (9460 kg /ha) over RDF (7010 kg /ha) and lower targeted yield levels (60 q/ ha and 7500 kg /ha). Interaction between hybrids and targeted yield revealed that Cargil 900-M with 9000 kg /ha targeted yield levels recorded 10540 kg /ha of grain yield which was 38.5% higher than RDF with the same hybrid. Similarly EH-434042 with 9000 kg /ha targeted yield recorded 30.9% higher yield than application RDF, which resulted in to an additional income of Rs. 23,387 and Rs. 14,424 over RDF respectively. The achieved grain yield of maize was significantly superior over targeted yield level treatments of 6000 kg /ha (7380 kg / ha) 7500 kg /ha (8450 kg /ha) and 9000 kg /ha (9460 kg /ha) as per the t-test of significance for unequal variance. The growth, yield components, NPK uptake and soil status after harvest of the crops increased significantly with both the hybrids with 9000 kg/ha targeted yield level as compared to

RDF and lower targeted yield levels. Both the chickpea varieties responded significantly to the application of higher dose of fertilizers (220:199:260 kg NPK for 4000 kg /ha). The JG-11 and A-1 with 4000 kg /ha targeted yield levels increased the grain yield by 61.1 and 77.7% with an additional income of Rs. 25,745/ha and Rs 29356/ha over RDF. The growth, yield components and uptake of NPK were also higher with both the varieties at higher targeted yield levels.

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Nitrogen management of castor using remote sensing techniques

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Nitrogen management practices under field conditions include soil test based nitrogen recommendation, tissue analysis based nitrogen management, site specific real time nitrogen management using leaf color charts and SPAD chlorophyll meters. However, these are all specific to the given field and only point information is generated. Since existing methods of soil and plant analysis are costly and time consuming (Peoples *et al*., 1995), focus is shifting towards approaches using remote sensing technologies. Remote Sensing techniques have a unique capability of recording data in visible as well as invisible parts of electromagnetic spectrum, where the spectral characteristics of plants are good indicators of their health and nitrogen content in the tissues (Blackmer *et al*., 1996). Remote sensing is a valuable tool in the evaluation of plant nitrogen status and is of great interest in agricultural communities because nitrogen stress is often an important limitation of crop productivity. The normalized difference vegetation index (NDVI) is highly correlated with nitrogen uptake and can be used as a powerful tool in crop nutrient (Nitrogen) monitoring in crop production. Based on the above relevance, an experiment was taken up to establish a relationship between leaf nitrogen and satellite derived NDVI values and yield of castor.

METHODOLOGY

Different castor growing locations (20) in the study area (Nalgonda district) were chosen based on cropping intensity during 2005. Castor crop map of (*kharif,* 2005) covering study area as extracted from satellite data and NDVI map of the castor area depicting different crop densities in the study area are super imposed on it. Basic data on crop record, initial soil analysis, geographical locations, fertilizers applied were collected. The selected sites were visited at different intervals corresponding to vegetative stage (August), flowering stage (October) and secondary spike stage (November) during the crop growth period and plant samples were collected and estimated for nitrogen. Satellite data (IRS P6 LISS III) was obtained corresponding to vegetative (August) and secondary spike (November) stages of the crop growth. The digital data after making geometric corrections were processed using ERDAS imagine software. NDVI values were extracted for selected locations from where ground truth observations pertaining to leaf nitrogen were collected. Correlations were worked out between NDVI values and leaf nitrogen content and bean yield of castor.

RESULTS

Leaf nitrogen content of castor crop at vegetative stage ranged from 2.40% to 3.86% reflecting varied nitrogen management practices and thus the nitrogen status of the crop across selected locations of the study area. The extracted NDVI values from the satellite data for the corresponding periods and locations ranged from 0.012 to 0.296. During reproductive stage of the crop, the leaf nitrogen ranged between 2.50% to 3.61% and corresponding NDVI values ranged from 0.211 to 0.584 respectively. Cloud free satellite data could not be obtained during flowering stage. Leaf analysis results of castor crop at different crop growth stages across selected locations revealed that the nitrogen percent was high at vegetative phase in general and gradually decreased with the advancement of crop stage. Relationship between leaf nitrogen (%) of castor crop and satellite derived NDVI during November (secondary spike stage) and leaf nitrogen and bean yield of castor are worked-out and presented in Fig. 1 and 2. Positive and significant correlations were obtained between leaf nitrogen and satellite derived NDVI ($R^2 = 0.7925$) and leaf nitrogen at vegetative phase and bean yield of castor ($R^2 = 0.7388$). Similar positive relationship between plant nitrogen and satellite NDVI were also obtained by Aguera *et al*. (2011). Relationship between satellite derived NDVI and bean yield of castor (Fig. 3) revealed a significant and positive correlation ($R^2 = 0.9462$).

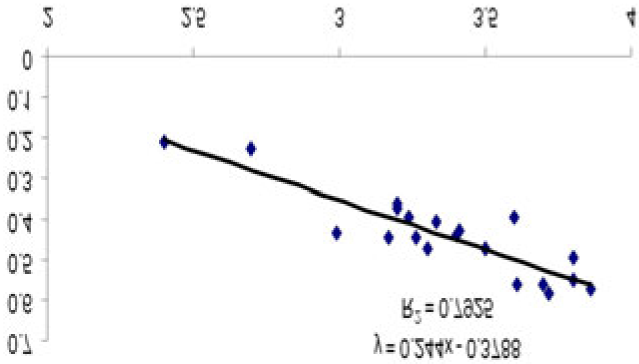

Fig. 1. Relationship between leaf nitrogen (%) of castor crop and satellite derived NDVI during November (secondary spike stage)

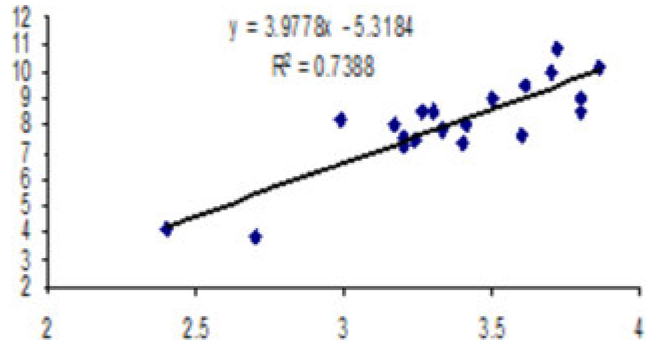

Fig. 2. Relationship between leaf nitrogen (%) of castor and bean yield (q/ha)

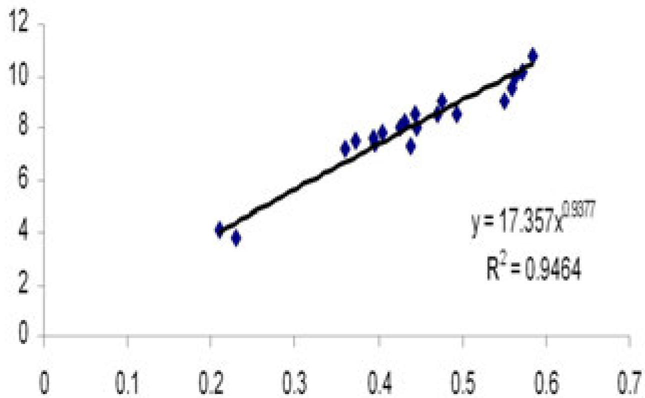

Fig. 3. Relationship between satellite derived NDVI during November 2006 and bean yield of castor (q/ha)

CONCLUSION

Based on the results of the study, it can be concluded that nitrogen status of castor crop can be assessed and effectively monitored during crop period over a larger area for nitrogen management using satellite derived NDVI data. The recent advances in sensor technology may aid in detection of variations in nutrient stress in crops.

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Marginal rate of return as influenced by zinc and boron application in wheat (*Triticum spp.*) varieties in vertisols of Central India

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Wheat (*Triticum spp.*) is second important food-grain crop of India after rice. At present, due to growing of high yielding crop varieties resulted higher nutrients uptake, continuous degradation of organic matter from the soil, imbalanced use of fertilizers etc., wheat crop is showing deficiency symptoms of different micronutrients in different part of the country. In many areas of Central Zone, micronutrients viz., zinc and boron deficiency is seen at farmers' field in wheat crop and have adverse effect on wheat productivity. As per practical experience, this problem is increasing year after year and as corrections measure of above nutrients deficiency this trial was undertaken.

METHODOLOGY

The field experiment was undertaken for three consecutive years from 2009-10 to 2011-12 at IARI, Regional Station, Indore, Madhya Pradesh ($22^0 37'$ N, $75^0 50'$ E with an altitude of 557 m above MSL) to find out the effect of Zn and B application on the productivity of wheat varieties. The soil of the experimental site was light black (vertisols), medium in organic carbon (0.52%), low in available N (242.0 kg/ha), medium in available P (12.4 kg/ha), high in available K (460.0 kg/ha), low in DTPA extractable zinc (0.54 mg/kg) and extractable boron (0.43 mg/kg) along with pH 8.0 and EC 0.14 dS/m). The treatments consisted of two wheat varieties viz., HI 1544 (*Triticum aestivum*, bread wheat) and HI 8498 (*T. durum*, durum wheat), three Zn levels viz., 0, 5.0 and 10.0 kg/ha, and three B levels viz., 0, 1.0 and 2.0 kg/ha laid out in factorial randomized block design with three replications. All recommended agronomic package of practices were followed for growing healthy crop. Marginal rate of return analysis was done as suggested in manual of CIMMYT (1988).

RESULTS

Pooled data over 3 years indicated that the yield performance of bread wheat variety HI 1544 was significantly better than durum wheat variety HI 8498 and recorded almost 5.56 and 6.18% higher grain (5.69 t/ha) and biological (13.57 t/ha), respectively . Higher yield of HI 1544 was the function increased values of growth and yield contributing characters viz., plant height (100.4 cm.), earheads/sq.m (346.2), length of spike (9.24 cm.) no. of spikelets/spike (15.9) and no. of grains/spike (46.9) over HI 8498 like 89.8 cm., 304.2, 6.46 cm., 15.8 and 42.6, respectively. Favourable effect of Zn and B on yield attributes further got reflected on grain and biological yields and significantly increased the grain and biological yields upto the level of 5.0 kg Zn/ha (GY 5.63 and BY 13.24 t/ha) and 1.0 kg B/ha (5.63 and 13.35 t/ha). Thereafter, differences were non-significant. Jat *et al.* 2013 also reported similar results. Application of B by putting favourable impact on nutrients absorption from soil and improving the developmental activities might have increased the crop yields. Response equations computed on the basis of grain yield of wheat indicated that application of Zn in bread wheat variety HI 1544 showed its linear response ($Y = 5.465 + 0.045x^2$) but in durum wheat variety HI 8498 response was quadratic ($Y= 5.11 + 0.063x – 0.0084x^2$). Whereas, in case of B application both varieties response was recorded to be quadratic viz., HI 1544 ($Y= 5.48 + 0.435x – 0.135x^2$) ($Y= 5.21 + 0.405x – 0.135x^2$). Where Y is the grain yield of wheat in tonne per hectare and x is dose of respective nutrient in kg/ha. Based on above equations, maximum yield doses of Zinc and B for durum variety HI 8498 were worked out to be 7.50 and 1.5 kg/ha, respectively. Maximum yield dose of Boron was recorded to be 1.61 kg/ha for bread wheat variety HI 1544. Computation of maximum expected grain yield of wheat were HI 1544 with B application 5.83 t/ha and HI 8498 with Zn and B application should be 5.58 and 5.51 t/ha, respectively. The marginal rate of return analysis showed that what farmers can expect to gain as return for their investment when they decide to change from one practice to another. In present study, adoption of Zn and B nutrition in different wheat varieties implies a 124.4% rate of return in bread wheat variety HI 1544 at application of Zn @ 5.0 kg/ha and thereafter return was 91.2%, which was not acceptable to recommend (Table 1). Whereas, MRR value due to B application was higher 688.9% at 1.0 kg/ha and thereafter return was 126.7% at 2.0 kg B/ha, which is also above acceptable limit and can be

Table 1. Effect of Zn and B on the marginal rate of return of wheat varieties

Variety	HI 1544						HI 8498					
MRR Analysis	Zinc levels (kg/ha)			B levels (kg/ha)			Zinc levels (kg/ha)			B levels (kg/ha)		
	0	5.0	10.0	0	1.0	2.0	0	5.0	10.0	0	1.0	2.0
(A) Partial budget												
Average yield (kg/ha)	5456	5720	5900	5483	5780	5812	5114	5533	5527	5210	5481	5483
Adjusted yield (kg/ha)	4638	4862	5015	4661	4913	4940	4347	4703	4698	4428	4659	4661
Gross field benefits (Rs./ha)	69564	72930	75225	69908	73695	74103	65203	70546	70469	66427	69883	69908
Cost that vary (Rs./ha)	0	1200	2400	0	180	360	0	1200	2400	0	180	360
Cost of application (Rs./ha)	0	300	300	0	300	300	0	300	300	0	300	300
Total cost that vary (Rs./ha)	0	1500	2700	0	480	660	0	1500	2700	0	480	660
Net benefits (Rs./ha)	69564	71430	72525	69908	73215	73443	6523	69046	67769	66427	69403	69248
(B) Marginal analysis												
Total cost that very	0	1500	2700	0	480	660	0	1500	2700	0	480	660
Marginal cost (Rs./ha)	0	1500	1200	0	480	180	0	1500	1200	0	480	360
Marginal benefits (Rs./ha)	0	1866	1095	0	3307	228	0	3842	-1276	0	2975	-154
MRR (%)	0	124.4	91.2	0	688.9	126.7	0	256.1	-106.4	0	619.8	-85.8

Note: Net price of wheat grain – Rs. 15/kg, Labour wage – Rs. 300/- per man-day, yield adjustment 15% and acceptable minimum rate of return – 100%.

recommended for farmers practice. In case of durum wheat variety HI 8498, both nutrients application implies a higher rate of return viz., 256.1% with Zn @ 5.0 kg/ha and 619.8% with B @ 1.0 kg/ha, and thereafter higher doses of nutrients recorded values lower even in negative than acceptable limit of 100% (Zn -106.4% @ 10 kg/ha and B -85.8% @ 2.0kg/ha). Due to that higher doses of Zn and B in durum wheat varieties are not safe for farmers' recommendation.

CONCLUSION

Overall concluded that on the basis of marginal rate of return application of Zn @5.0 kg and B 2.0 kg/ha in bread wheat variety HI 1544 and Zn @ 5.0 kg and B @ 1.0 kg/ha for durum wheat variety HI 8498 are economical doses and safe for farmers recommendation. However, Zn @ 7.5 kg/ha and B @ 1.61 kg/ha can also be considered for maximum productivity of wheat in vertisols of Central India.

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Effect of foliar application of plant nutrients on yield and economics of maize under rainfed condition

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Maize (*Zea mays* L.) is an important cereal crop of the world and has economic value in livestock. It is considered as one of the three important cereal crops in India and plays a fundamental role in human and animal feeding. Micronutrients are required in small amounts and they affect directly or indirectly photosynthesis, vital processes in plant such as respiration, protein synthesis, reproduction phase. Iron is a constituent of many enzymes involved in the nutritional metabolism of plant. Zinc plays an important role as a metal component of enzymes (superoxide dismutase, carbonic anhydrase and RNA polymerase) or as a functional, structural, or regulator cofactor of a large number of enzymes (Kabata-Pendias and Pendias, 1999). According to survey of soil analysis report of micronutrients project, the soils of North Gujarat agro-climatic zone are found deficient in Fe (55.0%), Zn (20.0%) and S (32.0%). Chlorosis is a common occurrence in maize due to deficiency of micronutrients like; Fe and Zn or macronutrients like; N and S deficiency. In order to correct the chlorosis in maize crop, foliar spray of Fe, Zn, S and N may found beneficial. So, to find out the effect of spray of micro and macro nutrients on maize yield and nutrients concentration. To balance nutrition in maize through inclusion of micronutrients. To increase the productivity of maize by correcting micronutrients deficiency.

METHODOLOGY

A field experiment was conducted during *kharif* 2010 to 2014 at the Maize Research Station, Khedbrahma, North Gujarat having semi-arid and sub-tropical climate. The soil of experimental field was medium black having low infiltration rate (0.64 cm/hr), maximum water holding capacity (66.6%) and also medium in organic carbon (0.26%), available N (160.0 kg/ha), whereas medium in available P_20_5 (30.4 kg/ha) and K_2O (201 kg/ha). The experiment was conducted with eight treatments viz., T_1: Water sprays, T_2: $ZnSO_4$ spray @ 0.5%, T_3: $ZnSO_4$ spray @ 1.0%, T_4: $FeSO_4$ spray @ 0.5% + citric acid @ 0.05%, T_5: $FeSO_4$ spray @ 1.0% + citric acid @ 0.05%, T_6: $ZnSO_4$ spray @ 0.5% + $FeSO_4$ spray @ 0.5%, T_7: Urea spray @ 1.5%, T_8: Ammonium sulphate spray @ 1.0% were replicated thrice with randomized block deign.

RESULTS

Foliar application of micronutrients influenced their significant effect on growth and yield of maize. The result revealed that the plant height, grain and fodder yields were affected significantly due to different treatments of foliar spay of micronutrients (Table 1). The highest plant height (190.7 cm), grain yield (1143 kg/ha) and fodder yield (3548 kg/ha) were recorded due to spraying of $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% in the pooled result, over rest of the treatments. The fodder yield of maize was at par with spraying of $ZnSO_4$ @ 0.5% and 1.0% solution. However, the lowest grain yield of maize was recorded in water sprays treatment. The similar findings shown as the synergetic role of micronutrients in improving plant growth and other biochemical and physiological activities by Mohsin *et al*., (2014). On the basis of pooled results the soil moisture and rain water use efficiency were not affected significantly, however foliar application of $ZnSO_4$ with $FeSO_4$ @ 0.5% each gave higher values of soil moisture content (4.37%) and RWUE (1.16 kg/ha.mm) as compared to remaining treatments. The results presented in table 2 showed that application of different foliar treatments had non-significant effect on soil available macro nutrients i.e. N, P_2O_5 and K_2O status in pooled. But the application of different foliar treatments had significant effect on available Fe and Zn contents in soil (Table 2). Significantly, higher Fe (5.10 ppm) and Zn (0.497 ppm) content in soil after harvest of the maize crop was recorded due to foliar sprays of $FeSO_4$ spray @ 1.0% + citric acid @ 0.05% and $ZnSO_4$ @ 1.0%, respectively. These results are in close conformity with those obtained by Saeed and Mohammad (2012).As far as economics is concerned, mean data showed that combined sprays of $FeSO_4$ @ 0.5% along with $ZnSO_4$ @ 0.5% recorded the maximum net return (Rs. 18074), as well as benefit cost ratio (2.99). It is concluded from the above discussion that maize can be grown on medium black soil being deficient in

Table 1. Effect of different treatments on yield of maize (Pooled of years 2010-2015)

Treatment	Plant height (cm)	Yields (kg/ha) Grain	Fodder	Soil moisture (%)	RWUE (kg/ha.mm)
T_1 Water sprays	156.0	797	2358	4.03	0.81
T_2 $ZnSO_4$ spray @ 0.5%	182.9	1016	3354	4.31	1.03
T_3 $ZnSO_4$ spray @ 1.0%	182.0	1062	3444	4.33	1.07
T_4 $FeSO_4$ spray @ 0.5% + citric acid @ 0.05%	174.5	993	3170	4.19	1.00
T_5 $FeSO_4$ spray @ 1.0% + citric acid @ 0.05%	182.5	1021	3191	4.26	1.03
T_6 $ZnSO_4$ spray @ 0.5% + $FeSO_4$ spray @ 0.5%	190.7	1143	3548	4.37	1.16
T_7 Urea spray @ 1.5 %	176.3	995	3133	4.19	1.01
T_8 Ammonium sulphate spray @ 1.0%	175.1	1016	3161	4.20	1.03
SEm$\pm$	2.4	21	73	0.11	
CD (P=0.05)	6.7	60	206	NS	
Year × Treatment					
SEm$\pm$	5.31	47	163	0.14	
CD (P=0.05)	NS	NS	NS	NS	

Table 2. Effect of different treatments on yield of maize (Pooled of years 2010-2015)

Treatment	Available nutrients status of soil				
	Macro (kg/ha)			Micro (ppm)	
	N	P_2O_5	K_2O	Fe	Zn
T_1 Water sprays	153.8	28.0	187.5	4.37	0.371
T_2 $ZnSO_4$ spray @ 0.5%	161.0	30.9	197.6	4.51	0.438
T_3 $ZnSO_4$ spray @ 1.0%	160.6	30.3	196.3	4.44	0.497
T_4 $FeSO_4$ spray @ 0.5% + citric acid @ 0.05%	167.7	31.8	204.5	4.81	0.439
T_5 $FeSO_4$ spray @ 1.0% + citric acid @ 0.05%	169.6	32.3	206.6	5.10	0.410
T_6 $ZnSO_4$ spray @ 0.5% + $FeSO_4$ spray @ 0.5%	167.8	31.7	201.2	4.68	0.459
T_7 Urea spray @ 1.5 %	174.6	33.6	212.4	4.48	0.428
T_8 Ammonium sulphate spray @ 1.0%	176.0	34.0	212.1	4.59	0.458
SEm$\pm$	5.3	0.97	8.6	0.06	0.011
CD (P=0.05)	NS	NS	NS	0.161	0.031
Year × Treatment					
SEm$\pm$	6.8	1.23	9.89	0.13	0.018
CD (P=0.05)	NS	NS	NS	0.36	0.056

Fe and Zn under rainfed condition of North Gujarat by apply three sprays of $FeSO_4$ @ 0.5% along with $ZnSO_4$ @ 0.5% (with 0.05 % citric acid and lime solution @ 0.25%) at 30, 40 and 50 DAS along with recommended dose of fertilizers (80+40 kg N, P_2O_5/ha) for getting higher grain and fodder yield as well as net monetary returns.

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Effect of major and micro nutrients on growth, seed yield, quality and uptake of nutrient status of clusterbean

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A field experiment was conducted to study the effect of major and micro nutrients on growth seed yield, quality and uptake of nutrients of clusterbean (*Cyamopsis tetragonoloba*) at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *rabi* 2014. Among the different levels of major and micro nutrients, application of N:P_2O_5:K_2O @ 20:50:50 kg/ha and $ZnSO_4$:$FeSO_4$ @ 10:10 kg/ha recorded significantly higher plant height, leaf area index, total dry matter at harvest, seed yield, stalk yield and harvest index compared to control and combined application of N:P_2O_5:K_2O @ 20:50:50 kg/ha + $ZnSO_4$:$FeSO_4$ @ 10:10 kg/ha significantly increased the uptake of nitrogen, phosphorus, potassium, zinc and iron over control. Similarly application of N: P_2O_5: K_2O @ 20:50:50 kg/ha and $ZnSO_4$:$FeSO_4$ @ 10:10 kg/ha recorded higher protein per cent and crude gum. Higher gross return (₹ 42,460), net return (19,047) and B: C ratio (1.81) was recorded with the nutrient combination of N, P_2O_5, K_2O @ 20, 50, 50 kg/ha and $FeSO_4$, $ZnSO_4$ @ 10, 10 kg/ha.

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Performance of hybrid maize (*Zea mays*) under varying phosphorus and potassium Levels

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Maize (*Zea may* L.) is one of the most important crop and widely cultivated throughout the country. It is an important for its versatility of adoption under wide range of agro-climatic conditions. Currently maize is cultivated over 9.23 m ha area with 23.67 m t production with average yield of 2.56 t/ha (Govt. of India, 2015).The maize production has shown a remarkable increase which is mainly associated with significant genetic enhancement from the area of open pollinated composite breeding to double and three way hybrids and recent development in single cross hybrids. These hybrids are nutrient exhaustive and require very high dose of the nutrients (Singh, 2010). Amongst nutrients, next to nitrogen, phosphorus is of paramount importance in plant system. P stimulates early root development and essential for energy transfer in living cells by mean of high energy. Phosphate bonds of ATP which are unstable in water and act as carrier for vital reactions like oxidation of sugars through enhancing enzymatic activities and in initial reaction of photosynthesis and respiration of plants. Alike this potassium is another important primary nutrient as it activates many enzyme in plant systems, maintains turgor, reduces water loss, aids in photosynthesis and food formation, enhances translocation of sugars and starch, produces grain rich in starch and protect crop against biotic and abiotic stresses. The phosphorus and potassium recommendation for maize developed by researchers is based on crop responses over large areas. These recommendations are periodically revised, although the periodicity may be as long as 5 to 10 years. This often results in over or under fertilization leading to yield and economic losses. Thus considering these facts and paucity of research findings on these aspects in south-east Rajasthan.

METHODOLOGY

The field experiment was carried out during *kharif* 2015 at the Instructional Farm, Rajasthan College of Agriculture, Udaipur, which is situated at 23°34'N latitude and 73°42'E longitude at an altitude of 582.17 meter above the mean sea level. The soil of the experiment site was clay loam having pH 7.5, organic carbon 0.66, available nitrogen 271.4 kg/ha, phosphorus 19.5 kg/ha and potassium 365.5 kg/ha in the plough layer. The well distributed rainfall of 542.0 mm was recorded during crop growth period. The treatment consisted combinations of four phosphorus levels (30, 45, 60 and 75 kg K_2O/ha) and four potassium levels (30, 40, 50 and 60 kg K_2O/ha). These sixteen treatment combinations were evaluated under factorial randomized block design with three replications. Maize hybrid "Pratap Hybrid Makka-3" released by MPUAT, Udaipur was used as test variety. The crop were sown manually on 7th July, 2015 by placing two seeds at a depth of 5-6 cm maintaining rows and plants spacing at 60 x 25 cm, respectively. The experimental plot size was 15 m^2. Thinning was carried out at 15 days after sowing to maintain required plant population. Phosphorus and potassium were applied as basal, through DAP and MOP as per treatments, whereas recommended nitrogen (90 kg/ha) was applied in 3 equal splits viz., 1/3 as basal, 1/3 at knee high stage and remaining 1/3 at initiation of tassel stage. In order to minimize weed competition, pre-emergence application of atrazine at 0.5 kg/ha followed by one hoeing and earthing up at 20 days after sowing was carried out.

RESULTS

Significant improvement in growth, yield attributes and yield appears to be on account of enrichment of soil with P along with N to the level of sufficiency through synergistic interactions between these nutrients. These improvements might have contributed to higher root growth and its proliferation which help in better uptake of required nutrient from soil. The improvement in the nutrient status of plant (P and N) resulted in better availability of nutrient for growth and development of the plant right from early stage which promoted improvement in these parameters. Likewise the plant height, dry matter accumulation and LAI increased significantly by applying 40 kg K_2O/ha over 30 kg K_2O/ha. Days to 50 per cent silking failed to record significant variation under increasing K_2O levels. Increasing K_2O level from 30 to 40 kg K_2O/ha significantly increased CGR between 30 to 60 days after sowing. The K_2O levels had no significant bearing on RGR between 60 days after sowing to harvest. Application of 40 kg K_2O/ha improved the yield attributing characters *viz.,* grains/cob, test weight, shelling percentage and length of cob consequently grain, stover, biological yields, N, P, and K up take and protein content of grain and stover over preceding K_2O level and proved economically profitable. In plant system potassium act primarily as catalytic in nature. The enzyme activation is regarded as potassium's single most important function and these enzymes are involved in so many plant physiological process. Further potassium provide much of the osmotic "Pull" that draws water in plant roots thus make full use of water and withstand water stress and plays an important role in photosynthesis. Potassium plays special role in activating various metabolites like chlorophyll, enzymes, hormones and these metabolites influence various other secondary physiological process which in turn affect growth and productivity of plant and also protect them against biotic and abiotic stresses.

Table 1. Effect of phosphorus level and potassium level on growth, yield attributes, yield and economics

Treatment	DM at 60 DAS (g/plant)	LAI at 60 DAS	CGR30-60 DAS	RGR30-60 DAS	Length of cob (cm)	Yield (t/ha) Grain	Yield (t/ha) Stover	Net returns (₹/ha)
P_2O_5 kg/ha								
30	68.2	2.56	14.15	0.091	15.13	2.97	4.56	24753
45	83.4	2.89	17.01	0.100	17.03	3.46	5.32	31593
60	95.7	3.08	19.29	0.105	18.68	3.96	6.10	38593
75	96.6	3.08	19.50	0.105	18.91	3.99	6.17	38408
SEm±	0.50	0.02	0.11	0.003	0.11	0.03	0.05	472
CD (P = 0.05)	1.46	0.05	0.32	0.008	0.32	0.09	0.14	1364
K_2O kg/ha								
30	75.5	2.63	15.56	0.100	16.48	3.17	4.88	27020
40	88.6	2.99	17.95	0.100	17.75	3.69	5.68	34827
50	90.0	2.99	18.25	0.100	17.76	3.76	5.79	35812
60	89.8	3.00	18.20	0.101	17.76	3.76	5.80	35687
SEm±	0.50	0.02	0.11	0.003	0.11	0.03	0.05	472
CD (P = 0.05)	1.46	0.05	0.32	NS	0.32	0.09	0.14	1364

DM, Dry matter; LAI, Leaf area index; CGR, Crop growth rate (g/m^2/day); RGR, Relative growth rate (g/g/day)

CONCLUSION

It is therefore concluded that under prevailing agro climatic conditions maize hybrid fertilized with 60 kg P_2O_5/ha and 40 kg K_2O/ha proved most efficient and economically profitable.

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Response of semi *rabi* castor (*Ricinus communis*) to irrigation and nitrogen fertigation

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Castor (*Ricinus communis* L.) is non edible oil seed crop having high industrial importance due to presence of unique fatty acid and ricinoleic acid. The crop is grown mainly under irrigated condition. Nitrogen is another important input, which is essential for vegetative and reproductive growth of crop and is the most limiting nutrient in our soil. The judicious use of fertilizer is necessary to boost up the efficiency of applied nutrients. The castor crop gives good response to nitrogen application, as it is long duration crop. Fertigation through drip system of irrigation, if applied in more splits, save fertilizer and give good fertilizer use efficiency, as it is applied in the root zone only with omission of leaching. Nitrogen levels for optimising the castor yield is to be worked out with the objectives to determine irrigation schedule of drip system to enhance yields of semi *rabi* castor; to find out optimum dose of nitrogen for higher production through fertigation in semi *rabi* castor; to study the interaction effect of drip irrigation schedule and nitrogen fertigation in semi *rabi* castor and to work out economics of different treatments/combinations.

METHODOLOGY

An experiment was conducted during semi rabi seasons of 2013-14 and 2014-15 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha (North Gujarat) to study “Response of semi *rabi* castor (*Ricinus communis* L.) to irrigation and nitrogen fertigation”. Castor variety GCH 7 was used as a test crop. The soil of experimental field was loamy sand having good drainage capacity. It was low in organic carbon (0.27 %) and available nitrogen (161 kg/ha), medium in available phosphorus (36.7 kg/ha), sulphur (10.51 ppm) but high in available potash (284 kg/ha). This zone is characterized by semi-arid climate with extreme cold winter and hot and dry windy summer. The experiment was laid out in split plot design with four replications.The treatments comprised of four schedules of irrigation (0.6 ADFPE, 0.8 ADFPE, 1.0 ADFPE through drip system and surface method) and three levels of nitrogen fertigation (N_1: 50 % RDN, N_2: 75 % RDN and N_3: 100 % RDN (i.e. 80 kg/ha), thereby making twelve treatment combinations.

RESULTS

Significantly the highest test weight (30.29 g), seed yield (2553 kg/ha) and stalk (3024 kg/ha) were obtained under drip irrigation treatment at 1.0 ADFPE, while significantly the lowest test weight, seed yield and stalk were noticed under irrigation level I_1 on pooled basis but it remained at par with irrigation level I_4 (surface method). The magnitude of increase in seed yield under treatment 1.0 ADFPE was to the extent of 9.36 and 21.73 and 19.23% over treatment at 0.8 ADFPE, 0.6 ADFPE and surface method on pooled basi, respectively. The increase in seed yield under drip irrigation 1.0 ADFPE might be due to maintenance of adequate soil moisture status in the root zone which in turn helped plants to maintain better turgor pressure, thus utilized moisture as well as nutrients more efficiently from wetted area and ultimately enhanced vegetative as well as reproductive growth of the crop. Nitrogen application @ 100 per cent RD produced significantly the highest test weight, seed and stalk yields as compared to rest of the treatments. A perusal of data in Table 1 reflected the economics as influenced due to various irrigation schedules treatment. The drip irrigation schedules treatment 1.0 ADFPE earned the highest net realization (Rs. 66153/ ha) along with BCR value of 2.97. This might be due to

Table 1. Test weight, yields and economics as influenced by irrigation schedules and nitrogen fertigation in semi *rabi* castor

Treatment	Test weight (g)	Yield (t/ha) Seed	Stalk	Net realization (x 10^3 Rs./ha)	Benefit: cost ratio
Irrigation schedule (I)					
I_1: 0.6 ADFPE	26.33	2.00	2.54	47.58	2.55
I_2: 0.8 ADFPE	29.89	2.31	2.83	58.21	2.80
I_3: 1.0 ADFPE	30.23	2.55	3.02	66.15	2.97
I_4: Surface method	27.37	2.06	2.48	46.26	2.35
SEm±	0.65	0.058	0.053		
CD (P=0.05)	1.93	0.013	0.010		
Nitrogen fertigation (N)					
N_1: 50 % RDN	26.99	2.01	2.60	46.96	2.49
N_2: 75 % RDN	29.01	2.24	2.72	54.84	2.68
N_3: 100 % RDN	29.36	2.45	2.83	61.87	2.83
SEm±	0.41	0.040	0.039		
CD (P=0.05)	1.17	0.115	0.111		

higher cost of inputs. Benefit cost analysis (Table 1 further showed that net realization/ ha and BCR values increased with graded level of nitrogen fertigation. Treatment 100 % RDN accrued the highest net return of Rs. 61871/ha. With the BCR value of (2.83).While the lowest BCR value (2.49) was observed under treatment 50 per cent RDN.

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Impact of different crop establishment techniques with source of nutrients on growth and yield attributes of Karnataka Rice Hybrid-4

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Rice is most important cereal crop of India occupying largest acreage. The nutrient requirement of hybrid rice is very high. There is need to identify the suitable combinations of nutrient sources to get better yields and profits.

METHODOLOGY

A field experiment was conducted during rainy seasons of 2012 and 2013 at All India Co-ordinated Research Project on Rice (AICRP on Rice), Zonal Agricultural Research Station, V. C. Farm, Mandya to study the impact of different crop establishment techniques with source of nutrients on growth and yield attributes of Karnataka rice hybrid-4 (KRH-4).

RESULTS

Among different crop establishment techniques, system of rice intensification (SRI) recorded significantly higher growth attributes *viz.* plant height (109.43 cm, pooled over two years), number of leaves (73.38), number of tillers/hill (32.61), leaf area (2379 cm^2/hill), leaf area index (3.66), leaf area duration (91.72 days) and total dry matter accumulation (139.52 g/ hill) and yield attributes *viz.* panicle length (23.45 cm), panicle weight (4.84 g), 1000 grain weight (23.38 g), total number of tillers/hill (32.61), number of filled grains/panicle (240.11), number of chaffy grains/panicle (34.30), chaffy grain percentage (12.62 %), grain yield (8.55 t/ha) and straw yield (10.07 t/ha, pooled over two years) compared with conventional and aerobic technique of crop establishments. Among different source of nutrients, recommended dose of fertilizer (100 % N through neem coated urea) recorded higher growth attributes *viz.* plant height (110.23 cm, pooled over two years), number of leaves (69.60), number of tillers/ hill (31.16), leaf area (2234.5 cm^2/hill), leaf area index (3.44), leaf area duration (90.14 days) and total dry matter accumulation (119.06 g/hill) and yield attributes *viz.* panicle length (23.95 cm), panicle weight (4.83 g), 1000 grain weight (23.77 g), total number of tillers/hill (31.16), number of filled grains/panicle (245.58), number of chaffy grains/panicle (35.09), chaffy grain percentage (12.73 %), grain yield (8.4 t/ ha) and straw yield (9.82 t/ha, pooled over two years) compared with RDF (100 % N through Urea), 50 % N through paddy straw incorporation + 50 % N through Urea + Rec. P & K, 50 % N throughFYM + 50 % N through Urea + Rec. P & K and 50 % N through *In-situ* green manuring (Sunhemp) + 50 % N through Urea + Rec. P & K.

CONCLUSION

Different crop establishment techniques with source of nutrients did not shown any interaction effect on growth and yield attributes of KRH-4. Among different source of nutrients, recommended dose of fertilizer (100 % N through neem coated urea) recorded higher grain and straw yields as compared with RDF.

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Nutrient management for yield maximization in niger

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Niger [(*Guizotia obyssinica* (L.f) cass] is a popular oilseed crop of the tribals which contains 38 to 43% oil, 20% protein and 20% Sugar (This crop has potential to produce yields up to 600 kg/ha on the research farm with the adoption of improved varieties and production technologies. It can be grown with the use of negligible quantity of manures of fertilizers. It responds well to considerably higher quantity in balanced manner. Since, the adequate quantity of fertilizer application is unaffordable by the most of the niger growers. Hence, integrated nutrient management (INM) through various organic and biological sources appears to be an alternative for its proper nutrient management. The information pertaining to INM in Niger crop for the region is meagre. Hence the present investigation for assessment of niger crop as influenced by various sources of plant nutrients to (i) maximize the seed yield with use of enhancement fertilizer doses, (ii) To maximize the seed yield with the use of fertilizers and bio fertilizers, (iii) To maximize the seed yield with integrated use of fertilizers and organic manures.

METHODOLOGY

The field experiment was conducted during semi-rabi season of 2015 under irrigated production system. The soil of the experiment field was clay loam in texture. Twelve treatments consisting of different increased doses of chemical fertilizers integrated with the organic manures in different combinations (Table 1) were tested in randomised block

Table 1. Effect of integration of organic sources on seed yield, economics and oil yield, Jabalpur

Treatment	Seed yield (kg/ha)	NMR (Rs./ha)	B:C Ratio	Oil yield (kg/ha)
T_1- 100% RDF	466	8179	1.80	174
T_2- 125% RDF	501	9334	1.89	175
T_3- 150% RDF	529	10170	1.94	201
T_4- 100% RDF +PSB + Azotobacter	480	7824	1.69	182
T_5- 150% RDF+PSB + Azotobacter	508	8470	1.72	170
T_6- 100% RDF + 50% N through FYM	519	5945	1.42	190
T_7- 100% RDF + 50% N through vermi compost	530	8997	1.76	212
T_8- 100% RDF + 50% N through oil cake	525	8791	1.74	190
T_9 –100% RDF + 50% N through FYM (17%) + Vermicompost (17%) + oil cake (16%)	515	7525	1.60	199
T_{10} –100% RDF + 75% N through FYM (25%) + vermicompost (25%) + oil cake (25%)	535	7028	1.10	209
T_{11}–100% RDF + 100% N through FYM (34%) + vermicompost (33%) + oil cake (33%)	545	6129	1.41	182
T_{12} –100% RD F + FYM + vermicompost + oil cake(30:30:30% N, respectively) + Azotobacter + PSB	533	6163	1.43	212
CD (P=0.05)	29.4	1131.87	0.09	NS

design with three replications. Sowing of niger*cv.* IGPN 2004 was done on October 09, 2015 in rows 30 cm apart by using 5 kg seeds/ha at about depth of 3 cm. Treatment wise full quantity of phosphorous, potassium and 1/3rd quantity of N of RDF was applied as basal. Remaining 2/3rd quantity of N was top dressed at 30 day growth stage of crop. The required quantity of all organic manures viz.VC, FYM and NOC were applied before sowing by broadcast method and then well mixed in the soil. The crop was harvested on February 16, 2016. Data on yield attributing characters viz. capitula/plant, seeds/capitula and 1000 seed weight were recorded at harvesting. Then the seed and stover yields were recorded and harvest index was worked out. The oil content in seeds was estimated and oil yields were determined. Finally, economics of all treatments was estimated. Data recorded for various observations was statistically analysed and results were interpreted.The significant findings of the investigations are as under.

RESULTS

Themaximum seed yield of 545 kg/ha was recorded with application of T_{11}which was at par T_{10}, T_{12}, T_7 and T_3 (Table 1). The minimum seed yield of 466 kg/harecorded in T_1 was followed and at par to 480 kg/ha in T_4 and was significantly less than 501 kg/ha in T_2 [125% 1 4 2RDF].The maximum NMR of Rs 10170/ha in T_3 was at par to Rs 9344/ha in T_2 and significantly higher than the NMR of Rs 8997/ha in T_7 which was at par to Rs 8791/ha in T_8. The minimum NMR of Rs 5945/ha in T_1 was at par to Rs 6129/ha in T_{11}, Rs 6163/ ha in T_{12} and Rs 7028/ha in T_{10} the values being at par. The maximum B: C ratio of 1.94 in T_3 was at par to 1.89 in T_2 and significantly superior than 1.80 in T_1. The minimum B: C ratio of 1.41 in T_{11} was at par to 1.42 in T_6 and 1.43 in T_{12}.The mean oil yield was found to be unaffected by different treatments. The maximum oil yield of 212 kg/ha was recorded in T_7 and T_{12}. The minimum oil yield of 170 kg/ha was noted in T_5.

CONCLUSION

Nutrient management system as T_3-150% RDF is recommended for higher yield and remunerative production as this fetched the maximum NMR of Rs9096/ha and B: C ratio (1.63) in niger.

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Aqua-fertilization and Ethopian mustard + lentil intercropping on system productivity and water use efficiency under rainfed condition

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Compatibility of crops is the important factor in a successful rainfed intercropping systems and success of intercropping in rainfed areas rely on the selection of crops which competes for solar radiation, soil moisture and nutrients. The combination of a leguminous crop with a non-leguminous might be expected to produce more yields compared to sole cropping since their canopy architectures are different. Intercropping not only helps to solve the problem of pulses and oilseed production but also helps to bring additional income to farmers and numerically the land uses can be intensified. The potential of Ethopian mustard has not explored much in India and there is a need to cultivate this crop along with suitable cropping system, moisture and nutrient management to obtain higher yield.

METHODOLOGY

A field experiment was conducted during *rabi*season of 2012-13 on sandy loam soil under rainfed conditions with soil at IARI, New Delhi. The sandy loam soil had 210 kg/ha of alkaline $KMnO_4$ oxidizable–N, 14.0 kg/haavailable–P, 202 kg/ ha1 N NH_4OAc exchangeable–K and pH 7.2 (1:2.5 soil and water ratio). The experiment was laid–out in a split plot design with three replications for two years.

RESULTS

Results revealed that Intercropping of Ethiopian mustard with lentil resulted in significantly higher system productivity in terms of mustard equivalent yield, water productivity and system profitability compared to sole planting of mustard. Among aqua-fertilization treatments, application of 20,000 litres of water/ha proved significantly superior in terms of system productivity, water productivity and profitability over 15,000 litres of water/ha and dry sowing. With respect to nutrient management, significantly higher system productivity of 2.14 t/ha, water productivity of 9.76 kg/ha-mm and system profitability of INR 52,708/ha were recorded with

Table 1. Effect of Aqua-fertilization, intercropping system, and fertility levels on yields and net returns

Treatment	Mustard equivalent yield (t/ha)	Consumptive use (mm)	WUE (kg/ha-mm)	Net returns (INR/ha)
Cropping Systems				
Ethiopian mustard	1.77	210.7	8.40	43,890
Ethiopian mustard + Lentil	2.49	219.9	11.32	64,338
LSD (*P*=0.05)	0.09	-	0.84	2,700
Aqua-fertilizations				
Dry sowing (Traditional method)	1.29	207.2	6.23	29,490
15000 (liters water / ha)	1.69	218.6	7.73	40,042
20000 (liters water / ha)	1.93	220.1	8.77	46,669
LSD (*P*=0.05)	0.12	-	0.92	3,600
Fertility levels				
Control	1.07	208.4	5.13	22,890
30 Kg N + 20kg P_2O_5/ha	1.52	215.5	7.05	35,249
30 Kg N + 20 kg P_2O_5/ha + PSB	1.81	218.1	8.30	43,776
60 Kg N + 40 kg P_2O_5/ha	2.14	219.2	9.76	52,708
LSD (P=0.05)	0.13	-	0.96	3,645

application of 60 kg N + 40 kg P_2O_5/ha + PSB as compared to other fertility levels.

CONCLUSION

Overall, Ethiopian mustard + lentil intercropping system with aqua fertilization and nutrient management would be better option to sustain the productivity and profitability and to increase moisture use efficiency in rainfed condition.

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Studies on irrigation and fertigation levels on post kharif maize (*Zea mays*)

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There is great scope for increasing the productivity of maize by using advance agronomic package of practices. Precise use of water and nutrient is the key for increasing productivity and also for saving these important resources.

METHODOLOGY

In view of this the field trial was conducted during post *kharif,* 2015 on clay soil at experimental farm of AICRP on Irrigation Water Management, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra). The experiment was laid out in split plot design with three replications. The main plot treatments comprised of three irrigation levels viz., 0.6, 0.8 and 1.0 PE, while in sub plot treatment four fertigation levels viz., 100% RDF (150:75:75 NPK kg/ha) through drip, 75% RDF through drip, 50% RDF through drip, 100% RDF through soil application were executed.

RESULTS

Data pertaining to yield attributes indicated that yield attributing characters *viz*., average weight of cob, number of grains/cob, number of grain rows/cob and weight of grain/ plant were significantly influenced by different treatments of irrigation (Table 1). Amongst irrigation levels, 1.0 PE (I_1) recorded significantly higher values of above referred yield attributing characters over 0.6 PE (I_3) and was comparable with 0.8 PE (I_2). This might be due to the water stress under low PE which resulted in poor plant growth due to restriction imposed on nutrient translocation, photosynthesis and metabolic activities of plant system. All these above referred yield attributes were decreased with subsequent decrease in the level of irrigation. These findings are in close conformity with those of Bharti *et al*. (2007). Irrigation levels significantly

Table 1. Mean yield attribute, yields and harvest index of maize as influenced by various levels of irrigation and fertigation.

Treatment	No of grain/ cob	No of grain row/cob	Grain weight/ plant (gm)	Cob weight/ plant (gm)	Grain yield (kg/ha)	Fodder yield (kg/ha)	Biological yield (kg/ha)	Harvest index
Irrigation Levels								
I_1 at 1.0 PE	483.7	14.0	186.7	233.5	8845	12511	23199	38.1
I_2 at 0.8PE	451.6	13.1	174.3	218.1	8259	11815	21795	37.9
I_3 at 0.6PE	425.2	12.3	164.1	205.3	7775	11213	20609	37.7
SEm±	9.3	0.2	3.5	4.4	170	245	451	-
CD (P=0.05)	36.5	1.0	14.1	17.6	668	965	1772	-
Fertigation Levels								
F_1 at 100% RDF Through drip	488.1	14.1	188.4	235.7	8926	12653	23436	38.0
F_2 at 75% RDF Through drip	471.3	13.7	182.0	227.6	8619	12251	22624	38.0
F_3 at 50% RDF Through drip	415.0	12.0	160.2	200.4	7590	10928	20145	37.6
F_4 at 100% RDF Through soil	439.5	12.7	169.7	212.2	8038	11552	21265	37.8
SEm±	13.0	0.3	5.0	6.3	239	342	627	-
CD (P=0.05)	38.8	1.1	15.0	18.7	711	1016	1863	-
Interaction (I x F)								
SEm±	22.6	0.6	8.7	10.9	414	592	1086	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	-

influenced the grain yield of maize. Drip irrigation at 1.0 PE. (I_1) registered significantly higher grain yield of maize than 0.6 PE (I_3) and was at par with 0.8 PE (I_2) (Table 2). This might be attributed to better growth and yield attributes under 1.0 PE (I_1) compared to irrigation at lower PE values. These findings are in conformity with the findings of Ponnuswamy and Santhi (2008). Significantly higher fodder yield and biological yield was observed with irrigation at 1.0 PE (I_1) than irrigation at 0.6 PE (I_3), however, it was found comparable with 0.8 PE (I_2).Yield attributing characters of maize *viz*., average weight of cob, number of grains/cob, number of grain rows/cob and weight of grain/plant were differed statistically due to various fertigation levels (Table1). 100% RDF through drip (F_1) recorded significantly higher values of all above referred yield attributes over 100% RDF through soil application (F_4) and 50% RDF through fertigation (F_3), respectively. However, the treatment 100% RDF through fertigation (F_1) was at par with 75% RDF through fertigation (F_2) for all yield attributes. The lowest values of yield attributes were observed with 50% RDF through drip (F_3) and were at par with 100% RDF through soil application (F_4). This effect was obviously due to high efficiency and easy availability of plant nutrients through the water soluble fertilizers. As availability of source in respect of maize increased with the increase in level of fertigation, the production in sink in the crop also followed same trend. Significantly higher grain yield, fodder yield and biological yield was observed with 100% RDF through drip (F_1) than 100% RDF through soil (F_4) and 50% RDF through drip (F_3), however, it was found comparable with 75% RDF through drip (F_2).

CONCLUSION

It can be concluded from the results that in Marathwada region during post *kharif* season maize crop under drip should be irrigation at 1.0 PE and fertigated with 75 % RDF through drip (WSF) for obtaining higher grain and fodder yield, net returns. However, due to higher cost of water soluble fertilizers (4 times more than straight fertilizers), it is advisable that maize should be grown under drip irrigation with 1.0 PE and fertilized with 100 % RDF through soil application for getting maximum B : C ratio.

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Productivity, profitability and soil nutrient status of soybean-based cropping systems as influenced by nutrient management

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The widening gap between demand and supply of edible oil in the country has drawn attention of the agricultural researchers to increase the production of oilseeds. Among the oilseeds, soybean being a leguminous oilseed crop having wider adaptability fits well in any of existing cropping systems in India. Since there is very little scope for horizontal growth, only alternative left is vertical growth through increased productivity of the crop. Thus, cropping system approach in contrast to component approach encompasses wide-ranging issues related to overall productivity, economics, available resources and microenvironment at the farm level in holistic manner (Vyas *et al*., 2008). Secondly, Indian agriculture is continuously facing the problem of increase in fertilizer prices and imbalanced use of fertilizers. Integrated use of fertilizers, organic manure and biofertilizers along with residual fertility plays important role in maintaining soil health as well as raising productivity of the system (Kumar *et al*., 2009).

METHODOLOGY

A field experiment was conducted during *kharif*, *rabi* and summer seasons of 2011-12 and 2012-13 at the research farm of IARI, New Delhi. The soil was low in available nitrogen (157 kg/ha) and organic carbon (0.42%), medium in available phosphorus (14.2 kg/ha) and potassium (240 kg/ha). The treatments comprised of 4 cropping systems [soybean–wheat–fallow (S-–W–F), soybean–wheat–mungbean (S-–W–MB), soybean–chickpea–sorghum (Fodder) (S-–CP–FS) and soybean–potato–mungbean (S-–P–MB) and 5 nutrient sources *viz*., control, 100% RDF, 50% RDF + 50% RDN through FYM, 50% RDF + 25% RDN through FYM + biofertilizers and 25% RDF + 50% RDN through FYM + biofertilizers. The experiment was laid out in strip plot design and replicated thrice. Economic yield of the component crops were converted to soybean-equivalent yield (SEY), taking into accountthe prevailing minimum support price (MSP)/ market prices of the crop. System productivity was calculated by adding the SEY of the component crops.

Table 1. System productivity, economics, land use and production efficiencies of soybean-based cropping systems under different nutrient sources

Treatment	SEY (t/ha)	Gross returns (x10^3 Rs./ha)	Net returns (x10^3Rs./ha)	LUE (%)	PE (kg SEY /ha/day)	PE (Rs./ha/ day
Cropping system						
S-–W–F	4.89	119.5	78.8	70.6	19.0	306
S-–W–MB	5.46	145.0	91.1	88.4	17.0	283
S-–CP–FS	6.92	147.0	92.2	88.5	21.5	286
S-–P–MB	7.68	161.3	64.5	75.9	27.6	228
SEm±	0.04	–	0.4	–	–	–
CD (P=0.05)	0.13	–	1.3	–	–	–
Nutrient source						
Control	4.75	109.6	59.4	81.0	16.1	201
100% RDF	6.72	154.3	92.8	81.0	22.8	315
50% RDF + 50% RDN-FYM	6.79	155.5	87.6	81.0	23.0	297
50% RDF + 25% RDN-FYM + bio.	6.40	146.7	84.1	81.0	21.7	285
25% RDF +50% RDN- FYM + bio.	6.53	150.0	84.4	81.0	22.2	286
SEm±	0.09	–	2.7	–	–	–
CD (P=0.05)	0.28	–	8.9	–	–	–

RESULTS

System productivity of soybean-based cropping system in terms of soybean-equivalent yield (SEY) and gross returns was significantly higher under soybean–potato–mungbean system (7.61 t/ha and 161.3 x10$^{3\,1}$ ./ha). Soybean–chickpea–fodder sorghum system expressed maximum. Soybean–wheat–fallow gave lowest LUE as no summer crop was grown in this system. Soybean–potato–mungbean system registered highest production efficiency (PE) based on SEY. The higher system productivity and net returns with relatively shorter duration of system increased the PE under soybean–potato–mungbean system (Table 1). The status of nutrients in soil after two years cropping cycle revealed that the available nitrogen and phosphorus contents of soil were significantly highest after soybean–wheat–mungbean and soybean–potato–mungbean systems, which were significantly superior to soybean–chickpea–fodder sorghum and soybean–wheat–-fallow systems.Among the nutrient sources, application of 50% RDF + 50% RDN through FYM registered significantly highest SEY (6.79 t/ha). The significantly highest system net returns were obtained under 100% RDF (92.8 x10$^{3\,1}$ /ha) which remained statistically similar to substitution of 50% RDN through FYM (87.6 x10$^{3\,1}$ ./ha).Application of 50% RDF + 50% RDN through FYM and 100% RDF recorded highest PE in terms of SEY and monetary returns. The higher system productivity and returns under these treatments corresponded with higher PE. Significantly maximum contents of available nitrogen, phosphorus and potassium in soilafter two years cropping cycle were recorded with the application of 50% RDF + 50% RDN through FYM followed by 25% RDF + 50% RDN through FYM + biofertilizers.Slow release of N from FYM, positive balance of SOC and increased availability of N by biofertilizers might have increased the N status of soil under FYM and biofertilizer integrated treatments. The addition of FYM increased Olsen-P because of its P content and possibly by increasing retention of P in soil through release of various organic acid and CO_2 during process of decomposition of organic matter.

CONCLUSION

Soybean–potato–mungbean cropping system was found to be most productive and remunerative. Among the nutrient sources application of 50% RDF + 50% RDN through FYM could sustain the productivity of systems besides improving the soil nutrient availability as compared to 100% RDF alone.

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Scheduling of nitrogen fertilization in spring maize in North East Haryana

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Maize (*Zea mays*) is one of the major cereal crops with wide adaptability to diverse agro-climatic conditions around the world. Maize is cultivated throughout the year in all the states of India for various purposes including grain, fodder, green cobs, sweet corn, baby corn and popcorn. Predominantly maize is grown as rainfed crop and its productivity is higher than rice which is mainly grown under assured irrigation conditions. In rice-wheat cropping system areas of North east Haryana, the water table is going down mainly because of cultivation of summer puddled transplanted rice. Haryana government has banned the cultivation of summer rice which is generally grown during the water scarcity period of April-June. By introducing spring maize, problem of declining water table can be solved to some extent. Haryana state has an ample scope to increase its acreage and productivity. However, the package of practices for spring maize cultivation in Haryana is not worked out. It is well known that fertilizer management especially nitrogen is one of the most important factors that affect the growth and yield of crop plants including maize. Hence, there is an urgent need to develop package of practices of spring maize for Haryana. The present study was therefore, aimed at to evaluate the dose and time of nitrogen application on growth, yield and quality of spring maize.

METHODOLOGY

A field experiment was conducted at CCS Haryana Agricultural University, Regional Research Station, Karnal, India during spring seasons of 2013 and 2014. The experiment was laid out in strip plot design with three replications. The treatments comprised of four dose of nitrogen (150, 165, 180 and 195 kg/ha) and four times of nitrogen applications viz., 50% at sowing+ 25% at 8 leaf + 25% at tassel initiation, 25% each at sowing+ 4 leaves + 8 leaf + silking, 20% at sowing+ 30% at 6 leaf + 40% at flowering + 10% at grain formation and 20% at 2 leaf+ 30% at 6 leaf + 40% at tassel initiation + 10% at grain formation. A uniform basal dose of 60 kg/ha P_2O_5 and 60 kg/ha K_2O was applied at sowing time. Soil of experimental plot was clay loam in texture, slightly alkaline in reaction, low in available nitrogen and phosphorus and high in available potassium. Quality protein single cross maize hybrid, HQPM-1 was sown by manual dibbling of seeds on 5 March in 2013 and 10 March in 2014 on ridges 60 cm apart with a plant to plant distance of 20 cm by using 20 kg seed/ha. The crop was sprayed with carbaryl @ 2 g/litre of water 30 days after sowing to control shoot fly. Irrigation was scheduled based on the crop water requirement and gap in rainfall. To supplement the rainfall five and three irrigations were given during 2013 and 2014, respectively.

RESULTS

The dose and the time of nitrogen application significantly influenced phenology, plant growth, yield and quality of spring maize. Application of higher doses of nitrogen (180 and 195 kg/ha) prolonged the reproductive period, while reverse was true for lower doses of nitrogen (150 and 165 kg/ha). Similarly application of nitrogen at in four splits, 20% at sowing+ 30% at 6 leaf + 40% at flowering + 10% at grain formation and 20% at 2 leaf+ 30% at 6 leaf +40% at tassel initiation + 10% at grain formation prolonged maturity period while application, 50% at sowing+ 25% at 8 leaf + 25% at tassel initiation, and 25% at each at sowing+ 4 leaf+ 8 leaf + silking shortened the maturity period. Higher dose of nitrogen application in later stages of maize increased cell division and cell enlargement so leaf longevity increased this delayed both tasseling and silking in maize. Maximum values of growth parameters such as plant height, total dry matter, CGR, RGR, NAR were recorded with application of 195 kg N/ha, which was statistically similar with 180 kg N/ha but significantly higher than 165 and 150 kg N/ha. The grain, straw and biological yield was recorded higher with the application of 195 and 180 kg N/ha when applied 25% each at sowing+ 4 leaf + 8 leaf + silking and 50% at sowing+ 25% at 8 leaf + 25% at tassel initiation as compared to remaining treatments. These results corroborated the findings of Wasaya*et al.* (2011) who reported that maize yield was increased with increasing nitrogen rate. A critical review of data showed that late or early application of nitrogen did not have positive effect probably due to lack of sufficient time for physiological, agronomic and nitrogen uptake activities. Quality parameters such as lysine, tryptophan and protein content significantly improved with the increase in application of nitrogen, recorded maximum with 195 kg N/ha and minimum with 150 kg N/ha. Application of nitrogen at 20% at 2 leaf+ 30% at 6 leaf +40% at tassel initiation + 10% at grain formation significantly improved lysine, tryptophan and protein contents than application at 25% each at sowing+ 4 leaves + 8 leaf + silking and 50% at sowing+ 25% at 8 leaf + 25% at tassel initiation. Li *et al.* (2010) found that optimum dose of nitrogen was necessary for improving quality in maize.

CONCLUSION

The findings of the study concluded that application of 180 kg N/ha in three splits, i.e. 50% at sowing, 25% at 8 leaf and 25% at tassel initiation was found to be optimum to attain higher and economical production of spring maize.

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Customized fertilizer for balanced nutrient application

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Inadequate and imbalanced use of fertilizer nutrients, lack of integration with organic resources, non-availability of fertilizers/ manures in time, and outdated soil testing services are key issues related to nutrient management in post green-revolution India. As a result factor productivity for fertilizer nutrients is dwindling, fertilizer utilization efficiency is dismally poor, declining crop response and nutrient mining is prevalent; in spite of eight-fold increase in fertilizer use during the last forty years. About 57% of our land is under some form of degradation and multi-nutrient deficiency is more of an order than exception. Soil Health Mission program of GOI is expected to provide National level base data to reveal severity of the problem and at the same time it would provide opportunity to test new and innovative approaches in nutrient management. The objectives were to develop the customized fertilizers for the soils of western UP in selected districts for Paddy, Wheat, Sugarcane and Potato.

METHODOLOGY

Scientific principles for nutrient prescription to crops are for point application. Hence, the challenge is to apply such principles to handle variability in soil nutrient availability values in as large areas as a few districts. The approach for development of crop specific grades (nutrient contents and ratio) is elucidated below:*Selecting target area and crop:* As the fertilizer is both region and crop specific, one need is to first delineate the boundary conditions. Choice of crop was dependent on market research – which led us to choose potato, sugarcane paddy and wheat as the major crop in the western Uttar Pradesh for developing the customized fertilizer.*Building database:* As the customized fertilizer is crop and region specific, a detailed database for both soil (fertility) and crop (yield, nutrient requirement) was found imperative. In order to ensure uniform and intensive data points, we digitized the geo-referenced map of target area, and placed cross-grids of 0.05’ X 0.05’; which corresponded to 1 km x 1 km (approx.). Intersections of the grids formed the sampling points. Trained agronomists armed with GPS went to the specific locations and collected soil samples along with a questionnaire for collecting information on farmers’ practices. For crop sample, a 1-m^2 area was chosen at cross-grid and collected to analyze economic yield as well as nutrient uptake. The analytical data were fed to GIS platform for further treatment. Concept of Fertility Management ZonesTreatment of soil fertility data in GIS environment generated fertility-contours for each nutrient. Overlaying of such contours for N, P and K helped delineation of fertility management zones. Omission plot data were generated for NPK to quantify soil contribution.The analysis of secondary and micronutrients in soil helped to identify crucial ones for possible inclusion in customized fertilizers. In case of our target area for paddy-wheat, bajra-potato and sugarcane-sugarcane rotation Zn, B and S were found to be most crucial for CF; Fe might be the next candidate.*Establishment of Nutrient Requirement:* Crop analysis at grid samples established nutrient requirements (see below), while yield data helped us to assume realistic targeted yield for each crop. *Grade fixation for Customized Fertilizer:*Nutrient demand and soil fertility data were overlaid. Various approaches like STCR, QUEFTS, Nutrient Manageretcwere studied to arrive at possible grades. Prescription for secondary and micronutrients were primarily based on response curve along with reported critical limits.Various experimental grades were formed and were subjected to large scale agronomic response trials in all the soil fertility management zones.

RESULTS

In order to validate the concept of customized fertilizers experiments were conducted on sugarcane, paddy, potato and wheat at various locations in the defined geography of western UP and the results have confirmed yield increase varying from 8 to 23% over current farmer practice in different crops, marginal B:C ratio was 2 or more against benchmark of best practice and SGR. Current commercial gradesimproved Partial factor productivity for all the major nutrients in most of the cases.Tata Chemicals started sale of customized fertilizer in in the year 2010 and till March 2016 achieved a figure of 143895MT in four different crops. The sale hadhelped in adoption of balance fertilization approach in a large area which otherwise was very difficult to reach by the extension agencies through one to one contact and by promoting the application of fertilizers based on soil health reports. Customized fertilizers lead to improvisation of microbial population in soils of rice –wheat cropping system as reported by SK Singh *et al*. (2016).

Table 1. Customized fertilizers sale (MT) and touch points

Grade	Sale of CF from 2010-2016 Total	Rate of application (kg/ha)	Area under CF application (ha)	Average Land Holding of growers in UP (ha)	No. of farmers reached adopted CF or balance fertilisation
Paddy	27065	250	108261	1.5	72174
Potato	51255	625	82008	2	41004
Sugarcane	48039	500	96077	2	48039
Wheat	17537	250	70146	1.5	46764
Total	143895				207981

CONCLUSION

Customized fertilizers provided all-in-one easy-to-use solution for farmers; increases yield and improves farm income; decreases soil mining; and ensures uniform distribution of micronutrients. Customized Fertilizers has a great potential to improve soil health and microbial population in longer term; specifically so if applied in integration with organic nutrient sources.

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Response of rice crop to nitrogen applied through nano clay polymer composites

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INTRODUCTION

Nitrogen (N) is an essential element for the growth and development of plants.It is a crucial component of chlorophyll, amino acids, proteins, ATP (adenosine triphosphate), nucleic acids such as DNA, etc.Thus, it plays many important roles in plant. It is a critical input in crop production. Therefore application of nitrogenous fertilizers is mandatory for optimum crop yield. But the applied fertilizers are lost through various processes viz. gentrification, leaching, volatilization etc., which results into very low use efficiency of applied N fertilizers, barely exceeds 30–35% in the year of its application. Therefore, developing a controlled release technology will be helpful in increasing nitrogen use efficiency (NUE) by minimizing its loss and synchronizing the N release with different crop growth stage. In this context, the use of nanoclay polymer composites (NCPC) as a slow release carrier of nutrients and some other agrochemicals. In the present investigation, we have used NCPC as a slow release carrier of nitrogenous fertilizer. The aim of this study was to evaluate N loaded NCPC in enhancing NUE using rice as a test crop.

MATERIALS AND METHODS

A greenhouse experiment was conducted using rice as a test crop to assess the response of applied N loaded NCPCs. Treatment combinations consisted of control, 100% N applied through Urea, 50% N applied through NCPC and 100% N applied through NCPC.Recommended basal dose of P and K was also applied.Each treatment was replicated four times using a Completely Randomised Design. Fertilizer N was applied in 3 equal splits i.e. basal, active tilleringstage and panicle initiation stage. Riceseedlings (*cv.*PB-1402) were transplanted in the pots. The plants were harvested at maturity. After harvesting, grain, straw and respective soil samples were collected. After proper processing N content in grain and straw was determined. Available N content was also estimated in post harvest soil samples.

RESULTS AND DISCUSSION

Results indicated that the highest available N in soil was recorded in 100% N application through NCPC, which was at par with 100% N application through urea. Interestingly, 50% N application through NCPC was statistically at par with

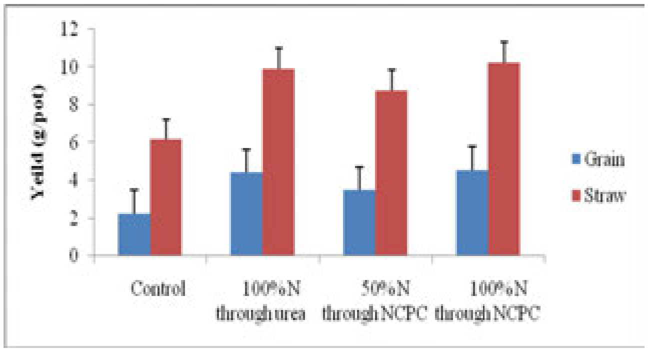

Fig. 1. Effect of applied N loaded NCPC on yield of rice

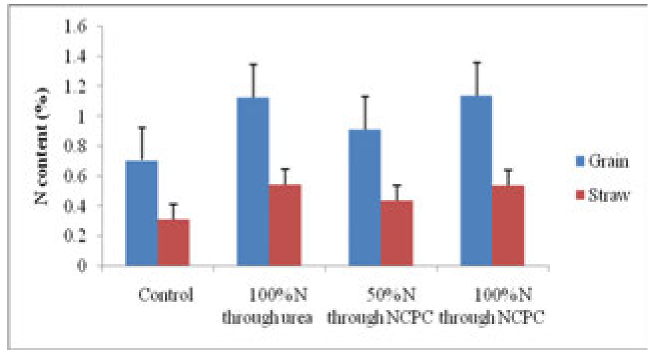

Fig. 1. Effect of applied N loaded NCPC on N content in grain and straw of rice

100% N application through Urea. This indicates that half of recommended dose of N applied through NCPC is equally capable of maintaining high available N in soil with full dose applied through Urea. Similarly, the half dose of N applied through NCPC was equally effective with full dose of N applied through Urea as far as grain and straw yield and N content in grain and straw were concerned. (Fig. 1 and 2).

CONCLUSION

Nitrogen loaded NCPC has potential of enhancing use efficiency of applied N leading to curtailing the dose of costly nitrogenous fertilizers.

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Response of cotton (*Gossypium hirsute*) cultivar H-1098(i) to different spacing and nitrogen doses

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Cotton (*Gossypium hirsutum* L.) is important cash, commercial and natural fibre crop of India as cotton plays a key role in Indian farming and textile industry. Therefore, cotton is considered as a major agricultural commodity sustaining Indian economy. In India, cotton was cultivated on an area of 11.8 million ha with a production of 26.8 million bales and average productivity of 494 kg/ha (Anonymous, 2016). The productivity is still lower as compared to countries like Australia (1910 kg/ha), Brazil (1536 kg/ha) and China (1524 kg/ha). Thus, there is a need to increase its yields through adoption of suitable agronomic practices like maintenance of suitable plant density, use of optimum nitrogen dose along with other agronomic practices. The yield and its components vary with fertilizer application under various spacing. Keeping in view the above facts, the present investigation was planned to find out the optimum spacing and nitrogen doses for achieving high yield of cotton cultivar H-1098(i).

METHODOLOGY

An experiment was conducted at cotton research station, Sirsa, CCS Haryana Agricultural University during *kharif* season 2015. The experiment consisting of four spacing *viz.* S1= 67.5 cm x 10 cm, S2= 67.5 cm x 15 cm, S3= 67.5 cm x 22.5 cm and S4= 67.5 cm x 30 cm in main plot and four nitrogen levels (N1= 75% Recommended dose (RD), N2= 100% RD, N3= 125%, and N4= 150% RD) in sub plots, was laid out in split plot design and replicated three times. Recommended dose of nitrogen was 87.5 kg/ha. The soil of the experimental field was loamy sand in texture having alkaline pH (8.5), EC (0.56 dS/m). The organic carbon (0.35%) and available nitrogen (137 kg/ha) was low in the experiment field. The dose

Table 1. Number of bolls/plant and yield (kg/ha) of cotton as influenced by spacing and nitrogen doses

Treatment	Number of Bolls/plant	Seed cotton yield (g/plant)	Seed cotton yield (kg/ha)	Stick yield (kg/ha)	Biological yield (kg/ha)
Main plot: Spacing (row x plant)					
S1: 67.5 cm x 10 cm	7.4	22.3	2205	10314	12519
S2: 67.5 cm x 15 cm	13.7	35.6	2438	9023	11461
S3: 67.5 cm x 22.5 cm	15.1	43.3	2073	8346	10419
S4: 67.5 cm x 30 cm	17.0	49.8	1971	7816	9788
CD(P=0.05)	1.2	4.9	222	521	611
Sub plot (Nitrogen level)					
N1: 75% of RDN	11.9	33.1	1888	8034	9922
N2: 100% of RDN	13.0	36.6	2127	8793	10921
N3: 125% of RDN	14.7	41.8	2354	9253	11608
N4: 150% of RDN	13.7	39.6	2318	9419	11737
CD(P=0.05)	0.9	2.6	167	487	485

of nitrogen in form of urea was applied in two equal splits at squaring and flowering stage. The data on number of bolls plant^{-1} and yield of cotton was recorded at final picking.

RESULTS

The data in Table 1 indicate that highest seed cotton yield (kg/ha) was obtained at closer spacing of 67.5 cm x 15 cm as compared to 67.5 cm x 10 cm, 67.5 cm x 22.5 cm and 67.5 cm x 30 cm whereas, number of bolls/plant and seed cotton yield/ plant were recorded higher with wider spacing of 67.5 cm x 30 cm spacing which was significantly more than rest of spacing. However, 67.5 cm x 10 cm spacing produced significantly higher stick yield (kg/ha) and biological yield (kg/ha) as compared to rest of treatments. The maximum number of bolls/plant, seed cotton yield/plant and seed cotton yield (kg/ ha) was recorded with 125% RD of nitrogen which was statistically at par with 150% RD but significantly higher than 75% and 100% RD of nitrogen. However, highest stick yield (kg/ha) and biological yield (kg/ha) was recorded with 150% RD of nitrogen which was at par with 125% RD of nitrogen but was significantly higher than 75% RD and 100% RD of nitrogen.

CONCLUSION

It may be concluded that cotton cultivar H-1098 (i) may be sown at spacing of 67.5 cm x 15 cm and fertilized with 125% RD of nitrogen (109. 37 kg N/ha) for achieving higher seed cotton yield (Kg/ha).

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Correlation of normalized difference vegetation index with leaf-nitrogen content and yield of maize (*Zea mays*) under adequate and deficit water and nitrogen conditions

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Maize (*Zea mays*) is the staple food for over 1200 million people in the world. Besides being consumed as human food, it is used as feed for cattle and for deriving many industrial products (Ghosh *et al*. 2016). India produces 24.2 mt maize grain from an area of 9.3 mha with a low average productivity of 2.60 t/ha owing to mismanagement of resources like water and nutrients. Maize requires heavy amount of N-fertilizers, which adds to the cost of production and also leads to heavy N-losses. Precise N scheduling by matching N-supply with in-season plant demand could be important solution to these problems. However, cconventional approaches of soil and plant analysis are costly, time consuming and require high level of skill and expertise, and often, N-deficiency cause the damages before N hunger is determined. The optical plant sensors like Green Seeker is capable of determining plant N-status, and scheduling N using this optical sensor has been shown to save 25–50% N without yield penalties (Bijay-Singh *et al.,* 2011). But, before use under field conditions, the sensor needs to be standardized for N-determination in maize plant, particularly under variable soil moisture-regimes. Thus the current investigation was carried out to study the effect of variable soil moisture regimes and N-rates on maize productivity and workout the correlation between NDVI values and leaf –content and between NDVI and grain yield.

METHODOLOGY

A field experiment was conducted during rainy (*kharif*) season 2015 at research farm of Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi**.** Soil (0–15cm) of the experimental site was sandy loam in texture with organic C 0.54%, and available N 216 kg/ha, phosphorus 16.7 kg/ha and potassium (245 kg K_2O/ha). The treatments comprised 3-irrigation regimes, irrigation at 25 and 75% depletion of available soil moisture (DASM), no-irrigation (rainfed) assigned to main-plots and 8-N rates (0, 40, 80, 120, 160, 200, 240 and 300 kg N/ha) to sub-plots. The experiment was laid-out in a three-time replicated split-plot design. Maize variety used was PEEHM 5. The NDVI measurements were taken with the Green Seeker™ Handheld Optical Sensor Unit (N Tech Industries, Inc., USA) in the central rows of all plots. Leaf N content and NDVI value were measured at three growth stages of maize *viz.* knee high stage (prior to N application and post N application), tasseling stage and maturity stage.

RESULTS

In general, leaf -N content was higher under ideal soil moisture condition (irrigation at 25% DASM) as compared to rainfed, at all the stages with maximum at tasseling stage and it declined at maturity uniformly for all the treatments. Among the N-application rates, the leaf N-increase with each increment of 40 kg N/ha, was found significant upto 120 kg N/ha at knee high (pre N top-dressing.), upto 160 kg/ha (post N top-dressing) and 200 kg N/ha at tasseling stage (2.39%). Grain yield was 27 and 82.9% higher with irrigation at 25% DASM compared to irrigation at 75% DASM and rainfed crop, respectively. Applying 160 kg N/ha returned the highest grain yield under water-stressed environment (irrigation at 75% DASM and rainfed crop), however under adequate irrigation, maize yield was the highest with 200 kg N/ha). Straw yield was the highest with the application of 240 kg N/ha (9.92 t/ha) that was 98.4% higher than control treatment. The highest harvest index was found at 80 kg N /ha among N treatments. The NDVI values that are indicative of leaf-N content and overall vigour of the plant, were found to be higher when irrigations were given at 25% DASM than other two moisture conditions. The NDVI at knee-high (Pre-N), increased from 0 to 120 kg N/ha, however at KH (post N topdressing) and tasseling increased significantly only upto 80 kg N/ha. Under all irrigation regimes, NDVI values were strongly correlated with leaf-N content at knee high stage prior to N-top-dressing with R^2 =0.81 (irrigation at 25% DASM), 0.75 (irrigation at 75% DASM) and 0.72 (rainfed crop), but at later stages with increase in water stress weakened the correlation. Top-dressing of N caused reduction in correlation rather than improving it (R^2=0.79 for irrigation at 25% DASM, 0.69 for irrigation at 75% DASM and 0.62 (for rainfed crop). The correlation again proved stronger at tasseling under sufficient soil moisture conditions and weaker under rainfed condition (R^2=0.84, 0.8 and 0.61, respectively). At tasseling stage NDVI showed better correlation with leaf N content as compared to knee high stage but it was strongly affected by the water stress and gave poor correlation in rainfed at both the stages. The highest correlation was found at tasseling under 25% DASM (R^2=0.81) and lowest at knee high stage under rainfed condition (R^2=0.34).

CONCLUSION

During initial stage (knee high), NDVI values measured using Green Seeker showed a strong correlation with leaf-N content prior to N-top-dressing. However at later stages, increase in water stress weakened the correlation. At initiation of tasseling, the correlation was stronger under sufficient soil moisture conditions and weaker under rainfed condition. These findings indicate that NDVI values can be used for real-time N-precise management in maize, particularly under adequate soil moisture conditions.

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Response of groundnut (*Arachis hypogaea*) to sulphur application under different land configuration in summer season

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The field investigation entitled "Response of groundnut (*Arachis hypogaea* L.) to sulphur application under different land configuration in summer season." was conducted at Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra during the *summer* season of 2015. The main objective of the experiment was to identify the suitable methods of groundnut cultivation for getting higher yield.The experimental field was leveled and well drain. The soil was medium black, clayey in texture, alkaline in reaction, low in available nitrogen, medium in phosphorous, rich in potash and low in available soil sulphur. The experiment was laid out in a Split plot design with 12 treatment combinations, comprised of three land configurations and four sulphur levels. The main plots treatments were viz. L_1- BBF, L_2- Ridges and Furrow and L_3- Flat bed and sulphur levels were 0 kg S/ha, 20 kg S/ha, 40 kg S/ha and 60 kg S/ha respectively. Each experimental unit was replicated three times. The net plot size 5.4 m x 4.8 m. Sowing was done by dibbling on 10^{th} February 2015 at spacing of 30 cm x 10 cm. The recommended dose of fertilizer (25:50:00 kg NPK/ha) was applied at the time of sowing through urea and DAP.The result from the experiment revealed that land configuration with BBF method recorded significantly higher growth and yield *viz.*, plant height (cm), number of branches, total dry matter (g), number of gynophores, number of pods/plant, dry pod kg/ha, haulm yield kg/ha, biological yield kg/ha, followed by Ridges and Furrow. Among the sulphur levels 60 kg and 40 kg sulphur were at negligible differences for all the above growth parameters and in case of yield parameters 40 kg sulphur was found to be significantly superior which was followed by 60 kg sulphur level as compared to the lower levels i.e. 0 kg sulphur and 20 kg sulphur level. Similarly higher economic benefits were recorded on BBF method among the other method (i.e. Ridges & Furrow and Flat Bed) and among sulphur level 40 kg sulphur/hawas found to give better benefit cost ratio. However, different land configuration and sulphur levels did not influence the quality attributes i.e. oil and protein content.

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Productivity and profitability of soybean (*Glycine max* L.) as influenced by tillage and nutrient sources under mid-hill conditions of Himachal Pradesh

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Soybean (*Glycine max* L.) is the second most important *Kharif* oilseed crop in Himachal Pradesh. India is the fifth largest producer of soybean in the world. It is the largest source of vegetable oil and protein in the world. It improves soil fertility by adding organic matter to the soil and fixing atmospheric nitrogen. The organic nutrient sources supply both macro and micro nutrients to the crops besides improving physical and chemical properties of soil. Tillage plays an important role in influencing growth, yield and crop's micro-environment. Conservation tillage decreases soil erosion, adds organic matter, improves soil and water quality, increases infiltration, decreases run-off and pollution,

Table 1. Effect of tillage, organic sources and fertility levels on yield attributes, yield and economics of soybean

Treatment	Pods/plant (number)	Seeds/pod (number)	Test weight (g) **	Seed yield (t/ha)	Productivity (kg/ha/day)	Profitability (¹ /ha/day)
Tillage						
Zero	59.00	2.50	131.93	1.72	11.95	48.05
Minimum	59.67	2.44	132.33	1.74	12.10	39.62
Conventional	60.67	2.56	133.90	1.78	12.33	35.70
SEm±	0.22	0.15	0.48	0.0068	0.05	1.46
CD(P=0.05)	0.68	NS	1.52	0.0214	0.15	4.93
Organic source						
Farm yard manure (10 t/ha)	59.48	2.30	132.35	1.73	12.00	72.00
Vermicompost (5 t/ ha)	60.07	2.70	133.10	1.76	12.25	10.25
SEm±	0.18	0.12	0.39	0.0055	0.04	1.28
CD(P=0.05)	0.56	0.38	NS	0.0175	0.12	4.02
Fertility level						
50 % of RDF*	58.17	2.28	132.08	1.68	11.70	36.36
75 % of RDF*	59.39	2.56	132.54	1.75	12.15	42.24
100 % of RDF*	61.78	2.67	133.55	1.80	12.52	44.78
SEm±	0.24	0.09	0.27	0.013	0.09	2.82
CD(P=0.05)	0.69	0.26	0.79	0.039	0.27	NS

*RDF- recommended dose of fertilizers ** 1000 seed weight

optimizes soil moisture, etc. Continuous use of inorganic nutrient sources (chemical fertilizers) results in poor crop productivity, profitability and soil health. Considering the above said facts, the present investigation was undertaken to study the effect of tillage and nutrient sources on soybean under mid-hill conditions of Himachal Pradesh.

METHODOLOGY

A field experiment was conducted during *Kharif* 2015 at Research Farm of the Department of Agronomy, Forages and Grassland Management, CSK HPKV, Palampur (32^o 06´ 39.1" N and 76^o 32´ 10.5" E and 1290 m amsl), Himachal Pradesh, India. The soil of the experimental site was silty clay loam in texture and acidic in reaction with 5.3 pH having 16.35g organic carbon/kg soil, 203.84 kg available N/ha, 33.6 kg available P/ha and 142.56 kg available K/ha. The weekly maximum and minimum temperature ranged from 13.06 °C to 32.39 °C and 3.50 °C to 21.89 °C, respectively. The mean relative humidity ranged from 52.43 % to 94.15 % and total of 1899.8 mm rainfall were received during the crop season. The experiment was laid out in split plot design with eighteen treatment combinations (3 tillage - zero, minimum and conventional, 2 organic sources- farm yard manure @10t/ha and vermicompost @5t/ha and 3 fertility levels - 50, 75 and 100 % of recommended dose of fertilizer (20:60:40 NPK kg/ ha). Treatments were randomly allocated in different experimental plots and replicated thrice. Soybean *cv.* Hara soya was used as test crop and it was sown at 45 cm inter-row spacing on 19th June, 2015 and harvested on 9th November, 2015. Other package of practices recommended for the region was also followed.

RESULTS

The highest number of pods/plant, test weight (1000 seed weight), seed yield and productivity was recorded in conventional tillage whereas the lowest was in the zero tillage except pods/plant and test weight which were significantly lower in zero tillage followed by minimum tillage. This might be due to better soil conditions and minimum weed growth in conventional tillage than no tillage. Safeer *et al.* (2013) also observed significantly higher number of seeds/pod, test weight and seed yieldin conventional tillage. Application of vermicompost resulted in significantly higher number of pods/plant, seeds/pod, seed yield and productivity than farm yard manure. Fertility levels affected the different yield parameters significantly. The highest pods/plants, test weight, seed yield and productivity was noted in 100% recommended dose of fertilizers whereas the lowest was in 50% of the recommended dose of fertilizer. This might be due to better availability of nutrients to the crop. Khaki *et al.* (2013) also observed the highest seeds/plant, filled pods/plant, 100-seed weight and, seed and straw yield with the application of 100% recommended dose of fertilizers. Profitability was significantly influenced by tillage and organic nutrient source. The highest profitability was recorded in zero tillage. This might be because of minimum power used for seed bed preparation. Farm yard manure resulted in significantly higher profitability than vermicompost. This was due to higher cost of vermicompost.

CONCLUSION

The experimental results indicated that vermicompost @5 ton/ha, 100 % recommended dose of chemical fertilizers and conventional tillage proved to be better treatments for getting higher productivity while farm yard manure @10 t/ha, 50 % recommended dose of chemical fertilizers and zero tillage were most profitable treatments.

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Effect of genotypes and fertility levels on yield and economics of multi-cut forage sorghum

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In India, there is a short supply of green fodder especially during summer season. Sorghum is an important crop widely grown for grain and forage. It is fast growing and warm weather annual which provides palatable, nutritious fodder during lean period and utilizes as silage and hay besides fresh fodder. Genetic factor plays vital role in increasing the fodder production and multi-cut ability reduces the cost of establishing new crops. During last few years, a number of high yielding multi-cut forage sorghum genotypes have been developed. The new multi-cut genotypes are heavy feeder of nutrients and remove large amount of nutrients from the soil (Sumeriya and Singh, 2014). These genotypes are responding well to high dose of fertilizer. Hence, identification of suitable genotypes for high fodder production at different levels of fertility can be worked out. Keeping this in view, the present investigation was carried out to find out suitable multicut genotype of sorghum for higher fodder production and its nutrient requirement and to assess economic viability.

METHODOLOGY

A field experiment was conducted during *Kharif* season of 2013 at Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan) situated at 24º35' N latitude, 74º42' E longitude and altitude of 579.5 m above mean sea level. The soil of the experimental field was sandy clay loam in texture, slightly alkaline in reaction (pH 8.2), medium in available nitrogen (295.30 kg /ha) and phosphorus (21.69 kg /ha), while high in available potassium (275.70 kg /ha). The experiment consisted of 28 treatment combinations comprising seven multi-cut forage sorghum genotypes (SPV 2242, SPH 1700, SSG 59-3, CSH 20 MF, CSH 24 MF, Mp Chari and CoFS-29) and four fertility levels *viz.,* 50 per cent recommended dose of fertilizer (RDF), 75 per cent RDF and 100 per cent RDF (80 kg N+40 kg P_2O_5+40 kg K_2O/ha). These treatments were tested in factorial randomized block design with three replications. The 1st and 2nd cuttings for green fodder were taken at 60 days after sowing, 45 days after 1st cuttings, respectively.

RESULTS

Green and dry fodder yield of multi-cut sorghum genotypes was significantly influenced by genotypes. The highest green and dry fodder yield at the time of 1st cutting was recorded in genotype SPH 1700 which was closely followed by genotype CSH 24 MF; however, this genotype significantly enhanced green and dry fodder yield over genotypes CSH 24 MF, CSH 20 MF, SSG 59-3, SPV 2242, CoFS-29 and MP Chari. While at 2nd cuttings, CoFS-29 recorded higher green and dry fodder yield which was significantly higher than rest of the genotypes under test except SPV 2242 *i.e*. at par with CoFS-29. Further genotype CoFS-29 produced highest total green (74.78 t/ha) and dry (23.77 t/ha) fodder yield registering significant increases of 8.72, 11.24 and 17.41 per cent in total green fodder yield and 8.78, 11.28 and 16.80 per cent in total dry fodder yield as over the genotypes CSH 24 MF, CSH 20 MF and MP Chari, respectively but was observed at par with genotypes SPV 2242, SSG 59-3 and SPH 1700. The highest fodder yield of genotype CoFS-29 could mainly be attributed to comparatively higher plant height, stem girth and ratoonability of genotype. Further genotype CoFS-29 fetched higher net returns (₹ 66430/ha) and B C ratio (2.15), which was found at par with genotypes SPV 2242, SSG 59-3 and SPH 1700. The genotype CoFS-29 registering significant in per cent increase of net returns by 17.35, 13.30 and 27.70 and B C ratio by 13.15, 17.48 and 27.97 per cent over genotypes CSH 20 MF, CSH 24 MF and MP Chari, respectively. Fertility levels had significant effect on green and dry fodder yield during 1st and 2nd cuttings. The crop fertilized with 125 per cent RDF produced higher green and dry fodder yield which was significantly higher than lower dose of fertilizer during 1st and 2nd cuttings. A significant increase of 35.52, 19.82 and 8.82 per cent in total green fodder and 45.13, 18.90 and 9.63 per cent in total dry fodder yield was recorded with the application of 125 per cent RDF over 50, 75 and 100 per cent RDF, respectively. The significant increase in fodder yield with increase in fertility levels was due to fact that all these nutrients were involved in increasing protoplasmic constituents, root, shoot growth and accelerating the process of cell division, enlargement and elongation which in turn showed luxuriant vegetative growth and resulted in higher green and dry fodder yield. Similar results were also obtained by Duhan (2013) and Sumeriya and Singh (2014). Thus, when compared to 50, 75 and 100 per cent RDF, the crop under the influence of 125 per cent RDF fetched highest net returns of 71814/ha and B C ratio of 2.23 registering significant increase in per cent of 51.12, 26 91 and 11.55 in net returns and 37.65, 19.25 and 8.25 in B C ratio, respectively.

CONCLUSION

Overall, among multi-cut forage genotypes, CoFS-29 proved most efficient as it gave significantly higher green, dry fodder yield on the basis of total of two cuts, net monetary returns of 66430 /ha and B C ratio 2.15. The crop fertilized with 125 per cent RDF recorded significantly higher green and dry fodder yield on the basis of total of two cuts over application of 50, 75 and 100 per cent RDF. Application of 125 per cent RDF also fetched highest net returns (71814 /ha) as well as maximum B C ratio (2.23) as compared to lower fertility levels.

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Effect of land configurations and fertilizer levels on sunflower productivity

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Sunflower (*Helianthus annuus* L.) oil is preferred among the consumers in India for its health benefits and sunflower oil is the largest selling oil in the branded oil segment. It is also a crop of choice for farmers due to its wider adaptability, high yield potential, shorter duration and profitability. However, the average productivity of 752 kg/ha and that of Maharashtra it is only 425 kg/ha (Anonymous, 2016). The low productivity of sunflower in Maharashtra is due to its cultivation mainly under rainfed conditions with sub optimal crop stand, imbalanced nutrition and lack of soil moisture conservation techniques, thus leading to poor seed set and high per cent of chaffy seed, low oil content and yield. The crops grown under rainfed condition are either subjected to excess water or water deficit condition. Intermittent dry spell of 10 to 15 days or even more are commonly observed affecting growth of the crop. Therefore it is necessary to reduce water loss from soil. Under rainfed conditions, response to the applied fertilizers varies with the available soil moisture. Hence, efficient soil moisture conservation is the key for successful crop production under this situation. Appropriate combination of land configuration along with fertilizer levels not only meets the crop nutrient requirements and sustain productivity but also improve soil health. Considering these facts the present study has been undertaken to study the effect of land configurations and nutrient levels to improve the productivity of sunflower.

METHODOLOGY

The present experiment on sunflower was conducted during *kharif* 2015 at Oilseed Research Unit farm, Dr. PDKV, Akola. The soil of experimental site was clay loam with pH of 8.1, electrical conductivity 0.32 dS/m, low in organic carbon

(0.38 %), low in available nitrogen (181.17 kg/ha) and phosphorus (14.12 kg/ha) and marginally high in available potassium (323.33 kg/ha). The experiment was laid out in split plot design consisting of twelve treatments combinations and replicated thrice. The main plots consisted of : L_1- Flat bed, L_2- Ridges and furrow, L_3- Paired row planting and L_4- Broad bed and furrow and the three fertilizer levels viz., F_1- 75% RDF, F_2- 100 % RDF(80:60:30 N, P_2O_5 and K_2O kg/ha) and F_3- 125 % RDFwere the sub plot treatments.The sunflower hybrid (DRSH-1) was sown on 7th August and harvested on 6th November, 2015. Full dose of P_2O_5 and K_2O along with half of the nitrogen in all the treatments was applied as basal. Remaining nitrogen was applied at 30 DAS as per the treatments. Need based plant protection measures were taken. The crop was grown completely under rainfed conditions. A total of 258.4 mm rainfall was received in 12 rainy days during the crop growth period.

RESULTS

The data presented in Table 1 revealed that, Significant effect on all the yield attributing characters and the yield except 100 seed weight and diameter of disc was observed with different land configurations.Among the land configurations, ridges and furrow recorded significantly higher yield attributes viz., filled seed, unfilled seed, seed yield/plant. Similarly, the same treatment found significantly superior in respect of seed yield (1.32t/ha)and straw yield/ha (3.29 t/ha) as compared to paired row planting and flat bed. However, it was at par with broad bed furrow method of planting in respect of the entire yield attributing character.Higher yield producing characters under ridges and furrow and broad bed furrow might be due to the adequate availability of soil moisture in these treatments as compared to flat bed planting and the paired row planting. These findings are in close accordance with Byomkesh*et al*. (2014) who recorded higher yield attributes with ridges and furrow method of planting.Significant differences in yield attributing characters and the yield of sunflower were observed due to different the fertilizer levels. Application of 125 % RDF recorded significantly higher yield attributing characters *viz*., diameter of disc, filled seed, seed yield/plant, 100 seed weight. Similarly, seed yield (1.37 t/ha) recorded by 125 % RDF was significantly higher over 100 % RDF (1.19 t/ha) and 75 % RDF (1.10 t/ha). This increase in seed yield with application of 125 % RDF was to the tune of 14.96 and 23.78 % over 100 % and 75 % RDF, respectively. Higher yield attributing characters and yield with application of 125 % RDF might be registered due tooverall better growth as well as yield attributes viz., more number of filled seeds and the 100 seed. Similar results were also reported by Paulpandi*et al*. (2008). Similar trend as that of seed yield was noticed in respect of straw yield and the biological yield.

CONCLUSION

Planting with ridges and furrow improved all the yield attributes and recorded the highest seed yield, straw yield and the biological yield. Application of 125 % RDF enhanced the yield attributes and registered significantly highest seed yield, straw yield and the biological yield of sunflower.

Table 1. Yield attributes of sunflower as influenced by land configuration and fertilizer level

Treatment	Diameter of disc	Filled seed	Seed yield/ plant (g)	100 seed weight (g)	Seed yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)
Main plot (Land configuration)							
L_1 -Flat bed	14.82	599	28.83	3.66	1.08	3.01	4.09
L_2-Ridges and furrows	15.44	758	35.14	3.95	1.32	3.29	4.63
L_3-Paired row planting	15.21	685	29.44	3.78	1.21	3.18	4.35
L_4 -Broad bed furrow	15.37	729	S32.00	3.87	1.27	3.22	4.50
SEm±	0.35	18	1.00	0.17	.028	.053	.074
CD (P=0.05)	NS	64	3.46	NS	.097	.018	.026
Sub-plot (fertilizer levels)							
N_1	-75% RDF	14.68	625	28.60	3.70	1.10	2.99
4.10							
N_2	-100% RDF	15.06	705	31.30	3.56	1.19	3.13
4.31							
N_3	-125% RDF	15.89	749	34.17	4.18	1.37	3.40
4.77							
SEm±	0.31	13	0.62	0.15	.021	.040	.055
CD (P=0.05)	0.93	41	1.87	0.44	.063	.012	.016
Interaction (L x N)							
SEm±	0.062	28	1.27	0.29	.042	.082	.011
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

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Effect of organic and inorganic source of nutrients on productivity and economics of basmati rice, in rice (*Oryza sativa* L.) - wheat (*Triticum aestivum* L.) cropping system

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With declining soil fertility farmers are forced to use more and more fertilizer per year to obtain optimum yield (Hobbs et al., 1990). The excessive and imbalanced use of inorganic fertilizers is reported to be the major constraint of declining productivity of the rice-wheat cropping system**.** For sustaining soil fertility and productivity of rice-wheat cropping system, it is important to apply chemical fertilizers in conjunction with organic source of soil nutrients viz. bio-solids consisting farm yard manure (FYM), crop residues, industrial and urban wastes in such a way that nutrient use efficiency, crop yield and net return could be maximized. Long term sustainability of rice-wheat cropping system could be better assured with the integrated use of chemical and organic sources of nutrients.

METHODOLOGY

A field experiment was conducted at the Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India which is situated at a latitude of 29^0 402 North and longitude of 77^0 422 East and at an altitude of 237 meter above mean sea level, during the rainy (June-October) season of 2013 on a sandy loam soil. The mean annual rainfall of Meerut is about 650 mm, of which nearly 80 per cent is received in the monsoon period from July to September. The soil of the experimental field had 155.40 kg/ha alkaline permanganate oxidizable nitrogen (N), 14.76 kg/ha available phosphorus (P), 139.82 kg/ha 1 N ammonium acetate exchangeable potassium (K) and 0.45% organic carbon. The pH of soil was 7.6 (1:2.5 soil and water ratio; Prasad et al., 2006).

Ten organic and inorganic fertilizers treatments viz. Control, 100% recommended dose of fertilizers (RDF), 125% RDF, 50% RDF + vermicompost (VC), 50% RDF + farm yard manure (FYM), 50% RDF + poultry manure (PM), 50% RDF + VC + FYM, 50% RDF + VC + PM, 50% RDF + FYM + PM and 50% RDF + FYM + PM + VC were laid out in a randomized block design with three replications.

The experimental field was disk-ploughed twice and levelled. A dose of nitrogen, phosphorus and potash were applied through Urea, di ammonium phosphate and muriate of potash to the entire plot except control as basal application. Top dressing of nitrogen was applied through urea as per treatment. The remaining 50% of nutrient through organic manure (FYM, VC and PM) were calculated on the basis of nutrient present in that particular organic manure. All the organic manure were applied and mixed in soil 15 days before the transplanting.

Data on plant height, effective tillers/hill, panicle length, grains/panicle, grain weight/panicle, 1,000-grain weight and grain and straw yields from different green manuring plots were recorded and measured separately. Data were analyzed using the F-test. Least significant difference (LSD) values at P = 0.05 were used to determine the significance of differences between treatment means.

RESULTS AND DISCUSSION

Growth, yield attributes and yields

Organic and inorganic fertilizers application increased all the growth characters, yield attributes, grain and straw yields over control. Plant height (cm) recorded at 30, 60, 90 and at harvest of crop growth increased with application of 125% RDF, over other organic and inorganic fertilizers treatments. The highest plant height at all stages was recorded with application of 125% RDF. An application of 125% RDF significantly increased effective tillers/hill, dry matter accumulation, number of panicles, filled grains/panicle and grain weight/panicle. However, 1,000-grain weight was not influenced significantly due to application of 125% RDF over others treatment. The highest values of all the yield attributes were recorded with 125% RDF. An application of 125% RDF produced significantly higher grain yield (4.56 t/ha) compare to all treatments except50% RDF + PM. The highest straw yield (6.49 t/ha) was obtained with 125 % RDF which was statistically at par with 100% RDF. Similarly biological yields were also significantly influenced due to application of 125% RDF.

Economics

Application of 125% RDF + VC gave the highest gross return than all other treatments whereas application of 125% RDF gave the highest net return than all treatments.

CONCLUSION

It is concluded that an application of 125% RDF recorded higher productivity and net returns from the transplanted basmati rice over other organic and inorganic treatments.

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Effect of vermicompost and zinc on mungbean

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Pulse crops play an important role in Indian agriculture and India is the largest producer and consumer of pulses in the world. Pulses contain high percentage of quality protein nearly three times as much as cereals (Upadhayay *et al*., 1999). Thus, they are cheaper source of protein to overcome malnutrition among human beings. The factors attributed for low yields of pulses in India are non- availability of quality seeds of improved and short duration varieties, growing of pulses under marginal and sub marginal soils with low inputs under rainfed conditions, poor pest and disease management, growing pulses under moisture stress, unscientific post harvest practices and storage conditions. Hence, there is scope to improve the productivity of pulses by growing them under assured rainfall, irrigated conditions, providing organic manures, inorganic fertilizers and bio-fertilizers and adopting integrated pest management practices. Vermicompost is a sustainable organics prepared from organic wastes using earthworms. It adds organic carbon to the soil and helps to release the nutrients slowly besides improving physico-chemical properties of the soil. It also acts as powerful biocide against diseases and nematodes. In many part of country, zinc deficiency is widespread and more serious on calcareous, organic matter deficient, arid and semi arid soils. Among micronutrients disorders, soils of arid and semi arid region may often test below the critical level of zinc availability. Hence, an experiment was undertaken to evaluate the effect of vermicompost and zinc on growth, yield and quality of mungbean.

METHODOLOGY

A field experiments was conducted during *kharif* season of 2014 at the Agronomy farm, S.K.N. College of Agriculture, Jobner (Jaipur) situated at a latitude of 26°05' North, longitude of 75°28' East, and 427 m above the mean sea level. The mean annual rainfall of Jobner is around 350 mm. The area falls in semi-arid eastern plain zone of Rajasthan. The soils of experimental site had 130 kg/ha available nitrogen, 16.52 kg/ha available P_2O_5 /ha, 151.8 kg/ha available K_2O and 0.14% organic carbon. The pH of the soil was 8.2 (1:2 soil water suspensions). The experiment was laid out in randomized block design with three replications, keeping four levels of vermicompost (control, 2, 4 and 6 t/ha) and four treatments of zinc (control, 2.5, 5.0, 7.5 kg/ha) thereby making sixteen treatment combination were tested. Mungbean variety RMG – 268 was sown at the rate of 20 kg/ ha as per treatments. The zinc was applied through zinc sulphate having 21% zinc.

Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash, respectively. To keep the crop free from weeds, one manual weeding and hoeing were done at 30 DAS.

RESULTS

Results indicated that application of 4 t/ha vermicompost remained at par with 6 t/ha and significantly increased plant height at 50 DAS and at harvest, dry matter accumulation at 25, 50 DAS and at harvest, number of branches per plant at 50 DAS and at harvest, relative growth rate at 25-50 DAS. leaf area index, crop growth rate at 25-50 DAS and 50-at harvest, total cholorophyll content at 40 DAS, pods/plant, seeds/pod and test weight, seed yield (1195 kg/ha), straw yield (2337 kg/ha) and biological yield (3532 kg/ha) over control and 2 t/ha. Significant increase in N, P, and Zn concentration and their uptake by seed and straw and protein content in seed and net returns over lower levels due to application of 4 t/ha vermicompost was also observed. Results further indicated that application of zinc @ 5 kg/ha significantly increased plant height at 50 DAS and at harvest, dry matter accumulation at 25, 50 DAS and at harvest, number of branches per plant at 50 DAS and at harvest, relative growth rate at 25-50 DAS, leaf area index, crop growth rate at 25-50 DAS and 50 DAS -at harvest, total chlorophyll content at 40 DAS, pods/plant, seeds/pod and test weight, seed yield (1169 kg/ha), straw yield (2292 kg/ha), and biological yield (3461 kg/ha) over control and 2.5 kg Zn/ha. Significant increase in N, P, and Zn concentration and their uptake by seed and straw and protein content in seed and net returns over control and 2.5 kg Zn/ha was also observed due to application of 4 t/ha vermicompost. However, application of 5 kg Zn/ha remained at par with 7.5 kg Zn/hawith respect to all parameters.

CONCLUSION

It is concluded that higher seed yield and net returns of mungbean could be obtained with the use of 4 t/ha vermicompost (1195 kg/ha and Rs 59,535/ha) and soil application of zinc @ 5 kg/ha (1169 kg/ha and Rs 60,624/ha) independently.

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Extended Summaries Vol. 2 : 4th International Agronomy Congress, Nov. 22–26, 2016, New Delhi, India

Split application of nitrogen in *kharif* maize (*Zeal mays* L.)

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Split and delayed basal fertilizer applications are possible strategies to improve the crop yield and reduce nutrient loss. This can improve nitrogen use efficiency. Split application reduces the risk of losses through leaching. Split application of nitrogen can increase grain yield and grain protein content.Split application is a N management strategy that will likely gain momentum in the next 5 to 10 years.Nitrogen is vital for most plant metabolic activities and plays an important role in tillering, stalk elongation and photosynthesis. Splitting nitrogen applications can have significant benefits if environmental conditions lead to poor nitrogen availability later in the growing season. High organic matter soils are able to mineralize large amounts of nitrogen quickly and make it available to the plant if needed.

METHODOLOGY

An experiment was carried out on Experimental farm of cotton research station,Vasantrao Naik Marathwada Agriculture University , Parbhani during kharif season 2015. Seven different times of nitrogen fertilizer application evaluated were 100% Nitrogen at sowing (T_1), 75%N at sowing +25%N at 30 DAS (T_2), 50%N at sowing +50% N at 30 DAS (T_3) , 25% N at sowing +75%N at 30 DAS (T_4) , 25%N at sowing +50% N at 30 DAS + 25% at 60 DAS (T_5), 33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS (T_6) and 25% N at sowing + 25%N at 30 DAS+ 25% at 60DAS +25% N at 60 DAS (T_7). A gross and net plot sizes of 6.0m X 5.4m and 4.8m X 4.6m, respectively were used for each sub plots. In each plot maize was planted at inter and intra row spacing of 60 cm and 30 cm, respectively. Data were collected on labour (man days) for fertilizer application, grain yield (kg/ha), plant height (cm), one thousand seed weight (g) and grain price.

RESULTS

Significantly higher grain yield was recorded under treatment (T_6) 33%N at sowing + 33%N at 30 DAS + 33% at

Table 1. Mean seed yield, straw yield, biological yield of maize as influenced by various treatments

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)
T1 –100% Nitrogen at sowing	2073	4592	6665
T2 –75%N at sowing +25%N at 30 DAS	2206	5365	7571
T3 – 50%N at sowing +50% N at 30 DAS	2296	5367	7663
T4 – *25% N at sowing +75%N at 30 DAS*	2303	5427	7730
T5 –25%N at sowing +50% N at 30 DAS + 25% at 60 DAS	2753	5774	8527
T6 – *33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS*	2950	6332	9282
T7 – 25% N at sowing + 25%N at 30 DAS+25% at 60DAS +25% N at 75 DAS	2599	5599	8198
CD (P=0.05)	458	671	802

Table 2. Gross monetary returns (GMR), net monetary returns (NMR) and benefit :cost (B:C)ratio as influenced by different treatments.

Treatment	GMR	NMR	B:C ratio
T1 –100% Nitrogen at sowing	36,133	17,449	1.93
T2 –75%N at sowing +25%N at 30 DAS	9,408	20,364	2.06
T3 – 50%N at sowing +50% N at 30 DAS	40,582	21,358	2.11
T4 – *25% N at sowing +75%N at 30 DAS*	40,793	21,389	2.10
T5 –25%N at sowing +50% N at 30 DAS + 25% at 60 DAS	47,337	27,213	2.35
T6 – *33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS*	51,014	30,530	2.49
T7 – 25% N at sowing + 25%N at 30 DAS+25% at 60DAS +25% N at 75 DAS	44,985	26,221	2.27
CD (P=0.05)	6,588	3,468	—
Mean	4,2893	23,510	2.18

Note: Maize grain price Rs. 13.00 /kg and Stover price Rs. 0.75 /kg

60 DAS than rest of the treatments, but it was found to be at par with treatment (T_5) 25%N at sowing +50% N at 30 DAS + 25% at 60 DAS by recording, (T_7) 25% N at sowing + 25%N at 30 DAS+25% at 60 DAS +25% N at 75 DAS (Table 1). Significantly the lowest grain yield was recorded under treatment (T_1) 100% nitrogen at sowing.The grain yield (kg/ha)analysis indicated that maize crop needs more of nitrogen to applied at knee height and tasseling stage. Here it can be included that for maize, nitrogen should be applied at 33% nitrogen at the time of sowing, 33% at 30 DAS (knee height) and 33% nitrogen at the 60 DAS (tasseling stage).Split application of 33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS (T_6) recorded significantly higher net monetary return which was at par with treatment $T_{2,}$ T_3, T_4,$T_5$and T_7 but this was significantly superior over with T_1 (Table 2). The mean benefit: Cost ratio of maize was 2.07.The highest benefit: cost ratio (2.45) was recorded with Split application of nitrogen as per 33% N at sowing + 33%N at 30 DAS + 33% at 60 DAS (T_6). The lowest B: C ratio was record by treatment 100 %N at sowing (T_1).

CONCLUSION

Split application of nitrogen with T_6 i.e.(33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS) recorded highest grain yield, net monetary returns and benefit cost ratio (2.49) which was followed by split application of nitrogen with T_5 i.e. (25%N at sowing +50% N at 30 DAS + 25% at 60 DAS).

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Productivity, profitability and partial factor productivity of nitrogen fertilizer in rice with Green-Seeker sensor based precision application: Evidence from Climate Smart Villages in Haryana

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With the advent of *Green Revolution*, food grain production in India increased substantially over time, however fertilizer response ratio (i.e. grain yield per unit of fertilizer use) decreased dramatically from 13.4 to 3.7 kg grain/kg NPK during 1970 to 2005 (Biswas and Sharma, 2008) due to inappropriate nutrient management approaches. Continually skewed nutrient use led soil nutrient imbalances and low factor productivity is one of the major concerns of agriculturein India. The approach of 'more inputs- more output' is now known to be ecologically intrusive, economically unsustainable and environmentally unsafe. Hence, innovative tools and techniques for precision nutrient management in smallholder systems for example Nutrient Expert (NE) decision support tool, Green-Seeker sensor etc have shown potential to providessite/farmer-specific fertilizer nutrient prescription for enhancing productivity, profitability and use efficiency (Pampolino *et al*., 2012; Singh *et al*., 2015). Green-Seeker is an integrated optical sensing and application system that measures crop status in response to the crop's N-requirements and provides prescription for precision N application for estimated attainable yield identified from normalized difference vegetative index (NDVI) and an environmental factors (Bijay-Singh *et al*., 2015) enabling farmers to dynamically adjust N dose as per the crop demand in specific fields. We therefore, conducted participatory validation trials on Green-Seeker guided N application in rice within 24 climate smart villages (CSVs) of the Karnal district of Haryana India and evaluated for crop yield, profits and partial factor productivity of N compared to farmer's fertilizer practice.

METHODOLOGY

Participatory validation trials were conducted during monsoon 2015 in 28 climates smart villages (CSVs) of Karnal. A total of 215 validation trials were carried-out in rice comparing Green-Seeker based N-application with that of farmers' fertilizer practice. NDVI readings were taken at 42, 49 and 56 days after rice transplanting to calculate the third dose of nitrogen applied through urea using the algorithm developed and validated by Singh *et al*. (2015). For, farmers practice of N management; we followed the practice they adopted. Most farmers follow ah-hoc and relatively high doses of N irrespective of soilnutrient status and cropping system management. In general farmers apply urea in 3 splits after transplanting based on the yellowness/greenness of the crop. For Green-Seeker based N prescriptions, we established the N-rich strips along the test plots in all the CSVs. The NDVI readings were recorded at defined days after transplanting (DAT) in both N-rich and test plots. The NDVI values were used to calculate the fertilizer N rate using the algorithm developed by Singh *et al*. (2015) which was translated into Android Phone App based Urea calculator (http://knowledgecenter.cimmyt.org/cgi-bin/koha/opac-detail.pl?biblionumber=57571&searchid=scs_1457981265500;http://www.cimmyt.org/mobile-app-will-power-greenseeker-use-in-south-asia/) and Crop yield were recorded following the standard procedure. The net returns were computed considering the cost of cultivation and market price (MSP) of the produce. Partial factor productivity of N (PFP-N) is the ratio of grain yield to nitrogendose and expresses as (kg grain/kg-N).

RESULTS

In all the four blocks of Karnal, on an average the farmers used 10.4 kg/ha higher dose of N compared to Green-Seeker guided applications averaged at 142.8 kg N/ha with the similar yield levels.However, the Green-Seeker guided N varied by blocks as in Gharonda block, higher dose of N was required under Green-Seeker based application compared to farmers practice. Green-Seeker based N-application target the N requirement as per demand of the crop at a particular crop growth stage (Singh *et al.,* 2015; Jat *et al.*, 2014). Higher yield of rice was recorded under Green-Seeker guided N application which ranged from 3.43 to 5.61 t/ha compared to farmer's N-management practice that varied 3.31-5.42 t/ha across all the CSVs. Similarly, higher net returns ranged from ¹ 35183-57301/ha and averaged at ¹ 44952/ha were recorded with Green-Seeker based N-application compared to farmer's

Table 1. Nitrogen rate, rice yield, net returns and PFP-N under two N management strategies in farmers field trails across CSVs located in various blocks of Karnal, Haryana

Blocks	No. of villages and (trials)	N applied (kg/ha)		Yield (t/ha)		Net return (¹ /ha)		PFP (kg grain/kg-N)	
		Green Seeker	Farmer's practice	Green Seeker	Farmer's practice	Green Seeker	Farmer's practice	Green Seeker	Farmer's practice
Nilokheri	12 (87)	137.08± 24.9	147.4± 26.1	4.29± 0.80	4.42± 0.78	49555± 10719.9	48516± 10766	32.0± 6.70	29.33± 6.10
Indri	10 (78)	135.06± 24.5	158.8± 33.4	4.54± 0.53	4.48± 0.52	38876± 5202.06	37747± 5011.9	34.6± 6.99	29.35± 6.14
Gharonda	4 (35)	145.04± 25.2	135.62± 34.4	4.55± 0.48	4.45± 0.47	39792± 3937.4	38657± 3455.1	32.2± 6.40	35.41± 12.0
Nissing	2 (15)	154.16± 33.02	171.0± 22.2	4.50± 1.15	4.41± 1.18	51467± 8097.6	49443± 7259.4	31.3± 12.43	26.2± 7.28

*Figures in parenthesis indicates the number of trials

practice which ranged at ¹ 33672-53692/ha). Green-Seeker based N application improved the partial factor productivity of N (PFP-N) by 2.5 kg grain/kg-N compared to farmers practice.

CONCLUSION

Green-Seeker coupled with android phone App based urea calculator was found farmers friendly tools and helped in targeting the need based application at right time to increase the profit under small holder production while reducing the cost incurred on N-fertilizers.

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Potential of soil acid phosphatase activity and microbial biomass –C concentration in variousland use and soil depths under north eastern Himalayan region

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The biological mechanism of the soil can be used as short-term agro system quality indicators, given their high compassion to any alteration of the system or change in the environment, as well as their close relationship with plant root systems, stress tolerance, productivity and adaptability, among other agro system characteristics (Lau and Lennon, 2011). Soil microorganisms and enzymatic activities control organic carbon (C) sequestration and decomposition in soils, and therefore have a strong impact on the terrestrial C cycle. While abiotic controls of soil organic C sequestration have been intensively studied during the last two decades (Lau and Lennon, 2011), the importance of the microbial processing and enzymatic activities relation to the organic C has only recently received more attention (Schmidt *et al*., 2011). Production of acid phosphatase and dehydrogenase is a large microbial investment and therefore they are thought to be important indicators of P and C availabilities in soils. These enzymes activity are regulated by addition of forest/crop biomass, the effects of which may vary with forest and land use.

METHODOLOGY

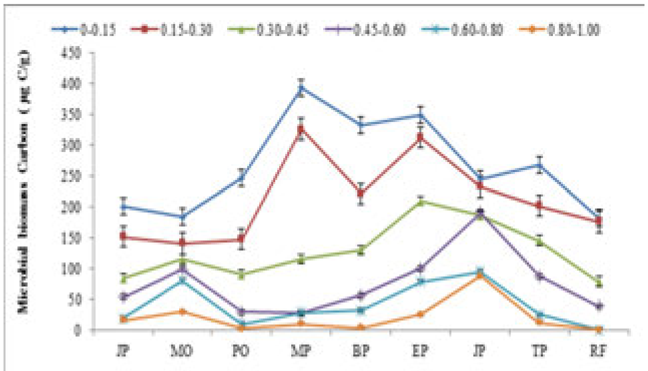
The study area represents 2.2327 million ha geographical area, which constitutes 0.7 % of the total land surface of India. Because of hilly topography, only 21% of the GA is cultivated. Ninety Percent of the total geographical area of the state and state has vast area of forest covering as much as 1.7418 million ha (Economic survey, 2015-16). The soils for the present study were collected from the altitude varies between 750 to 800 m in acidic soils of North Eastern Himalayan Region of India. All the sites had subtropical climate with an average annual maximum and minimum temperature of 25.3±0.9 and 13.4±0.9°C, respectively and rainfall of 1244±228 mm, ~80% of which falls during June to September. The topography is characterized by very steep to gentle slopes. Soils of valleys are formed from transported materials of shale origin and recent alluvium deposits. Taxonomically, three soil orders namely Inceptisol followed by Entisols and Ultisols dominate the soils of the region. The depth of soil across the study area varies considerably because of physiographic positions and slopes. The data were collected from nine land uses Jatropha plantation (JP), Mango orchard (MO), Passion fruit orchard (PO), Mixed plantation (MP), Bamboo Plantation (BP), Eucalyptus plantation (EP), Jackfruit plants (JfP), Treebean plantation (TP) and Rice Fallow (RF).

RESULTS

Soil enzymes have been regarded as very good indicators of the changes in the biological properties of soil because of their sensitivity to soil management practices (Deng and

Table 1. Effect of land uses on acid phosphatase enzyme activity

Land use	Acid phosphatase (μ mol *p*-NP/g soil/h)					
	0.00-0.15	0.15-0.30	0.30-0.45	0.45-0.60	0.60-0.80	0.80-1.00
JP	6.84	6.55	6.04	4.67	4.33	3.45
MO	7.47	4.30	4.55	4.28	3.27	2.81
PO	5.64	3.76	2.79	2.24	2.54	1.90
MP	12.51	8.80	6.68	3.55	3.25	2.31
BP	8.48	7.12	4.27	3.70	3.37	2.22
EP	12.32	11.34	6.43	4.03	3.64	3.20
JfP	7.13	6.51	6.45	6.22	5.40	3.84
TP	13.25	5.63	5.49	4.95	3.25	3.40
RF	8.22	2.30	2.12	1.35	0.49	1.01
Mean	9.09	6.26	4.98	3.89	3.28	2.68
L S D (P=0.05)	0.37	0.42	0.16	0.04	0.06	0.23



Tabatabai, 1997). Among the all land use we have recorded maximum acid phosphatases enzymatic activity (ACP) under Treebean plantation (13.25 µ mol p-NP/g soil/h) followed by mixed plantation forest (*Alnus nepalensis*, *Schima wallichii*, *Bauhinia spp* and *Emblica officinalis*) (12.51 µ mol p-NP/g soil/h) than other system in 0-0.15 m soil depth. The minimum ACP activity was found in passion fruit plantation (5.64 µ mol p-NP/g soil/h) followed by Jatropha plantation (6.84 µ mol p-NP/g soil/h). Across the nine land use ACP activity was decreased from 46.1 to 87.7% in 0.80 -1.00 m soil depth as compared to 0.00-0.15 m. Our results showed that the leguminous plantations had higher ACP activities compared to the forest plantation and land use. Among the nine land uses, we found that microbial biomass carbon (MBC) under mixed plantation forest land use pattern (394.06 µg C/g) than other system in 0-15 cm soil depth. The minimum MBC was recorded in Rice Fallow system (182.90 µg C/g). MBC decreases in all land uses towards soil depth increases.

CONCLUSION

Wide variability in ACP and MBC concentration and stock was observed between non-agricultural (higher in GL and mixed forests) and agricultural land uses. Among the land uses, most potential was Treebean plantation and mixed plantation forest than others.

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Integrated nitrogen management on sweet corn (*Zea mays* L. sub sp. *saccharata* Sturt) hybrid

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Corn requires high quantities of nitrogen during the period of efficient utilization, particularly at 25 days after sowing and pre-tasseling (40 days after sowing) stages for higher productivity (Bravo, *et al.,* 1995). Though the continuous use of fertilizers had significantly improved the crop productivity, heavy fertilizer application on the same field will drain the soil fertility rapidly and results in a plethora of problems *viz.*, decline in crop productivity, deficiency of micro nutrients, environmental pollution, etc. (Gaur and Kumawat, 2000). But, the use of organic manures alone cannot sustain the production system due to limited availability and their relatively low nutrient content (Palm *et al.*, 1997).Thus, it has been realized that application of chemical fertilizers in conjunction with organic manures will improve the productivity of sweet corn kernel quality and also maintain the fertility of soil. Therefore, it is necessary to compare various organic sources of nutrients with chemical fertilizers in order to find out the most effective combination.

METHODOLOGY

Field experiment was laid out in randomized block design with 12 treatments and replicated thrice. The treatments include, T_1 (25% N as FYM + 75% N as inorganics), T_2 (25% N as vermicompost + 75% N as inorganics), T_3 (25% N as poultry manure + 75% N as inorganics), T_4 (25% N as goat manure + 75% N as inorganics), T_5 (25% N as biogas slurry + 75% N as inorganics), T_6 (50% N as FYM + 50% N as inorganics), T_7 (50% N as vermicompost + 50% N as inorganics), T_8 (50% N as poultry manure + 50% N as inorganics), T_9 (50% N as goat manure + 50% N as inorganics), T_{10} (50% N as biogas slurry + 50% N as inorganics), T_{11} (100% N as inorganic) and T_{12} (100% N as inorganic + FYM @ 12.5 t /ha) which is the recommended practice and fixed as bench mark. Sugar 75, a Syngenta hybrid was used as test crop. All the package of practices was carried out as per recommendation of CPG (2012). The biometric observation on growth attributes was recorded on 30, 60 DAS &at harvest, and the yield attributes were recorded at the time of harvest. The crop was harvested at its physiological maturity. Plant uptake and soil available nutrient status was analyzed at 30, 60 DAS and at harvest. Urease activity was assayed by quantifying the rate of release of ammonium (µg NH_4^+ g^{-1} soil 24 h^{-1}) from the hydrolysis of urea as described by Tabatabai and Bremner (1972) from soil. Data of each character collected were statistically analyzed using standard procedure of variance analysis.

RESULTS

At harvest, taller plants with more leaves and thick stems was recorded from plots treated with 25 per cent N as poultry manure + 75 per cent N as inorganic fertilizers. It is due to increased uptake of N which being the chief constituent of protein and protoplasm, which vigorously induced the vegetative development of the plants. The higher availability of nitrogen seems to have promoted development of morphological structure by virtue of multiplication of cell division. (Kumar, 2008). Leaf area index and dry matter were significantly correlated demonstrating that LAI is an indicator of its photosynthetic capacity and translocation. Application of 25 per cent N as poultry manure with 75 per cent N as inorganic fertilizer produced heaver green cobs with more kernels per rowof longer corn embedded with more kernel rows /corn, which is comparable with application of 25 per cent N as goat manure with 75 per cent N as inorganic fertilizer. This might be on account of overall improvement in growth as evinced from higher dry matter, leaf area index, and N uptake. Sufficient availability of nitrogen nutrient suggest greater availability of metabolites synchronized to demand for growth and development of each reproductive structure consequently enhanced green cob and fodder plant. Application of 25 per cent N as poultry manure with 75 per cent N as inorganic fertilizer produced higher biomass i.e. higher green cob yield of 23.5 t /ha and green fodder yield of 27.1 t /ha, which is comparable with application of 25 per cent N as goat manure with 75 per cent N as inorganic fertilizer. Even after the completion of crop growing period, mineralization of N could be continued to the soil pool. Changes in the soil enzyme activities at different crop growth stages are presented in Table 2. Soil urease activity ascended gradually with sweet corn growth and reached highest value at tasseling stage then after it decreased. The soil fertilized with the recommended level released 47.2 µg of NH_4^+ N released g^{-1} soil 24 h^{-1} at tasseling stage. Among the integrated treatments application 50 per cent N as biogas slurry + 50 per cent N as inorganic (T_{10}) reported 42.9, 46.5 and 40.2 µg of NH_4^+ N released /gsoil 24 h^{-1} at vegetative, tasseling and at harvest stages respectively, which was on par with T_6, T_7 and T_9. Balanced nutrition of crop, responsible for better proliferation of root (rhizosphere) was responsible for the maximum activity of enzymes.

CONCLUSION

On the basis of results emanated from the present experiment conducted during *rabi* 2014-15, it was concluded that under prevailing agro-climatic conditions, sweet corn hybrid 'Sugar 75' applied with 25 per cent N as poultry manure + 75 per cent N as inorganic fertilizer produced higher yield, thus proved to be most efficient and economically profitable practice. However half substitution of organic manure with inorganic fertilizers added more available soil nitrogen because of slow release.

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Site specific major nutrient variation maps through GIS and recommendations for coconut gardens

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Major coconut growing districts in Karnataka are Tumkur, Hassan, Dakshina Kannada, Chikkamagaluru and Chitradurga, which together account for more than 85 per cent of coconut-growing area. Hence, it is very important horticultural crop having a very high impact on the economy of farmers of Hill, Southern Transition and Central Dry Zones. By and large, the crop as it is being envisaged, grown with middle to less care. The perennial nature of crop, the tall upper canopy, unavailability of skilled labours, biotic stress etc paves way for not caring situations. The crop is grown in diversified soil and climatic conditions. Basically, the soils also differ with that of agro climatic situations and not possible to generalize the soil nutrient status as it is a dynamic factor. At present, there is a uniform recommendation of major nutrients to each of these crops across soils of various agro-climatic zones. The present recommendation for coconut is 170:120:400 and 330:200:800 g nitrogen, phosphorus and potassium per palm in two split dosage for all nut bearing trees. Well established coconut growers were selected across these agro climatic situations with an objective to classify the soil nutrient status as a part of site specific management and to understand them the variability of their fields for improving the garden fertility status for sustainable yields.

METHODOLOGY

The study area included Chikkapattanagere of Chikkamagaluru district where tank fed irrigation is dominant, Doddaghatta of Davangere district enjoy the supply of tank irrigation around the year, Siriyur of Shivamogga district also enjoys the Bhadhra river water supply and Madhure of Chitradurga district with limited success of tube wells irrigation. A total of 200 acre representing 50 acre at a stretch gardens in each location was chosen. The standard technique of grid (50 m x 50 m) method was employed to drawn soil samples from the selected study area. Each grid is recognised by its own GPS co-ordinate to make area geo-referenced. Further, using GPS co-ordinates, the base maps of the study area was developed by GIS software. After taking soil samples from each grid, the soil was dried, powdered and analyzed by following the standard methods of analysis for available nitrogen, phosphorous and potassium (Jackson, 1973). Also with the help of soil analytical results for nitrogen, phosphorus and potassium on grid basis, maps were prepared based on low, medium and high classification criteria for each of them on base map of each study location, with the help of GIS. Based on these values of classification, by adopting STL method of fertilizer recommendations, each site is calculated further for fertilizers quantity. The package recommendation and the site specific recommendation based on STL approach are compared. For each location depending on its site specific variations, approaches for future is advised.

RESULTS

Chikkapatttangere: Status of nitrogen remained low in both the profiles studied. With respect to P and K status for top soil layer 70 per cent of samples were medium; again at 30-60 cm depth, the phosphorus status remained same as that of top layer while potassium has only 40 per cent medium sparing the remaining of that of top to low status un altering the high status for both profiles. It appears that management of crop with different approaches by farming community dictated the top layer nutrient status. Doddaghatta: Depth wise no variation with respect to nutrient status is observed. In both depths, N remained low, Majority of samples showed medium status (> 95 %) for P content while K content varied from medium (around 70 %) to high (around 30 %) status. These unique minor variations are due to relevant cultural practises with good management where bearing ability of gardens are in higher order as compared to other places in the study. Madhure: The distribution of nitrogen over profiles had shown uniformity with low content. The status of P in top layer remained high (around 66 %) to medium (around 33%) and reverse trend is observed at 30-60 cm depth. Potassium largely remained almost medium (around 72 %) in top layer while become medium to low at deeper layer of 30-60 cm. Siriyur: In top layer nitrogen has shown low (around 62 %) to medium (around 37 %) status and nullified at deeper layer with low status. Phosphorus was high (around 74 %) to medium (around 26 %) for 0-30 cm depth, while at deeper layer remained largely medium. Potassium largely had medium status (around 80 %) at top layer as it moves to deeper sections it become almost equal proportion of medium and low status. Based on these variations of major nutrient contents on grid basis, base map of study area is considered for further classification of these major nutrients into status and same has been drawn using GIS technology. It is evident that nitrogen status remained low while that of phosphorus sharing almost medium and high in equal proportion (Bopathi and Sharma, 2006) while 68 per cent high with respect to potash for top soil depth of 0-30 cm. Hence it becomes crucial to manage these elements. Here based on package recommendations, STL method is employed to make further calculations grid wise. Usually farmers apply in the form of DAP, urea and muriate of potash. The total requirement of fertilizers based on package recommendation for these areas is indicated in pictorial depiction respectively along with calculated STL approach.

CONCLUSION

It is observed from the above result that for coconut crop, across all locations, slightly nitrogen application needs to be applied more while potassium needs to be applied less with almost no perceptible change in application of phosphorus.

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Nutrient management in chewing tobacco + annual *Moringa* intercropping system

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Chewing tobacco (*Nicotiana tabaccum*) is one of the commercial crop grown in an area of around 10,000 to 15,000 ha in different districts of Tamil Nadu. Annual *moringa (Moringa oleifera)* is grown throughout Tamil Nadu as a pure crop and also as an intercrop in chillies, tobacco, onion etc., Since the growth habit of the crops viz., Tobacco and annual moringa varied, farmers cultivate chewing tobacco intercropped with annual *moringa*. Intercropping increases not only productivity per unit area but also the net returns. Kumaresan and Rao (2013) reported that the Tobacco equivalent yield was higher with chewing tobacco + Annual moringa intercropping system as compared to many other crops grown in *rabi* season. The existing nutrient management practices are based on individual crop and very little information is available on nutrient management in intercropping systems. Hence the present study was conducted to find out a suitable nutrient management practice for chewing tobacco +annual moringa intercropping system, where annual moringa was planted at different populations.

METHODOLOGY

A field experiment was conducted at the farm of the ICAR-Central Tobacco Research Institute Research Station, Vedasandur during 2012-13 to 2014-15. The experiment was laid out in a split plot design with three replications. The main plot treatment consisted of Chewing tobacco + Annual moringa (100% population), Chewing tobacco + Annual moringa (75% population), Chewing tobacco + Annual moringa (50% population). The sub-plot treatments consisted of 125, 100 and 75% recommended dose of fertilizer (RDF) applied to both chewing tobacco and annual moringa. The sole crop of chewing tobacco and annual moringa was raised in a separate plot for comparison. The recommended dose of fertilizers for chewing tobacco and annual moringa was 125+50+50 and 90+30+60 kg/ha $N+P_2O_5+K_2O$, respectively. Farm yard manure @ 25 t/ha was applied basally. The variety of chewing tobacco and annual moringa raised was Abirami and PKM-1, respectively. The first grade leaf yield (FGLY)and total cured leaf yield (TCLY) was recorded after bulking and standard processing. Economics was calculated based on the prevailing market prices of inputs and economic produce value.

RESULTS

The annual moringa intercropped at different population levels did not affect the FGL and TCLY of chewing tobacco (Table 1). The fertilizer levels significantly influenced the

Table 1. Yield and economics of chewing tobacco+Annual moringa intercropping system as affected by inter crop plant population and fertilizer rate.

Treatment	FGLY (kg/ha)	TCLY (kg/ha)	*Annual Moringa (kg/ha)	*Gross return (Rs x 10^3)	*TEY (kg/ha)	*Net return (Rs x 10^3)	*B:C ratio
Intercropping system							
Tobacco + Annual moringa (100%)	2731	3399	3745	314.24	4497	202.74	1.86
Tobacco +Annual moringa (75%)	2805	3410	3033	304.03	3858	194.33	1.78
Tobacco +Annual moringa (50%)	2867	3464	2398	288.78	3496	184.00	1.76
CD (P=0.05)	NS	NS					
Fertilizer level							
75%RDF	2652	3245	3017	293.08	3826	185.54	1.76
100%RDF	2855	3431	3038	304.10	4004	192.15	1.79
125%RDF	2939	3510	3122	310.83	4067	209.39	1.80
CD (P=0.05)	102	157					
Sole tobacco	2790	3383		213.58	3383	127.03	1.93
Sole Annual moringa	-	-	3542	73.05	2285	9.58	0.49

*Data not statistically analyzed

tobacco yield. The RDF at 125 and 100 % recorded a comparable FGLY and TCLY. Annual *moringa* yield increased with increase in population. The annual *moringa* yield increased when there was an increase in fertilizer level. Higher annual *moringa* yield of 3362 kg/ha was recorded at 125% RDF applied to tobacco and annual *moringa*. The Gross return, Net return and B:C ratio were higher with chewing tobacco + 100 % Annual Moringa population. The 125% RDF to chewing tobacco +Annual Moringa recorded a higher gross return, Net return and B:C ratio followed by 100% RDF (Table:1). Tobacco equivalent Yield (TEY) was higher with Chewing tobacco+100% Annual Moringa population (4578 kg/ha) and at 125% RDF to chewing tobacco+Annual Moringa (4607 kg/ha), followed by Tobacco +Annual Moringa at 75% population fertilized with 100% RDF to both chewing tobacco and Annual moringa.

CONCLUSION

Annual moringa at different population levels does not significantly affect the yield of chewing tobacco in chewing tobacco+annual moringa intercropping system. Similarly, application of fertilizers in excess of recommended dose has not resulted in significant improvement in tobacco yield. However, increased rate of fertilizer application @ 125% RDF proved beneficial in terms of TEY and net returns.

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Soil spatial variability assessment and precision nutrient management in cotton

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Maintenance of soil health is an important issue in improving productivity per unit area. Proper balance of soil nutrients constitutes an important element of soil health. The high input demanding crop like cotton require precision resource management for sustained yield, enhance cost effectiveness and keeping the environment, pollution free.Keeping these points in view investigations on precision nutrient management in cotton to achieve desired target yields was carried out at Main Agricultural Research Station, Dharwad (Karnataka) during 2014-15 and 2015-16 with the objectives to assess soil spatial variability with respect to soil chemical properties and to study the effect of precision nutrient management on growth, yield and quality parameter of Bt cotton.

METHODOLOGY

The experimental site (3.20 ha) distributed from5^{o} 30.01' to 15^{o} 30.11' N latitude and 74^{o} 59.16' to 75^{o} 59.15' East longitude comprising 80 grids (20x20 m). Gridwise soil spatial variability for major, secondary and micro nutrients was assessed as per the procedure by following standard analytical techniques. During 2014-15 two management zones were delineated (LHM, LHH) and each zone was assigned with four target yields (2.5, 3.0, 3.5 and 4.0 t/ha) along with RDF and absolute control. During 2015-16, four different management zones (LHH, LMH, LLH and MHH) were delineated by following nearest neighborhood technique at the same site. Variations in management zone were due to application of nutrients to achieve target yields and uptake by crop. The actual rain fall was deficit than normal in the month MAY, JUNE and JULY and forecasting of further deficit of the rain fall during crop growth period lead to fixing reduced target yields (1.5, 2.0, 2.5 and 3.0 t/ha). The nutrient prescription maps were generated based on site specific nutrient management (SSNM) principles and the target yield to be achieved. The amount of nutrients required to achieve target yield were calculated by using the formula (Biradar *et al.*,2012) NR= {Nutrient uptake by crop (kg/t) × T} ± per cent ENR. Intra-hirsutum cotton hybrid (First-class) was used for the studies. Variable rate of nutrients were applied to each grid manually. During 2014-15, nutrients were applied in split doses *i.e.* 50 per cent each of N, K_2O and entire P_2O_5 as basal dose and remaining 50 percent of N and K_2O was applied as top dressing at 60 days after sowing. Because of lower rainfall during 2015-16, 50% of P_2O_5 and K_2O have been applied in two splits as basal and top dressing at 60 days and nitrogen in three splits (33.3 % as Basal, 33.3 % at 60DAS and 33.3 % at 90DAS).

RESULTS

Soil spatial variability was observed with respect to soil chemical properties within the study area. The soil organic carbon varied from 0.09 - 1.02% with an average of 0.55 % Similarly, major nutrients also varied widely ranging from 131.21 to 213.22, 27.95 to 93.84 and 49.08 to 412.8 kg available N, P_2O_5 and K_2O/ha respectively with an average value of 161.2, 112.8 and173.19 kg available N, P_2O_5 and K_2O/ha, respectively during 2014-15. During 2015-16, major nutrients also varied widely, ranging from 113.24 to 487.55 kg N/ha with an average of 241.97 kg /ha, 5.46 to 72.75 kg P_2O_5/ha and 334.32 to 1741.68 kg K_2O/ha with an average valueof 38.37 and 730.87 kg P_2O_5 and K_2O /ha, respectively.Further, soil fertility status revealed that, grids were low (L), medium (M) and high (H) in available N status. With respect to P_2O_5, grids were low, medium and high in available status. However, in all the grids, available K_2O status was high. For available Sstatus grids recorded low to medium with minimum of 15.86 kg/ ha,maximum of 229.39 and with an average of 66.96. Micronutrient status was not different from major nutrients. Most of the soil samples were at sufficiency level in available Ca, Mg, Cu and Zn. Maximum samples were at excess level in available Fe. Available Fe, Zn, Mn, Cu ranged from 1.354 to 11.568, 0.36 to 3.494, 5.42 to 66.79, and 1.624 to 3.99 ppm , with an average of 4.438, 1.972 , 30.124 and 2.399 ppm respectively. During 2014-15, the seed cotton yield levels varied from 1.34t/ha (Absolute control) to 3.62t/ha (Target yield LHH 4.0 t/ha). Maximum seed cotton yield of 3.56 and 3.62t/hawere recorded with the application of nutrients required to achieve 4.0 t/hatarget yield in LHM and LHH management zone respectively followed by 3.50 and 3.51 t/ harecorded with the application of nutrients required to achieve 3.5 t/hatarget yield in LHM and LHH management zone respectively (Table 1). Based on 2015-16 yield data, it is clear that, target yield 3.0 t/ha has recorded significantly higher seed cotton yield (2.84 t/ha) over other target yield 1.5, 2.0, 2.5 t/ha,RDF and absolute control. Yield of 2.47 t/hawas achieved in target yield of 2.5 t/ha. Yield of 2.23 t/ha and 1.76 t/hahave been achieved in target yield 2.0 t/haand RDF respectively. However, target yield of 1.5 t/haand RDF (17.6 and 17.4 respectively) were on par with each other. Whereas, absolute control recoded significantly lower grain yield (0.71 t/ha). Similar results were reported by Biradar *et al.* (2012) and Manjunath *et al.* (2014). Further, the results are also in line with the findings of Bhalerao *et al.* (2012) who reported that application of 150 per cent RDF (200:100:100 NPK kg/ha) resulted in significantly higher seed cotton yield and yield attributing characters in cotton due to combined effect of N, P_2O_5 and K_2O. Response of cotton to higher doses of nitrogenbe attributed to the vital role of N in cell division and cell elongation. Potassium hadsignificant effect on improving the resistance capacity of the crop to drought andalleviates the negative effects of water functioning as the main osmotic solute in plants.Further, phosphorus facilitates plant to respond to nitrogen and potassium fertilization(Kalaichelvi *et al.*, 2006).

CONCLUSION

Target yield of 2.0, 2.5, 3.0 and 3.5 t/ha was achieved in the present study. Whereas shortfall of 0.44 and 0.39t/ha were recorded with application of nutrients to achieve target yield of LHM 4.0 and LHH 4.0 t/harespectively. Application of nutrients through precision nutrient management to achieve target yield of 3.5 t/ha was found to be promising for higher yield.

Table1. Kapas yield (t/ha) achieved against target yield under different management zones over the years

Treatment	2014-15		2015-16				
	LHM*	LHH *	Target yield (t/ ha)	LHH*	LMH*	MHH*	LLH*
T_1- Target yield 2.5 t/ha	25.30	26.00	1.5	16.95	13.90	16.00	-
T_2- Target yield 3.0 t/ha	30.43	30.90	2.0	20.56	19.20	19.90	-
T_3- Target yield 3.5 t/ha	35.03	35.13	2.5	24.07	23.75	24.25	24.15
T_4- Target yield 4.0 t/ha	35.58	36.15	3.0	27.37	26.15	27.70	26.60
T_5- RDF	18.75	19.50	RDF	14.30	17.40	17.35	11.70
T_6-Absolute control	13.38	13.80	Abs. cont.	7.10	7.10	7.10	7.10

*Management Zones.

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Enhancing the quality of quality protein maize by nitrogen and sulphur fertilization

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Maize (*Zea mays*) the American Indian word for corn means literally "that which sustains life". Maize is emerging as an important world cereal crop after wheat and rice. It is known as the ''Queen of Cereals'' due to its high yielding potential. It provides basic raw material for production of starch, oil, protein, alcoholic beverages and food sweeteners etc. But cereals are deficient in lysine and tryptophan resulting in low biological value and protein malnutrition in developing countries. To combat such situations, researchers of International Maize and Wheat Improvement Center (CIMMYT) had developed a special type of maize called as Quality Protein Maize, which is exactly similar to normal maize in grain texture, taste, colour but possesses double the level of lysine (4%) and tryptophan (0.8%), produces high yields and tolerates biotic and abiotic stresses. Hence it is necessary to study the agronomic performance of quality protein maize so as to improve its productivity and quality through different agronomic practices, among which plant nutrition is considered to be the major one (Jeet *et al.*, 2012). Among the essential nutrients, Nitrogen and Sulphur are important for higher protein quality of maize.

Table 1. Protein, tryptophan and lysine content of quality protein maize as influenced by nitrogen and sulphur levels

Treatment	Protein (%)	Tryptophan content (%)	Lysine content (%)
Nitrogen level (kg/ha)			
N_1 (60)	8.36	0.7	2.8
N_2 (120)	9.75	0.73	2.92
N_3 (180)	10.14	0.77	3.07
N_4 (240)	11.95	0.81	3.23
SEm±	0.09	0.01	0.02
CD (P=0.05)	0.25	0.02	0.07
Sulphur level (kg/ha)			
S_1 (15)	9.09	0.65	2.58
S_2 (30)	9.98	0.76	3.03
S_3 (45)	11.08	0.85	3.4
SEm±	0.08	0.01	0.02
CD (P=0.05)	0.22	0.02	0.06
Interaction			
N_1 S_1	7.27	0.59	2.37
N_1 S_2	8.14	0.73	2.92
N_1 S_3	9.66	0.78	3.11
N_2 S_1	8.78	0.62	2.47
N_2 S_2	9.77	0.76	3.03
N_2 S_3	10.7	0.82	3.27
N_3 S_1	9.3	0.66	2.65
N_3 S_2	10.18	0.75	3.01
N_3 S_3	10.93	0.88	3.53
N_4 S_1	11	0.71	2.84
N_4 S_2	11.82	0.79	3.17
N_4 S_3	13.04	0.92	3.68
SEm±	0.15	0.01	0.04
CD (P=0.05)	0.4	0.03	0.13

METHODOLOGY

A field experiment was conducted during *rabi*, 2014-15 on sandy loam soils of College Farm, S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh to study the "Productivity of Quality Protein Maize as influenced by Nitrogen and Sulphur nutrition". The experiment was laid out in a randomized block design with factorial concept and replicated thrice. The treatments consisted of four nitrogen levels viz. 60 kg nitrogen/ha (N_1), 120 kg nitrogen/ha (N_2), 180 kg nitrogen/ha (N_3), 240 kg nitrogen/ha (N_4) and three sulphur levels viz. 15 kg sulphur/ha (S_1), 30 kg sulphur/ha (S_2) and 45 kg sulphur/ha (S_3). HQPM-1 hybrid was tested in the experiment. Quality Protein Maize hybrid (HQPM-1) was sown on 15th November, 2014 with a seed rate of 20 kg/ha at a spacing of 60 × 25 cm. A basal dose of 80 kg P_2O_5 and 80 kg K_2O was applied uniformly to all the treatments. Sulphur was applied as basal as per the treatments. The source of sulphur used was gypsum. The scheduled nitrogen was applied in three equal splits viz. first half at the time of sowing as basal, 1/4 as top dressing at knee high stage and remaining 1/4 as top dressing at tasseling stage.

RESULTS

Increasing levels of nitrogen from 60 to 240 kg N/ha significantly improved the protein, tryptophan and lysine content in QPM grain. Higher protein, tryptophan and lysine contents (11.95, 0.81 and 3.23%, respectively) were obtained with 240 kg N/ha (N_4) and lower protein, tryptophan and lysine contents (8.36, 0.70 and 2.80%, respectively) were registered with 60 kg N/ha (N_1). As regards the sulphur levels, quality protein maize supplied with 45 kg S/ ha (S_3) resulted in higher protein, tryptophan and lysine content (11.08, 0.85 and 3.4%, respectively) compared to the preceding levels while lower value was obtained with 15 kg S/ ha (S_1). Interaction effect between N and S on protein, tryptophan and lysine contents of QPM was found to be significant. The maximum content of protein, tryptophan and lysine (13.04, 0.92 and 3.68%) was recorded with the application of 240 kg N/ha (N_4) and 45 kg S/ha (S_3) whereas, lower value was recorded with the combination of 60 kg N/ha (N_1) and 15 kg S/ha (S_1) as furnished under (Table 1). The increase in protein and amino acids with increase in the level of nitrogen and sulphur might be due to the fact that nitrogen forms the principal constituent of protein and nucleic acids while sulphur is essential in synthesis of amino acids. The increase in the rate of sulphur increases the availability and uptake of nitrogen which resulted in higher percentage of protein and amino acids.

CONCLUSION

From the study it can be concluded that application of 240 kg Nitrogen/ha along with 45 kg Sulphur/ha resulted in higher quality of Quality Protein Maize.

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Optimization of nutrient requirement for different sesame (*Sesamum indicum*) genotypes

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Sesame is the oldest oilseed crop. Its seed has rich source of food, nutrition, edible oil and bio-medicine. The seed contains two constituent viz. sesamin and sesamol. These two are responsible for very high stability at room temperature and frying temperature which make sesame as a health care product. West Bengal ranks first in sesame productivity in India in all season. To meet our countries requirement scientists have come together to utilises this area's potentiality towards increasing the production through developing new genotypes with high production ability and bio-medical potentiality. In this context the present experiment was carried out with the objectives of determining the optimum nutrient requirements of the test varieties, increase the productivity.

METHODOLOGY

The experiment on different nutrient levels for augmenting the productivity of different genotypes of sesame with diverse quantum of inorganic nutrients (chemical fertilizers) was carried out at Agricultural Research Farm of University of Calcutta, Baruipur, South 24-Parganas, West Bengal during the *pre-kharif* seasons of 2015 and 2016. The experiment was laid out in split plot design replicated thrice with three nutrient levels in main plots (F_1- 50% of RDF, F_2- 100% RDF, F_3- 150% RDF), eight different genotypes (G_1: RT-351, G_2: LT-210, G_3: TKG-501, G_4: PT-10, G_5: GT-10, G_6: TKG-22, G_7: MT-75, G_8: JTS 8) in sub plots.60: 30: 30 kg of N, P and K/ha of nutrient was applied as recommended for that zone in addition to 20 kg of S/ha. The experimental site belongs to costal humid climate with an average annual rainfall of 1460 mm and the mean temperature ranges from 10°C to 37°C.The investigational location was situated at $22^0 35'$ N latitude and $88^0 43'$ E longitude with the altitude of 9 meters above the mean sea level (MSL).The soil is clay in nature with neutral in reaction. The relative performances of all the genotypes in terms of plant height, dry matter accumulation and yield attributes were assessed.

RESULTS

Plant height, dry matter accumulation and yield attributes were varied with different nutrient level and also with different genotypes. Application of higher doses of inorganic nutrients increased the yield and oil content (Table 1). Higher values of net return and cost benefit ratio were found with higher doses of nutrient i.e 150% of RDF (Fig. 2). The genotype GT-10 shows better performance in terms of growth and yield attributes among the eight genotypes. Among different genotypes GT-10showed the best result in terms of yield as well as economics (table 1 and fig. 1 & 2). This might be due to the fact that application of higher dose nutrients to crop caused an increase inthe availability of nutrients content of soil. These results are in conformity with the findings of Mankar and Satao (1995),Barik and Fulamli(2011) and Ghosh *et al.*(2013).

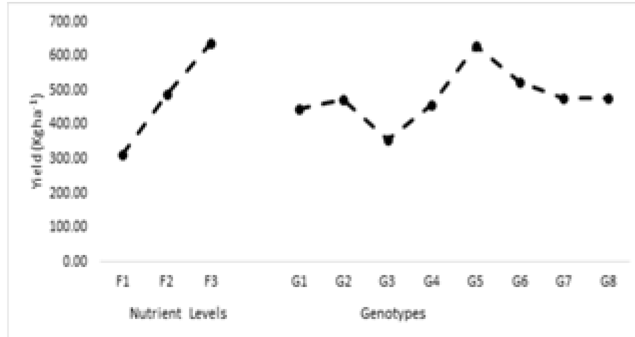

Fig. 1. Seed yield of Sesame

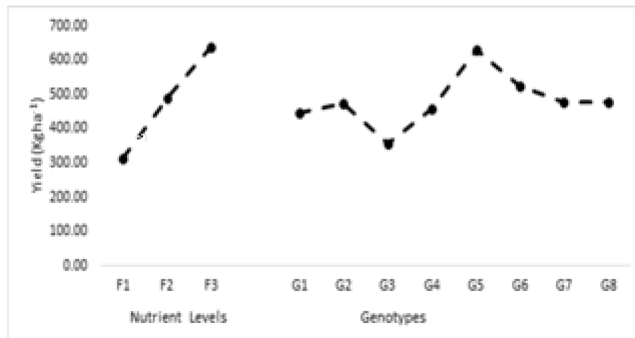

Fig. 2. Economics of Sesame

Table 1. Effect of different nutrient levels and genotypes on growth parameters and yield attributes of sesame.

Treatment	Plant height(cm)	Productive branches/plant	Productive capsules/plant	Plant stand (Nos.)
Nutrient Level				
F_1	86.83	4.48	152.25	13.61
F_2	93.18	5.46	187.43	11.30
F_3	99.45	5.31	195.33	14.19
SEm±	1.69	0.368	2.77	1.14
CD (P=0.05)	4.67	1.024	7.68	3.17
Genotype				
G_1	95.85	4.71	177.11	11.96
G_2	93.41	6.24	188.56	14.48
G_3	88.18	4.24	164.78	14.00
G_4	95.18	5.15	182.91	13.22
G_5	108.11	7.53	233.89	12.44
G_6	94.51	6.89	194.44	11.81
G_7	99.31	5.95	156.78	12.59
G_8	96.46	5.84	162.61	13.78
SEm±	2.29	0.732	26.18	0.90
CD (P=0.05)	4.62	1.478	52.84	1.83
Interaction F × G				
SEm±	3.62	1.173	16.01	2.74
CD (P=0.05)	NS	NS	NS	NS

CONCLUSION

From the above discussion it may be opined that the application of 150% RDF (i.e. 75 kg N + 45 kg P+ 45 kg K/ ha)exhibited the best results in terms of various growth, yield and quality parameters along with yield and economics. Among different genotypes GT-10 emerged as the best in terms of growth, yield and economics.

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Effect of micronutrient zinc and boron on fibre yield of sunnhemp

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Micronutrients play an important role in increasing yield of legumes through their various effects on the plant. Deficiencies of these nutrients have been very pronounced under multiple cropping systems due to excess removal by HYV of crops and hence their exogenous supplies are urgently required. Zinc and B deficiency is widespread in the country especially in light textured and calcareous soils. Zn deficiency is one of the most common widespread disorders in plants and soils of different regions of India (Takkar *et al.*, 1989). Zinc is involved in auxin formation, activation of dehydrogenase enzymes and stabilization of ribosomal fractions. Boron is essential element for all vascular plants, whose deficiency or excess causes impairments in several metabolic and physiological processes (Reid, 2007; Camacho *et al.*, 2008) including cell wall structure and function. Keeping these points in view the present study was undertaken to assess the effect of micronutrient zinc and boron on growth and fibre yield of sunnhemp.

METHODOLOGY

The field experiment was conducted during the pre-monsoon seasons of 2014 and 2015 at Sunnhemp Research Station (ICAR), Pratapgarh, Uttar Pradesh, India. The experiment was laid out in randomized block design (factorial) with three replications. The treatments consisted of combinations of four levels of zinc sulphate (0, 10, 20, 30 kg/ ha) and four levels of borax (0, 5, 10, 15 kg/ha). Micronutrients were applied at the time of sowing as per treatment. Recommended dose of NPK (20: 40: 20 kg/ha) was applied as basal. Sunnhemp (cv. Ankur) was sown with a row-to- row spacing of 25 cm and plant-to-plant spacing of 5-7 cm. The crop was harvested after 90 days of sowing, retted in water and fibre was extracted manually.

RESULTS

The results obtained from the experiment indicated significant variations in yield and yield attributes of sunnhemp due to application of different levels of zinc sulphate and borax (Table 1). Fibre yield of the crop increased with increasing levels of zinc sulphate and borax. The highest fibre yield (0.97 t/ha) was recorded with the application of zinc sulphate at the rate of 30 kg/ha being at par with 20 kg/ha (0.95 t/ha). The lowest yield (0.82 t/ha) was noted under control. Similar trend of zinc application was noticed on plant height, basal diameter and green biomass too. Application of borax at the rate of 10 kg/ha recorded significantly higher fibre yield (0.94 t/ha) compared to 5 kg/ha (0.89 t/ha) and control (0.85 t/ha). The yield variation between borax application of 10 and 15 kg/ha was found to be non significant. Plant height, basal diameter and green biomass followed similar trend. The better yield and yield attributes of crop might be attributed to balanced nutrient supply in the presence of zinc and boron micronutrients.

CONCLUSION

Thus it is concluded that better fibre yield of sunnhemp may be realized with the application of micronutrient zinc and boron.

Table 1. Effect of micronutrient zinc and boron on yield and yield attributes of sunnhemp (pooled data of 2 years)

Treatment	Plant height (cm)	Basal diameter (mm)	Green biomass (t/ha)	Fibre yield (t/ha)
Zinc sulphate				
0 kg/ha	220.75	8.24	28.88	0.82
10 kg/ha	243.50	9.16	31.97	0.89
20 kg/ha	262.78	9.82	34.69	0.95
30 kg/ha	269.20	9.97	35.53	0.97
SEm±	4.54	0.13	0.646	0.015
CD (P=0.05)	12.84	0.37	1.829	0.042
Borax				
0 kg/ha	234.57	8.80	29.92	0.85
5 kg/ha	245.75	9.20	32.12	0.89
10 kg/ha	256.63	9.54	34.20	0.93
15 kg/ha	259.29	9.64	34.82	0.95
SEm±	4.54	0.13	0.646	0.015
CD (P=0.05)	12.84	0.37	1.829	0.042

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Integrated nutrient management in greengram (*Vigna radiata*)

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Greengram (*Vigna radiata* L. Wilczek) occupies prime position among pulses by virtue of its short growth period and outstanding nutrient value as food, feed and forage. Among the pulses, greengram is one of the most important and extensively cultivated pulse crops. It contains about 25 per cent protein, 1.3 per cent fat, 3.5 per cent minerals, 4.1 per cent fiber and 56.7 per cent carbohydrate. It is consumed as a whole grains as well as dal in a variety of way, being easily digestible it is preferred by patients. It is valued for its excellent taste, flavour and high digestibility and free from the “flatulency effect” which is associated with other pulses. When seeds of greengram are allowed to sprout, ascorbic acid (Vitamin C) is synthesized besides riboflavin and thiamine is also increased. In India, greengram occupies an area of about 3.51 million hectare producing 1.80 million tonnes with the productivity of 511 kg/ha. Fertilizers played a vital role in agriculture production and productivity in India but continuous and imbalanced use of chemical fertilizer creates problem in the production and deterioration of soil health. Hence, use of chemical fertilizer in combination with organic manure is required to improve the soil health (Bajpai *et al.,* 2006). For a sustained agricultural growth, pulses have become inevitable to enhancing the crop productivity and sustain natural resources base through recycling of organic matter. Hence, the present investigation carries out to study the impact of organic manures substituting inorganic fertilizers on productivity and profitability of green gram.

METHODOLOGY

A field experiment was carried out at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during the summer season of the year 2014. The soil of the experiment site was clayey in texture (clay 66.7 %, sand 13.7 % and silt 19.3 %) with pH 7.8 and electrical conductivity (EC) 0.48 ds/m in the top 30 cm soil. The soil was low in available nitrogen (229 kg/ha) and organic carbon (0.44 %)

and medium in available phosphorus (29 kg/ha) and rich in available potassium (385kg/ha). Nine treatments comprised *viz.*T_1-100 % RDF (20:40:00 NPK kg/ha), T_2-75 % RDF, T_3-50 % RDF, T_4-FYM @ 2 t/ha, T_5-75 % RDF + FYM @ 2 t/ha, T_6- 50 % RDF + FYM @ 2 t/ha, T_7-vermicompost @ 1.25 t/ha, T_8-75 % RDF + vermicompost @ 1.25 t/ha T_9- 50 % RDF + vermicompost @ 1.25 t/ha. The experiment was laid out in randomized block design with three replications. Vermicompost and FYM in different treatments were applied as per the treatments before 9 days to sowing and thoroughly incorporated into 15 cm top soil layer. Nitrogen and phosphorus were applied as urea and single super phosphate fertilizers, respectively.

RESULTS

The data (Table 1) regarding growth attributes were significantly influenced by various nutrient management treatments. An appreciable increase in growth attributes *viz.,* plant height, number of branches and number of leaves was observedwith increasing age of crop. The growth attributes *viz.,* plant height (55.38 cm), number of branches (4.14) and number of leaves (20.42) were registered significantly higher with application of 75 % RDF + vermicompost @ 1.25 t/ha (T8) over rest of the treatments but it was at par with 100 % RDF, 75 % RDF + FYM @ 2 t/ha, 50 % RDF + FYM @ 2 t/ha and 50 % RDF + vermicompost @ 1.25 t/ha in case of plant height and number of leaves and with 75 % RDF + FYM @ 2 t/ha in case of number of branches. The possible reason for higher growth characters might be due to availability of essential plant nutrients, growth hormones, organic matters and another favourable condition through vermicompost. Different treatments did not show significant role on protein content but protein yield was significantly influenced by various treatments (Table 2). Application of75% RDF + vermicompost @ 1.25 t per ha produced significantly higher protein yield (216 kg/ha), which was at par with treatments 75% RDF + FYM @ 2 t per ha and 100% RDF. The increase in protein yield was mainly due to higher seed yield under treatment 75 % RDF + vermicompost @ 1.25 t per ha. The data on economics (Table 3) revealed that treatment 75% RDF + vermicompost @ 1.25 t per ha accrued maximum net realization (₹ 42359 /ha) with BCR (2.91), which was followed by treatment 75 % RDF + FYM @ 2 t/ha (₹ 41550 /ha and 2.81, respectively) and treatment 100%RDF (₹ 40532 /ha and 2.88, respectively).

Table 1. Yield and nutrient uptake of green gram as influenced by nutrient management

Treatment	Yield (kg/ha)			Nutrient uptake(kg/ha)					
	Seed	Stover	Protein	N		P		K	
				Seed	Stover	Seed	Stover	Seed	Stover
T_1 - 100 % RDF (25:50:00 NPK kg/ha)	964	2560	197	31.53	18.14	6.78	5.74	12.46	22.54
T_2 - 75 % RDF	858	2319	171	27.39	16.18	5.83	5.16	10.9	19.95
T_3 - 50 % RDF	728	2035	140	22.44	13.92	4.85	4.36	9.25	17.36
T_4 - FYM @ 2 t/ha	787	2053	153	24.54	14.12	5.29	4.44	9.98	17.66
T_5 - 75 % RDF + FYM @ 2 t/ha	998	2571	204	32.66	18.24	7.12	5.87	13.01	22.79
T_6 - 50 % RDF + FYM @ 2 t/ha	874	2363	176	28.18	16.51	6.01	5.26	11.21	20.51
T_7 - Vermicompost @ 1.25 t/ha	838	2248	163	26.20	15.51	5.68	4.90	10.69	19.37
T_8 - 75 % RDF + vermi compost @ 1.25 t/ha	1016	2593	216	34.82	18.51	7.33	5.96	13.61	23.09
T_9 - 50 % RDF + vermi compost @ 1.25 t/ha	876	2445	177	28.39	17.16	6.08	5.46	11.29	21.23
CD (P=0.05)	137.13	185.06	31.97	3.92	1.52	1.08	0.54	2.29	1.83

On the basis of the results, it can be concluded that summer cultivation of green gram cv. Meha was found more productive and profitable with application of 75% RDF (18.75 kg N + 37.50 kg P_2O_5) + vermicompost @ 1.25 t/ha. It was closely followed by 75% RDF + FYM @ 2t/ha. The use of organic manure in combination with inorganic fertilizers helps in increasing productivity and profitability.

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Real time nitrogen management in sweet corn (*Zea mays saccharata* L.) through decision support tools in sub-tropical India

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Limited nitrogen supply and availability decreases biomass and yield production of sweet corn in sub-tropical environments of India. Blanket recommendations based on fixed-time application of N fertilizers at specified growth stages of corn do not consider the dynamic soil N supply and crop N requirements, and lead to improper application of N fertilizer. Therefore, need based fertilizer N management in corn will help to improve N efficiency and to reduce N losses. Real time N requirement of corn can be accomplished by different decision support tools. Existing literature have indicated that gadgets such as leaf colour chart (LCC) and chlorophyll meter (SPAD), GreenSeeker are efficiently used for guiding real-time N top dressings in cereals. The objective of the investigation was to study the relationship of leaf greenness as measured by LCC, SPAD meter, GreenSeeker readings on sweet corn performance and to find out threshold values for top dressing N fertilizers according to crop needs.

METHODOLOGY

A field experiment was conducted at Main Agricultural Research Station, Raichur Karnataka during *Rabi* 2014-15 and 2015-16. The soil of the experimental site was sandy loam with pH 7.8, Initial soil available NPK was in medium range. Protective irrigation was provided throughout the crop growth without shortage in soil moisture. The hybrid Sugar-75 was selected for the study. Treatments consist of recommended nitrogen (150 kg/ha) in two and three splits, Leaf color chart panel 4 and 5, SPAD readings 40 and 50 Green Seeker 0.6 and 0.8 as thresholds compared without nitrogen and 2% urea foliar spray. The top most fully expanded leaf was placed on the LCC and the color of the middle part of the leaf was matched with greenness of the panels on the LCC. The SPAD readings were recorded by inserting the middle portion of the index leaf in the slit of SPAD meter. From each plot, readings from ten randomly selected plants were averaged. Optical sensor readings were taken with a hand held GreenSeeker measured canopy reflectance at red (656nm) and near infrared (NIR) regions (774 nm) represent the fraction of emitted NIR and red radiation reflected back from the sensed area, respectively. The sensor was passed over the crop at a height of about one meter. For those treatments with LCC, SPAD and Greenseeker threshold nitrogen fertilizers were applied. However, subsequent N was applied based on pre fixed threshold levels. At fortnightly interval, LCC, SPAD and GreenSeeker based NDVI observations were recorded. In addition, basal application of 75 kg N followed by foliar sprays of 2 % urea at 30, 45 and 60 DAS and without N application as check. Experiment was laid out in RCBD with three replications. The crop was planted in November and harvested at milky stage (87 DAS) by removing the fresh cobs from 19.2 m^2 net plot. Nitrogen content in grains at final harvest was estimated by following standard procedure.

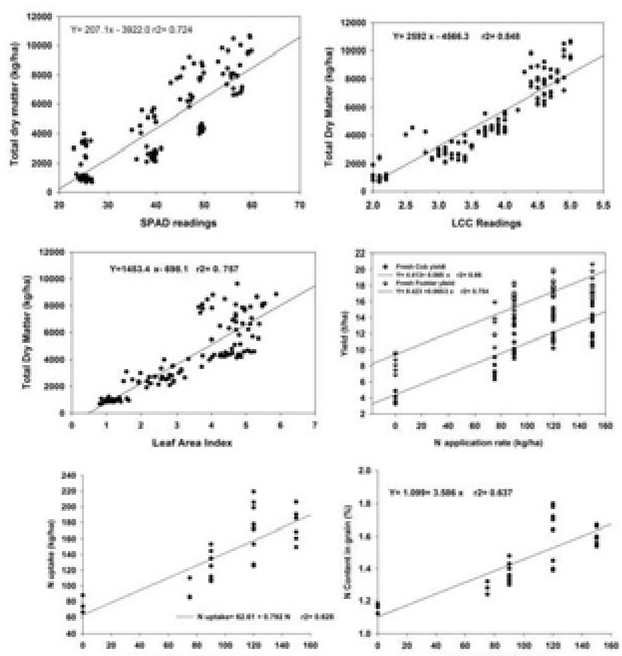

Fig. 1. Relationship between total dry matter, fresh cob yield, nitrogen uptake and grain N content and LCC scores, SPAD readings and N application rate. The data was pooled over two years (2015 and 2016) and three replications (n= 60) throughout the crop growth period.

RESULTS

The quantity of N fertilizers reduced under LCC, SPAD and GreenSeeker thresholds was upto 30-60 kg/ha (30 %) over blanket recommendation (150 kg N/ha) without sacrifice in yield of sweet corn. The results of the study pooled over two years indicated that sweet corn cob yield greatly influenced by nitrogen application through different decision support tools. A strong linear relationship was observed between LCC scores (r^2=0.848, n= 60) and SPAD readings (r^2=0.724, n=60) and leaf area index (r^2=0.757, n=60) on above ground dry matter production in both the years. These are showed as effective tools than blanket N recommendation and influence on biomass production. Intensity of fully exposed leaf colour as measured by comparison with different shades of green colour on a LCC was strongly indicated in-season sufficiency or deficiency. Lower LCC thresholds might be inadequate to meet the crop N requirement. Nitrogen application rate based on theses decision tools influence fresh cob yield (r^2=0.66) and green fodder yield (r^2=0.754). However, low relationship was observed between N application and grain N content (r^2= 0.637) and uptake (r^2=0.628). It might be due to early harvest of the cobs before full maturity and grain formation has resulted in low accumulation of N in grains. The decision support tools are highly suitable in achieving higher sweet corn yield with lower N application rate.

CONCLUSION

Thus LCC and SPAD could reliably indicate chlorophyll content in maize leaves and help guide in-season N fertilizer applications. Among all tools LCC being cheaper, simple and farmers' friendly thus could be used to improve fertilizer use efficiency and productivity over costly SPAD meter and GreenSeeker.

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Yield maximization of Bt cotton through fertigation

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Management of water and nutrients plats a key role in breaking of the undesired tempo in productivity plateau after major enhancement by introduction of Bt cotton which occupies more than 85% area under cotton. Since indiscriminate use of water through conventional type with 60 per cent application efficiency is causing serious threat to available ground water resources on the other hand drip-fertigation, where fertilizer is also applied through an efficient irrigation (drip) system, Nutrients Use Efficiency could reach as high as 90 per cent besides achieving > 95 per cent application efficiency. Therefore, the amount of fertilizer lost through leaching could be as low as 10% in drip fertigation as compared to 50% in the traditional one besides achieving higher seed cotton yield. Nitrogen plays an important role in growth and development of cotton. Limited nitrogen supply and availability in soil decreases yield production of Bt cotton in sub-tropical regions of India. Blanket recommendations based on fixed-time application of N fertilizers at specified growth stages of Bt cotton do not consider the dynamic soil N supply and crop N requirements, and lead to improper application of N fertilizer. Therefore, need based fertilizer N management in corn will help to improve N efficiency and to reduce N losses. N requirement of Bt cotton can be improved by drip fertigation at different intervals.

METHODOLOGY

A field experiment was conducted at Main Agricultural Research Station, Raichur, Karnataka during *Kharif* 2014-15 and 2015-16. The soil of the experimental site was medium black with pH 7.4, Initial soil available Nitrogen, Phosphorus and Potassium were in medium range. The experiment was conducted with RCBD having 11 treatments replicated thrice. The treatments were: T_1: Control (Surface irrigation with rec. NPK/ha), T_2: 75% N through drip at 5 days interval, T_3: 75% N through drip at 7 days interval, T_4: 75% N through drip at 10 days interval Protective, T_5: 100% N through drip at 5 days interval, T_6: 100% N through drip at 7 days interval, T_7: 100% N through drip at 10 days interval, T_8: 125% N through drip at 5 days interval, T_9: 125% N through drip at 7 days interval, T_{10}: 125% N through drip at 10 days interval and T_{11}: 100% N through water soluble fertilizers drip at 10 days interval. Seventy five per cent of recommended N, 100% Nitrogen and 125% N was applied to the crop at 5 days, 7 days and 10 days interval through drip fertigation up to 110 days of crop growth.

Table 1. Pooled ancillary characters, seed cotton yield (kg/ha), nitrogen use efficiency (kg/kg N applied) and water use efficiency (kg/ha-cm) as influenced by different fertigation treatments during 2014-15 & 2015-16

Treatments		No.of Mono-podia/ plant	No.of Sym-podia/ plant	No.of Bolls/ plant	Boll weight (g)	Seed Cotton Yield (g/pl)	Seed Cotton Yield (t/ha)	NUE (kg/kg N applied)	WUE (kg/ha-cm)
T1:	Control (Surface irrigation with rec. NPK/ha)	1.3	20.5	29.1	4.68	108.2	2.30	19.13	25.51
T2:	75% N through drip at 5 days interval	1.6	27.7	36.6	4.99	131.1	2.30	29.98	47.11
T3:	75% N through drip at 7 days interval	1.2	25.6	34.5	4.95	127.0	2.52	28.03	51.18
T4:	75% N through drip at 10 days interval	1.1	24.1	32.7	4.89	123.1	2.43	27.00	54.69
T5:	100% N through drip at 5 days interval	1.6	30.6	40.9	5.22	136.4	2.81	23.47	49.31
T6:	100% N through drip at 7 days interval	1.5	28.3	38.6	5.13	133.5	2.73	22.76	55.55
T7:	100% N through drip at 10 days interval	1.2	26.7	36.9	5.07	130.2	2.62	21.86	59.22
T8:	125% N through drip at 5 days interval	1.8	33.7	44.2	5.48	144.5	2.98	19.85	52.13
T9:	125% N through drip at 7 days interval	1.6	21.8	41.7	5.41	140.7	2.82	18.84	57.50
T10:	125% N through drip at 10 days interval	1.4	30.9	39.6	5.24	137.3	2.76	18.73	62.45
T11:	100% N through WSF drip at 10 days interval	2.0	34.7	45.8	5.59	152.8	3.09	25.76	63.02
	SEm±	0.06	1.3	1.6	0.16	6.1	0.101	0.86	2.03
	CD (P=0.05)	0.2	3.6	4.7	0.44	17.5	0.289	2.46	5.82

RESULTS

Pooled experimental results of two years (2014-15 & 2015-16) revealed that significantly higher seed cotton yield (3091 kg/ha), number of monopodia/plant (2.0), number of sympodia/plant (34.7), number of bolls/plant (45.8), boll weight (5.59 g), seed cotton yield (152.8 g/ plant) were obtained 100% N through WSF drip at 10 days interval followed by 125% N through drip at 5 days internal (2977 kg/ha), 125% N through drip at 7 days interval (2825 kg/ha) and 100% N through drip at 5 days interval (2817 kg/ha) which found on par with each other. Significantly higher Nitrogen Use Efficiency was achieved with 75% N through drip at 5 days interval (29.98 kg/kg N applied) followed by 75% N through drip at 7 days interval (28.03 kg/kg N applied) which found on par with each other. Significantly higher water use efficiency was achieved with 100% N through WSF drip at 10 days interval (63.02 kg/ha-cm) followed by 125% N through drip at 10 days interval (62.45 kg/ha-cm) and 100% N through drip at 10 days interval (59.22 kg/ha-cm) which found on par with each other.

CONCLUSION

Split Nitrogen application through fertigation thus helps in getting higher seed cotton yield and increased Nitrogen Use efficiency and Water Use Efficiency.

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Effect of foliar application of potassium nitrate, ferrous sulphate and magnesium sulphate on growth, yield and quality of chilli (*Capsicum annuum*)

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A field experiment was conducted during the *kharif* season of 2013-14 at MARS, UAS, Dharwad to investigate the effect of foliar application of potassium nitrate, ferrous sulphate and magnesium sulphate on growth, yield and quality of chilli (*Capsicum annuum* L.) Cv. Dyavanurdabbi. The experiment was laid out in randomized complete block design with three replications and eight treatments. Treatments consisted of foliar application of KNO_3, $FeSO_4$ and $MgSO_4$ each @ 1% alone and its combinations at 60 and 90 DAT. Application of KNO_3 + $FeSO_4$ + $MgSO_4$ each @ 1 per cent at 60 and 90 DAT recorded higher growth parameters like plant height (112.3 cm), number of branches/hill (20.6) and total dry matter accumulation, yield parameters like number of fruits/hill (49.7), hundred fruit weight (168.0 g), fruit yield (14.8 q/ha), quality attributes like colour value (269.63 ASTA units), oleoresin content (16.43%), oleoresin yield (231.1 kg/ha) and lower discoloured fruits (5.43%). While lower growth parameters like plant height (96.2 cm), number of branches/hill (16.2) and total dry matter accumulation, yield parameters like number of fruits/hill (41.0), hundred fruit weight (148.47 g), yield (12.27 q/ha), lower quality attributes were recorded in control (193.17 ASTA units, 11.92 per cent and 136.96 kg/ha, respectively). The same treatment were recorded higher net returns of Rs. 1,03,830/ha with an B:C ratio of 3.35 whereas lower net returns (Rs. 54,063/ha and 2.42, respectively) values were obtained in control. Significantly positive correlation was observed between yield Vs number of branches per hill (r=0.949**), total dry matter production per hill (r=0.933**), number of fruits per hill (r=0.991**) and 100 dry fruit weight (r=0.889**), quality parameters like colour value (r=0.885**) and oleoresin content (r=0.907**), however discoloured fruits negatively correlated (r=-0.716*) with yield.

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SPAD meter based N management strategy for rice in Indo-Gangetic plain of Bihar: a case study

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Insufficient N supply results in smaller leaf surface and lower photosynthesis and chlorophyll content, leading to loss of yield and quality. Therefore, N recommendations must be based on the crop demand and supply capacity of the soil. Excessive application of N fertilizer as blanket recommendation increases not only production cost but also environmental pollution. It is very essential to develop effective diagnosis of rice N status for sustainable rice production (Ghosh *et al*., 2013). Therefore, the difference between the nitrogen supply from the soil and crop need must be mitigated to increase the crop productivity as well as to maintain soil health (Peng *et al*., 1996). Minolta Camera Company developed a portable chlorophyll meter or SPAD (Soil-Plant Analyses Development) meter which can be used to estimate chlorophyll levels in leaves. N is the key element in chlorophyll molecules that capture sunlight used in

Table 1. N rate, No. of split of applied N, yield and yield attributes of rice grown under different nitrogen management practices

Treatment	N rate (kg /ha)	No. of split of applied N	Grain yield (t/ha)	Straw yield (t/ha)	Panicles /m²	Grains /panicle	Test Weight (g)
$S_{34} N_{15}$	55	3	3.45	4.60	238	74	23.2
$S_{34} N_{20}$	65	3	3.93	5.20	267	81	23.3
$S_{34} N_{25}$	75	3	4.67	5.60	288	78	24.0
$S_{36} N_{15}$	70	4	4.39	5.55	280	77	23.5
$S_{36} N_{20}$	65	3	4.04	5.22	261	76	24.0
$S_{36} N_{25}$	67	3	4.40	4.92	267	78	24.8
$S_{38} N_{15}$	70	4	4.33	5.73	282	72	23.8
$S_{38} N_{20}$	85	4	5.19	6.82	296	85	24.4
$S_{38} N_{25}$	75	3	4.55	5.77	288	76	25.1
$S_{40} N_{15}$	85	5	4.89	5.93	290	80	23.4
$S_{40} N_{20}$	78	4	4.44	6.73	292	72	23.9
$S_{40} N_{25}$	92	4	4.36	6.80	297	75	24.2
FTNM	100	4	4.47	7.50	311	78	24.5
Control	0	-	2.56	2.70	188	65	22.2
LSD (P=0.05)			0.55	1.00	30	10	1.5

Note: The subscripts of S represent the SPAD threshold value and the subscripts of N represent the amount top dressed as kg N /ha in each application; FTNM-Fixed time Nitrogen management; LSD-Least significant difference

photosynthesis. Using SPAD Meter showed that the same rice yield could be achieved with 20-30% less use of fertilizer N and provides good N utilization efficiency (Singh *et al*., 2002). SPAD meter can synchronize the time of fertilizer N application in a non-destructive manner with actual crop demand for precision N management. Now the challenge is to convert the applied N in soil to grain with maximum use efficiency as N is the most critical inputs in rice based cropping system. Generally subtropical belt is located between the tropical and temperate belts and is characterized by periodic alternation of tropical and temperate climatic conditions. Tropical and subtropical soils often have lower organic matter contents than soils in temperate zones but the rate of decomposition is higher as compared to temperate climate. Thus fertilizer N use efficiency of cereals remains low in subtropical belt as compared to temperate belt. The present investigation was focused as to how chlorophyll meter help in determining optimal N management through real time N application for improving growth, productivity of subtropical rice.

METHODOLOGY

Field experiment was conducted in the sandy loam soil of the experimental farm of Bihar Agricultural University, Sabour, Bhagalpur during the *Kharif* season of 2013. The soil was neutral in reaction with a pH 6.9, and 118, 20 and 112 kg/ha available N, P and K respectively. The experiment was carried out during the wet season (June to October) of 2013 in completely randomized block design with three replications. Rice variety *Rajendra Sweta* was used in the present investigation and the experiment includes twelve treatment combinations of four SPAD values (34, 36, 38, and 4) and three N levels (15, 20, and 25 kg/ha), at each topdressing as real time N management (RTNM), one fixed time N management (FTNM) with 100-40-20 kg N-P_2O_5-K_2O/ha, and control (zero-N). All treatment combinations except control received 25-40-20 kg N-P_2O_5-K_2O/ha as basal. In the RTNM treatments, N was top dressed in the form of urea when the SPAD value went below the threshold level up to the first flowering (Fig. 1). In FTNM, N was top dressed at 25 kg/ha each at active tillering, panicle initiation and heading stages of rice crop. The SPAD meter (SPAD 502) was used for SPAD measurement started from active tillering (20 days after transplanting - DAT) and was continued up to the first flowering stage (80 DAT) at 10 days interval for all treatments and replications. The fully youngest expanded leaf was used for the SPAD measurement. Readings were taken on one side of the midrib of the leaf blade, midway between the leaf base and tip. A mean of 15 readings per plot was taken as the measured SPAD value. The sources of chemical fertilizers were urea, single super phosphate and muriate of potash.

RESULTS

The rice grain yield did not much vary significantly among the N management treatments at same SPAD values except SPAD 34 under RTNM. FTNM recorded high grain yield, which was comparable to most of the N managements under RTNM with higher N rates (Table 1). Among the RTNM, the SPAD value of 38 and N rate of 20 kg/ha with four times split applications achieved the highest grain yield against total application of 85 kg N/ha and was significantly superior to FTNM at 100 kg N/ha. Our data suggest that excessive use of N input might have reduced the yield advantage of FTNM over RTNM during the study. The control plots produced the lowest grain yield among all other treatments. The results showed that timely adequate N application through RTNM could considerably reduce the N application rate by 15% to 33% of the existing N fertilizer recommendation in FTNM without reducing the rice grain yield. This not only reduces the cost of rice cultivation by saving the fertilizer N but also increases its use efficiency. The straw yield showed somewhat different trend from that of the grain yield during both the years (Table 1). It increased significantly due to high rate of N application in FTNM over low and medium rate of SPAD values (SPAD 34, 36 and 38) under RTNM. Almost similar straw yield was obtained by reducing 8% to 22% N through RTNM over FTNM. FTNM recorded the maximum number of panicles per unit area resulted in reducing the grain number per panicle as compared to that of RTNM. The study suggested that increasing the number of panicles per unit area decreased the number of grains per panicle and maintained the test weight (Table 1).

CONCLUSION

The results showed that SPAD meter based real time N application in rice produced yields similar to that of existing fertilizer recommendation (FTNM) and saved 15 to 33% fertilizer N compared to FTNM. However, maintaining 38 SPAD threshold and application of 20 kg N/ha could save 15% fertilizer N in addition to 16% higher grain yield than that of FTNM.

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Effect of integrated nutrient management practices on growth and productivity of wet season transplanted rice

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Enhancing the rice productivity through the improvement of yield potential of genotypes and appropriate nutrient management has been the main thrust of Indian rice policy. Inorganic fertilizer is one of the key factors to increase the rice productivity. Rice yield has increased rapidly due to increased use of chemical fertilizers. In the recent years, crop productivity has stagnated or decreased in spite of consumption of increased rate of chemical fertilizers (Chen *et al.* 2011). As a result, agricultural ecosystems remain in a state of chemical nutrient saturation, leading to huge nutrient losses throughleaching, runoff, volatilization, emissions, immobilization and subsequent low nutrient use efficiency (Zhang *et al.* 2012). It is high time to search for innovative practices, which can guarantee higher yields with minimal deterioration of natural resources. Integrated nutrient management has been shown to considerably improve rice yields by minimizing nutrient losses to the environment and managing the nutrient supply, and thereby results in high nutrient use efficiency (Mondal *et al.* 2015). With this perspective present investigation was carried out to study the effect of different integrated nutrient management practices on growth and productivity of wet season transplanted rice.

METHODOLOGY

Field experiment was carried out during *Kharif*season of 2015 at Agriculture Farm, Palli Siksha Bhavana(Institute of Agriculture), Visva-BharatiUniversity, Sriniketan, West Bengal.Eight treatments comprisedof T1: Control;T2:100% RDN;T3:75% RDN +25%N as FYM;T4:75% RDN +25% N as MOC, T5:75% RDN +*Dhaincha* green mannuring (GM), T6:75% RDN + *Dhaincha* brown manuring (BM);T7:75% RDN + Azolla dual culture andT8:50% RDN+25%N as FYM+Azolla dual cultureThe experiment was laid out in randomized block design with three replications.Ricevariety was MTU 1010.The recommended dose of fertilizer applied was80 kg N, 40 kg each of P_2O_5 and K_2O/hectare. Phosphorus and potassium were applied uniformly in all the treatments. All other recommended agronomic practices and plant protection measures were adopted to raise the crop. The data on growth attributeswere recorded at different growth stages of rice crop.Grain and straw yield

Table 1. Effect of integrated nutrient management on plant height, number of tillers, filled grains per panicle, grain yield and straw yield oftransplanted rice.

Treatment	Plant height at harvest	Number of tillers/m^2 at 60 DAT	No of filled grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)
T1: Control	113.0	262	111	2.90	4.09
100% RDN	121.0	336	125	5.90	7.16
75% RDN+25%FYM	120.5	312	130	5.38	6.93
75% RDN+25%MOC	119.2	321	122	5.44	6.86
75% RDN+GM	123.9	339	130	5.84	7.00
75% RDN+BM	122.6	306	125	5.85	7.05
75% RDN+Azolla	123.2	336	132	5.50	7.15
50% RDN+25%FYM+Azolla	124.4	319	123	5.44	7.09
CD (P=0.5)	5.2	29	12	0.593	0.718

RDN:Recommended dose of fertilizer N (80 kg/ha), FYM: Farm yard manure, MOC: Mustard oil cake, GM: Green manuring, BM: Brown manuring.

of rice along with yield components were recorded at harvest.

RESULTS

Nutrient management practices showed significant effect on increasing plant height, tiller number in transplanted rice. The crop receiving 50% RDN+25%FYM+Azolla registered highest plant height at harvest which was statistically at par with all other nutrient management practices. The highest number of tillers was recorded with incorporation of 75% RDN+GM but it was at par with all other treatments except control. Dual culture of *azolla* with transplanted rice along with application of 75% RDN had resultedhighest number of filled grains per panicle which was at par with all other nutrient management practices. Though the grain yield (5.90 t/ha) and straw yield (7.16t/ha) recorded was highest with 100% RDN, but all the integrated nutrient management treatments (T3 to T8) registered at par grain and straw yield with 100% RDN treatment. Among the different integrated nutrient management practices brown manuring recorded highest grain yield (5.85t/ha) which was closely followed by green manuring (5.84 t/ha). Integrated use of appropriate proportion of organic manures and chemical fertilizers increases N accumulation in the foliage improves growth and controls senescence of the whole plant, causing more dry matter production ultimately resulting in higher values of yield attributes and yield. The lowest grain yield (2.90 t/ha) was recorded under control.

CONCLUSION

It may be concluded that integrated use of organics along with inorganic fertilizers recorded at par values with respect to 100% RDN in terms of improving growth attributes, yield components and productivity of transplanted rice.

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Effect of application of oxalic acid and phosphate solubilising bacteria loaded clay polymer composite on phosphorus availability in soil

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Phosphorus (P) is an essential nutrient element required for growth and development of plant and often a limiting factor in crop production. Therefore, application of fertilizer P is necessary to increase crop yield and to improve nutritional quality of crops. But soil application of phosphatic fertilizers leads to its fixation by soil constituents, which results in severe waste of P fertilizers, lowering P use efficiency (PUE) and heavy economic loss, as only 15–30% of applied fertilizer P is taken up by crops in the year of its application. Low molecular weight organic acids such as oxalic acid or citric acid are known to solubilise fixed P in soil. Hence, these can be used to increase P availability in soil. Therefore, our aim was to develop controlled delivery system using clay and polymer which will release oxalic acid and phosphate solubilising bacteria (PSB) in soil to increase P availability. A series of clay polymer composite (CPC) loaded with oxalic acid and PSB was applied in soil with the objective to increase p availability in soil.

METHODOLOGY

A series of CPC loaded with oxalic acid and PSB was prepared using acrylic acid and bentonite following the method of Liang and Liu, 2007. An incubation experiment was carried out to study the effect of application of oxalic acid and PSB loaded CPC in soil on P availability in soil. For this purpose, a calculated amount of CPCs (5% oxalic acid @40 mg kg^{-1} soil) was added to 50 g of soil. Same amount of CPC as required in oxalic acid loading was soaked in 1 mL of 7 days old pure culture of PSB and was added to soil and thoroughly mixed. One absolute control sample i.e. only soil was also kept. These soils were then incubated for 45 days at ambient temperature. Moisture content was maintained at field capacity. At different time intervals, soil was extracted with 0.5 M $NaHCO_3$ solution by shaking for 30 min. Phosphorus content in the extract was determined with ascorbic acid blue color method (Watanabe and Olsen, 1965).

RESULTS

Results indicate that there was significant increase in soil available P when oxalic acid and PSB was applied through CPC over control. Very high soil available P (33.6 mg kg^{-1}) was maintained up to 30 days of incubation (DOI) where PSB loaded CPC was applied. At 45 DOI available P content in soil was higher at oxalic acid and PSB treated samples over control. But soil available P content at 45days was lower as compared to up to 30 DOI. This implies that when oxalic acid and PSB is applied through CPC in soil is highly effective in increasing the available P in soil by solubilizing some reserve P of this soil.

CONCLUSION

Oxalic acid and PSB loaded CPC is found to be effective in increasing P availability of soil by solubilising some reserve P of the soil. They can maintain high available P up to 30 days after application.

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Drip fertigation effects on productivity and nutrient use efficiency of elephant foot yam (*Amorphophallus paeoniifolius*)

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Elephant foot yam (*Amorphophallus paeoniifolius*) is a widely spaced crop grown for its starchy underground modified stem botanically known as corm. It is a crop of tropical region. In Indian it is cultivated in Andhra Pradesh, Bihar, Gujarat, Karnataka, Kerala, Maharashtra, Odisha, Tamil Nadu, Uttar Pradesh, West Bengal and North eastern states. Being a cash crop, it is cultivated with protective irrigation. This long duration crop (8 months) requires huge amount of water and nutrients. In Tamil Nadu, it is raised by providing weekly irrigation (Srinivas and Ramanathan, 2005). Drip irrigation is advantageous for elephant foot yam and there was 40% yield increase under drip irrigation (Nedunchezhiyan *et al*., 2008). In elephant foot yam, very high amount of N-P-K fertilizers are applied. The use efficiency is around 20-30% only when applied in soil. Fertigation provides the most effective way of supplying nutrients to plant roots. A study was therefore undertaken to determine drip fertigation effects on productivity and nutrient use efficiency of elephant foot yam.

METHODOLOGY

A field experiment was conducted for two years (2013-14 and 2014-15) at the Regional Centre of ICAR-Central Tuber Crops Research Institute, Bhubaneswar, Odisha. The experiment was laid out in split plot design with fertigation interval (2, 3 and 4 days) in main plots and in sub plots the recommended fertilizer (water soluble fertilizer N- P_2O_5-K_2O 120-60-120 kg/ha) was split into 30(N- P_2O_5-K_2O 4-2-4 kg/ha/dose), 40 (N-P_2O_5-K_2O 3-1.5-3 kg/ha/dose) and 50 (N-P_2O_5-K_2O 2.4-1.2-2.4 kg/ha/dose) doses and applied through drip irrigation. A Check (furrow irrigation; P_2O_5 60 kg/ha basal application; N-K_2O 120-120 kg/ha soil application at 1 (40%), 2 (30%) and 3 (30%) months after planting (MAP)) and a control (furrow irrigation; no fertilizer application) treatments were also included. The treatments were replicated in three times. The treatments were imposed 10 days after planting. Farmyard manure 10 t/ha was incorporated in the last plough in all the treatments. The crop was drip irrigated 80% CPE. The irrigation was withheld 10 days before harvesting. The crop was harvested 8 MAP. The data was subjected to one way analysis and treatment means were compared with critical difference at 5% probability by following standard procedure.

RESULTS

The results revealed that maximum plant height and plant spread at 3 and 5 MAP was recorded in treatments received higher fertigation (Table 1). The treatment fertigation at 2-3 days interval with 30-40 split doses recorded higher plant height and plant spread at 3 MAP where as fertigation at 3 days interval with 50 split doses registered taller and wider plants at 5 MAP. This indicated that more nutrients are applied higher the growth parameters irrespective of the stage. However, nutrient application beyond 5 months, it was not influencing the shoot growth. The control treatment (no fertilizer) recorded lower plant height and spread at 3 and 5 MAP. Corm yield was increased with increasing fertigation interval from 2 to 4 days (Table1). Maximum corm yield was observed with fertigation at 4 days interval and 40 numbers of split of recommended dose of fertilizer. The treatment fertigation at 4 days interval with 50 numbers of split of recommended dose of fertilizer recorded lesser corm yield. Interpolation of fertigation duration indicated that the crop responded upto 180 days after planting. Plant unable to utilize nutrients applied after 180 days. Maximum nutrient use efficiency of 69.0% was noticed fertigation at 4 days interval and 40 numbers of split of recommended dose of fertilizer (Table 1). This was 35.9% higher nutrient use efficiency than soil application. Application of recommended dose of fertilizer in soil recorded just 33.1% nutrient use efficiency.

CONCLUSION

Drip fertigation at 4 days interval with 40 number of splits of recommended dose of fertilizer (water soluble fertilizer N- P_2O_5-K_2O 120-60-120 kg/ha) was required to achieve greater corm yield and nutrient use efficiency in elephant foot yam.

Table 1. Growth and yield of elephant foot yam as influenced by fertigation interval and number of splits (mean of 2 years).

Treatment	Plant height (cm)		Plant spread (cm)		Corm yield (t/ha)	NUE* (kg/kg)	NUE (kg/kg) over soil application
	3 MAP	5 MAP	3 MAP	5 MAP			
2 days interval , 30 splits	78	90	90	118	24.9	27.9	(-)5.3
2 days interval , 40 splits	82	91	94	120	28.2	39.4	6.3
2 days interval , 50 splits	80	94	90	122	30.1	46.3	13.3
3 days interval , 30 splits	82	89	93	119	30.1	47.0	27.9
3 days interval , 40 splits	78	92	91	123	33.4	59.4	26.3
3 days interval , 50 splits	75	97	89	126	35.2	65.2	32.2
4 days interval , 30 splits	77	92	91	124	32.6	81.4	22.7
4 days interval , 40 splits	74	93	86	123	36.0	69.0	36.0
4 days interval , 50 splits	71	92	83	122	32.4	57.4	29.4
Check (furrow irrigation; soil application of fertilizer)	72	92	83	120	26.4	33.1	-
Control (furrow irrigation; no fertilizer)	64	82	79	98	17.5	-	-
SEm±	1.7	3.1	1.0	1.7	0.6		
CD (P=0.05)	5	9	3	5	1.7	-	-

*NUE- Nutrient use efficiency

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Yield and yield parameters of compact cotton genotypes as influenced by graded levels of fertilizer under high density planting system

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A field experiment on "Yield and yield parameters of compact cotton genotypes as influenced by graded levels of fertilizer under high density planting system" was conducted under rain fed conditions at Main Agricultural Research Station, U.A.S., Dharwad for consecutive years during 2014-15 and 2015-16. This experiment consisted of four genotypes (RAH-274, RAH-99, DHG-7-96 and DSC-1351) as main plots, three spacings (60x15, 45x15 and 45x10 cm) as sub plots and two graded levels of fertilizer (100:50:50 and 80:40:40 kg NPK/ha) under sub-sub plots. Experiment was laid out in strip-split plot design with three replications. Among the cotton genotypes, RAH-99 recorded significantly higher seed cotton yield (3165 kg/ha) as compared to other genotypes. However, RAH- 274 (3101 kg/ha) and DSC-1351 (3105 kg/ha) also recorded on par yield that of RAH-99. While, significantly lower seed cotton yield was observed in DHG-7-96 (2882 kg/ha). The population density of 2,22,222 plants/ha (45x10 cm) produced significantly higher seed cotton yield (3383 kg/ha) over population densities of 1,48,148 plants/ha (45x15 cm) (3056 kg/ha) and 1,11,111 plants/ha (60x15 cm) (2750 kg/ha). There was significant difference in seed cotton yield due to application of graded levels of fertilizer. The application of higher levels of fertilizer appreciably influenced the seed cotton yield over lower level of fertilizer. The application of higher dose of fertilizer 100:50:50 kg NPK/ha (125% of RDF) recorded significantly higher seed cotton (3158 kg/ha) as compared to seed cotton yield obtained under the application of fertilizer of 80:40:40 kg NPK/ha (100% RDF). Interaction effect between cotton genotypes, spacing and fertilizer levels were found to be significant. RAH-274 sown at spacing of 45x10 cm with the application of 100:50:50 kg/ha recorded significantly higher seed cotton yield 3668 kg/ha as compared to rest of treatment combinations. Lower seed cotton yields were recorded by DHG-7-96 with wider spacing of 60x15 cm with the fertilizer application 80:40:40 kg NPK/ha as compared to rest of interactions. The yield parameters like number of bolls/plant, boll weight (g) and seed cotton yield (g/plant) were significantly higher at lower population density 1,11,111 plants/ha (60x15 cm) with higher level of fertilizer application (100:50:50 kg NPK/ha) as compared to higher density populations (1,48,148 and 2,22,222 plants/ha) and with lower level of fertilizer application (80:40:40 kg NPK/ha). High plant population per unit area leads to higher the seed cotton yield under high density planting system.

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Integrated nutrient management in bajra–napier hybrid (*Pennisetum glaucum* × *Pennisetum purpureum*) based cropping system for higher biomass

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Agriculture and animal husbandry in India are interwoven with intricate factors of the society. At present, the country faces a net deficit of 35.6% green fodder and 10.95% dry fodder and 44% in concentrates (IGFRI, 2013). If the nutrient management of the cropping sequence is not managed properly, then we may face the problem of decline in productivity and soil fertility status. The long term application of chemical fertilizers alone under intensive cropping may deplete the reserve pool of known applied nutrients and carbon, which if not properly managed led to deterioration of soil productivity and fertility (Patel, 2009). The present investigation was undertaken to study the effect of integrated nutrient management in bajranapier (BN) hybrid + cowpea (*Vignaunguiculata*) - berseem (*Trifoliuma-lexandrinum*) on forage productivity.

METHODOLOGY

A field experiment was conducted at the Central Research Farm of Indian Grassland and Fodder Research Institute, Jhansi during 2014-15. The soil of experimental site is sandy clay loam in texture and slightly acidic in reaction (pH 6.3). The soil was low in organic carbon (4.0 g/kg) and available nitrogen (199 kg/ha) and medium in available P (23 kg/ha) and low in available K (91 kg/ha). The experiment was laid out in randomized block design with three replications. The details of 9 treatments of nutrient management including control is given in Table 1. Paired row of BN hybrid ‘IGFRI-6’was planted in July, 2014 through rooted slips at spacing of 230×50 cm. In *kharif*, cowpea var‘BL-2’ and during *rabi*berseemvar‘Wardan’ was sown in between paired rows of BN hybrid.Nutrients were supplied through organic manures on nitrogen basis inBN hybrid andphosphorus basis in berseemand cowpea. During whole year six, one and five cuts of BN hybrid, cowpea and berseem were taken. Green fodder samples weighed and oven-dried at 65°C for 72 h for dry matter determination.

RESULTS

The green and dry fodder yields of different crops of system are presented in Table 1. Application of 50% nutrients through fertilizers, 25% through vermicompost + biofertilizer consortium improved green fodder yield of BN hybrid, cowpea and berseem by 48.0, 42.1 and 31.0% over control. This treatment remained on par with all other treatments except control and 75% RDF. Similarly, dry fodder yield of component crops responded to different nutrient management practices. Theeffect of treatment was more pronounced in case of BN hybrid followed by cowpea and berseem. System productivity in terms of green fodder yield was also significantly affected by different nutrient management practices. Similar to fodder yield of component crops, highest system productivity (101.6 t/ha) was achieved under T_7 which is 38.2% higher in comparison to control. All other treatments were also significantly superior over control. The enhancement in productivity of the fodder crops due to supplementation of nutrients through vermicompost +

Table 1. Effect of integrated nutrient management on fodder yield

Treatment		Green fodder yield (t/ha)			Dry fodder yield (t/ha)		
		BN hybrid	Cowpea	Berseem	BN hybrid	Cowpea	Berseem
T1	Control	24.2	11.2	38.1	5.9	2.5	7.6
T2	100% RDF	33.7	13.6	46.5	8.4	2.9	9.8
T3	75% RDF	31.7	13.3	44.5	7.7	2.8	9.2
T4	50% RDF + 25% FYM	32.3	14.3	47.0	8.0	2.8	9.1
T5	50% RDF + 25% FYM + BC	33.3	15.2	46.7	8.4	3.1	10.0
T6	50% RDF + 25% Vermicompost	33.6	15.5	48.7	8.2	3.2	10.1
T7	50% RDF + 25% Vermicompost + BC	35.8	15.9	49.9	8.9	3.2	10.2
T8	50% RDF + 25% Enriched compost	32.4	14.0	45.5	8.1	2.8	9.5
T9	50% RDF + 25% Enriched compost + BC	32.9	14.2	47.1	8.2	2.9	9.9
	SEm±	0.8	0.9	1.5	0.3	0.1	0.5
	CD (P=0.05)	2.4	2.6	4.5	0.9	0.4	1.4

RDF, Recommended dose of fertilizers; FYM, Farm yard manure; BC, Biofertilizer consortium (*Rhizobium*/PSB/*Azotobacter*); Enriched Compost, (Rock Phosphate + Urea + *Parthenium*).

biofertilizer consortium could be due to itsbeneficial role in improving soil physical, chemical and biological properties (Prajapat*et al*., 2014). In general, the low productivity in control plot could be mainly ascribed to intensive cropping which gradually disturbed the balanced nutrition ofthe crops due to higher removal of major and micronutrients without their supplementation inappropriate quantity.

CONCLUSION

On the basis of one year experiment, it can be concluded that application of 50% RDF + 25% vermicompost + Biofertilizer consortium in BN hybrid based cropping system could be recommended for realizing higher system productivity.

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Nutrient requirement of cotton under high density planting system

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Cotton (*Gossypiumhirsutum* L.) growth and development are influenced by environmental conditions, as well as seasonal management practices. Due to high cost of transgenic cotton, the concept of optimal plant populations was introduced by altering the plant geometry, so as to reduce the input cost (Siebert *et al*, 2006). However, the development of compact genotypes, availability of growth regulators and cotton picking machines have initiated the adoption of high density plantingfor cotton in India. Although, still on nascent stage, a pertinent question to be resolved is whether the demand for nutrients is higher under such systems, since the plant population is higher (Venugopalan*et al.*, 2013).Managing the balance of vegetative and reproductive growth is the essence of managing a cotton crop,thus, study was planned to find out the optimum plant geometry and fertilizer requirement for cotton in high density planting system.

METHODOLOGY

The experiment was laid out in a split plot design with three Fertilizer levels (100%, 125% and 150 % of recommended dose of fertilizer) in the main plots and six spacing levels (67.5 cm x 10 cm, 67.5 cm x 15 cm, 80 cm x 10 cm, 80 cm x 15 cm, 67.5 cm x 20 cm and 67.5 cm x 60 cm).The recommended dose of fertilizer (RDF) for the cotton in Punjab is 75 kg N, 30 kg P_2O_5, 30 kg K_2O per hectare. N was applied through Urea in two equal split applications after first irrigation and at the time of initiation of flowering. First irrigation to the cotton was applied four weeks after sowing and thereafter subsequent irrigation were applied at 2-3 week interval depending upon the climatic conditions.Five representative plants were selected in each treatment for recording the data of yield parameters on plant basis and seed cotton yield of whole plot was recorded from all the pickings done from the treatment plots and converted to kg/ ha. The data was subjected to ANOVA to evaluate the differences between treatments and significance of interaction effects; means were compared using LSD test (p = 0.05).

RESULTS

The data from the two years revealed that there were no significant differences between different fertilizer levels for seed cotton yield. Also, in 2014, boll number/ plant and boll weight were similar among three fertilizer levels, while, during 2015, only boll weight showed non-significant differences. Higher dose of fertilizers i.e., 125 % and 150 % RDF resulted in production of more bolls as compared to 100 % RDF, although these differences did not reflect in the seed cotton yield. Plant geometry with more spacing resulted in more number of bolls/ plant. Boll weight was same in all plant geometries during 2015, while bolls were heavier in 67.5 cm x 60 cm and their weight decreased as the plant density

Table 1. Effect of fertilizer doses and plant geometry on seed cotton yield.

Treatments	Boll weight (g)		Bolls/ plant		Seed cotton yield (kg/ha)	
	2014	2015	2014	2015	2014	2015
Fertilizer levels						
100 % RDF	3.13	2.24	43.2	10.0	2270	1068
125% RDF	3.17	2.23	43.1	11.1	2338	1118
150% RDF	3.20	2.21	43.9	11.6	2360	1227
LSD (p=0.05)	NS	NS	NS	1.0	NS	NS
Plant geometry						
67.5 cm x10 cm	2.92	2.20	40.9	7.4	2418	1344
67.5 cm x15 cm	3.20	2.27	40.5	9.1	2452	1199
80 cm x10 cm	3.18	2.10	41.9	10.1	2322	1288
80 cm x15 cm	3.18	2.24	42.4	10.6	2335	1094
67.5 cm x20 cm	2.87	2.27	43.6	10.5	2275	998
67.5 cm x 60 cm	3.65	2.27	51.1	18.0	2134	902
LSD (p=0.05)	0.27	NS	4.7	1.4	196	100

increased in 2014. Although, boll weight and boll number/ plant were more in 67.5 cm x 60 cm plant spacing, this did not resulted in more seed cotton yield on area basis, the main factor being the variability in number of plants per unit area. Seed cotton yield was higher in denser plant geometry, i.e., 67.5 cm x10 cm and 67.5 cm x15 cm in 2014 and 67.5 cm x10 cm and 80 cm x10cm in 2015, resulted in higher productivity as compared to 67.5 cm x20 cm and 67.5 cm x 60 cm plant spacing (Table 1).

CONCLUSION

The study suggests the suitability of Cotton variety F2383 for high density planting, however, more number of plants need not require more amount of fertilizer, as was expected. This may be due to the lesser yield potential of cotton on per plant basis, when sown in dense planting system.

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Sulphur management in *Bt* Cotton

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A field experiment was conducted at Maharashtra, India for 3 years (2013-2015), in randomized block design with 3 replications. The soil of experimental plots was clay loam and slightly alkaline (pH8.10), low in available nitrogen (247 kg/ha), medium in available phosphorus (20 kg/ha) and high in potassium content (324 kg/ha). The treatments consisted of RDF (60:30:30), RDF + 15 kg S/ha through gypsum, RDF + 30 kg S/ha through gypsum, RDF + 45 kg S/ha through gypsum, RDF + 15 kg S/ha through bentonite sulphur, RDF + 30 kg S/ ha through bentonite sulphur, RDF + 45 kg S/ha through bentonite sulphur, RDF (60:30:30) through urea, MOP and DAP (no sulphur) and no fertilizer (absulute control). Results it is revealed that significantly highest plant height was recorded with the application of 45 kg S through gypsum (107.30 cm) and it was at par with 15 and 30 kg S/ha through gypsum and 15, 30, and 45 kg S/ ha through bentonite sulphur. The number of sympodial branches were recorded significantly higher with the application of 45 kg S through gypsum (15.27) and it was at par with 15, 30, and 45 kg S/ ha through bentonite sulphur. The harvested bolls/plant significantly higher with the application of 45 kg S through gypsum (24.13) and it was at par with 15 and 30 kg S/ha through gypsum and 15, 30, and 45 kg S/ ha through bentonite sulphur. The boll weight (g) was recorded significantly higher with the application of 45 kg S through gypsum (4.55) and it was at par with all other treatments except no sulphur and absolute control. The seed index (g) was recorded significantly higher with the application of 45 kg S through gypsum (7.66g) than all other treatments. Application of 45 kg S through gypsum recorded significantly higher seed cotton yield (kg/ha) and it was at par with all other treatments except no sulphur and absolute control. The stalk yield (2615 kg/ha) and oil content (20.7%) was significantly higher with the application of 45 kg S/ ha through gypsum and it was at par with application of 45 kg S/ ha through bentonite sulphur. Gross and net monetary returns were higher with the application of 45 kg S/ha through gypsum (Rs. 73937/- and Rs. 37193/-) and it was at par with all other treatments except no sulphur and absolute control. The highest B: C ration of 2.01 was recorded with the application of 45 kg S/ ha through gypsum. Application of 45 kg S/ha through gypsum recorded significantly higher uptake of N, P, K and S (kg/ ha) and it was at par with application of 45 kg S/ha through bentonite sulphur. Overall, application of S through gypsum or bentonite sulphur recorded higher seed cotton yield over the no sulphur treatment.

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Growth and yield of wheat as affected by crop residue mixed farm yard manure and fertilizer combinations in maize-wheat cropping system

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In Indo Gangetic plains of India, about 250 million Mg of crop residues are produced annually in rice-wheat cropping systems (Gupta *et al.,* 2004).Wheat residue is used as animal feed however, rice residues are generally not used as cattle feed in India. Conjoint use of organic manures/compost and chemical fertilizers is very essential as this sustains higher level of productivity and also improves crop yield, seed formation, plant protein, cereal quality for baking, nutritional quality of crop and root growth and it has least impact on food quality as well as environment.

METHODOLOGY

A field experimentwasconducted during *kharif* and *rabi* seasons of 2011-12 and 2012-13 at research farm of the IARI, New Delhi. The experimentwas laid out in factorial randomized block design (FRBD) with three replications, consisting of 5 different treatments in rainyand winterseason*viz.*,for *kharif* (maize): Control, 100% RDF, 75% RDF + 25% RDN (recommended dose of nitrogen), 50% RDF + 50% RDN, 50% RDF + 25% RDN + Biofertilizer (BF) and for *rabi* (wheat) *viz*., Control, 100% RDF, 75% RDF, 50% RDF + 25% RDN, 37.5% RDF +3 7.5% RDN + Biofertilizer (BF). Recommended dose of nitrogen (RDN) were applied through crop residue mixed farm yard manure (CRFYM). Well rotten CRFYM containing 0.45-0.2-0.45 % N-P-K was applied as per the treatments at the time of sowing.

RESULTS

Plant height, dry matter accumulation (DMA) at 90 DAS, grain yield and protein content were influenced significantly due to application of different treatments during both the years of study (Table 1). However, highervalues of all these parameters were recorded with the application of 100% RDF and it was significantly higher over control. This treatment was closely followed by 37.5% RDF + 37.5% RDN + BF. Among nutrient applied treatments 75% RDF have lowest values of all the parameters followed by application of 50%

Table 1. Growth, yield attributes, yields and protein content of wheat under integrated nutrient

Treatment	Plant height (cm)at 90 DAS		DMA (g/m^2) at 90 DAS		Grain yield (t/ha)		Protein content (%)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Treatment to maize								
Control	73.3	70.5	666.1	569.1	4.55	4.06	11.5	11.0
100% RDF	75.0	72.1	695.7	609.1	4.94	4.41	11.6	11.1
75% RDF + 25% RDN	75.4	72.2	696.7	611.2	4.95	4.43	11.6	11.1
50% RDF + 50% RDN	76.1	72.5	699.6	625.1	4.98	4.45	11.7	11.1
50% RDF + 25% RDN + BF	75.9	72.4	699.0	619.1	4.97	4.44	11.6	11.1
SEm±	0.97	1.12	8.90	9.99	0.11	0.11	0.02	0.02
CD (P=0.05)	NS	NS	25.32	28.40	0.30	NS	0.04	0.06
Treatment to wheat								
Control	69.5	67.5	568.4	477.5	4.21	3.62	11.3	10.7
100% RDF	80.7	74.8	774.3	695.7	5.21	4.73	11.6	11.1
75% RDF	73.1	71.7	676.2	566.7	4.87	4.40	11.6	11.0
50% RDF + 25% RDN	74.9	72.5	700.5	629.2	4.98	4.46	11.7	11.2
37.5% RDF + 37.5% RDN + BF	77.4	73.1	737.6	664.7	5.11	4.58	11.8	11.3
SEm±	0.97	1.12	8.90	9.99	0.11	0.11	0.02	0.02
CD (P=0.05)	2.77	3.19	25.32	28.40	0.30	0.31	0.04	0.06
Interaction								
SEm±	2.18	2.51	19.91	22.33	0.24	0.25	0.03	0.05
CD (P=0.05)	NS	NS	56.61	63.51	0.68	0.70	NS	NS

RDF + 25% RDN. Maximum values of these parameters were observed with the application of 100% RDF because it supplied highest amount of essential nutrients as compared to other treatments. Application of chemical fertilizers alone or with organic manure increased plant height significantly due to the stronger role of nutrients in cell division, cell expansion and enlargement which ultimately affect the vegetative growth of plant and ultimately higher dry matter production and grain yield. Residual effects of applied treatments to maize on plant height of wheat had not significantly affected except DMA 90 DAS, protein yield and grain yield during both the years and 2011-12, respectively. Residual effect of nutrients applied to maize on wheat was highest with the application of 50% RDF + 50% RDN followed by 50% RDF + 25% RDN + BF.

CONCLUSION

A combination of 37.5% RDF + 37.5% RDN + BF produced about similar yield as obtained from 100% RDF through fertilizer. So, it can be concluded that the application of 37.5% RDF + 37.5% RDN + BF in wheat was found better nutrient management practice using fertilizers and crop residues in the form of FYM for higher growth, yield and protein content.

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Tillage practices and sulphur fertilization effects on system productivity, profitabilityand soil properties of pearl millet (*Pennisetum glaucum*) –mustard (*Brassica juncea*) cropping system under rainfed condition

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Pearl millet (*Pennisetum glaucum* L.)–mustard(*Brassica juncea* L. Czernj and Coss.)has been most important cropping system of arid and semi-arid regions of India. The productivity of this cropping system is far below its potential. The main reason is low moisture availability to crops during growing season as low water holding capacity of soil. Widespread deficiency of sulphur in soils of semi-arid region of India is also reported by Sahrawat*et al.* (2007). In recent years, interest of farmers in conservation tillage has increased because of escalation of capital and production costs. Use of crop residue in conservation tillage is a viable approach to retain soil moisture and nutrients under rainfed condition (Vaidya *et al*., 1995). Crop residues have competing uses like fodder in rainfed areas because of dominance of livestock. Therefore, it is necessary that suitable amount should be applied to enhance crop productivity in a cost-effective manner.

METHODOLOGY

A field experiment was conducted at the Research Farm of Indian Agricultural Research Institute, New Delhi during the 2013-15. The soil of experimental site is sandy loam in texture and slightly alkaline in reaction (pH 7.8). The soil was low in organic carbon (4.5 g/kg) and available nitrogen (139.7 kg/ha) and medium in available P (15.2 kg/ha) and K (178.8 kg/ha) and deficient in available S (8.8 mg/kg soil). The experiment was laid out in split-plot design with three replication. The main plot treatments consisted of five tillage and residue management practices, *viz.* conventional tillage (CT) without residue; CT with 2 and 4 t/ha residue; zero tillage (ZT) with 2 and 4 t/ha residue, while four sulphur levels (0, 15, 30 and 45 kg S/ha) were assigned in sub-plot. In conventional tillage, field was prepared with a disc plough followed by two pass of a disc harrow and planking in the last to have a uniform seed bed of fine tilth. No tillage operation was carried out in zero-tilled plot except for sowing. Crop residues of previous season crop were applied by spreading the material uniformly on the field just after sowing. Sulphur was applied through agriculture grade gypsum at the time of field preparation as per treatment in both the seasons. The economics was computed using prevailing prices of inputs and outputs. Benefit cost ratio (B:C) ratio was calculated by dividing net returns by cost of cultivation. The energy use indices were calculated as per the procedure given by Devasenapathy*et al.* (2009). Soil properties were determined as per standard procedure.

RESULTS

Highest system productivity in terms of pearl millet grain equivalent yield is recorded under ZT with 4 t/ha residue followed by CT with same residue level (Table 1). The increment in system productivity under this treatment was 24.0% over CT without residue. The increase in system productivity with 4 t/ha crop residue under both tillage systems might be due to the better availability of moisture and addition of organic matter. A maximum net return was also calculated under same treatment. However, maximum B:C ratio was found under ZT with 2t/ha residue.Input energy consumption under various tillage and crop residue management practices was varied from lowest in CT without residue (19.2 GJ/ha) to maximum in CT with 4 t/ha residue (119.4 GJ/ha). The input energy requirement under 2 and 4 t/ha crop residue was about 3.5 and 6.5 times higher than no-residue, respectively. The effect of energy saving by zero tillage was nullified by heavy energetic crop residues. Higher output energy was generated under ZT with 4 t/ha residue (268.8 GJ/ha) treatment which was closely followed by energy output under CT with 4 t/ha residue (259.8 GJ/ha). Contrary to input and output energy, maximum net energy (202 GJ/ha) and energy-use efficiency (11.5) were recorded under CT without residue during and minimum under CT with 4 t/ha residue. The energy-use efficiency was reduced with the application of crop residue under both the tillage system.Results further revealed that increasing levels of sulphur up to 45 kg S/ha significantly increased the system productivity, profitability and energy indices.Maximum soil organic carbon (SOC) was registered under ZT with 4t/ha residue (4.96 g/kg), which was at par with rest of treatments except CT without residue (Table 2). Crop residue application significantly improved soil physical properties over no-residue irrespective of tillage. Maximum values of these parameters were recorded under ZT with 4 t/ha crop residue.

CONCLUSION

On the basis of two years experiment, it can be concluded that planting of pearl millet and mustard in zero tillage with 4 t/ha crop residue along with 30 kg S/ha through gypsum could be recommended for realizing higher system productivity andprofitability. It also improved soil organic carbon and soil physical properties.

Table 1. Effect of tillage, crop residue and sulphur fertilization on system productivity, economics and energy relationship in pearl millet—mustard cropping system (mean data of 2 years)

Treatment	System productivity (t/ha)	Net returns (Rs/ha)	B:C ratio	Input energy (GJ/ha)	Output energy (GJ/ha)	Net Energy (GJ/ha)	Energy-use efficiency
Tillage and crop residue							
CT without residue	6.16	65.2	1.74	19.2	221.2	202.0	11.5
CT with 2 t/ha residue	6.76	65.3	1.38	69.3	242.2	172.8	3.5
CT with 4 t/ha residue	7.37	65.6	1.17	119.4	259.8	140.4	2.2
ZT with 2 t/ha residue	6.96	74.5	1.84	65.0	246.5	181.5	3.8
ZT with 4 t/ha residue	7.64	76.2	1.53	115.1	268.8	153.7	2.3
SEm±	0.13	2.0	0.05		4.3	4.3	0.1
CD (P=0.05)	0.42	6.5	0.15		14.0	14.0	0.3
Sulphur levels kg/ha)							
0	6.11	57.1	1.29	77.2	220.5	143.3	4.1
15	6.86	67.7	1.50	77.5	243.1	165.5	4.5
30	7.33	74.6	1.64	77.7	259.5	181.7	4.9
45	7.61	78.1	1.70	78.0	267.8	189.8	5.1
SEm±	0.09	1.3	0.03		2.7	2.7	0.1
CD (P=0.05)	0.25	3.9	0.08		7.7	7.7	0.2

CT, Conventional tillage; ZT, zero tillage.

Table 2. Effect of tillage, crop residue and sulphur fertilization on organic carbon and physical properties of soil after end of 2 cropping cycle

Tillage and Crop Residue	Soil organic carbon, g/kg (0-5 cm)	Infiltration rate, mm/hr	Hydraulic conductivity, mm/hr (0-15 cm)	Mean weight diameter, mm (0-5 cm)
CT without residue	4.37	13.8	12.1	0.69
CT with 2 t/ha residue	4.70	14.7	13.6	0.84
CT with 4 t/ha residue	4.89	15.2	14.2	0.96
ZT with 2 t/ha residue	4.75	15.4	14.7	0.99
ZT with 4 t/ha residue	4.96	15.9	15.3	1.13
SEm±	0.09	0.3	0.4	0.03
CD (P=0.05)	0.30	0.9	1.1	0.09

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Productivity, sustainability and carbon management index of different jute based cropping systems under nutrient and crop residue management practices

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Jute (*Corchorus olitorius* L.) grown as a cash crop in summer season under intensive triple cropping system mostly by small and marginal farmersin the eastern India (Mahapatra *et al*., 2012).Sustainability of jute based intensive cropping systemsrecorded to be lowbecause of fluctuating market price of products and exploitation of natural resource like soil nutrients, water and energy which led to reduction in productivity and soil quality (Kumar *et al*., 2014). Therefore, we must think for more productive, more efficient and remunerative intensive jute based cropping systems, which practice sustained use of natural resources and maintain the productivity and soil quality. Moreover, nutrient management which is dominating factor to enhance and sustain the productivity of crops and cropping system needs to be standardized. Crop residues which are one of the sources of nutrient found to be beneficial to soil health crop productivity and nutrient use efficiency can be alternative source of nutrient. It can be fully or partially substitute with inorganic fertilizers not only reduced the burden on inorganic fertilizers but also maintain the soil health.Hence, the experiment has been planned to find out the productive jute based cropping systems under nutrient and crop residue incorporation practices for maintaining and enhancing soil health.

METHODOLOGY

A field experiment was conducted to study the effect of nutrient and crop residue incorporation on productivity jute based cropping systemin split plot design during 2012-14. The main plot comprised of five cropping systems *viz.,* rice-rice (R-R), jute-rice-wheat (J-R-W), jute-rice-baby corn-leafy vegetable jute (J-R-Bc-Vj), jute-rice-garden pea (J-R-Gp), jute-rice-mustard-mung bean (J-R-M-Mu) and four nutrient management practices *viz.* 75% recommended doses of fertilizers (RDF) for each crop in a system with and without crop residue and 100 % RDF with and without crop residue with their respective cropping system in sub plot.Residue of rice, wheat and corn @ 4t/ha were incorporated in R-R, J-R-W and J-R-Bc-Jv cropping systems, respectively, and residue of garden pea and mung bean @ 2 t/ha incorporated in J-R-Gp and J-R-M-Mu cropping system, respectively.Crop residues were incorporated through power tiller before sowing of jute in every year.System productivity was calculated on the basis of jute equivalent yield and sustainable yield index calculate for three year *i.e.* 2012-14 (SYI = Y –ó/Y_{max}:where Y is the estimated average yield of a practice over years, ó is its estimated standard deviation, Y_{max} is the observed maximum yield in the experiment over the years of cultivation). Carbonmanagementindex (CMI), which provides a useful parameter to assess the capacity ofcropping system and nutrient management system into promote soil quality calculated as per Blair *et al.* (1995) except oxidation of soil carbon done by different strength of H_2SO_4 instead of $KMnO_4$. Least square difference (LSD) was worked out where variance ratio (F-test) was significant at P d" 0.05.

RESULTS

Jute fibre yield and system productivity varied significantly under different cropping system but rice yield did not vary significantly (Table 1). Maximum jute fibre yield (3.28 t/ha) was recorded in J-R-Gpand it was significantly higher than in other cropping systems. This is due to residual effect of garden pea which was sown prior to jute in J-R-Gp cropping system. System productivity of J-R-Bc-Vjcropping system was significantly higher than other cropping systems. System productivity of J-R-Gp was recorded second to superior J-R-Bc-Vjcropping system. System productivity of J-

R-Bc-Vj was higher due to higher price of baby corn and jute leafy jute vegetable, as system productivity was calculated on the basis of jute equivalent yield which is the functions prevailing market price of crops' products. Nutrient and crop residue management practices did not affect significantly the jute fibre yield, however, maximum jute fibre and rice yield as well as system productivity was recorded with 100% RDF with crop residue. Sustainable yield index (SYI) of jute was the highest (0.87) in jute-rice-garden pea system while SYI of rice and system productivity was the highest in J-R-Bc-Vj. Among nutrient management practices SYI of jute, rice and cropping system was the highest in100% RDF + crop residue. Carbon management index (CMI) was significantly influenced by different cropping system.J-R-M-Mu cropping system recoded highest CMI (60.8) followed by J-R-Bc-Vj (55.10). This may be due to mustard and mungbean were sown in zero tillage in this cropping system and this system help to restore the carbon in the soil. Among nutrient management practices comparatively higher CMI was recorded when inorganic fertilizers applied with crop residues.

CONCLUSION

It is concluded that J-R-Bc-Vj cropping system recorded the highest system productivity and sustainability followed by J-R-Gp. Higher CMI was recorded with J-R-M-Mu cropping system. Application of 100 %RDF with crop residue increased the system productivity, sustainability and CMI of all cropping system.

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Response of castor (*Ricinus communis*) to varying crop geometry and dates of sowing with levels of nitrogen under *rabi* season

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A field experiment was conducted at Main Castor-Mustard Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha (North Gujarat) on loamy sand soil during *rabi* season of 2011-12 and 2012-13 to study eighteen treatments comprising of three dates of sowing *viz.,* 15th September, 30th September and 15th October, crop geometry *i.e.* 150 cm x 60 cm, 120 cm x 60 cm and 90 cm x 60 cm and levels of nitrogen *i.e.* 80 kg and 120 kg/ha were evaluated in split-split plot design with four replications, keeping dates of sowing in main plots, crop geometry in sub plots whereas, levels of nitrogen in sub-sub plots.The experimental results revealed that the in general, growth and yield attributes decreased with delay in sowing from 15th September to 30th October. The growth characters *viz.,* plant height, number of branches per plant and numbers of nodes up to primary spike as well as yield attributing parameters *viz.,* length of primary spike, number of capsules per primary spike, number of effective spikes per plant, seed yield per primary spike and per plant as well as seed yield of first and second pickings were significantly higher under early sown crop *i.e.* 15th September than late sown crop *i.e.* 15th October. When crop sown on 15th September it produced significantly the highest seed (2141 kg/ha) and stalk (2477 kg/ha) yields. The increase in seed and stalk yields by 15th September sown crop were to the tune of 12.21 and 33.65 as well as 12.54 and 38.61% as compared to 30th September and 15th October, respectively. Similarly, productivity per day and oil yield were also significantly higher under 15th September sown crop than 15th October sown crop. Removal of nitrogen, phosphorus, potassium and sulphur by seed, stalk and castor crop decreased significantly with each delay in sowing. The maximum gross and net realizations, BCR and net income/day were earned by sowing the crop on 15th September. The plant population at 30 DAS and at harvest recorded significantly higher under crop geometry of 90 cm x 60 cm over crop geometry of 120 cm x 60 cm and 150 cm x 60 cm, respectively. The growth parameters *viz.,* plant height and number of nodes up to primary spikes were significantly higher under crop geometry 90 cm x 60 cm than 150 cm x 60 cm crop geometry. While, number of branches/plant was the significantly maximum under crop geometry at 150 cm x 60 cm. Significantly the higher values of yield attributes were recorded under crop geometry of 150 cm x 60 cm as compared to crop geometryof90 cmx 60 cm. Both the wider crop geometry *i.e.* 150 cm x 60 cm and 120 cm x 60 cm were at par and recorded significantly higher seed and stalk yields as well as productivity per day than crop geometry of 90 cm x 60 cm. Crop geometry of 150 cm x 60 cm also remarkably increased oil yield as compared to 90 cm x 60 cm crop geometry. Uptake of phosphorus, potassium and sulphur by seed, stalk and crop were significantly higher with crop geometry 150 cm x 60 cm than 90 cm x 60 cm geometry except removal of potash by seed. However, varying levels of crop geometry did not exert any significant response on nitrogen uptake by seed, stalk and crop. The maximum gross and net realizations, BCR and net income per day registered under sowing of castor crop at 150 cm x 60 cm geometry.Fertilizing the castor crop with 120 kg N/ha significantly increased growth and yield parameters as well as seed and stalk yields of castor than 80 kg N/ha.The productivity per day and oil yield of castor was increased with increase in levels of nitrogen from 80 to 120 kg/ha. Nitrogen, phosphorus, potassium and sulphur uptake by seeds, stalks and crop were significantly higher under 120 kg nitrogen/ha than 80 kg nitrogen/ha. Different levels of nitrogen did not exert any significant influence on plant population at 30 DAS and at harvest.Application of 120 kg N/ ha accured the higher gross and net realizations, BCR and net income per day than 80 kg N/ha. However, differences in growth *i.e.* days to first spike emergence, yield 100-seed weight and harvest index and quality attributes *viz.,* oil content in seed, ricin content and shelling percentage as well as available nutrient status of soil *viz.,* nitrogen, phosphorus, potassium and sulphur after harvest of crop were not reach the level of significant. Among different treatment combinations, interaction effect between dates of sowing and crop geometry was significant and D_1xG_1*i.e.* crop sown on15th September at 150 cm x 60 cm crop geometry recorded the maximum number of branches per plant, number of effective spikes per plant, seed yield per plant, seed yield of first and second pickings, seed and stalk yields as well as productivity per day. Gross and net realizations, BCR and net income per day were also the maximum under this treatment combination (D_1G_1). Based on the findings and economics, it can be concluded that the economically potential production from *rabi* castor crop can be secured by sowing the crop on 15th September at crop geometry of 150 cm x 60 cm with application of 120 kg nitrogen/ha in loamy sand soils of North Gujarat.

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Potassium dynamics in acid soil with continuously addition of chemical fertilizers and amendments in maize – wheat cropping system

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Potassium is one of the major nutrient elements which will require a greater attention in order to ensure enhanced crop production and mitigation of biotic and abiotic stress as well as improvement in produce quality. Potassium is second only to nitrogen in the quantity required by plants for healthy growth but Indian agriculture has traditionally relied on the native soil resource of potassium. Increasing incidences of potassium deficiencies demonstrate that we need a better understanding of potassium fertilization in agriculture. Continuous application of chemical fertilizers either alone or in combination with FYM or lime for forty years influenced different fractions of potassium significantly. Continuous cropping without fertilization resulted in depletion to the order of 21.5,16.6,11.7 and 5.5 per cent in water soluble, exchangeable, 0.5 N HCl extractable, non exchangeable-K, respectively.

METHODOLOGY

The present study was undertaken in the on going long-term fertilizer experiment initiated during 1972 at experimental farm of Department of Soil Science, College of Agriculture, CSK HPKV, Palampur in randomized block design with eleven treatments replicated three times.The treatments are as follows. T_1: 50% NPK; T_2: 100% NPK; T_3: 150% NPK; T_4:

Table 1. Effect of continuous application of chemical fertilizers and soil amendments on different forms of soil K (mg/kg)

Treatment	Water soluble K		Exchangeable K		Non-exchangeable K		HCL extractable K	
	0 - 0.15 m	0.15-0.30 m	0 - 0.15 m	0.15- 0.30 m	0 - 0.15 m	0.15- 0.30 m	0 - 0.15 m	0.15-0.30 m
T_1: 50% NPK	14.53	8.57	55.37	50.8	528.47	532.57	121.07	114.93
T_2: 100% NPK	17.77	16.2	56.23	50.27	665.83	670.6	154.83	123.57
T_3: 150% NPK	25.6	22.43	59.9	54.53	710.77	734.43	180.07	167.87
T_4: 100% NPK+ HW	16.4	15.4	60.4	52.07	502.57	549.83	146.7	112.83
T_5: 100% NPK+ Zn	21.2	17.63	50.07	42.77	601.7	613.4	231.77	201.7
T_6: 100% NP	8.9	7.77	50.53	45.57	512.83	560.47	125.47	86.37
T_7: 100% N	16	14.33	49.3	42.2	532.57	580.33	132.13	106.4
T_8: 100% NPK+ FYM	22.83	19.53	66.27	58.63	627.5	642.8	215.33	173.9
T_9: 100% NPK (-S)	15.7	9.63	63.43	61.83	680.6	698.57	195.6	132.2
T_{10}: 100% NPK+ lime	18.77	13.57	58.4	52.63	643.67	645.3	174.67	142.37
T_{11}: Control	13.23	10.47	44.57	39.97	545.7	560.53	125.43	112.83
CD (P= 0.05)	3.38	2.95	8.65	5.43	36.97	53.72	34.63	30.47

100% NPK+ HW; T_5: 100% NPK+ Zn; T_6: 100% NP; T_7: 100% N; T_8: 100% NPK+ FYM; T_9: 100% NPK (-S); T_{10}: 100% NPK+ lime; T_{11}: Control.

RESULTS

Water soluble- K: Water soluble K varied from 8.90 to 25.60 and 7.77 to 22.43 mg/kg in 0-0.15 and 0.15-0.30 m soil depths, respectively. Among the various treatments, the maximum amount of water soluble K was recorded in 150% NPK treated plots which may be due to its higher rate of application. Application of FYM along with 100% NPK increased the water soluble K status of the soil over 100% NPK. Such an increase in the content of water soluble K due to addition of organic material has also been reported previously by Sood *et al*. 2008. Exchangeable- K: Exchangeable K varied from 44.57 to 66.27 and 39.97 to 58.62 mg/kg in 0-0.15 and 0.15-0.30 m soil depths, respectively. In comparison to control, exchangeable K increased in all the treatments. Applications of FYM along with 100% NPK recorded higher values of exchangeable K followed by 100% NPK (-S) treated plots. Similar effect of addition of FYM on the exchangeable-K has also been reported by Sood *et al*. (2008); Sepehya *et al*. (2012). Non exchangeable- K: The amount of non exchangeable-K varied between 502.57 mg/kg under 100% NPK + HW and 710.77 mg/kgunder 150% NPK in 0-0.15 and 0.15-0.30 m soil depths. Continuous application of super optimal dose of potassium resulted in highest level of non exchangeable-K which may be due to its higher application rates and lower crop removal due to decline in productivity. 0.5 N HCL extractable- K: It is evident from the data presented in table 1 that 0.5 N HCl extractable -K varied from 121.07 to 231.77 mg/kg in 0-0.15 m layer. Application of 100% NPK + Zn resulted in highest amount of HCL-K followed by 100% NPK + FYM.

CONCLUSION

Different fractions of potassium were significantly higher in the plots which received organics and in-organics (100%NPK+FYM) compared to the plots receiving chemical fertilizers only (100%NPK alone) for forty years.

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Effect of organic manures and nitrogen levels on fodder yield and HCN content of multi-cut fodder sorghum

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Cultivation of sorghum over other fodder crops is widely practiced due to its high tolerance and suitability to wide variation in soil and climatic conditions and having many advantages like quick growth, high biomass accumulation, high dry matter content and wide adaptability besides drought withstanding ability. The green fodder availability from single cut sorghum is seasonal while multi-cut sorghum helps to supply green fodder throughout the year. With suitable scientific management practices, higher fodder yield from ratoon crops could be achieved (Girija and Natarajaratnam, 1996). Ratoon crop saves 50-60 per cent labour, avoids land preparation and requires less water. Ammaji and Suryanarayana (2003) observed significant increase in green forage and dry forage yield of sorghum with increased nitrogen application. However, high nitrogen fertilization leads to increased HCN poisoning in forage sorghum. Hence, it was felt necessary to optimize the dose of FYM and nitrogen application and to study the effect of different organic manures on HCN content.

METHODOLOGY

A field experiment was conducted during *rabi* season of 2015 at Tamil Nadu Agricultural University, Coimbatore to study the effect of organic manures and nitrogen levels on forage yield and quality in multi-cut forage sorghum. The experiment was laid out in randomized block design replicated thrice using Co (FS) 31 multi-cut fodder sorghum as the test variety. The treatments comprised of application of FYM @ 25 t /ha+ 100% N (90 kg N /ha), FYM @ 10 t /ha+ 100% N, FYM @ 10 t /ha+ 125% N, goat manure @ 5 t /ha+ 100% N, goat manure @ 2.5 t /ha+ 125% N, vermicompost @ 5 t /ha + 100% N, vermicompost @ 2.5 t /ha+ 125% N. The observations were made on growth parameters, green and dry fodder yield, quality parameters under various levels of application of organic manures and inorganic nitrogen fertilizer.

RESULTS

Among the treatments, application of FYM @ 10 t /ha+ 125% N recorded the highest green fodder yield during first and second cut of fodder sorghum.Green forage yield obtained in this treatment was 19% higher over application of FYM @ 25 t /ha + 100% N for both first cut and second cut. Research findings showed that organic manure has stimulatory effect on efficiency of chemical fertilizer and this resulted in higher availability of N and accelerating the process of cell division, enlargement and elongation. This in turn showed luxuriant vegetative growth and resulted in higher green and dry forage yield. Similar results were also obtained by Sumeriya and Singh (2014). The lowest HCN content was recorded by application of FYM @ 10 t /ha+ 100% N and goat manure @ 5 t /ha+ 100% N during first and second cut of fodder sorghum crop, respectively.This might be due to decreased soil nitrogen availability which

Table 1. Effect of organic manures and N levels on green fodder yield (t /ha) and HCN content (ppm) of multi-cut fodder sorghum

Treatment	Green fodder yield		HCN content	
	I cut	II cut	I cut	II cut
FYM 25 t /ha + 100% N	32.4	16.5	145.6	88.5
FYM 10 t /ha + 100% N	25.2	14.1	103.3	72.6
FYM 10 t /ha + 125% N	38.7	19.2	145.6	92.7
Goat manure 5 t /ha + 100% N	32.5	15.6	130.8	71.6
Goat manure 2.5 t /ha + 125% N	37.0	16.1	166.8	82.1
Vermicompost 5 t /ha + 100% N	29.5	16.8	236.6	103.3
Vermicompost 2.5 t /ha + 125% N	36.0	17.8	251.5	124.5
CD (P=0.05)	5.1	2.6	36.2	19.9

decreased nitrogen uptake this leads to lowest HCN content of forage sorghum. The HCN content reached safer limits at flowering stage. This might be due to enzyme activity which gradually decreased at 50% flowering stage. This is supported by Kumar and Devender (2010).

CONCLUSION

From the results of the present study, it is concluded that application of FYM @ 10 t /ha with 125 per cent N as inorganic fertilizer, produced higher fodder yieldand safe HCN content in multi-cut forage sorghum.

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Evaluation of organic, inorganic and integrated crop management practices on crop productivity, economics and soil health of different cropping systems

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'Green Revolution' of India has undoubtedly changed the scenario of foodgrain production from 'ship-to-mouth' status to self-sufficient status. However, chemical intensive exploitative agriculture that has been followed after 'Green Revolution' has resulted into damaging impacts on environment, human animal and soil health; and water resources (Anonymous, 2001). Auspiciously, alternatives to chemical agriculture are available in organic and eco-technological farming approaches. Fortunately, due to its diverse agro-climatic conditions, India is bestowed with lot of potential to produce all varieties of organic products. Moreover, 74% of Indian farmers are having less than 2 ha land and these small holdings can adopt the organic principles easily and can manage the on-farm inputs and labour efficiently (Babalad*et al.*, 2008). But as the organic farming requires huge quantity of organic manure for nutrient supply, it always suspected for low yield and returns. Therefore, field studies were carried out to assess the impact of organic, inorganic and integrated management practices on productivity, economics and soil health of different cropping systems.

METHODOLOGY

Field experiment was carried out during 2014-15 at Research Farm, ICAR-IIFSR, Modipuram, Meerut, in strip plot arrangement consisting of six crop management practices *viz.*, 100% organic; 75% organic + innovative practices (biofertilizers&*Pannchgavya*); 50% organic + 50% inorganic; 75% organic + 25% inorganic; 100 % inorganic; farmer's practice (6 t FYM+ recommended dose of fertilizer) in main plots. In sub plots, four cropping systems *viz.,* basmati rice (PB-6)–durum wheat (HI-8498) - *Sesbania*green manure; coarse rice (Saket-4) – malt barley (DWRB-91) – green gram (Pusavishal); pop corn (Bajaura) – potato (chipsona-3)–okra +*Sesbania* green manure; and sweet corn (Madhuri) – mustard (Pusa Bold) - *Sesbania* green manure were taken following the standard package of practices for each crop. The organic source nutrients were supplied equally through FYM and vermicompost based on recommended dose of nitrogen. While in inorganic management the nutrients were supplied through urea, DAP and MoP based on recommended dose of NPK for each crop. Biofertiloizers and *Panchagavya* were applied as per recommended practice. On the basis of prevailing market price system productivity in terms of Basmati Rice Equivalent Yield (BREY) and net returns were calculated and soil organic carbon (SOC) was estimated as per standard laboratory procedures (Walkley and Black, 1934).

RESULTS

The results in Table 1 reveals that due to higher and consistent nutrient supply by organic manures and fertilizers

Table 1. Effect of different crop Management practices and cropping systems on BREY, net returns and soil organic carbon status

Treatment		BREY(t/ha)	Net Returns (Rs./ha)	SOC (%)
Crop Management practices				
Organic	100% Organic	8.15	167768	0.862
	75%organic + Innovative practice	8.09	170766	0.825
Integrated Crop Management	50% organic+50% inorganic	7.99	184066	0.803
	75% organic+25% inorganic	8.28	183362	0.811
Inorganic	100% inorganic	5.86	131361	0.368
	State recommendation	7.21	171977	0.634
Cropping System				
Basmati rice-wheat	6.75	162051	0.726	
Rice– barley–green gram	4.55	74334	0.696	
Pop corn– potato– okra	13.43	296103	0.701	
Sweet corn – mustard	5.65	140378	0.746	

in combination, highest system productivity in terms of BREY was recorded under 75% organic+25% inorganic closely followed by 100% organic and 75% organic + Innovative practice. Due to higher cost of organic manures involved inorganic practice; the combination of 50% organic+50% inorganic recorded highest net returns (Rs. 184066/ha) which were Rs. 52705/ha and Rs. 12090/ha higher as compared to 100% inorganic and farmer's practice, respectively. Moreover, taking the advantage ofbiofertilizers and panchgavya application and partially cost reduction of manures, 75%organic + innovative practices registered 38.2 and 12.3% higher BREY and fetch Rs. 39404/ha higher net returns over 100% inorganic and was comparable to farmer's practice. Besides, due to higher application and slow mineralization, 100% organic practice recorded 134.3 and 36.1% higher SOC as compared to 100% inorganic and farmer's practice. Due to higher productivity per unit time, short duration crops and better market price, popcorn– potato– okra system recorded 98.9 and 82.7% higher BREY and net returns, respectively over conventional cropping system of basmati rice-wheat. Among cropping systems, sweet corn–mustard registered highest SOC (0.746%); and it was because of higher root biomass and leaf fall these crops.

CONCLUSION

The higher and consistent nutrient supply by organic manures and fertilizers in combination ensured higher system productivity and net returns across the cropping systems. However, organic crop management of 75% organic + innovative practice besides recording highest SOC; registered comparable productivity and net returns to integrated crop management practices and markedly higher productivity and returns to inorganic practices. Among cropping systems, pop corn– potato– okra system recorded highest BREY and net returns across nutrient management practices.

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Agronomic biofortification of hybrid rice (*Oryza sativa* L.) with zinc and iron

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Rice is the only cereal crop cooked and consumed mainly as whole grain and the quality considerations are much more important than for any other food crop (Ravindrababu *et al.,* 2013). It provides 23 % of the calories consumed by the world's population and provides 50–80 % of the energy intake of the people in the developing countries which is more than that of wheat or corn (Anon., 2006a). However, rice is a poor source of many essential minerals and organic substances especially iron (Fe), zinc (Zn) and lysine (Lys) and other essential amino acids for human nutrition. Currently, malnutrition of Fe and Zn afflicts more than 50 % of the world's population (Welch, 2005). This weakens immune function and impairs growth and development (Welch, 2002) and continuous heavy consumption of rice with low concentration of Fe and Zn has been considered a major contributor and Zn deficiency is currently listed as a major risk factor for human health and causes of death globally. Fertilization is the key point of nutrient-integrated management in agronomic approaches to enhance crop quality and yield, so that fertilization could be one of the sustainable and low cost strategies to improve Fe and Zn density in edible portions of staple food crops.

METHODOLOGY

The field experiment was conducted by using KRH-4 Hybrid during Kharif 2014 at College of Agriculture, V. C. Farm, Mandya. The experimental soil is Red sandy loam in texture with alkaline in soil reaction (pH 8.40), medium in Zinc (0.6 ppm) and Iron (3.5ppm). The experiment consisted of three main plots as methods of cultivation of rice and four sub plots with the micronutrient management practices. Totally there were twelve treatments replicated thrice. The fertilizers were applied as per the treatments *viz.,* urea, single super phosphate, muriate of potash, Zinc sulphate ($ZnSO_4$) and iron sulphate ($FeSO_4$) to supply N, P, K, Zn and Fe, respectively for the experiment. The fertilizers were applied as per recommended practice (120:60:60 kg NPK per ha) and applied as 50 per cent N, full dose of P and K as basal dose at the time of sowing / transplanting and the remaining 50 per cent N was applied in two equal splits at 30 DAT and at panicle initiation. Zinc and Iron fertilizers were applied either to soil or seed treatment or as foliar spray as per the treatments. Suitable plant protection measures were carried out as per recommended practices to control weeds, diseases and pests.

RESULTS

Higher zinc, Iron and Protein (23.69 ìg g^{-1}, 85.44 ìg g^{-1} and 12.24 % respectively) content in dehusked rice grain was observed in S4 (seed treatment of $ZnSO_4$ and $FeSO_4$ at 0.2 and 0.1 % respectively along with foliar spray of $FeSO_4$ and $ZnSO_4$ at the rate of 0.5 % at boot leaf stage and panicle initiation stage (in Table 1).This may be due to the Phloem transport of Zinc which has been indicated to be more important for Zn accumulation in rice grain and play a greater role in enrichment of grains with Zinc especially when the zinc foliar spray was given after the flowering as observed by Hekmat *et al.* (2010) and Panomwan Boonchuay *et al*.(2013).

CONCLUSION

For enhancing the grain quality particularly Zinc, Iron and protein content in rice hybrid, agronomic biofortication through seed treatment combined with foliar sprays at boot

Table 1. Zn, Fe and Protein content in dehusked rice as influenced by Agronomic biofortification

Treatment	Zn (μg g^{-1})	Fe (μg g^{-1})	Protein (%)
S_1 = Control without Zn and Fe	12.42	31.34	7.93
S_2 = $ZnSO_4$ at 20 kg per ha+ $FeSO_4$ at 10 kg per ha through Soil application	20.68	57.10	10.99
S_3 = $ZnSO_4$ at 0.2 % and $FeSO_4$ at 0.1 % as Seed treatment	21.73	71.96	10.75
S_4 = $ZnSO_4$ at 0.2 % and $FeSO_4$ at 0.1 % as Seed treatment + Foliar spray of $ZnSO_4$ at 0.5 % and $FeSO_4$ at 0.5 % at panicle initiation and boot leaf stage	23.69	85.44	12.24
S.Em±	0.72	5.35	0.62
C.D(P=0.05)	2.14	15.91	1.85

leaf and panicle initiation is the best method compared to the other micronutrient management practices.

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Effect of different sweet corn hybrids and various fertilizer levels on yield and economics of sweet corn in *kharif* season (*Zea mays*)

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Maize (*Zea mays* L.) is a miracle crop. It is known as corn and is the world's important cereal crop after wheat and rice. It has very high yield potential than other cereals and that is why called as 'Queen of cereals'. It is grown for grain as well as for fodder. Over 85 percent of maize produced in a country is consumed as human food. The productivity of maize crop in India as well as in Maharashtra is particularly low mainly because of lack of adoption of agro techniques for maize cultivation, uneven distribution of rainfall, drought, dry spell during critical crop growth stages and poor economic condition of the farmers.Many farmers are showing interest in growing sweet corn due to short duration, green fodder at harvest and high market prices. There are many queries from the farmers regarding use of hybrid varieties and fertilizer levels for sweet corn during *kharif* season. Very less research has been carried out on this aspect of sweet corn. In Maharashtra, the farmers are utilizes composite low yielding varieties of sweet corn. In order to yield maximization, it is necessary to use effective sweet corn hybrids.The systematic and detailed research work regarding N, P and K requirement of sweet corn has not been carried out in Maharashtra state. Farmers follow the general fertilizer dose of maize to sweet corn. In view of obtaining good quality produce, it is necessary to find out the optimum dose of fertilizer for sweet corn.With this background, a field trial was carried out to study the "Response of different sweet corn hybrids to various fertilizer levels in *kharif*season (*Zeamayssaccharata*Sturt)" at Post Graduate Research Farm, College of Agriculture, Kolhapur during *kharif*- 2013.

METHODOLOGY

The study was carried out on medium black soil at the Post graduate research farm, College of Agriculture Kolhapur during *kharif* 2013. The soil of the experimental field was medium black (vertisol), fairly leveled, well drained, clay in texture, medium in available nitrogen (307.48 kg/ha), high in available phosphorus (24.30 kg/ha) and very high in available potassium (384.3 kg/ha) content, also the soil was slightly alkaline in reaction (pH 7.7). The experiment was laid out in factorial randomized block design with three replications. There were sixteen treatment combinations comprising of four hybrids *viz.,* 'Sugar-75', 'US-80', 'Misthi', and 'NU-5' and four fertilizer levels *viz.,* 75% RDF (90:45:30 kg NPK/ ha), 100% RDF (120:60:40 kg NPK/ha), 125% RDF (150:75:50 kg NPK/ha) and 150% RDF (180:90:60 kg NPK/ha). Urea, single super phosphate and murate of potash were used as source of N, P and K respectively. After field preparation, basal dose of 1/3rd of N and full dose of P_2O_5 and K_2O was applied at sowing. The remaining quantity of N was given 30 and 45 days after sowing.

RESULTS

The data revealed that green cob and green yield was significantly influenced by different hybrids. Significantly, higher green cob and green fodder yield was recorded by H_1

Table 1. Effect of different hybrids and fertilizer levels on yield and economics of sweet corn

Treatments	Green cob yield	Green fodder yield	Cost of cultivation (Rs/ha)	Gross monetary returns (Rs/ha)	Net monetary returns (Rs/ha)	B:C ratio
Hybrids (H)						
H_1 = Sugar-75	169.21	255.53	80827	314891	234064	3.89
H_2 = US-80	154.79	248.82	81577	298558	216981	3.66
H_3 = Misthi	162.14	251.41	81827	307759	225932	3.76
H_4 = NU-5	150.95	245.7	80327	289784	209457	3.61
SEm±	0.51	0.73	—	3437	3422	—
CD (P=0.05)	1.52	2.12	—	10318	10266	—
Fertility levels (F)						
F_1 = 75% RDF(90:45:30 kg NPK/ha)	150.12	240.85	78970	278987	200017	3.53
F_2 = 100% RDF(120:60:40 kg NPK/ha)	156.11	244.47	80416	295616	215200	3.68
F_3 = 125% RDF(150:75:50 kg NPK/ha)	164.69	257.05	81862	313419	231557	3.83
F_4 = 150% RDF(180:90:60 kg NPK/ha)	166.16	259.08	83308	322969	239661	3.88
SEm±	0.51	0.73	—	3437	3422	—
CD (P=0.05)	1.52	2.12	—	10318	10266	—

i.e. Sugar-75 than other hybrids tried, mainly because of significant improvement in all the growth and yield contributing characters. These findings regarding Sugar-75 are in conformity with the results reported by Bhatt (2012) and Chougale (2013). Application of 150% RDF (180:90:60 kg NPK/ha) recorded significantly superior green cob and green fodder yield over75% RDF (90:45:30 kg NPK/ha) due to increase in all growth and yield attributes, and it was comparable with 125% RDF (150:75:50 kg NPK/ha). The results arecorroborated with those reported by Verma (2011). The hybrid Sugar-75 recorded significantly higher gross and net monetary returns and B:C ratio (Rs. 3,14,891/ha and Rs. 2,34,064/ha and 3.89, respectively) as compared to hybrid NU-5 (Rs. 2,89,784/ha and Rs. 2,09,457/ha and 3.61, respectively) and it was at par with Misthi (Rs. 3,07,759/ha and Rs. 2,25,932/ha, respectively). These findings regarding Sugar-75 are in conformity with the results reported by Bhatt (2012) and Chougale (2013).Application of 150% RDF recorded significantly higher gross and net monetary returns and B:C ratio (Rs. 3,22,969/ha and Rs. 2,39,661/ha and 3.88, respectively) as compared to 75% RDF, however it was on par with 125% RDF (Rs. 3,13,419/haand 2,31,557/ha and 3.68, respectively).

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Study on the effects of foliar and soil application of micronutrients on yield of sorghum

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According to survey of soil analysis report of micronutrients project, the soils of North Gujarat agro-climatic zone are found deficient in Fe (55.0 %), Zn (20.0 %) and S (32.0 %). Chlorosis is a common occurrence in sorghum and maize due to deficiency of micronutrients like; Fe and Zn or macronutrients like; N and S deficiency. Micronutrient deficiency is widespread due to the calcareous nature of soils, high pH, low organic matter, salt stress, continuous drought, high bicarbonate content in irrigation water, and imbalanced application of NPK fertilizers. Some of the adverse effects of micronutrient deficiency-induced stress in plants include low crop yield and quality, imperfect plant morphological structure (such as fewer xylem vessels of small size), widespread infestation of various diseases and pests, low activation of phytosiderophores, and lower fertilizer use efficiency .Qualitative and quantitative plant products can only be achieved if they are combined with proper plant nutrition. Besides the three macro elements (N, P, K) essential microelements are inevitable. Because of their function in the enzyme activity we have to give priority to the essential microelements copper and zinc in the nutrient supply of soil and plants. Their lack greatly influences both the quantity and the quality of plant products. Sorghum has an especially sensitive response to these microelements. Agricultural soils usually show iron, copper and zinc deficiency.

METHODOLOGY

A field experiment was conducted during *kharif* 2010 to 2014 at the farm of All India Co-ordinated Research Project, Sardarkrushinagar Dantiwada Agricultural University, North Gujarat having semi-arid and sub-tropical climate situated in 24° 19' North latitude 72° 19' East longitude and 154.52 meter above mean sea level to find out effect of foliar and soil application of micronutrients on yield of sorghum . The soil of experimental field was loamy sand having mean values of high infiltration rate(15 cm/hr.), poor water holding capacity (21.65%) and also low in organic carbon (0.18 %), available N (141.6 kg/ha), whereas medium in available P_20_5 (27.1 kg/ha), K_2O (197 kg/ha), Fe(4.63 ppm) and Zn(0.37 ppm). The experiment was conducted with eight treatments viz., T_1: three water sprays, T_2: three foliar sprays of $FeSO_4$ @ 0.5 %+citric acid @0.05 % T_3: three foliar sprays of $ZnSO_4$@ 0.5 % , T_4: three foliar sprays of $FeSO_4$ @ 0.5 % + $ZnSO_4$@ 0.5 % +citric acid @0.05 %, T_5: 12.5 kg $FeSO_4$ /ha as soil application, T_6: 7.5 kg $ZnSO_4$ /ha as soil application , T_7: 12.5 kg $FeSO_4$ /ha as soil application + three sprays of $FeSO_4$ @ 0.5 %, T_8: 7.5 kg $ZnSO_4$ /ha as soil application+ three sprays of $ZnSO_4$ @ 0.5 % were replicated thrice with randomized block deign.

RESULTS

Grain and straw yields of sorghum were influenced significantly due to different treatments. In pooled results, application of 7.5kg $ZnSO_4$/ha as soil application along with three sprays of $ZnSO_4$ @ 0.5% had recorded highest grain (0.9 t/ha) and straw (7.32 t/ha) yields of sorghum which was significantly superior over rest of the treatments. However, the lowest grain and straw yields of sorghum were recorded due to three water sprays (Table 1). Similar results were also found by Sharma and Kumar (2009). Similarly, significantly higher seed and stalk yield of sesame were also recorded due to Zn and Fe like micronutrients application. These results are also in agreement with the findings of Rajshekhar (1995). Significantly higher plant height was observed due to application of 7.5kg $ZnSO_4$/ha as soil application+ three sprays of $ZnSO_4$ @ 0.5%, but it was at par with 12.5 kg $FeSO_4$/ha as soil application+three sprays of $FeSO_4$ @ 0.5% (Table 1).The pooled results presented in table 2.0 showed that application of different foliar & soil application of micronutrients had non-significant effect on available N, P_2O_5 & K_2O contents in soil, while application of different foliar and soil application of micronutrients had shown significant effect on available Fe and Zn contents in soil. The maximum Fe

Table 1. Effect of different treatments on yield of sorghum (Pooled of years 2010-2014)

Treatment	Yields (t/ha)		Net income	B : C	Plant height	Soil moisture
	Grain	Straw	(¹ /ha)	ratio	(cm)	(%)
T1: Three water sprays	0.571	4.71	17696	3.25	127	2.261
T2:Three foliar sprays of $FeSO_4$ @ 0.5 % + citric acid @ 0.05 %	0.71	5.64	22842	3.78	138	2.221
T3: Three foliar sprays of $ZnSO_4$ @ 0.5 %	0.72	5.83	23936	4.00	140	2.409
T4: Three foliar sprays of $FeSO_4$ @ 0.5% + $ZnSO_4$ @ 0.5% + citric acid @ 0.05%	0.75	5.82	24039	3.89	141	2.503
T5:12.5 kg $FeSO_4$ /ha as soil application	0.73	5.88	24236	4.00	142	2.411
T6: 7.5 kg $ZnSO_4$ /ha as soil application	0.77	6.22	26353	4.38	144	2.562
T7:12.5 kg $FeSO_4$/ha as soil application + three sprays of $FeSO_4$ @ 0.5%	0.78	6.24	25714	3.99	149	2.425
T8: 7.5 kg $ZnSO_4$ /ha as soil application+ three sprays of $ZnSO_4$ @ 0.5 %	0.90	7.32	31753	4.86	155	2.476
SEm$\pm$	0.0297	0.203			3.2	0.050
CD (P=0.5)	0.0862	0.569			9.2	NS
Year × Treatment						
SEm$\pm$	0.0455	0.424			5.50	0.074
CD (P=0.5)	0.128	NS			15.4	NS

content in soil after harvest of crop was recorded due to application of 12.5 kg $FeSO_4$/ha as soil application + three sprays of $FeSO_4$ @ 0.5% i.e. 5.60 ppm which was significantly superior over the rest of the treatments in pooled results (Table 2). As far as economics is concerned, the maximum gross income (¹ 39973), net income (¹ 31753), B:C ratio (4.86) and RWUE(1.01 kg/mm ha) were recorded due to application of 7.5 kg $ZnSO_4$ /ha as soil application along with three sprays of $ZnSO_4$ @ 0.5 % (Table 1).

CONCLUSION

It is concluded from the above discussion that application of 7.5 kg $ZnSO_4$ /ha as soil application along with three foliar sprays of $ZnSO_4$ @ 0.5 % at 30, 40 and 50 DAS in Zn deficient loamy sand soil resulted in higher grain and fodder yield of sorghum as well as monetary return in addition to maintain Zn status of soil.

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Integrated nutrient management in *kharif* sorghum [*Sorghum bicolor (*L.) Moench]

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Sorghum is mostly grown in rainfed areas, where soil moisture and nutrients are limiting factors. Soil related constraints viz. depletion of soil organic matter, multi nutrient deficiencies under intensive agricultural practices, decline in soil health, unsustainable crop productivity and environmental pollution due to no use of organic manure and imbalanced use of chemical fertilizers has developed renewed interest on use of organic sources of nutrients. On the contrary, use of organics alone may not yield enough to meet the growing demand of sorghum crop. Therefore, the present investigation is conducted to find out the effectiveness of organic manure and bioinoculantscombination with chemical fertilizers on growth and yield under prevailing agro climatic condition of Malwa plateau in Madhya Pradesh.

Table 1. Effect of integrated nutrient management on plant height, ear head length, grain and stover yield, net returns and rain water use efficiency in *Kharif* sorghum (Pooled of 2014 and 2015)

Treatment	Grain yield (t/ ha)	Stover yield (t/ ha)	Net returns (₹/ha)	Rain water use efficiency (kg/ ha/ mm)
100% RDN through inorganic fertilizer	5.06	13.89	82678	3.96
50% RDN through inorganic fertilizer +50% RDN through FYM	4.30	11.80	63172	3.28
75% through inorganic fertilizer +25% RDN through FYM	4.53	13.07	71471	3.18
50% through inorganic fertilizer +50% RDN through VC	4.39	12.16	63806	3.26
75% through inorganic fertilizer +25% RDN through VC	4.71	13.71	75147	3.74
50% RDN inorganic fertilizer +25% RDN through FYM+25% RDN through VC	4.48	12.53	65647	3.28
75% RDN inorganicfertilizer+25% RDN through FYM + PSB + *Azospirillum*	4.56	13.07	70414	3.28
75% RDN through inorganic fertilizer +25% RDN through VC+ PSB + *Azospirillum*	5.25	14.25	83917	4.15
75% RDN inorganic fertilizer +PSB + *Azospirillum*	4.71	13.34	76180	3.20
CD (P=0.05)	0.47	1.24	8297	0.69

RDN, Recommended dose of nitrogen; FYM, Farmyard manure; VC, Vermicompost; PSB, Phosphorus solubilizing bacteria

METHODOLOGY

Nine treatment combinations thus formed mentioned in the table 1 were laid out in a Randomized Block Design with three replications.Sorghumhybrid 'CSH 16' was taken for this experiment. The dose of fertilizer was applied in sorghum as per the treatments. The fertilizer sources of NPK were urea, single super and murate of potash. Sorghum seed were treated with PSB + *Azospirillum* @ 10 g /kgof seed as per treatment. Seed rate of sorghum was used 8 kg/ ha. The sowing was done at 45 cm row to row distance. Total rainfall received during the crop growing period was 685.7 mm with 21 rainy days and 942.2 mm with 26 rainy days respectively for the year 2014 and 2015.

RESULTS

Among all the treatments, application of 75% RDN through inorganic fertilizer + 25% RDN through vermicompost + seed treatment with PSB + *Azospirillium* gave significantly higher plant height, length of earhead, grain and stover yield, net returns and rain water use efficiencyas compared to other treatments but at par with 100% RDN through inorganic fertilizer. This was perhaps due to presence of PSB and *Azospirillum*, which increased the availability of nitrogen, phosphorus and potassium in soil and inorganic fertilizer continued supply of these nutrients to the crop at the early stages and through the organic manure at later stages of crop, which might have increased the supply of assimilates to grain, which ultimately produced more grain and stover yield.

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Effect of application of Urea-DAP-MOP briquette in direct seeded rice

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Rice (*Oryza sativa* L.) is a major food grain crop of the world and more than half of the population subsists on it. Direct dry seeding offers such advantages as faster and easier planting, reduced labour, earlier crop maturity by 7–10 days, more efficient water use and higher tolerance of water deficit, less methane emission and often higher profit in areas with an assured water supply (Balasubramanian and Hill 2002).A major impediment in the successful cultivation of direct-seeded rice (DSR) in tropical countries is nutrient management. Rice plants obtain much of their required P and K from the soil, crop residues, organic amendments, and irrigation water; but the supply of P and K from these naturally occurring, indigenous sources are typically insufficient to sustain high rice yields. Supplemental P and K from fertilizers are thus essential for sustaining high and profitable yields of rice without depleting the fertility of soil. For best effect, farmers should apply the fertilizers in proper dose, time and method. But farmers generally broadcast the straight fertilizers which have meager fertilizer use efficiency. Hence, the management of nutrients for rice requires a new approach, such as use of Urea-DAP-MOP briquette which enables adjustments in applying N, P, and K to accommodate the field-specific needs of the rice crop for supplemental nutrients.

METHODOLOGY

The experiment was conducted during 2011-2014 at Agricultural Research Station, VadgaonMaval, Tal. Maval, Dist. Pune. The experiment was laid out in factorial randomized block design. One factor as sowing of seed at different spacing as S1 drilling at 22.5 cm and S2 drilling at 30 cm. Second factor consist of application of Urea-DAP-MOP briquette as M_1 – Use of straight fertilizers by drilling as per RDF (100:50:50), M_2 –Application of 100% RDF through Urea-DAP-MOP briquette in alternate row, M_3 –Application of 75% RDF through Urea-DAP-MOP briquette in alternate row and M_4 – Application of 50% RDF through Urea-DAP-MOP briquette in alternate row. Thus there were total 8 treatment combinations replicated for three times with the individual gross plot size of 3.60m x 3.84m. The rice seeds direct seeded rice as per the treatments. The fertilizers were applied as per the treatments. The experiment was conducted and the data generated for 2011-12, 2012-13 and 2013-14 was analyzed and pooled for three years.

RESULTS

Datashowed that the drilling of rice at 30 cm spacing produced significantly more mean grain (5.6t/ha) and straw yield (5.8t/ha) than drilling at 22.5 cm spacing with mean grain (4.3 t/ha) and straw yield (4.9 t/ha). Similarly, the drilling of rice at 30.0 cm recorded significantly mean highest net returns per ha (¹ 37394/ ha) than the drilling of rice at 22.5 cm.The significantly maximum mean grain (5.6 t/ha) and straw yield (6.5t/ha) was produced by the treatment M_2 i.e. application of 100% RDF through Urea-DAP-MOP briquette in alternate

Table 1. Pooled mean grain yield (t/ha), straw yield (t/ha) and net returns (Rs/ha) of rice as affected by interaction of different treatments.

Spacing	Application of Urea—MOP briquette				Mean
	M_1	M_2	M_3	M_4	
S_1	4.32	4.94	4.67	3.31	4.31
	(4.90)	(5.63)	(5.35)	(3.78)	(4.92)
	[25590]	[33510]	[31225]	[10712]	[25259]
S_2	4.55	6.27	5.99	3.39	5.05
	(5.12)	(7.28)	(6.95)	(3.83)	(5.79)
	[29152]	[55421]	[52950]	[12052]	[37394]
Mean	4.44	5.61	5.34	3.35	
	(5.01)	(6.45)	(6.15)	(3.81)	
	[27371]	[44466]	[42087]	[11382]	
			Grain	Straw	Net returns
CD (P=0.05)			0.441	0.472	7529

Figures in parenthesis ( ) indicates straw yield of rice (t/ha), Figures in parenthesis [ ] indicates net returns (Rs/ha) of rice

row which was at par with the treatment M_3 i.e. application of 75% RDF through Urea-DAP-MOP briquette in alternate row with mean grain (5.4 t/ha) andstraw yield(6.2 t/ha). Similarly, the treatment M_2 i.e. application of 100% RDF through Urea-DAP-MOP briquette in alternate row significantly produced significantly higher net returns per ha (¹ 44466/ ha) than rest of all the treatments except it was at par with the treatment M_3 i.e. application of 75% RDF through Urea-DAP-MOP briquette in alternate row having mean net returns/ha (¹ 42087/ ha).

CONCLUSION

From pooled data it is to be concluded that the drilling of rice at 30.0 cm with application of 75% RDF through Urea-DAP-MOP briquette in alternate row was produced significant higher grain and straw yield and also remunerative with higher net returns/ha (Rs.52950). Hence, drilling of rice at proper spacing with management of nutrients through a new approach, such as use of Urea-DAP-MOP briquette which enables adjustments in applying N, P, and K to accommodate the field-specific needs of the rice crop for higher sustainable yields.

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Effect of nitrogen fertilization on yield attributes and grain yield of high-yielding aromatic and basmati genotypes

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Basmati and aromatic rice cultivation is quite preferred cropin Punjab, Haryana, Delhi and western Uttar Pradesh. The injudicious application of nitrogenous fertilizers in basmati rice cultivation leads to environmental pollution, higher incidence of insect-pests and diseases, reduced profits and lodging of crop. All these losses could be minimized if appropriate amounts of nitrogen are applied in basmati varieties. Hence, a field experiment was conducted to assess the effect of nitrogen fertilization on grain yield and its attributes in basmati rice varieties.

METHODOLOGY

A field experiment was conducted during *kharif*2015 to study the response of 11 rice entries/ cultures/ checks (Pusa Basmati 1, Pusa Basmati 1121, Pusa Sugandh 5, Pusa Basmati 6, IET 24565, IET 24566, IET 24570, IET 24573, IET 24575, IET 24576, IET 24577) under 3 N levels (60, 120 and 180 kg /ha). The treatments (33) were allocated in a split-plot design with 3 replications. N levels were kept in main plots and rice entries in sub plots. 25-days old seedlings were transplanted in

Table 1. Grain yield and yield attributes of transplanted rice as affected by N rates and rice cultures/entries

Treatment	Grain yield (t/ha)	Fertile tillers/ m^2	Panicle weight (g)
N rate (kg/ha)			
60 kg N/ha (50 %N)	4.34^{C}	399^{C}	2.70^{B}
120 kg N/ha (100% N)	5.67^{B}	447^{B}	2.86^{A}
180 kg N/ha (150% N)	5.86^{A}	488^{A}	2.87^{A}
Entries/ cultures			
Pusa Basmati 1	4.39^{D}	399^{C}	2.76^{ABC}
Pusa Basmati 1121	5.13^{C}	501^{A}	2.74^{ABC}
Pusa Sugandh 5	5.61^{B}	430^{B}	2.92^{AB}
Pusa Basmati 6	4.63^{D}	430^{B}	2.78^{ABC}
IET 24565	5.42^{B}	449^{B}	2.70^{C}
IET 24566	5.54^{B}	446^{B}	2.73^{BC}
IET 24570	5.41^{B}	442^{B}	2.70^{C}
IET 24573	5.12^{C}	440^{B}	2.91^{AB}
IET 24575	5.08^{C}	435^{B}	2.94^{A}
IET 24576	5.63^{B}	437^{B}	2.81^{ABC}
IET 24577	6.24^{A}	483^{A}	2.92^{AB}

Means followed by the same letter or letters do not differ significantly at P d" 0.05 by Duncan's multiple range test.

second week of July 2015 at a spacing of 20 cm x 10 cm. 60 kg P_2O_5, 40 kg K_2O and 5.0 kg zinc /ha, through SSP, muriate of potash, and zinc sulphate, respectively, were uniformly applied in all plots before transplanting. N, as per treatment, was applied through prilled urea in three splits, i.e. 50% basal, 25% at tillering and 25% at panicle initiation.

RESULTS

Results showed that the grain yield of different AVT-1 rice entries/ varieties increased significantly up to 120 kg N /ha (Table 15). The highest N level (180 kg N /ha) could not bring a significant improvement in grain yield or its attributes (number of panicles m^{-2}, panicle weight, grains panicle^{-1} and 1000- grain weight) over its preceding level (120 kg N /ha). Different rice entries/ varieties also differed significantly with respect to their grain yield and its attributes. Highest grain yield was recorded with IET 24577, which was significantly greater to all other varieties /entries. The next best rice entry was IET 24576, which was at par with IET 24565, IET 24566, IET 24570 and Pusa Sugandh-5. Entry IET 24576 gave significantly higher grain yield over Pusa Basmati 1, Pusa Basmati-1121, Pusa Basmati-6, IET 24573 and IET 24575. A significant variation in major yield attributes caused a significant variation in grain yield response of AVT entries and rice varieties.

CONCLUSION

Basmati/aromatic rice genotypes responded up to the highest N level (180 kg/ha). The highest grain yield was recorded with IET 24577, which was significantly greater to all other varieties /entries.

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Kinetic release behaviour of DTPA-extractable Mn in soils of different cropping systems and total Mn content associated with soil particles

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Manganese (Mn) deficiency is a emerging in some crops grown on coarse textured alkaline soils of India. Understanding the releasing pattern of Mn in soils under different cropping system and distribution of total Mn content with different soil particles, a field survey and laboratory experiment was conducted in the Department of Soil Science, CCS HAU, Hisar. The purpose of this research was to know mechanism of Mn distribution in different soil particles helps to know its retention in soils and release to plants. Results showed that DTPA-Mn content release in soils of different cropping system varies from soil to soil as well as system to system. In paddy-wheat cropping system the releasing of Mn was upto 40 days and thereafter the release of Mn appear remain constant and in cotton-wheat, sugarcane-sugarcane cropping system it was upto 50 days whereas in pearl millet-wheat, pearl millet-mustard and fellow-mustard cropping system, the releasing of Mn upto 30 days and thereafter the Mn release remain constant in the leachate. Maximum Mn releasing was found upto 10 days and thereafter it gradually decreased in the leachate with increase in incubation interval. It means that the magnitude of release of inherent Mn is governed by many factors i.e. type and amount of clay, Mn status, alternate wetting and drying cycles, pH, moisture content etc. However, Mn associated with different soil particles was found in the order of: Silt > Clay > Sand i.e. 52.8% > 32.3% > 14.9% of total soil Mn, respectively. Among all cropping systems, silt and clay particles showed greater affinity towards Mn adsorption may be due to their high surface areas and nutrient retention capacity. These mechanisms will help to develop Mn fertilization scheduling improve the yield and quality of crops in coarse textured and alkaline soils of India.

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Effect of fertility levels on yield and economics of Niger (*Guizotia abyssinica* (Lf.) cass.) genotypes under rainfed condition

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Niger (*Guizotia abyssinica*) is an important traditional oilseed crop. India is the largest producer of niger in the World which was grown over an area of 2.77 lakh hectare with a production of 0.89 lakh tones and productivity of 321 kg/ha (Anonymous, 2015). Niger although considered minor oilseed crop, is important in terms of its 32 to 40 per cent of quality oil with 18 to 24 percent protein in seed. It is also used as an oilseed crop in India where it provides about 3 per cent of the edible oil requirement of the country. The niger oil is also used in cooking as a substitute of ghee and olive oil. The productivity of niger can be increased with high yielding varieties and judicious use of fertilizers. Therefore, there is a need to lookout actual fertilizer requirement of AVT genotypes to increased productivity of niger.

METHODOLOGY

Treatment consisted of four AVT genotypes *viz.,* G_1- IGPN-2004-1, G_2 -ONS-162, G_3- IGPN-1102, G_4- JNC-9 with one local check variety Birsa niger-1 in main plot, three fertility level *viz.,* 50%, 100% and 150% of recommended dose of fertilizer in sub plot laid out in a split plot design and replicated thrice. The recommended dose of fertilizer was 20:20:20 kg NPK/ha. Full dose of NPK fertilizers was applied as a basal at the time of seed sowing. The recommended cultural and agronomic practices were followed, the crop was grown under rainfed situation. The crop was sown by maintaining spacing of 30 cm row to row distance. Thinning at 20, hoeing and hand weeding at 3o days after sowing was done during the crop

Table 1. Productivity and profitability of niger genotypes as influenced by different fertility levels

Treatment	Seed Yield (t/ha)	Stalk Yield (t/ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C Ratio
Genotype					
IGPN-2004-1	0.43	1.83	15675	8175	2.1
ONS-162	0.48	2.31	17645	10144	2.3
IGPN-1102	0.47	2.10	17049	9549	2.3
JNC-9	0.41	1.54	14658	7158	1.9
BN-1(LC)	0.44	1.76	15933	8433	2.1
CD (P=0.05)	0.04	0.13	1676	1676	0.3
Fertility level					
50% of RDF	0.34	1.45	12294	6294	2.1
100% of RDF	0.47	1.99	16946	9446	2.3
150% of RDF	0.53	2.28	19335	10335	2.1
CD (P=0.05)	0.05	0.22	1883	1883	NS

growing season. The seed was sown on 27th August,2014 using seed rate @ 5 kg/ha and crop harvested on 5th December, 2014.

RESULTS

Niger genotypes, ONS-162 recorded significantly higher (Table 1) grain yield (0.48 t/ha) and stalk yield (2.31 t/ha) which ultimately led to gross return (¹ 17644/ha), maximum net return (¹ 10144/ha) and B: C ratio (2.33) as compared to other niger genotypes. Among Application of 150% recommended dose of fertilizer produced significantly higher grain yield (0.53 t/ha), stalk yield (2.28 t/ha), gross return (¹ 19335/ha), net return (¹ 10335/ha) and benefit cost ratio (1.70) as compared to 50% recommended dose of fertilizer.

CONCLUSION

Application of 150% recommended dose of fertilizer produced significantly higher grain yield (0.53 t/ha), stalk yield (2.28 t/ha), gross return (¹ 19335/ha), net return (¹ 10335/ ha) and benefit cost ratio (1.70) as compared to 50% recommended dose of fertilizer.

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Effect of biofertilzers on lentil (*Lens Culinaris*)

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Among pulses, lentil (*Lens culinaris* medic) holds an important position because of its wider climate and soil adaptation. India accounts for 37% of the global lentil area with production of 32% share in global scenario. Lentil is grown in almost all states in our country during *rabi* season. Productivity of lentil may be attributed to a number of factors. However, poor crop nutrition is most significant. Continuous use of chemical fertilizer has resulted in depletion of soil organic matter along with increasing soil production constraints such as ground water depletion, stability, acidity & alkanity etc. Intensive agriculture practices resulted micronutrient deficiency, deterioration of soil health and declining crop yield. No single source of nutrient is capable for supplying plant nutrients in balanced proportion. Biofertilizer cannot only add nitrogen and solubilise native phosphorus but help in decomposition of plant residue, stimulation of plant growth and finally the production. The information on biofertilizer with respect to lentil is quite meager. Hence, a study on effect of biofertilizers in lentil under irrigated condition was executed.

METHODOLOGY

A field experiment was conducted at Oilseed Research Farm of C. S. Azad University of Agriculture and Technology, Kanpur during *rabi* season of 2013-14. The annual precipitation received during the year was 980 mm which was erratically distributed. The soil was sandy loam in texture with low organic carbon. Nine treatments comprised of control,

Table 1. Effect of Treatments on grain yield, straw yield, harvest index and economics of lentil

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index (%)	Economics Net income (Rs/ha)	B:C ratio
Control	720.00	1450.00	33.20	6358	1.25
RDF 50%	1030.00	1636.66	38.60	18011	1.67
RDF 100%	1163.33	1784.66	39.46	22126	1.77
RDF 50% + *Rhizobium*	1180.28	1798.33	39.62	24506	1.91
RDF 50% + Rhizobium + PSB	1190.11	1795.00	39.86	24892	1.92
RDF 50% + *Rhizobium* + PSB + PGPR	1208.00	1810.00	40.01	25628	1.95
RDF 100% + *Rhizobium*	1280.24	1876.66	40.51	27170	1.95
RDF 100% + *Rhizobium* + PSB	1322.90	1896.66	41.07	28984	2.01
RDF 100% + *Rhizobium* + PSB+PGPR	1489.57	1980.00	42.89	36192	2.26
C.D (P=0.05)	93.50	63.89	1.57	1902	0.07

RDF 50%, RDF 100%, RDF 50% + *Rhizobium*, RDF-50% + *Rhizobium* + PSB, RDF 50% + *Rhizobium* + PSB + PGPR, RDF 100% + *Rhizobium*, RDF 100% + *Rhizobium* + PGPR and RDF 100% + *Rhizobium* + PSB + PGPR were tested in RBD with three replications. Seeds of lentil were treated with biofertilizer @200 g/10 kg of seed as per treatments either alone or in combination. Fertilizer were applied as per recommendation of the crop, growth attributes were recorded at 60, 90 and maturity stage, whereas, yield attributing characters and yield were recorded at harvesting stage.

RESULTS

Result revealed that amongst the fertilizer doses, the maximum, growth and yield attributes and yield (1489.57 kg/ha) net income (Rs. 36193/-) and B:C ratio (1:2.26) were recorded under 100% RDF alongwith *Rhizobium* + PSB+PGGPR. It might be due to combined use of chemical fertilizer and biofertilizer and increase in nutrient availability at different stages of crop due to biofertilizer application. The lowest yield (720 kg/ha), net income (Rs. 6358) and B:C ratio (1:1.25) was fetched under the control.

CONCLUSION

On the basis of results, it is concluded that the highest grain yield of lentil (1489.57 kg/ha) net income (Rs. 36192/ha) and B:C ratio (1:2.26) were obtained with the combined use of inorganic fertilizer and biofertilizer i.e. 100% RDF + *Rhizobium* + PSB + PGPR. Hence, it is recommended for higher production of lentil.

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Response of scented rice (*Oryza sativa*) varieties to different fertility levels

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In Uttar Pradesh state, scented rice is grown over an area of 3,18,750 ha and produces 12,70,090 tonnes, respectively (APEDA, 2012). Almost every state of the country has its own set of aromatic rice that is performing well in their own native areas. Increased yield, sustained soil fertility and considerable improvement in grain quality of aromatic rice has been observed under integrated use of organic and inorganic fertilizers as compared to RDF (Recommended dose of fertilizers) applied with inorganic fertilizer. Thus, the judicious use of suitable doses of fertilizer with respect to available soil moisture may play an important role in minimizing the present large gap between yields achieved and yield achievable.

METHODOLOGY

The experiments were conducted during 2011-2012 *kharif* season at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.). The experimental site falls under subtropical zone in Indo-gangetic plains having alluvial calcareous soil and situated at 26^o 47' N latitude, 82^o 12' E longitude with an elevation of about 113 m about mean sea level.The experiment consisted of three varieties viz; Kalanamak – 3131, Pusabasmati – 1 and Improved Pusabasmati in main plot and four fertility levels viz; F^1 (60+30+30 kg NPK/ha), F^2 (90+45+45 kg NPK/ha), F^3 (60+30+30 kg NPK + 6 ton FYM/ha) and F^4 (90+45+45 kg NPK + 6 ton FYM/ha) in sub plots and was replicated three times in split plot design. Rests of the inputs were applied as per package and practices of NDUA&T Kumarganj, Faizabad (U.P.).

RESULTS

The entireyield viz; grain yield (q/ha) and straw yield (q/ha) were significantly influenced due to different varieties and fertility levels except harvest index (Table 1).Significantly higher grain yield (39.41 q/ha) was achieved in variety Improved Pusabasmati and also significantly higher grain yield (38.67 q/ha) was recorded in F_4. Significantly higher straw yield (71.00) was recorded in variety Kalanamak – 3131 and also significantly higher (68.38) was recorded in F_4. The higher grain yield and straw yield obtained due to various treatments which contributed a lot in improving yield as under adequate nutrient level recorded by the variety Improved Pusabasmati which showed better vegetative growth which in turn contributed to higher yield attributes increased photosynthetic activating at leaves. The present findings in conformity to Gupta and Singh (1992) and Singh *et al.*(1997). Harvest index is the function of grain yield to the total biological yield (grain and straw). Harvest index varied non-significantly due to varieties and fertility levels. The higher harvest index was calculated in Improved Pusabasmati (39.28%) the higher fertility levels F_4 (90+45+45 NPK + 6 ton FYM/ha) contributed higher harvest index (36.37%)Pandey

Table 1. Yields as affected by scented rice varieties and various fertility levels.

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
Variety			
V_1-Kalanamak-3131	2890	7100	28.97
V_2-Pusa Basmati-1	3820	5930	39.19
V_3-Improved PusaBasmati	3941	6074	39.29
SEm±	164	178	1.63
CD (P=0.05)	644	699	NS
Fertility level			
F_1-60+30+30 Kg NPK/ha	3207	5919	35.10
F_2-90+45+45 Kg NPK/ha	3773	6625	36.24
F_3-60+30+30kg NPK+6ton FYM/ha	3355	6090	35.55
F_4-90+45+45kg NPK+6ton FYM/ha	3867	6838	36.37
SEm±	116	191	1.05
CD (P=0.05)	344	569	NS

and Tripathi (2012). Interaction effect due to varieties and fertility levels were found non-significant in all the parameter during present investigation. On economics computation it was found that higher grain yield and highest net return was assessed under (V_3) Improved Pusabasmati with (F_4)fertility level (90+45+45 kg NPK + 6 ton FYM/ha).

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Integrated nutrient management in pigeonpea (*Cajanus cajan*) based intercropping system under rainfed condition

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Pigeonpea [*Cajanus cajan* (L.) Millsp] is a multipurpose leguminous crop that can provide food, fuel, wood and fodder for the small and marginal farmers under rainfed conditions. Pigeonpea is an important source of protein for the poor as well as for the vegetarians which constitute major population of the country. The recent skyrocketing price rise in pulses has threatened the nutritional security of these people. In India, the cultivation of pigeonpea over an area of about 3.88 mha with production and productivity of 3.17 mt and 1.19 t/ha, respectively during 2013-2014. In Uttar Pradesh, it is grown on 0.64 ha area with production of 0.79 mt and productivity of 1.23 t/ha. At present more than 90% of the area under pulses is confined to unirrigated areas and in future also the bulk of pulse production will continue to come from unirrigated areas. Therefore, any plan for increasing pulse production in the country should be based on a long-term approach for improved productivity of these crops under rainfed farming conditions. India has only 2.3 % of the world's geographical area but supports 17 % of its population. Out of the estimated 141 m ha net cultivated land in India, 80 m ha is rainfed which produces 40 % of the food grains in the country. The low productivity of pigeonpea has been attributed to the fact that large areas is under rainfed situation having low nutrient status in soil grown in wider spacing. In Uttar Pradesh, the Blue Bulls ('Nilgai') are the major menace in pulse crop than insects and pests now-a-days. Pigeonpea is a deep rooted crop with slow initial growth rate between 45 and 60 days after sowing is well suited for intercropping. It is a long duration, slow initial growth and wider spacing crop so it provides good scope for intercropping of short duration cereals, pulses and oilseeds. When pigeonpea is grown as a sole crop, it is relatively inefficient because of its slow initial growth rate and low harvest index. Therefore, it is generally intercropped with sorghum, blackgram, greengram, sesamum, soybean and maize to increase the productivity of the system. So it is grown as intercrop, which helps in efficient utilization of available resources (sun light, space between two rows, nutrients in soil etc.) for enhancing the productivity and profit. Nutrient management in intercropping system is entirely different from sole cropping, as the requirement of each component crop has to be taken care of. Nutrient management is a key issue in obtaining potential yield of both crops in any intercropping system. Integrated nutrient management (INM) is some of the important options to improve soil health and crop productivity in rainfed drylands areas. In rainfed area, to raise production on a sustainable basis increased use of organic manures, biofertilizers, management of nutrients through intercropping system. The interactive advantages of combining organic, biofertilizers and inorganic sources of nutrients in integrated nutrient management have proved superior to the use of each component separately (Palaniappan and Annadurai 2007). Intercropping of pulses with other crops increases nutrient status of soil and improve the soil health (Singh *et al.* 2012).

METHODOLOGY

A field experiment was conducted during *kharif* season of 2013-14 at Agronomy farm of Narendra Deva Univ. of Agriculture & Technology, Kumarganj, Faizabad (U.P.). The soil of experimental plot was silty loam in texture having 0.29 % organic carbon, 155 kg/ha available N, 15 kg/ha P and 240 kg/ha available K with neutral in soil pH 7.3. The experiment was laid out in the factorial randomized block design with three replications. The treatments were consisted of three intercropping systems (pigeonpea sole, pigeonpea + black gram and pigeonpea + maize). Seeds of pigeonpea and blackgram were inoculated with *Rhizobium* , PSB and Nano biofertliser (Harit vardan) as per treatment and FYM was also incorporated in soil as per treatment before fifteen days of sowing. The crops (pigeonpea 'Narendra arhar-1', blackgram 'Narendra urd-1 and maize 'MM 1107') were sown in first week of July, 2013. Recommended dose of fertilizers for both pigeonpea and blackgram was 20:40:20 kg NPK /ha, which was applied as basal at the time of sowing. However, in maize half dose of nitrogen (40 kg/ha) and full dose of P (40 kg/ha) and K (30 kg/ha) were applied as basal and remaining half of N (40 kg/ha) was top dressed in two equal splits, one at knee height stage and another at tasseling stage of the crop at proper moisture. Fertilizers in intercropping treatments were given as per row arrangements. Recommended package of practices of crop production was adopted. The other cultural operations were done as per recommendation and crop requirement.

RESULTS

The higher grain yield of pigeonpea (1.87 t/ha) was recorded under pigeonpea + blackgram intercropping system which was significantly superior to pigeonpea sole (1.71 t/ha) and pigeonpea + maize (1.26 t/ha). Sizable reduction in pigeonpea yield (1.26 t/ha) under pigeonpea + maize intercropping system was due to more competition between maize and pigeonpea for space, nutrients, soil moisture and solar energy. Pulses crop seed Inoculated with PSB + *Rhizobium* culture along with RDF and FYM increased the grain yield of pigeonpea, black gram and maize. Higher pigeon pea equivalent yield (2.01 t/ha) and water use

Table 1. Yields of intercrops and pigeonpea as influenced by different integrated nutrient management system

Treatments	Yield (t/ha)			Pigeon pea equivalent yield (t/h)	RWUE (kg/ha/ mm)
	Pigeon pea	Black gram	Maize		
Intercropping system					
Pigeon pea sole	1.71			1.71	3.30
Pigeonpea+ Black gram	1.87	.671		2.01	4.87
Pigeon pea + maize	1.26		2.63	1.92	3.71
SEm±	0.033			0.034	
CD (P=0.5)	0.098			0.10	
Nutrient Management System					
RDF	1.37	0.50	2.25	1.13	3.34
PDF+*Rhizobium* + PSB	1.54	0.61	2.47	1.95	3.78
PDF+*Rhizobium* + PSB + FYM @ 5 t/ha	1.72	0.71	2.89	2.20	4.26
PDF + Rhizobium + PSB + FYM @ 5 t/ha + Harit-Vardan @ 5 kg/ha	1.81	0.78	2.94	2.31	4.47
SEm±	0.039			0.039	
CD (P=0.05)	0.113			0. 160	

efficiency (4.87 kg/ha/mm) were recorded under pigeonpea + black gram inter cropping system over pigeonpea sole and pigeonpea + maize intercropping system. Inoculation of pigeonpea and blackgram seeds with PSB and *Rhizobium* culture significantly increased PEY (1.95 t/ha) and WUE (3.78 kg/ha/mm) over RDF (PEY 1.13 t/ha and WUE 3.34 kg/ha/mm) alone. Similarly addition of FYM @ 5 t/ha along with RDF + PSB + *Rhizobium* culture were also significantly increased the PEY (2.20 t/ha) over rest of the nutrient management system, while at par with addition of harit vardan biofertilizer (2.31 t/ha). Significantly higher values of available nitrogen, phosphorus and potassium were found under the pigeonpea + blackgram intercropping system compared to pigeonpea sole and pigeonpea + maize intercropping system. Under nutrient management system, pigeonpea and blackgram seed inoculation with PSB and R*hizobium* culture was not significantly increased organic carbon, while, increased significantly N, P and K in soil over RDF alone supplied through inorganic fertilizers. Incorporation of FYM @ 5 t/ha significantly increased the availability of nitrogen and phosphorus in soil. Higher net return (‘ 68872/ha) as well as B:C (2.18) were fetched under pigeonpea + blackgram intercropping system than pigeonpea sole (‘ 42532/ha) and pigeonpea + maize cropping system (Rs.43869/ha) due to increase in pigeonpea yield and additional yield of blackgram, which resulted in higher pigeonpea equivalent yield (PEY). Maize crop adversely affected the yield of pigeonpea.

CONCLUSION

On the basis of results, it may be concluded that, when intercrop of pigeonpea + black gram with seems to be the most appropriate and profitable. However, the maximum benefit of above intercropping system can be achieved through application of FYM @ 5 t/ha along with RDF and biofertilizers.

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Effect of N, P and biofertilizer management practices on growth, yield and nutrient uptake of pearl millet (*pennisetum glaucum*)

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Pearl millet (*Pennisetum glaucum*) is the most widely grown type of millet. It is grown in Africa and the Indian subcontinent since prehistoric times. It is generally accepted that pearl millet originated in tropical Africa and was subsequently introduced into India. The earliest archaeological records in India dates back to 2000 BC, are available. Pearl millet is well adapted to production systems characterized by drought, low soil fertility, and high temperature. It performs well in soils with high salinity or low pH. Because of its tolerance to difficult growing conditions, it can be grown in areas where other cereal crops, such as maize or wheat, would not survive. But under Indian condition its productivity is very low due growing of pearlmillet by marginal and sub marginal farmers under rainfed situation without any fertilization. That’s why we have established a study on performance of pearlmillet under different N, P, and biofertilizer management practices.

METHODOLOGY

A field experiment entitled “Studies on N, P and biofertilizer management practices on growth, yield and nutrient uptake of pearl millet [*Pennisetum glaucum* (L.) R. Br.]” was conducted during *kharif*, 2013 on sandy soil of the Agricultural College Farm, Bapatla. The treatment details were T1: Control, T2: Biofertilizer alone (*Azospirillum* and PSB), T3: 20 kg N + 15 kg P_2O_5/ha, T4: 40 kg N + 30 kg P_2O_5/ha, T5: 60 kg N + 45 kg P_2O_5/ha, T6: T2 + T3, T7: T2 + T4 and T8: T2 + T5. The experiment was conducted in a randomized block design (RBD) and replicated thrice.

RESULTS

Grain and stover yields of pearl millet differed significantly with varying levels of nitrogen and phosphorus fertilizers in association with biofertilizers. The maximum grain yield and stover yield were recorded with the combined application of

Table 1. Yield, economics and nutrient uptake of pearl millet as influenced by N, P and biofertilizer management practices

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Net returns (Rs/ha)	B: C ratio	Nitrogen uptake (kg/ha)	Phosphorus uptake (kg/ha)
T1 : Control	13.2	36.9	11151	1.50	35.7	9.4
T2 : Biofertilizer alone (*Azospirillum* and PSB)	15.9	41.9	15609	2.07	48.0	13.4
T3 : 20 kg N + 15 kg P2O5/ha	20.0	44.1	17216	2.02	56.9	15.9
T4 : 40 kg N + 30 kg P2O5/ha	21.8	50.1	18526	1.92	64.1	17.5
T5 : 60 kg N + 45 kg P2O5/ha	25.1	60.5	21721	2.02	81.8	20.9
T6 : 20 kg N + 15 kg P2O5/ha + (T2)	22.8	51.6	20763	2.40	64.2	16.6
T7 : 40 kg N + 30 kg P2O5/ha + (T2)	27.2	58.3	25057	2.57	82.2	23.4
T8 : 60 kg N + 45 kg P2O5/ha + (T2)	29.7	67.5	27357	2.51	98.3	25.5
SEm±	1.07	3.13	-	-	2.81	0.92
CD (P = 0.05)	3.2	9.4	-	-	8.5	1.9

inorganic fertilizer and biofertilizers (60 kg N + 45 kg P_2O_5/ha + biofertilizer) but, it remained at par with 40 kg N + 30 kg P_2O_5/ha + biofertilizer. The magnitude of increase in grain yield with T8, T7 and T5 treatments over control was to the extent of 125.0, 106.1 and 90.1%, respectively. Application of biofertilizer alone recorded significantly higher grain and stover yields over the control. The highest harvest index (31.8 %) was recorded with the application of 40 kg N + 30 kg P_2O_5/ha + biofertilizer during the study followed by T3 treatment (31.2 %) which were on a par with rest of the treatments except control. Nutrient uptake of nitrogen and phosphorus were increased significantly with the increasing fertility levels. The highest nitrogen (98.3 kg/ha) and phosphorus (25.5 kg/ha) uptake of pearl millet was recorded with T8 treatment (60 kg N + 45 kg P_2O_5/ha + biofertilizer) which was on a par with 40 kg N + 30 kg P_2O_5/ha + biofertilizers but, proved significantly superior to control and application of biofertilizer alone. Similar trend was followed by total nitrogen and phosphorus uptake. The highest net returns (Rs 27357/ha) were recorded by the application of 60 kg N + 45 kg P_2O_5/ha + biofertilizers (T8) followed by 40 kg N + 30 kg P_2O_5/ha + biofertilizers (T7) and T5 treatments. Similarly application of biofertilizer alone gave a monetory benefit of 4458 over the control. Among all the treatments tried, highest benefit : cost ratio (2.57) was obtained with the application of 40 kg N + 30 kg P_2O_5/ha + biofertilizers (T7 treatment) followed by T8 treatment (2.51) and T6 treatment 2.40.

CONCLUSION

Overall, it can be concluded that application of 40 kg N + 30 kg P_2O_5/ha biofertilizers was more economical in obtaining higher net returns and benefit cost ratio whereas application of 60 kg N + 45 kg P_2O_5/ha + biofertilizers (*Azospirillum* and PSB) gave higher grain and stover yields and nutrient uptake of pearl millet.

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Phosphorus management in cowpea (*Vigna unguiculata*) on loamy sand soil

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A field experiment was conducted during *Kharif*-2014 at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The soil of the experimental field was loamy sand in texture, low in organic carbon (0.17%), available nitrogen (160.7 kg/ha) and available sulphur (8.50 mg/kg),medium in available phosphorus (38.9 kg/ha), available iron (7.60 mg/kg) and available zinc (0.58 mg/kg) and high in available potash (286 kg/ha) with pH 7.6.Fourteen treatment combinations comprising two levels of FYM *viz*., FYM 0 t/ha (F_0) and FYM 10 t/ha (F_1) whereas seven levels of phosphorus viz., PSB (P_1), 20 kg P_2O_5/ha (P_2), 20 kg P_2O_5/ha+PSB (P_3), 30 kg P_2O_5/ha (P_4), 30 kg P_2O_5/ha+PSB (P_5), 40 kg P_2O_5/ha (P_6) and 40 kg P_2O_5/ha+PSB (P_7) were evaluated in factorial randomized block design replicated thrice. The variety GC 4 of cowpea was used as test crop. Almost all the growth and yield attributes of cowpea such as plant height, number of branches/plant, number of pods/plant, number of root nodules/plant, weight of nodule/plant, pod length, number of seeds/pod, seed yield and stover yield were significantly influenced by application of FYM @ 10 t/ha, which ultimately reflected in higher seed (1392 kg/ha) and stover (2118 kg/ha) yields. Further, all the growth parameters and yield attributes of cowpea were significantly influenced by application of phosphorus @ 40 kg P_2O_5/ha+PSB, which was reflected in higher seed (1483 kg/ha) and stover (2197 kg/ha) yields. Significantly, maximum protein content and yield as well as N, P, K, S, Fe and Zn content and uptake in seed and stover were also observed under application of FYM @ 10 t/ha and 40 kg P_2O_5/ha+PSB. As far the economics is concern, the application of 40 kg P_2O_5/ha+PSB recorded maximum net realization (Rs. 54,909/ha) with BC ratio of 3.12.

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Evaluation of different extractants for boron availability in different soils using soybean as test crop

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Widespread deficiency of boron (B) in Indian soils necessitates B fertilization, particularly under intensive cropping systems. However, management of B in agricultural lands is somewhat complicated due to i) its narrow range between deficiency and toxicity in soils and plants, ii) difficulty in precise and routine assessment of native soil B status, and iii) complex reactions of applied B with soil constituents. The present investigation, therefore, aimed at a greenhouse experiment intended for evaluation of different extractants, both single and multi-nutrient, for assessing the availability of B in 20 soils varied in physico-chemical properties using soybean as test crop.

METHODOLOGY

Twenty soil samples (0-15 cm) with wide variation in physico-chemical characteristics were selected for greenhouse experiment. These samples were collected from cultivators' fields from different places in India. Agreenhouse experiment was conducted with these soils to assess the response of soybean to applied B (1.0 mg/kg). Selected soils were extracted for B using different extractants *i.e.* hot-water (HWB), hot-$CaCl_2$ (HCCB), modified Morgan's reagent (MB), ammonium acetate (AAB), Mehlich-3 (M3B), DTPA-sorbitol (DTPA-SB), and ammonium bicarbonate-DTPA (AB-DTPA). Boron content in extract was determined using spectrophotometer and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS).

RESULTS

Results indicated that drymatter yield of soybean was enhanced by 1.0 to 62% across the soils with application of 1.0 mg B/kg over control. Hot 0.01 *M* $CaCl_2$ extractant (HCCB) was more consistent in predicting available B in soils as compared to hot water soluble B method. Among multi-nutrient extractants, Mehlich-3 was superior to other multi-nutrient extractants for assessing available B in soils, and M3B was found to be the best index of available B in soil with a significant relationship with Bray's percent yield (r= 0.94, p<0.01), B uptake (r=0.76, p<0.01) and plant B content (r=0.89, p<0.01). This is in conformity with the finding of Redd *et al.* (2008), they also noted a significant correlation between Mehlich 3 extractable B and B concentration and total B uptake in alfalfa. As far as B determination technique is concerned, between spectrophotometer and ICP-MS determination, ICP-MS always estimated higher B in extractant by 1.43 over colorimetry and can be useful for extracts containing low B content. Critical limit of deficiency of extractable B was worked out for different extractants (Table 1) as 0.52 for HWB, 0.70 for HCCB, 0.25 for MB, 0.42 for AAB, 0.56 for M3B, 0.27 for DTPA-SB and 0.26 mg/kg for AB-DTPA-B. The critical limit of deficiency in plant (on dry weight basis) was worked out as 28 mg/kg using soybean as a test crop.

CONCLUSION

Soybean responded positively to applied B @ 1.0 mg/kg. Among different multi-nutrient extractants Mehlich-3 can be used to assess available B in soil. It was also superior and positively correlated with Bray per cent yield, plant B content and B uptake. ICP-MS was more precise and efficient technique over spectrophotometer (colorimetry). Critical limit of deficiency of extractable B different extractants was as 0.52 for HWB, 0.70 for HCCB, 0.25 for MB, 0.42 for AAB, 0.56 for M3B, 0.27 for DTPA-SB and 0.26 mg/kg for AB-DTPA-B and

Table 1. Critical limits of B for different extractants in soybean

Extractants	Graphical method		Statistical method	
	Critical limit (mg/kg)	R^2	Critical limit (mg/kg)	R^2
HWB	0.52	0.65	0.42	0.76
HCCB	0.70	0.87	0.78	0.76
MB	0.25	0.58	0.19	0.60
AAB	0.42	0.47	0.33	0.17
M3B	0.56	0.76	0.59	0.83
DTPA- SB*	0.27*	0.40	0.22	0.70
AB-DTPA*	0.26*	0.42	0.20	0.65

*B determined through ICP-MS

for plant (on dry weight basis) 28 mg/kg using soybean as a test crop.

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Effect of crop geometry and nutrient management on yield performance of sweet corn (*Zea mays* L. saccharata) under chhattisgarh plain ecosystem

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The uncertainty of rice in upland, especially in low rainfall areas lead the farmers to go for other alternative crops which give more remunerative returns. Under such circumstances, scope to grow sweet corn seems to be the better choice for upland farmers. In order to popularize its cultivation among the farming community, it is essential to standardize its agro-techniques for its potential. In Chhattisgarh, maize is grown in an area of 102.70 thousand ha with an annual production of 185.80 thousand million tonnes and an average productivity of 1.81 t/ha (Anonymous, 2010). Sweet corn is an exhaustive crop and it is harvested at milky stage and requires fertile soils for optimum production. The productivity of maize largely depends on its nutrient requirement and management particularly that of nitrogen, phosphorus and potassium (Arun Kumar *et al*., 2007). Keeping these points in view, an investigation was carried out with an objective to know the combined effect of nutrient management practices and crop geometry on the growth and cob yield of sweet corn.

METHODOLOGY

Field experiment was conducted at Research cum Instructional Farm, IGKV, Raipur. The experiment was laid out in split plot design with 3 replications. The treatments comprised of three planting geometry *viz.* 45 cm x 20 cm, 45 cm x 30 cm and 60 cm x 30 cm and six levels of nutrient management practices: control, 50 % RDF, 100 % RDF

Table 1. Effect of crop geometry and nutrient management on yield performance of sweet corn

Treatment	No. of cobs/ha	Weight of cobs (g) With husk	Weight of cobs (g) Without husk	No. of grains/cob	Green cob yield (t/ha)	Green stover yield (t/ha)
Crop geometry						
45 cm x 20 cm	62016.4	169.0	116.9	397.7	9.80	18.63
45 cm x 30 cm	53395.0	187.2	131.5	410.9	8.49	18.18
60 cm x 30 cm	45061.7	227.3	165.6	444.5	6.78	15.84
SEm±	2802.1	4.4	1.9	4.3	0.32	0.27
CD (P=0.05)	11002.4	17.4	7.5	17.2	1.26	1.07
Nutrient management						
Control	46510.2	151.3	102.2	351.4	4.91	13.58
50% RDF	50617.2	185.4	124.2	384.8	8.05	17.02
100%RDF(100:60:40 kg NPK/ha)	53086.4	185.4	134.5	402.2	8.57	18.10
50%RDF+Vermicompost(@3 tonnes/ha)	55946.5	197.1	132.4	432.9	9.04	18.32
100%RDF+Vermicompost(@3 tonnes/ ha)	56255.1	215	155.1	459.6	9.49	18.60
150% RDF	58641.9	233.7	179.5	475.2	10.09	19.69
SEm±	1978.96	5.5	3.9	6.4	0.33	0.61
CD (P=0.05)	5715.66	16.0	11.3	18.7	0.96	1.76

100:60:40 kg NPK/ha, 50 % RDF + vermicompost @ 3 tonnes/ ha, 100 % RDF+ vermicompost @3 tonnes/ha and 150 % RDF, Sweet corn var. Sweet corn cv. Sugar-75 was taken as test crop which has been developed by *Syngenta seed Limited, Thailand.*

RESULTS

A widely spaced crop *i.e.* 60 cm x 30 cm produced significantly heavier cobs (197.50 g) than that under narrow planted crop *i.e*. 45 cm x 20 cm. The weights of green cobs were increased from control (179.33 g) to 150% RDF (262.03 g). Shorter cobs (16.10 cm) were obtained from the crop raised through 45 cm x 20 cm, where long cobs (17.26 cm) were found in 60 cm x 30 cm and the differences between them were statistically significant. The number of grains/cob decreased significantly with the increase in plant population and the wider crop geometry (60 cm x 30 cm) produced significantly more number of grains/cob (444.58) than the closer geometry of 40 cm x 30 cm (397.72). Over nutrient management practices higher number of grains/cob (475.26) were observed under treatment 150% RDF grains/ cob and the lowest was (397.72) under control. The crop geometry of 45 cm x 20 cm gave maximum green cob yield (9.80 t/ha) and minimum (6.79 t/ha) yield was noticed under wider spacing 60 cm x 30 cm, respectively At higher planting densities, more number of cobs might have compensated the poor values of yield attributes, which consequently improved the grain yield. The weights of green cobs were increased from control to 150% RDF. The highest green cob yield (10.09 t/ha) was noticed from 150% RDF which was at par with 100% RDF+ vermicompost and significantly the lowest yield (4.92 t/ha) was obtained from control. Increasing levels of nutrient management practices at the same or different crop geometry enhanced the yield of green cob significantly from control to 150% RDF These results are in accordance with Thakur *et al*. (2015).

CONCLUSION

The present investigation confirmed that among the different crop geometry and nutrient management practices, 45 cm x 20 cm resulted in higher production of green cob yield and net return. It was found that an application of 150% RDF proved to be better followed by 100% RDF+Vermicompost (@3 tonnes/ha) in terms of yield attributes and nutrient uptake.

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Productivity of Indian mustard (*Brassica juncea*) as influenced by green manure, mustard straw cycling and fertilizer application under semi-arid tropics

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Indian mustard (*B. juncea* L.) is a major winter crop in semi-arid tropics of Indian subcontinent. Initially, increased use of inorganic fertilizers, clean cultivation practices and high seed replacement rate improved mustard productivity in the subcontinent. However, the technology could not sustain growth in mustard production in last decade as other soil health attributes became limiting in the fragile landscape of semi-arid tropics. The emerging multi-nutrient deficiency (MND) has decreased the response of yield to fertilizers (N, P, K) from 14–15 kg seed/unit fertilizer applied in 1960 to 4–5 kg seed/unit fertilizer in 2010. This loss of mustard productivity is attributed to overall deterioration in soil health especially soil organic carbon content. The phenomena could be reversed when inorganic fertilizers are supplemented with organic components (Hartman, 1996). Mustard residue due to poor fodder value is usually burnt to clear the fields but if incorporated into the soil has enormous potential to improve the soil organic pools an important soil health indicator. Additionally, green manuring during rainy season is advocated for improvement in mustard productivity of fallow–mustard sequence (Kumar *et al*., 1995). But the existing information lack in overall impact of organic incorporation on growth, productivity, quality of mustard and dynamics in soil properties on a long-term basis. Therefore, the purpose of this study was to evaluate the effects of mustard residue and green manure on soil health and mustard productivity.

METHODOLOGY

The present research was conducted for nine consecutive years at Directorate of Rapeseed-Mustard Research, Bharatpur from 2005-07 to 2014-15 on clay loam soil with 8.1 pH, 2.6 g/kg organic carbon, 95.4 kg $KMnO_4$ oxidizable N/ha, 5.4 kg 0.5N $NaHCO_3$ extractable P/ha and 267 kg 1.0N NH_4OAc exchangeable K/ha. The experiment was conducted in split-plot design with three replications. The main-plot received three combinations of organic sources *viz*., fallow-mustard (control), *Sesbania* (GM) - mustard and *Sesbania* (GM) + mustard straw @ 2.5 t/ha - mustard, while eight combinations of N (40, 80 kg/ha), P (8.7 and 17.4 kg/ha) and K (0 and 33.3 kg/ha) were assigned to sub–plots. For comparison of treatments the reference group received fallow-mustard (control) of organic treatments and $N_{40}P_{8.7}K_0$ of fertility levels. The mustard cv. *Rohini* was sown in the first fortnight of October during all the years. Half dose of N through urea and full dose of P as SSP and K as murate of potash were applied basal at the time of land preparation, whereas the remaining N in the form of urea was top-dressed after first irrigation. The above ground mustard straw (C:N ratio 70-80:1) after threshing was incorporated on the dry weight basis into the soil one month before the sowing of green manure crop. *Sesbania aculeata* (C:N ratio 19:1) as a green manure crop was sown in the first week of July every year. About 45 days old succulent green manure crop was ploughed down and incorporated into the soil for decomposition. On an average mustard straw 2.5 t/ha and

Table 1. Effect of integrated nutrient management on seed yield of mustard (kg/ha)

Cropping system (CS)	Fertility level*								Mean
	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	
Control	1770	1822	1853	1855	1904	1907	1940	1969	1878
Sesbania (GM)	2274	2535	2302	2581	2504	2731	2731	2732	2547
Mustard straw @ 2.5 t/ha + *Sesbania* (GM)	2375	2420	2590	2757	3036	3121	3170	3282	2844
Mean	2139	2259	2249	2398	2482	2586	2608	2661	-
CD (P=0.05)CS: 201, Fertility level: 182, CS x Fertility level: 315, Fertility level x CS: 355									

*F_1: N_{40} $P_{8.7}$ K_0, F_2: N_{40} $P_{8.7}$ $K_{33.3}$, F_3: N_{40} $P_{17.4}$ K_0, F_4: N_{40} $P_{17.4}$ $K_{33.3}$, F_5: N_{80} $P_{8.7}$ K_0, F_6: N_{80} $P_{8.7}$ $K_{33.3}$, F_7: N_{80} $P_{17.4}$ K_0, F_8: N_{80} $P_{17.4}$ $K_{33.3}$ (kg/ha)

Sesbania 4.1 t/ha on dry weight basis added 9.5 and 96.4 kg N/ha, respectively.

RESULTS

The long-term effect of soil organic carbon (SOC) and fertilizer management strategies on traditional fallow-mustard system is being evaluated since 2005-06. Continuous adoption of management strategies significantly influenced the mustard seed yield, soil microbial biomass carbon (MBC) and soil dehydrogenase activity. In general *Sesbania* green manure (SGM) significantly increased mustard seed yield by 35.6 % over control (Table 1). Supplementary incorporation of 2.5 t /ha mustard straw before sowing of SGM significantly increased the seed yield by 11.6% over SGM and 51.4% over control. And continuous application of balance NPK (80:17.4:33.3 kg/ha) maintained sustainable higher productivity than deficient doses. The combined adoption of mustard straw incorporation (MSI) + SGM and balance NPK synergistically increased the seed yield by 85.4% over suboptimal F1, 66.6% over optimal F8 and 38.1% over MSI + SGM treatment. The main effect of SOC management strategies over the period is presented in Fig 1.

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Response of urdbean [*Vigna mungo* (L.) Hepper] to phosphorus fertilization and thiourea

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Phosphorus deficiency is usually the most important factor for poor nodulation and low yield of leguminous crops including urdbean in all type of soils. An adequate supply of phosphorus has been reported well for better growth, yield, quality and enormous nodule formation in legumes (Sammauria*et al.,* 2009). The exogenous supply of growth regulators also modifies plant growth by hormonal control, differentiation, morphogenesis and key physiological processes such as carbon and nutrient assimilation, partitioning of photosynthates and utilization efficiency. Soaking of seeds and foliar spray of thiourea have been reported not only to improve growth and development of plants, but also the dry matter partitioning for increased grain yield (Arora, 2004). Therefore, an experiment was planned to assess the response of P fertilization and thiourea on urdbean.

METHODOLOGY

The relative humidity fluctuates between 43 to 87 per cent. The mean annual rainfall of Jobner is around 350 mm. The soils of experimental site had 132 kg/ha available nitrogen, 16.26 kg/ha available P_2O_5 /ha, 154.2 kg/ha available K_2O and 0.15% organic carbon. The pH of the soil was 8.2 (1:2 soil water suspension). The experiment consisted of four levels of phosphorus (0, 20, 40 and 60 kg/ha) and five thiourea treatments (control, thiourea 500 ppm at branching, thiourea 500 ppm at branching and flowering, thiourea 1000 ppm at branching and thiourea 1000 ppm at branching and flowering). The total 20 treatment combinations were tested in randomized block design with three replications. Urdbean variety T- 9 was sown on 4th July, 2015 in the rows spaced 30 cm apart.

RESULTS

Results revealed that progressive increase in level of phosphorus upto 40 kg/ha significantly increased the growth and yield determining characters of urdbean *viz*., plant height, number of branches/plant and crop dry matter accumulation/m row length at most of the stages, number and weight of root nodules/plant, number of pods/plant, seeds/pod and test weight over lower levels. It also recorded significantly higher seed (1164 kg/ha), straw (2272 kg/ha) and biological yield (3437 kg/ha) of urdbean over 20 kg/ha and control. The above treatments remained at par with 60 kg P_2O_5/ha. Nitrogen, Phosphorus and Potassium concentration in seed and straw, their uptake by crop and protein content in seed were also improved significantly due to phosphorus fertilization upto 40 kg/ha. It also fetched 15.5 and 80.3 per cent higher net returns over 20 kg/ha and control, respectively with the highest B: C ratio of 2.25. Every increase in level of phosphorus upto 40 kg/ha significantly increased the available phosphorus in soil after harvest of urdbean. Agronomic efficiency, apparent recovery and physiological efficiency of P showed declining trend with increasing levels of phosphorus. Whereas, organic carbon in soil after crop harvest did not differ significantly due to varying levels of phosphorus.Results further indicated that application of thiourea 500 ppm at branching and flowering significantly enhanced the plant height, number of branches/plant, dry matter accumulation, total and effective nodules/plant, fresh and dry weight of nodules, number of pods/plant, seeds/pod and test weight over thiourea (500 and 1000 ppm) at branching and control. Consequent upon the higher values of yield attributes, the significantly higher seed, straw and biological yields of urdbean (1167, 2270 and 3437 kg/ha) was also obtained under the above treatment. Application of thiourea 500 ppm at branching and flowering registered significantly higher concentration of N and P in seed and straw and total uptake of N,P and K as well as protein content in seed and available P_2O_5 in soil after crop harvest. Application of thiourea 500 ppm at branching and flowering also fetched significantly higher net returns (Rs 52564/ha) and B: C ratio of 2.27.

CONCLUSION

It is concluded that higher seed yield, net returns and B: C ratio could be obtained with the use of Phosphorus fertilization at 40 kg/ha (1164 kg/ha, Rs 52267/ha and 2.25) and spray of 500 ppm thiourea (1167 kg/ha, Rs 52564/ha and 2.27) from urdbean independently.

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Productivity of maize as affected by crop residue incorporation and nitrogen levels in legume- cereal sequence

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The full yield potential of maize crop can be exploited through adoption of hybrids with better nitrogen management practices. Over dependence on chemical fertilizers alone would lead to gradual decline in organic matter content and native fertility status of the soil, which in turn, reflects on productivity of maize crop. On the other hand organic manures need to be applied in bulk to meet the heavy nutrient requirement of maize crop. Hence, a strategy of integrated use of nitrogen through fertilizer in combination with any amount of cheaper organic source which is abundantly available should be tried to satisfy the higher nitrogen requirement of the crop to produce higher yield without impairing the soil health. Although, fertilizer practices plays a dominant role in increasing the production, crop residues still play an essential role in recycling and meeting the nutrient demand of the succeeding crop (Yadvinder-Singh *et al*. 2005). Thus the present work was under taken to determine the effect of legume crop residue incorporation in conjunction with nitrogen levels on the productivity of maize.

METHODOLOGY

Field experiments were conducted during*kharif* and *rabi* seasons of 2011-12 and 2012-13 at Agricultural college, Aswaraopet, Khammam (dist.), Telangana state. Soils of the experimental site was sandy clay in texture, slightly alkaline in reaction (P^H 7.8), low in available nitrogen, (148 kg /ha), medium in available phosphorus (33 kg /ha) and high in available potassium (256 kg /ha). The experiment was laid out in split- split plot design and the treatments were replicated thrice. The three legume crops, viz., cowpea, (M_1) fieldbean (M_2) and greengram (M_3) as main plot treatments taken up during the *kharif* season and two residue management practices viz., residue removal (I_0) and residue incorporation (I_1) were taken as sub- plot treatments. Four nitrogen levels 75 kg /ha (N_1), 150 kg /ha(N_2), 225 kg /ha (N_3) and 300 kg /ha(N_4) as sub- sub plot treatments to maize were applied during *rabi*. During two years of study Co-4, HA-3, MGG-295 varieties of cowpea, field bean and greengram, respectively, were raised as *kharif* legumes while 30-V-92 a popular maize hybrid was grown during *rabi*. In half of the plot residues are removed while in the another half of the plot residues are incorporated after harvesting the economic yield. The residue was allowed to decompose in the field for one month. Thereafter, field was thoroughly prepared to sow the succeeding maize. The maize crop was sown by adopting a spacing of 60 X20 cm for the two consecutive years. Nitrogen was applied in the form of urea as per the treatments in three splits viz., ¼ th at the time of sowing, ½ at knee-high stage and the remaining ¼ at tasselling stage. A common dose of 60 kg P_2O_5 and 50 kg K_2O was applied in the form of single super phosphate and muriate of potash at the time of sowing. The data was collected on growth parameters and yield attributes and yield. The data recorded for different parameters was analysed through analysis of variance (ANOVA) technique for split split plot design using Indostat software.

RESULTS

The highest kernel number of 320 and 325 per cob was recorded during first and second year, respectively, with cowpea as a preceding crop to maize and was significantly superior to other two legume crops. The residue incorporation or non incorporation has no significant effect on kernel number per cob during both the years. The number of kernels per cob increased significantly with increase in level of N application. The highest number of kernels per cob (370 and 371) was recorded with the application of 300 kg N /ha. However, the influence of N application @ 225 and 300 kg /ha during both the years of investigation could not influence the number of kernels per cob significantly.Among different *kharif* legume crops tested, cowpea preceded to maize resulted in significantly highest kernel yield of 6092 kg /ha and 6317 kg /ha during first and second year of study, respectively. While the difference between field bean and greengram as preceding crops to maize were comparable during both the years. Residue incorporation has resulted in significant increase in kernel yield of succeeding maize during both the years. The per cent increase in kernel yield of maize due to residue incorporation is six and seven per cent during first and second years, respectively. Increase in the level of nitrogen has significantly increased the kernel yield of maize. Application of 225 and 300 kg N /ha increased the grain yield by 48.3 and 54.7 per cent, respectively over 75 kg N /ha. Further, grain yield produced with 225 and 300 kg N /ha was not significant during 2011-12. Similarly, during second year, compared to 75 kg N /ha, application of 225 and 300 kg N /ha increased the grain yield by 18 and 27 per cent, respectively.

Table1. Dry matter production Yield and yield attributes of maize as influenced by *Kharif* legumes, residue management practices and nitrogen levels

Treatment	Dry matter Production (g)	No. of Rows per Cob	No. of Kernels per Cob	Yield (kg/ha)	Dry matter Production (g)	No. of rows per Cob	No. of Kernels per Cob	Yield (kg/ha)
	2011-12				2012-13			
Legume crops								
Cow pea	10854	15.70	320	6072	11000	16.16	325	6316
Field bean	10370	15.00	307	5646	10636	15.41	313	5864
Greengram	10084	14.45	300	5417	10536	14.87	302	5683
CD (P=0.05)	516	0.75	6.67	458	441	0.44	10.52	366
Residue management Practices								
ResidueRemoval	10072	14.61	304	5532	10372	15.00	309	5742
Residue incorporation	10800	15.50	314	5884	11116	15.97	318	6167
CD (P=0.05)	272	0.26	NS	329	432	0.21	NS	348
Nitrogen levels (Kg/ha)								
75	9446	13.33	229	4379	9696	13.66	234	4565
150	10215	14.72	277	5257	10517	15.22	284	5571
225	10813	15.83	361	6435	11133	16.38	364	6608
300	11270	16.33	370	6762	11631	16.66	371	7073
CD (P=0.05)	432	0.40	14.36	534.7	636	0.27	8.50	560.1

CONCLUSION

Incorporation of previous crop residues in conjunction with 300 kg N /ha may be adopted to enhance the productivity of maize in legume – maize sequence.

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Efficacy of mulches and integrated nutrient management in groundnut (*Arachis hypogaea*. L.) during *rabi*-hot weather season

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Low yield of groundnut in Maharashtra is mainly due to the fact that 90 per cent of the crop is cultivated during *kharif*season, under rainfed condition and only 10 per cent cultivation of groundnut is done in *rabi*-hot weather season under irrigation. Yield of *kharif*groundnut is three time less than yield of *rabi –hot* weather cultivated groundnut. However, during *rabi*season due to low temperatures in the month of January and February, groundnut seed germination and growth is adversely affected. Mulches has a positive effect in creating the congenial soil condition in terms of increase soil temperature, nutrient availability, simultaneously growth and ultimately yield of the crop. Balanced use of NPK proved highly significant with each successive increase in fertilizer dose (Dhawale 2005). *Panchagavya* help in enhancing the quality and productivity in all the crops (Somasundarum, 2003). Therefore, an excellent strategy for enhancing yield of this crop appear to be growing groundnut in *rabi*-hot weather under mulched condition with judicious combination of organic and inorganic fertilizers.

METHODOLOGY

A field experiment was conducted at Agronomy Farm, College of Agriculture, Dr. BalasahebSawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.) during *rabi*-hot weather seasons of 2006 and 2007. Investigation was carried out on lateritic clay loam soil. The experiment was laid out in split- split plot design with three replications. The treatments consisted of three levels of mulches *viz.*, control or no mulch,paddy straw mulch, transparent polythene mulch as main plot treatments, three fertilizer levels namely control, 50 % RDF, RDF as sub-plot treatments and growth stimulants i.e. Control and growth stimulants i.e. *Panchagavya* 3 per cent + *Amrutpani* as sub-sub-plot treatments. The seed of groundnut cultivar TG-26 was sown at 30 cm spaced rows. Holes of 3 cm diameter were made at 30 cm× 10 cm spacing before spreading the transparent polythene (7 micron) on the beds with the help of hole making board. Paddy straw mulch is locally available and it was applied @ 7 t/ha. It was spread 20 DAS between two rows of groundnut crop in the treatment plots. Essential plant nutrients, naturally occurring beneficial micro-organisms and plant protection substances in panchagavya and amrutpani help in enhancing the quality and productivity in all the crops (Somasundarum, 2003). 3% solution of *Panchagavya*,was applied @ 500 litre/ha at 15 days of interval after emergence up to pod development stage. Whereas,Amrutpani @ 500 lit/ha was also given through each irrigation after crop emergence upto pod development stage.

RESULTS

A significant variation existed in dry pod, haulm oil and protein yield of groundnut due to different treatment variables (Table 1). It might be due to better provision of growth requirements through epiterrian (solar radiation and CO_2) and subterrian (water, nutrient, air and CO_2 dissolved in water) environment and less weed population having less competition of weeds with crop plants under mulch than no mulch treatment plots.As regards economics, polythene mulch in groundnut crop recorded the maximum net returns with the highest B:C ratio of 2.18 (Table 2), followed by straw mulch with net returns of Rs. 57,977/ha and B:C ratio of 2.15. No mulched recorded the minimum net profit of Rs. 42,345/ha with B:C ratio of 1.88 only. It was due to the higher dry pod and haulm yield under polythene mulch followed by straw mulch and no mulch treatment in the order of significance. The crop where supply with RDF produced significantly

Table 1. Effect of mulches, fertilizer levels and growth stimulants on dry pod, haulm, oil and protein yield of groundnut (Pooled mean of the two years)

Treatment	Dry pod yield (t/ha)	Haulm yield (t/ha)	Oil yield (t/ha)	Protein yield (t/ha)
Mulches				
Control	3.48	4.14	1.13	0.633
Paddy straw mulch (7 t/ha)	4.20	4.83	1.42	0.828
Transparent polythene mulch	4.54	5.04	1.56	0.923
CD (P=0.05)	0.13	0.12	0.03	0.020
Fertilizer levels				
Control	3.31	3.87	1.06	0.586
50 % recommended dose	4.31	4.96	1.45	0.852
Recommended dose (RDF)	4.61	5.16	1.60	0.945
CD (P=0.05)	0.10	0.01	0.04	0.025
Growth stimulants				
Control	3.91	4.50	1.29	0.741
Panchagavya + Amrutpani	4.25	4.82	1.45	0.848
CD (P=0.05)	0.06	0.04	0.02	0.015

Table 2. Economics of groundnut crop as influenced by the mulches, fertilizer levelsand growthstimulants .

Treatment	Net returns (Rs/ha)	B : C Ratio
Mulches		
Control	42,345	1.88
Paddy straw mulch (7 t/ha)	57,977	2.15
Transparent polythene mulch	62,864	2.18
Fertilizer levels		
Control	38,047	1.80
50 % recommended dose	60,288	2.19
Recommended dose (RDF)	64,851	2.22
Growth stimulants		
Control	52,144	2.07
Panchagavya + Amrutpani	56,647	2.08

Price rates: Dry pods @ Rs 20,000/t and Haulm @ Rs 5000/t

higher growth as well as yield attributed than 50% RDF and control and hence it has produced significantly higher yield *i.e.* dry pods, haulm,oiland protein yield than 50% RDF and control.Thehigher net returnsunder RDF andB**:**C ratio was observed than 50% RDF and control.Application of growth stimulants to groundnut produced significantly high dry pod yield of than control. Similar trend was also observed in the haulm, oil and protein yield. The application of growth stimulants to groundnut realized higher net return and B **:** C ratio as compared to control.

CONCLUSION

The higher oil and grain yield and net returns from *rabi*groundnut were favorably influenced under transparent polythene mulchwith the application of recommended dose of fertilizeralong with five foliar spray of 3 % *Panchagavya* at 15 days interval from crop emergence and application of *Amrutpani*four times along with irrigation @ 500 lit/ha from crop emergence to 60 days after sowing.

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Effect of land configuration and potassium management on yield, quality, uptake and economics of safflower

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Deep black cotton soil (Vertisols) having high water holding capacity and stickiness in Nagpur region of Maharashtra limits the safflower cultivation due to poor drainage. Land configuration protects the crop from such ill drained situation by providing better soil condition for healthy, luxurious proliferation of roots and thereby good response to applied nutrients. The recommended dose of fertilizer to safflower under irrigated situation is 40:40:0 kg NPK/ha. The soils of Nagpur region are rich in potassium content. However, due to continuous mining of potassium and its unavailability in clayey soils, the crops are giving response to potassium application in deep black cotton soils. In view of this the present investigation was carried out to study effect of land configuration and potassium management on yield, quality, uptake and economics of safflower.

METHODOLOGY

A field experiment was conducted during *Kharif* season of 2014-15 at Agronomy Farm, College of Agriculture, Nagpur, Maharashtra State. The soil was slightly alkaline (pH 7.8) and clayey in texture. The soil was low in available N (174.20 kg/ha), low in available P_2O_5 (15.53 kg/ha) and rich in available K_2O (430.80 kg/ha). The experiment was laid out in split plot design with 12 treatment combinations replicated thrice. The main plot comprised of three different land configuration treatments viz. L_1- flat bed, L_2 – ridges and furrows and L_3- broad bed furrow and sub plot treatments consists of four potassium management viz. P_1 – potassium @ 0 kg/ha, P_2- potassium @ 30 kg/ha, P_3- potassium @ 45 kg/ha , P_4- potassium @ 60 kg/ha. The recommended dose of fertilizer (40:45:0 kg NPK/ha) was given as per schedule. Grain yield of soybean was recorded after harvest of the crop from respective treatments and the various economic parameters such as gross monetary returns, net monetary returns and benefit cost ratio was estimated according to prevailing market value of produce and inputs during respective year.

RESULTS

The data in table revealed that the land configuration and potassium management in safflower showed significant influence on seed and stover yield, oil content and oil yield, potassium uptake and economic returns. Seed and stover yield/ha was significantly influenced due to various land configuration treatments and was found significantly maximum with broad bed furrow (L_3) as against flat bed (L_1). The ridges and furrows treatment was at par with broad bed furrow. It is well known fact that land configuration treatments helps in moisture conservation and providing good drainage which might be the reason in producing higher yield. Similar effects of modified land configuration have also been reported by Jadhao *et al*. (2012). Land configuration treatments did not show any significant influence on oil content of safflower, however numerically it was highest in broad bed furrow. Whereas, oil yield ha^{-1}was significantly higher with broad bed furrow (512 kg/ha) over flat bed and was at par with ridges and furrows treatment. This might be due to increase in seed yield of safflower by adopting land configuration treatments. Similar trend was also found in potassium uptake by safflower. As regards economic returns, broad bed furrow recorded significantly higher gross monetory returns (Rs. 54396/-) and net monetory returns (Rs. 35749/-) as compared to flat bed and was at par with ridges and furrows treatment. Higher returns might be due to higher yield of safflower that had attributed by effective moisture conservation and adequate drainage during crop growth. The highest BC ratio was recorded with broad bed furrow followed by ridges and furrow. Similar findings were reported by Lakhera (2008). Application of Potassium @ 60 kg/ha recorded significantly higher seed and stover per hectare of safflower. Application of potassium @ 60 kg/ha recorded significantly higher seed and stover yield amongst all other treatments but was at par with 45 kg/ha. This might be due to readily availability of potassium that increased the vigour and growth of crop which helped in improving yield components and consequently yields. The oil content and oil yield ha^{-1} of safflower was significantly higher with the application of 60 kg potassium ha^{-1} (29.9 % and 537 kg/ha) amongst all rest of the treatments but was at par with application of potassium @ 45 kg/ha . This might be due to role of potassium in biosynthesis of fatty acids from the assimilated products

Table 1. Seed and stover yield, oil content and oil yield, economics and uptake of potassium by safflower as influenced by various treatments.

Treatment	Seed yield kg/ha	Stover yield kg/ha	Oil content (%)	Oil yield kg/ha	Potassium uptake kg/ha	GMR (Rs./ha)	NMR (Rs.ha)	BC ratio
Land configuration								
L_1- Flat bed	1665	3821	27.63	460	44.15	50773	31756	2.66
L_2- Ridges & Furrow	1701	3954	28.03	477	47.05	51870	32783	2.71
L_3- BBF	1784	4089	28.70	512	51.72	54396	35749	2.91
CD (P=0.05)	110	36	NS	36	5.69	3349	3349	-
Potassium management								
P_1- Potassium @ 0 kg/ha	1582	3686	26.85	424	38.83	48261	30323	2.69
P_2- Potassium @ 30 kg/ha	1634	3759	27.76	453	44.47	49847	31059	2.65
P_3- Potassium @ 45 kg/ha	1757	4009	28.15	495	49.85	53602	34389	2.78
P_4- Potassium @ 60 kg/ha	1843	4187	29.19	537	53.54	56214	36577	2.86
CD (P=0.05)	122	236	1.17	42	3.68	3712	3712	-

contributing more oil content and oil yield in seed. These results are in conformity with the findings of Ebrahimian and Soleymani (2013). The total uptake of potassium by safflower was also significantly higher with application of potassium @ 60 kg/ha (53.54 kg/ha) over rest of the treatments and was at par with the treatment of potassium @ 45 kg/ha. The uptake of potassium was higher due to readily availability of this nutrient at higher rate of application. Similar reports were reported by Brar *et. al*. (2010). As regards economic returns, the application of potassium @ 60 kg/ha recorded significantly higher gross monetory returns (Rs. 56214/-) and net monetory returns (Rs. 36577/-) amongst all other treatments. The highest B:C ratio was also found with the application of potassium @ 60 kg/ha (2.86) followed by potassium @ 45 kg/ha (2.78). The interaction effects were found to be non-significant.

CONCLUSION

Thus it can be concluded that, land configuration treatment comprising of broad bed furrow in safflower had significantly improved the seed, stover and oil yield as well as potassium uptake and economic returns. Similarly, application of potassium @ 60 kg/ha significantly increased seed and stover yield, oil content and oil yield, potassium uptake and economic returns of safflower.

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Productivity of fennel as influenced by intercropping with fenugreek and sulphur fertilization

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A spice is a dried seed, fruit, root, bark or vegetative substance used in flavouring, seasoning and imparting aroma in variety of food items and beverages. In India, wide varieties of spices are grown and many of them are native to the subcontinent and also known as “Home of Spices”. Among the seed spices, fennel commonly known, as *Saunf* is major seed spice crop belonging to apiaceae family. The bulb, foliage and seeds of the fennel plant are widely used in many of the culinary traditions of the world. Fennel is an important seed spice crop of Northern parts of the country. Wide spacing and slow growing nature during initial growth period of fennel make possible to raise short duration intercrops in between rows. Inclusion of vegetables like radish (*Raphanus sativus* L.), coriander (*Coriandrum sativum* L.) and fenugreek as intercrop has been reported to enhance the productivity and profitability per unit area in winter maize (*Zea mays* L.) as compared to its sole cropping (Singh and Kumar, 2002). Sulphur deficiency is becoming more critical with each passing year which is severely restricting crop yield, produce quality, nutrient use efficiency and economic returns on millions of farms. Like any essential nutrient, sulphur also has certain specific function to perform in the plant. Thus, sulphur deficiencies can only be corrected by application of sulphur fertilizer (Tandon and Messick, 2007). Keeping this in view, present investigation was undertaken to find out the optimum row ratio and level of sulphur for fennel-fenugreek intercropping system.

METHODOLOGY

The field experiment was conducted during *rabi* season of 2013-14 at Agronomy Farm of S.K.N. College of Agriculture, Jobner, Jaipur (26^0,05' North latitute, 75^0,28' East longitude and at an altitude of 427 metres above mean sea level) situated in agroclimatic zone III A (Semi-arid Eastern Plain Zone) of Rajasthan. The soil of experimental field was loamy sand in texture containing 0.16% organic carbon, 134.1 kg/ha available N, 17.1 kg/ha available P_2O_5, 170.1 kg/ha available k_2O and 8.34 ppm available SO_4^{-2} sulphur with 8.2 pH. The field experiment was laid out in three times replicated randomized block design with three intercropping systems (sole fennel, fennel + fenugreek in 1:1 and 1:2 row ratios) and four sulphur levels (0, 20, 40 and 60 kg S/ha). The crops were sown on October 30th in plots of 4.5 x 4 m size. The fennel was sown at row space of 50 cm in sole and 1:1 intercropping but the row space was 100 cm in 1:2 row ratios. One and two rows of fenugreek were planted in 1:1 and 1:2 row ratios after each row of fennel. A uniform basal dose of 40 kg N + 45 kg P_2O_5/ha through urea and DAP was drilled prior to sowing and sulphur through gypsum ($CaSO_4.2H_2O$) was incorporated in the soil before sowing as per treatments. The remaining 50 kg N/ha was given by side dressing through urea in rows of fennel at 40 DAS. All improved package of practices were followed to raise the crop under irrigated conditions.

RESULTS

Results showed that all the yield attributing parameters of fennel were influenced significantly by different intercropping systems. The fennel planting in 1:2 row ratio recorded significantly higher umbels/plant by 26.76 and 32.35%, umbellets/umbel by 22.96 and 25.01% and seeds/umbel by 24.47 and 25.52% over sole fennel and it’s planting in 1:1 row ratio, respectively. From the study, it was also noted that yield contributing characters of fennel were not significantly influenced by addition of one row of fenugreek in between two rows of fennel in 1:1 row ratio. Further examination of experimental data revealed that intercropping of fennel with fenugreek in 1:2 row ratio significantly reduced fennel yield where it recorded lowest seed (1.04 t/ha), straw (2.72 t/ha) and biological yields (3.76 t/ha) as compared to 1:1 row ratio (1.57, 4.24, 5.81 t/ha) and sole fennel (1.60, 4.30, 5.91 t/ha), respectively. The intercropping in 1:2 row ratio produced less seed, straw and biological yields of fennel by 33.67, 35.80 and 35.23% over 1:1 row ratio and 35.11, 36.76 and 36.32% as compared to sole fennel, respectively. However, intercropping in 1:1 row ratio could not produce significantly change in these above parameters as compared to sole crop of fennel. Intercropping systems brought about significant differences in the net returns. The fennel + fenugreek (1:1) gave significantly higher net returns (Rs. 126471/ha) as compared to fennel intercropping with fenugreek in 1:2 row ratio as well as its sole stand. The 1:1 row ratio recorded 38.78 and 15.39% higher net returns over 1:2 row ratio and sole cropping of fennel. Application of increasing levels of sulphur also brought significant changes in yield attributes and yield of fennel. Yield attributes of fennel *viz*., number of umbels/plant, number of umbellets/umbel and number of seeds/umbel increased significantly by 36.99, 31.61 and 32.99 % with 40 kg S/ha over control. Application of 60 kg S/ha recorded significantly higher test weight (5.83 g) by 7.36% over control. The seed, straw and biological yields increased significantly with increasing rate of sulphur application upto 40 kg/ha. The extent of increase in seed (1.56 t/ha), straw (4.08 t/ha) and biological yields (5.64 t/ha) with 40 kg S/ha was 42.07, 30.57 and 33.56% over control and 13.37, 10.60 and 11.43% over 20 kg S/ha, respectively. Significantly higher net returns (Rs. 100612/ha) were recorded under application of 40 kg S/ha over control and 20 kg S/ha.

CONCLUSION

Based on the study of present experiment**,** the results inferred that intercropping of fennel with fenugreek in 1:1 row ratio (addition) along with sulphur application at 40 kg/ha could be recommended for realizing higher profitability and system productivity.

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Effect of time and rate of *Panchagavya* application in combination with different NPK doses on nitrogen uptake by rice

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Long–term application of high rates of fertilisers without adequate measures to ensure their efficient use by the rice crop has undesirable environmental consequences (Ye *et al*., 2014). Realization of the potential yield of crops on sustained basis is possible through the use of various sources of nutrient in integrated manner which in turn can make the system more productive and profitable by restoring soil health (Pillai *et al*., 2007). Utilization of indigenous organic sources like panchagavya, may serve as alternatives or supplements to chemical fertilizers, and help in increasing the productivity of any cropping system (Manjappa and Kelaginamani, 2005). Keeping these facts in view, the above study was conducted for assessment of different doses of fertilizer, time and rate of Panchagavya application on nitrogen uptake by rice.

METHODODOLOGY

A field experiment was conducted during the rainy season of 2013-14 and 2014-15 at the Agricultural Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University,Varanasi. The soil of experimental field was sandy clay loam with pH 7.29. The soil was low in organic carbon (0.43%) and low in available nitrogen (202 kg/ha). Considering the nature of factors under study, the experiment was laid out in a split plot design by assigning four NPK levels in the main plot andfour levels of panchagavya applicationincluding control in sub- plots. The whole field was divided into three blocks each representing a replication.

RESULTS

Data revealed that the application of NPK at 120% RDF registered significantly higher uptake of nitrogen by grain (67.91 and 70.39 kg/ha during 2013 and 2014 respectively) and straw (47.02 and 48.71 kg/ha during 2013 and 2014 respectivly) as well as total uptake (114.93 and 119.10 kg/ha during 2013 and 2014 respectivly) followed by 100% and 80% RDF over control. Higher concentration of nitrogen in grain

Table 1. Effect of treatments on nitrogen uptake by rice

Treatment	Nitrogen uptake by grain (kg/ha)		Nitrogen uptake by straw (kg/ha)		Total nitrogen uptake (kg/ha)	
	2013	2014	2013	2014	2013	2014
Fertilizer Dose (4)						
F1-60 % of RDF	50.47	50.20	30.46	31.69	80.92	81.89
F2- 80 % of RDF	53.73	54.96	36.92	38.57	90.65	93.53
F3-100 % of RDF	61.17	62.61	41.21	42.78	102.38	105.39
F4- 120 % of RDF	67.91	70.39	47.02	48.71	114.93	119.10
CD (P=0.05)	2.74	2.93	2.61	2.52	5.17	3.58
Time and rate of Panchagavya application (5)						
D_0- Control	50.51	51.69	27.63	28.41	78.14	80.10
D_1- Three sprays at 15, 30 and 45 days after transplanting (DAT) @ 3%	57.64	58.62	39.50	40.86	97.13	99.48
D_2- Seedling dip + one sprays at 30 DAT + application through irrigation water at 60 DAT @ 3%	59.54	60.67	41.05	42.73	100.59	103.40
D_3- Three sprays at 15, 30 and 45 (DAT) @ 6%	61.27	62.27	42.66	43.86	103.94	106.13
D_4- Seedling dip + one spray at 30 DAT + application through irrigation water at 60 DAT @ 6%	62.62	64.45	43.66	46.32	106.29	110.77
CD (P=0.05)	1.25	1.23	1.05	3.34	2.14	3.76

and straw of rice were recorded under 120% RDF followed by 100% RDF. Reduction in the recommended levels of fertilizer (NPK) significantly decreased the nitrogen uptake. The N removal by grain and straw significantly increased with corresponding increase in NPK levels. Release of nutrients in soil solution depends on the intensity and capacity of soil to supply these nutrients and addition of nitrogen, phosphorus and potassium content in solution facilitates effective removal. Higher concentration of nitrogen in grain and straw were obtained under higher fertility level followed by medium and low. Among the panchagavya application, D4 treatment was found superior to the rest of the treatments. Seedling dip by panchagavya @6% increased nitrogen uptake as compared to control.

CONCLUSION

Based on the above findings it can be concluded that the application of 120% RDF in combination with seedling dip + one spray at 30 DAT + application of Panchagavya through irrigation water at 60 DAT @ 6%can increase N uptake by rice.

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Effect of nitrogen scheduling on growth and yield of maize under rainfed condition

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Maize is considered as the “Queen of Cereals”. Being a C4 plant, it is capable to utilize solar radiation more efficiently even at higher radiation intensity. Maize is an exhaustive crop and requires high quantities of nitrogen during the period of efficient utilization, particularly at 25 days after sowing and pre tasselling (40 days after sowing) stages for higher productivity. Nitrogen is indispensable for increasing crop production as a constituent of protoplasm and chlorophyll and is associated with the activity of every living cell (Mehta *et al.*, 2005). Split application of nitrogen (N) is a management strategy for corn that has been practiced on a limited basis for years. Coarse textured, sandy soils have often received split applications to improve N uptake and efficiency and reduce leaching loss. Some N (less than half) is generally applied prior to or at planting and the rest (usually more than half) is side dressed prior to tasseling. The side dress applications may consist of either a single application or multiple applications, which are usually associated with irrigation. Because a greater portion of the N is applied closer to the time of maximum N uptake, split application strategies are often considered as being more efficient and environmentally sound. For these reasons and others, split application of N is becoming more popular on medium and fine textured soils. Nitrogen supplement pattern by split application becomes important as if it is supplied ideally in a time when crop critically requires. Maize may differ in its requirement either by total or part of it in the different stages of crop. Thus, nitrogen use efficiency can be increased and better used to attain the objective of higher production; N supplementation period can be increased with number of splits. Hence, nitrogen requirement during critical stages can be better met with split application pattern, therefore, the experiment was conducted to study the effect of nitrogen scheduling on growth and yield of maize.

METHODOLOGY

An experiment was carried out on Experimental farm of Agronomy Department, College of Agriculture, Latur under Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani during *kharif* season 2013 to study the effect of nitrogen scheduling on growth and yield of maize during *kharif* season 2013. The soil of experimental plot was deep black in colour

Table 1. Yield attribute, grain and Stover yield of maize as influenced by various treatments at harvest

Treatments	Grain Yield/ plant (g)	Husk Yield/ plant (g)	Grain yield kg /ha	Stover yield kg /ha
T_1 : ½ Broadcast at sowing + ½ N top dressed at 25 DAS	75.08	5.50	4168	6950
T_2 : ½ N FA at sowing + ½ N FA at 25 DAS	88.70	6.30	4924	7271
T_3 : ½ N SBP at sowing + ½ SBP at 25 DAS	85.51	6.20	4746	7207
T_4 : S! N Broadcast at sowing + S! N top dressed at 25 DAS + S! N Top dressed at 45 DAS	81.31	6.00	4514	7080
T_5 : S! N FA at sowing + S! N FA at 25 DAS + S! N FA at 45 DAS	102.73	7.40	5702	7583
T_6 : S! N SBP at sowing + S! N SBP at 25 DAS + S! N SBP at 45 DAS	90.82	7.00	5043	7356
T_7: No nitrogen	55.48	3.00	3077	5851
CD (P=0.05)	11.83	1.41	856	297

FA- Furrow application, SBP- Side band placement and TP- Top dressing

with good drainage. The soil of experimental plots was clayey in texture and soil was low in available nitrogen (225 kg /ha), medium in available phosphorus (15.82 kg /ha), very high in available potassium (526 kg /ha) and alkaline in reaction having pH 8.17. The field experiments was laid as in randomized block design with seven treatments which includes viz, T_1 : ½ Broadcast at sowing + ½ N Top dressed at 25 DAS, T_2 : ½ N FA at sowing + ½ N FA at 25 DAS, T_3 : ½ N SBP at sowing + ½ SBP at 25 DAS, T_4 : S! N Broadcast at sowing + S! N Top dressed at 25 DAS + S! N Top dressed at 45 DAS, T_5 : S! N FA at sowing + S! N FA at 25 DAS + S! N FA at 45 DAS, T_6 : S! N SBP at sowing + S! N SBP at 25 DAS + S! N SBP at 45 DAS, T_7: No nitrogen and replicated thrice. Maize variety Pinnacle hybrid (Monsanto Company) was sown at the seed rate of 15 kg /ha at inter row of 60 and plant to plant spacing of 30 cm. Shallow furrows were opened and seeds were sown manually at the depth of 5 cm. Fertilizer application was made as per the treatments. Full dose of phosphorus, potash and ½ dose and S! dose of nitrogen were applied at sowing as basal application. ½ and S! dose of nitrogen are applied as top dressed, furrow application and side band placement at 25 and 45 DAS as per treatments.

RESULTS

Application of S! N FA at sowing + S! N FA at 25 DAS + S! N FA at 45 DAS (T_5) fertilizer treatment recorded higher growth and yield attributes viz., plant height, number of functional leaves, leaf area, total dry matter, cob diameter, cob girth and length of cob, grain yield/plant, grain yield kg/ha, stover yield kg/ha. Remarkable improvement in grain yield per plant (102.73 g) was noticed due to S! N FA at sowing + S! N FA at 25 DAS + S! N FA at 45 DAS (T_5) fertilizer treatment. This improvement may be the reflection of higher seed index. This treatment (T_5) played a major role in furnishing the needs of maize crop to attain its maximum yield potential. Grain yield (5702 kg /ha) and stover yield (7583 kg /ha) was appreciably improved due to S! N FA at sowing + S! N FA at 25 DAS + S! N FA at 45 DAS (T_5) fertilizer treatment. It was followed by S! N SBP at sowing + S! N SBP at 25 DAS + S! N SBP at 45 DAS (T_6). Significantly the lowest grain yield (3077 kg /ha) and stover yield (5851 kg /ha) was recorded under treatment no nitrogen (T_7).

CONCLUSION

N application as 1/3 N FA at sowing + 1/3 N FA at 25 DAS + 1/3 N FA at 45 DAS performed the best amongst the various N application schedules evaluated with regard to growth, yield attributing characters and yield of hybrid maize. Split application of nitrogen with T6 i.e. (1/3 N SBP at sowing + 1/3 SBP at 25 DAS + 1/3 N SBP at 45 DAS) was the second best treatment in improving growth, yield attributing characters and yield of hybrid maize (Pinnacle).

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Integrated nutrient management in greengram (*Vigna radiata*) cultivars

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Greengram is one of the most ancient and extensively grown pulse crops of India. The agronomical importance of greengram is linked to its high protein content and other essential minerals, especially micronutrients. The productivity of greengram in India is very low and far below the other greengram-growing countries. The high cost of chemical nitrogen fertilizer and low purchasing power of Indian farmers restricts its use on proper amounts, hampering crop production. With a view to reduce the losses and indiscriminate use of chemical fertilizers, substitution of part of the chemical fertilizer by locally available organic sources of nutrients (Farmyard manure) and biofertilizers(*Rhzobium* and PSB) is inevitable. The basic concept of integrated nutrient management is the supply of the required plant nutrients for sustaining the desired crop productivity with minimum deleterious effect on soil health environment (Balasubramanian, 1999). In the light of above facts and paucity of adequate research evidences, the present experiment was carried out.

METHODOLOGY

A field experiment was conducted during *kharif*season of 2014 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar.The total rainfall received during kharif season was 622.9 mm in 2014. The soil of the experimental field was loamy sand in texture, low in OC (0.17%) and available N (160.7 kg/ha), medium in available P_2O_5 (38.9 kg/ha) and available K_2O (286.0 kg/ha) with 7.2 soil pH. Fourteen treatment combinations comprising of two varieties of greengram viz., Meha and GM 4 and seven treatments of integrated nutrient management viz., 100% RDF(20:40:0 kg NPK/ha), 75% RDF + 2 t FYM/ha, 75% RDF+Rhizobium+PSB, 75% RDF+ 2 t FYM/ ha+Rhizobium+PSB, 50% RDF+4 t FYM/ha, 50% RDF+Rhizobium +PSB and 50% RDF + 4 t FYM/ha +Rhizobium+PSB) were evaluated in factorial randomized block design replicating three times.Recommended dose of phosphorus @40 kg P_2O_5/ha was applied at the time of

Table 1. Yield attributes, yield and economics of greengram as influenced by integrated nutrient management.

Treatment	Plant height (cm)	Pods/ plant	Pod length (cm)	Seeds/ pod	Seed yield (kg/ha)	Stover yield (kg/ha)
Varieties						
Meha	50.96	25.61	6.26	9.34	656	1693
GM 4	54.66	21.22	6.76	9.78	559	1468
SEm±	1.01	0.51	0.07	0.14	13	41
CD (P=0.05)	2.93	1.48	0.21	0.41	39	120
Integrated nutrient management						
100% RDF(20:40:0 kg NPK/ha)	51.47	23.10	6.41	9.40	565	1528
75% RDF+2 t FYM/ha	52.60	23.57	6.43	9.23	624	1621
75% RDF+*Rhizobium* + PSB	52.10	23.23	6.49	9.70	602	1559
75%RDF+2tFYM/ha+*Rhizobium*+PSB	58.20	26.00	6.95	10.23	746	1806
50% RDF + 4 t FYM/ha	50.33	21.60	6.31	9.20	543	1404
50% RDF+*Rhizobium* + PSB	49.37	21.73	6.30	9.17	499	1435
50%RDF+4tFYM/ha+*Rhizobium*+PSB	55.60	24.67	6.67	10.00	675	1713
SEm±	1.89	0.96	0.14	0.26	25	77
CD (P=0.05)	5.49	2.78	0.40	0.76	73	225

FYM: Farm yard manure, RDF: Recommended dose of fertilizer, PSB: Phosphate solublizing bacteria sowing. The Rhizobium and PSB culture (*Bacillus coagulans*, PBA-16) was prepared by dissolving 100 g Jaggary in 1:1 of boiled cooled water followed by addition of Liquid agar slant PSB & Rhizobium. culture @ 20 ml per one kg seed were sprinkled on seeds spread in thin layer and mixed then after dried in the shade before sowing.

RESULTS

Growth, yield attributes and yield of greengram were significantly influenced due to different varieties. Variety GM 4 recorded significantly higher plant height (54.66 cm), length of pod (6.76 cm) and number of seeds per pod(9.78) as compared to variety Meha, but more number of pods/ plant(25.61) was noted with Meha. This difference in yield attributing characters between two varieties might be due to genetic constitution of these varieties.The variety Meha registered significantly higher seed (656 kg/ha) and stover yields (1693 kg/ha) as compared to variety GM 4. Variety Meha increased the seed and stover yield to the tune of 17.3 and 15.3% over variety GM 4. This might be due to a variety of crop differed in its genetic built up and registered more numbers of pods per plant hence resulted in the yield potential. Application of 75% RDF +2 t FYM/ha+*Rhizobium* + PSB registered maximum plant height, pods/plant, length of pod and seeds/pod over rest of the treatment combinations. Maximum seed(746 kg/ha) and stover yield (1806 kg/ha) of greengram were recorded from plot fertilized with treatment combination of 75% RDF+2 t FYM/ha+*Rhizobium* +PSB followed by 50% RDF+ 4 t FYM/ha+*Rhizobium*+PSB. Both the treatments were found significantly superior over the rest of all other treatment for yield and yield attributing parameters. The highest seed yield per hectare gained under these treatments might be due to chemical fertilizer in conjunction with FYM and bio fertilizers might have provided favorable soil environment and nourishment for better plant growth resulted in maximum seed yield per hectare.

CONCLUSION

It is concluded that greengram variety Meha fertilized with 75% RDF (20:40:0 kg NPK/ha)+2 t FYM/ha along with seed inoculation of Rhizobium + PSB recorded maximum yield attributes, seed and stover yield in loamy sand soil during *kharif* season.

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Nutrient management through organic and inorganic source in pearl millet in arid ecosystem

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Pearl millet *[Pennisetum glaucum* (L.) *R.* Br, emend. Stuntz.] is found most important cereals after rice, wheat and maize in India. It is the most important staple food for millions of people in the semi-arid and arid tropics. Pearl millet survive in rain fed areas because of its drought escaping mechanisms but still respond well to all inputs including fertilizers (Shekhawat *et al*, 2014). The soils of the pearl millet growing regions in mostly light in texture embody low organic matter as well as micro nutrient. Organic matter and micro nutrient are the most important factor for successful crop production in dry land areas. Use of organic manures as well as application of fertilizer is effective in increasing the productivity of pearl millet. As information on this aspect is meager in the dry land conditions of Rajasthan, Therefore, the present investigation was conducted to find out the suitable nutrient management in rain fed pearl millet.

METHODOLOGY

The field experiment was conducted at Research Farm of Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Beechwal, Bikaner in three consecutive *Kharif* seasons of 2012, 2013 and 2014. The soils were loamy sand in texture with pH 8.1, organic carbon 0.15%, low in available nitrogen (90.6 kg/ha), medium in available phosphorus (18.4 kg P_2O_5 kg/ha) and available potassium (233.6 kg K_2O/ha). The experiment consisted of six treatment combinations, in which two levels of FYM *viz.*, without FYM and with FYM 5 t/ha and three levels of nutrient management viz. RDF, RDF+ zinc @ 20 kg/ha and RDF + Gypsum @ 250 kg/ha. The experiment laid out in factorial randomized block design with 3 replications.

Table 1. Effect of organic and inorganic source of major and trace elements on yield of rainfed pearl millet

Treatment	Pooled data of 3 years				
	Grain yield (kg/ha)	Stover yield (kg/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
FYM levels					
Without FYM	1,765	3,431	36,570	26,744	2.71
With FYM (5 t/ha)	2,018	3,809	41,363	29,454	2.49
CD	63	149	788	788	0.07
Nutrient management					
RDF	1751	3,328	36,156	26,795	2.86
RDF + Zinc @ 20 kg/ha	2,150	3,859	43,600	31,589	2.64
RDF + Gypsum @ 250 kg/ha	2,192	4,243	45,541	34,430	3.14
CD	108	258	1,365	1,365	0.13

RESULTS AND DISCUSSION

Data reveal (table.1) that the grain and stover yield of pearl millet was significantly higher under treatment 5 t FYM/ha as compared to without FYM. Similarly, the maximum gross return (Rs. 41,393/ha) and net return (Rs. 29,454/ha) was fetched with the application of FYM @ 5 t/ha. The significant increase in grain and stover yields due to the influence of FYM were largely a function of improved growth and the consequent improvement in yield attributes as mentioned above. Humic acid in FYM might have enhanced the availability of both native and added nutrients in soil and as a result improved growth & yield attributes and resulted in significantly increased grain yield of the crop (Rao *et al*, 1995).

Application of RDF + Gypsum @ 250 kg/ha gave the significantly higher grain yield (2192 kg/ha) and stover yield (4,243 kg/ha) of pearl millet which was closely followed by RDF + Zinc @ 20 kg/ha. Similarly, data further showed that maximum gross return (Rs. 45,541/ha), net return (Rs. 34,430/ ha) and B:C ratio (3.14) were recorded with the application of RDF + Gypsum @ 250 kg/ha and it was followed by RDF + Zinc @ 20 kg/ha. The magnitude of increase in grain, stover yield and net return was with the tune of 25.19, 27.49 and 25.96% over RDF, respectively. Zinc/Gypsum improved the growth and yield attributes of pearl millet increased amount of biomass accumulation and its greater diversion to sink resulted in increased biological yield as well as grain yield of pearl millet (Jain and Dahama, 2006), (Shekhawat *et al*., 2014).

CONCLUSION

It may be concluded that application of RDF (60 kg N +40 kg P_2O_5 + 20 kg K_2O/ha) + 250 kg gypsum with 5 tones FYM gave significantly higher grain, stover and net return over control.

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Hybrid rice yield response to elevated CO_2 under different nitrogen management in direct seeding and transplanting system

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Rice, a staple food for more than half of the world population, is commonly grown by puddled transplanted planting method in Asia. This planting method is labor, water, and energy-intensive and is becoming less suitable as these resources are becoming increasingly scarce. Further, the puddled condition deteriorates the physical properties of soil, adversely affects the performance of succeeding upland crops and contributes to methane emissions. Because of these factors, rice cultivation needs a major shift from puddled transplanting rice (PTR) to direct-seeded rice (DSR). Hence, there is a need for comparative assessment of PTR and DSR production system to evaluate the adaptation options for sustainable rice production under climate change scenarios. In view of this, the present investigation was formulated to understand the effect of elevated CO_2 environment on growth and yield of hybrid rice grown under varying nutrient management in DSR and PTR production system.

METHODOLOGY

Field experiment was carried out in the research farm of Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, India. The site receives an average rainfall of 1400 mm with an occurrence of 70-75% of the total rainfall in the monsoon months (June to October). The experiment was conducted during wet season of the year 2015 in Open Top Chambers (OTCs) under ambient and elevated CO_2 environment to understand the effect of varying N management on crop yield under two rain-fed production systems (DSR and PTR). The experiment was conducted in a split-split plot design, where each treatment had two replications. Four OTCs were used for the purpose; two OTCs with ambient CO_2 level (CO_2 H"390 ppm, AM); other two OTCs with elevated CO_2 level, i.e. 50 % higher than the ambient environment (CO_2 H"585ppm, EC). Hybrid rice (cv. Bio799) was grown with four N management treatments in direct seeding and transplanted system in each OTC. The N management includes chemical fertilizer (CF) at 100% (N1) and 150% (N2) of recommend dose, integrated nutrient management including CF and organic fertilizer (N3), and site-specific N management through CF using SPAD meter (N4). The recommended N dose was 120 kg/ha. For PTR, seedling of 20 days old hybrid rice was transplanted with 20 cm row spacing and 15 cm hill spacing. In DSR, seeds are sown at the spacing of 20 cm x10 cm. For all the N management treatments, common doses of P_2O5 at 50 kg ha^{-1} and K_2O at 60 kg/ha were applied at the time of final land preparation as basal dose. As per the treatment, N through chemical fertilizer (urea) was applied in four equal splits at basal, active tillering, panicle initiation and heading stages of the crop. For the treatment of N from organic fertilizer, the required amount through vermicompost was applied full as basal at the time of final land preparation. For the SPAD-based N management, 25% recommended N (30 kg N/ha) was applied through CF as basal and top dressing of N at 25 kg/ha was done when the SPAD value of rice leaf reached below 36 as per the literature (Ghosh et al., 2013).Observations on yield attributes and grain yield were recorded from one m^2 area marked at centre of each plot from where plant sampling was not done earlier.

RESULTS

The CO_2 content of the ambient OTC was 388 ppm (±22) and of the elevated OTC was 586 ppm (±30) during the crop growth period. With the CO_2 elevation of 200 ppm above ambient value (390 ppm) in OTC, the temperature increased by 1.4 ^{o}C during wet season at Kharagpur. Total growth duration of rice was four days shorter under DSR than PTR. DSR showed significantly higher tillering capacity, panicle/m2 than PTR (Table 1). Averaged over nutrient management treatments, DSR crop produced higher tillers per unit area than PTR (DSR produced 314 under elevated CO_2 environment and 282 in ambient environment whereas PTR produced 253 under elevated CO_2 environment and 210 in ambient environment). High tillering capacity was responsible for high panicles/m2 under DSR. Growth process without the uprooting and transplanting setback might be partly responsible for the high tillering capacity under DSR (Huang *et al.,* 2011). DSR showed lower grain yield than PTR in chemical fertilizer treatments under the both environmental condition, but the grain yield in DSR was comparable to PTR

Table 1. Significance of CO_2 environment (C), planting system (P), nitrogen (N), and their interactions on growth and yield parameters of the hybrid rice

	Maximum tiller /m2	Grain yield, t/ha	Filled grain percentage (%)
C	0.132[a]	0.024	0.962
P	0.042	0.295	0.061
C x P	0.738	0.793	0.486
N	0.042	0.364	0.571
P x N	0.135	0.665	0.007
C x N	0.301	0.113	0.218
C x P x N	0.220	0.275	0.910

[a] P-value

under integrated nutrient management and SPAD-based N management. The grain yield under elevated CO_2 was reduced in'D-N2' which was due to instance of disease infection after flowering stage. The grain yield of rice responded significantly to CO_2 (Table 1). The SPAD-based N management was effective in increasing the grain yield with reduced amount of fertilizer application in both planting system and CO_2 environment. The comparable grain yield in DSR with PTR under SPAD based-N management was attributed to improvement in both sink (panicle /m2) and source (above ground biomass).

CONCLUSION

DSR is a sustainable and feasible alternative to PTR in eastern India for both present environment and future elevated CO_2 environment. Integrated nutrient management and SPAD based N management showed promising result in DSR based on comparable yield performance.

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Responses of split application of nitrogen on the performance of *kharif* rice in terai zone of West Bengal

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Rice (*Oryza sativa* L.) is the vital food for more than two billion people in Asia and four hundreds of millions of people in Africa and Latin America. India is the leading rice producing country in terms of area and is the second largest producer next to China. Nitrogen is the main nutrient associated with yield, its availability promotes crop growth and tillering, finally determining the number of panicles and spikelet's during the early panicle formation stage. Nitrogen contributes to spikelet production during the early panicle formation stage, and contributes to sink size by decreasing the number of degenerated spikelets and increasing hull size during the late panicle formation stage. Nitrogen contributes to carbohydrate accumulation in culms and leaf sheaths during the preheading stage and in grain during the grain-filling stage by being a fertilization to prevent the occurrence of N deficiencies, as well as to prevent over fertilization, which contributes to increased lodging, poor grain filling due to mutual shading, and increased severity and incidence of diseases. Top dressing of N at heading helped the plants to maintain a high photosynthesis rate, with a subsequent significant increase of grain-filling rate, grain-filling duration, and higher percentage of filled grains, compared with basal

Table 1. Effect of split application of nitrogen on yield attributes and grain yield of rice

Treatment	No. of tiller/ hill	No. of panicle /m2	Panicle length (cm)	No. of filled grains/ panicle	1000 grain weight (g)	Grain yield (t/ha)
T_1	11.04	340.75	23.75	199.75	21.68	3.19
T_2	11.74	365.75	24.50	217.75	22.40	3.33
T_3	12.24	380.50	25.50	225.75	22.46	3.58
T_4	11.13	343.00	24.25	215.25	22.15	3.25
T_5	10.80	328.50	23.50	186.00	21.17	2.76
SEm ±	0.201	7.20	1.32	16.18	0.71	0.120
CD (P = 0.05)	0.627	22.44	NS	NS	NS	0.374

application or top dressing of N at tillering. Considering all the facts in mind present experiment was conducted to see the responses of split application of nitrogen on the performance of kharif rice.

METHODOLOGY

The experiment was conducted during *kharif* season 2015 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. The farm is situated at $26^0$19’86"N latitude & $89^0$23’53" E longitude, at an elevation of 43 meter above mean sea label. The soil of the experimental site was sandy loam having pH 5.50, organic carbon 0.91 %, available nitrogen 117.5 kg /ha, available phosphorus 20.25 kg /ha and available potassium 80.00 kg /ha. The variety used in this experiment was Ranjit. A set of 5 treatments was laid out in randomized block design with four replications. Twenty-six days old seedlings were transplanted at a spacing of 20 × 15 cm. Each plot size was of 10 m x 5 m. Treatment comprises of T_1= 50% N as basal+ 50% N at active tillering, T_2=50% N as basal+ 25 % N at active tillering + 25% N at panicle initiation, T_3=25% N as basal+ 25 % N at active tillering+25% N at panicle initiation+25% N at flowering, T_4=40% N as basal+ 30 % N at active tillering basal+ 30 % N at panicle initiation and T_5=100% N as basal. Fertilizers were applied at @ 80, 40 & 40 kg /ha of N, P_2O_5, and K_2O respectively in the form of Urea, single super phosphate and muriate of potash. Full dose of P_2O_5, and K_2O were applied at the time of transplantation. Data were recorded on yield attribute namely no. of tiller m^{-2}, no. of panicle m^{-2},panicle length, no. of filled grains/panicle, 1000 grain weight and grain yield. Standard statistical methods were used for comparing the treatment means.

RESULTS

Results of the experiment showed that application of nitrogen in four split ie. 25% N as basal+ 25 % N at active tillering+25% N at panicle initiation+25% N at flowering (T_3) recorded highest values of tillers/ hill (12.24), panicle/m (380.50), panicle length (25.50 cm), number of filled grains/ panicle (225.75), 1000 grain weight (22.46 g) and grain yield (3.58 t /ha) of rice which was followed by 50% N as basal+ 25 N % at active tillering basal+ 25 % N at panicle initiation stage (T_2) and 40% N as basal+ 30 % N at active tillering basal+ 30 % N at panicle initiation (T_4). Higher yield of rice to increase split of nitrogen is probably due to enhanced availability of nitrogen which enhanced more leaf area resulting in higher photo assimilates and there by resulted in more dry matter accumulation. Availability of nitrogen throughout the growth stages might be responsible for the better performance. Whenever full dose of nitrogen was applied as basal, yield is reduced to the extent of 15.58 to 29.71%.

CONCLUSION

It was concluded from the experiment that more splitting of nitrogen up to flowering will help in improving all the yield attributes and grain yield of rice.

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Effect of cultivars and nutrient management on seed production of jute (*Corchorus sp.*) in *terai* region of West Bengal

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The importance of jute as commercial fibre yielding cash crop in the economy of India, particularly of eastern region, needs no emphasis. Non-availability of quality jute seed to the farmers at a lower price and at proper time is one of the major constraints faced by jute community. So, possibility of taking up of commercialised seed production of jute, one of the major crops in the *terai* region of North Bengal, must be explored.

METHODOLOGY

Keeping the above perspective in mind, a field experiment was conducted at the farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during *kharif* season of 2012 for identification of the most suitable variety and optimisation of the fertilizer dose with regard to the quality seed production of Jute in *Terai* region of West Bengal. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 2 factors. The level of factor I *i.e.* Variety was six (V1 - JRO-524, V2 - JRO-8432, V3 - JRO-204, V4 - S-19, V5 - JRC-321 & V6 - JRC-212) and the level of factor II *i.e.* fertilizer dose (N: P: K Kg/ha) was three (F1 - 20:10:15, F2 - 40:20:30 & F3 - 60:30:45). So, there were total eighteen treatment combinations. Treatments were replicated thrice.

RESULTS

The results revealed that most of the growth and yield attributes were significantly influenced by different cultivars as well as by different levels of NPK fertilization. Irrespective of species, highest primary and secondary branches per plant at harvesting (11.8 and 4.2 respectively), capsules per plant (85.1) and seed yield (8800 kg/ha) were recorded for the cultivar V6 (JRC 212) while those of lowest (4.9, 2.2, 33.3 and 4.5 respectively) were recorded with the cultivar V1 (JRO 524). The cultivar V6 (JRC 212) was also found to be highly efficient in terms of obtaining highest B : C (2.14) ratio as well as highest net return (Rs. 40575.30). But, if intra species comparison was made, it was obvious that among the *capsularis* varieties JRC 212 was consistently the best in terms of all the growth attributes like number of primary branches per plant, number of secondary branches per plant, leaf area index & dry matter production per plant. JRC 212 came out as the best in terms of yield parameters like capsules per plant and seed yield also. Among *olitorius* varieties JRO 8432 performed the best in terms of pods or capsules per plant, seeds per capsule or pod & seed yield. Among *capsularis* varieties JRC 212 performed the best in terms of gross return (Rs. 76206/ha), net return (Rs. 40575/ha) & benefit: cost ratio (2.14). Among *olitorius* varieties, JRO 8432 performed the best in terms of gross return (Rs. 70459/ha), net return (Rs. 34828/ha) & benefit: cost ratio (1.98). So far as nutrient doses were concerned, performance of F3, i.e., 60, 30 and 45 Kg N, P and K per hectare respectively was the best at each growth stage of the crop in terms of all the growth attributes like number of primary branches per plant, number of secondary branches per plant, leaf area index and dry matter production per plant. F1 i.e. 20, 10 and 15 Kg N, P & K per hectare respectively exhibited the worst performance in terms of all the growth attributes like number of primary branches per plant, number of secondary branches per plant, leaf area index & dry matter production per plant. Naturally, NPK @ 40:20:30 Kg/ha performed best in terms of all yield parameters as well as seed yield. But,as higher stick and fibre yield were achieved by the highest fertiliser dose i.e. NPK @ 60:30:45 Kg/ha, highest gross return (Rs. 67922/ha) was obtained from F3. But, finally highest net return (Rs. 31418.91/ha) and B: C ratio (1.88) was obtained from the moderate fertiliser dose i.e. NPK @ 40:20:30 Kg/ha due to less cost of cultivation. The interaction effect was highly significant at later stage of crop growth for the growth parameters viz. leaf area index and the results revealed that highest values were recorded for the cultivar V6 (JRC 212) upon application of highest nutrient dose; while a non-significant interaction was found for the parameters *viz.* dry matter production, primary as well as secondary branches per plant, yield attributes viz. pods per plant, thousand seed weight and seed, stick and fibre yield. In the present investigation, the treatment combination V6F2 proved to be the best in terms of seed yield (9590 kg/ha), net return (Rs. 45524) and B: C ratio (2.28).

CONCLUSION

Thus, it may be inferred that taking up of jute seed production may be a profitable proposition in *terai* region of North Bengal and jute farmers will definitely be benefited upon getting good quality seed at proper time and at moderate price. Moreover, regarding the agronomic management of jute seed production in *terai* region of North Bengal, *capsularis* cultivar like JRC-212 or *olitorius* variety like JRO 8432 and fertiliser dose of 40:20:30N: P: K Kg/ha should be recommended to harvest maximum return. Approximately, a net return of Rs. 6214 to 45524/ha can be achieved from the cultivation of jute for seed crop.

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Productivity and profitability of wheat varieties improved by zinc fertilization

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Wheat is the leading cereal crop and major source for dietary calorie intakes, proteins and micro–nutrients, mostly in the developing countries. In many of the developing countries, it is responsible for ~50% of the daily calorie intake (Cakmak, 2008). As, wheat varieties differed in their input–use–efficiency due to inter– and intra–specific variation, thus, it may be possible to screen wheat cultivars that are capable of using nutrients more efficiently. The response of different wheat genotypes to Zn fertilization can support the expression of Zn–efficient and Zn–inefficient genotypes. Compared to other cereals, wheat cultivars possess high sensitivity to Zn deficiency, and thus, application of Zn fertilizers is an important strategy for enhancing productivity and quality of wheat cultivars. Foliar fertilization either through Zn sulphate or Zn–EDTA is an alternative strategy to fortify seed with Zn and also helps in improving productivity of cereals (Pooniya and Shivay, 2013). Therefore it is needed to assess the effects of Zn fertilization irrespective of sources and methods on productivity and profitability of wheat cultivars.

METHODOLOGY

The experiments were carried out during Rabi (November–April) seasons of 2013–14 and 2013–14 at research farm of ICAR–Indian Agricultural Research Institute, New Delhi, India. Soils are alluvium–derived sandy clay loam in texture. The soil had pH 7.8, organic C 0.51 %, available N 252.8 kg/ha, P 13.1 kg/ha, K 291.2 kg/ha and DTPA extractable Zn 0.63 mg/kg of soil. The experiment was initiated in split–plot design with three replications. Six promising wheat varieties *viz.* HD 2851, HD 2687, HD 2967, PBW 343, HD 2894, HD 2932 were taken in main–plots; and five Zn fertilization treatments *viz.* control (no Zn), soil application of Zn @ 5 kg/ha through $ZnSO_4.7H_2O$, soil application of Zn @ 2.5 kg/ha through $ZnSO_4.7H_2O$ + 0.5% foliar spray of $ZnSO_4.7H_2O$ (ZSHH) at maximum tillering (MT) and booting stages (BS), soil application of Zn @ 2.5 kg/ha through Zn–EDTA, soil application of Zn @ 1.25 kg/ha through Zn–EDTA + 0.5% foliar spray of Zn–EDTA at maximum tillering and booting stages, respectively. Wheat crop was grown as per the standard recommended package of practices and was harvested in the month of April during both the years of experimentation. All the observations were recorded by using standard procedure.

RESULTS

Significant variation was reported among different varieties of wheat regrading to yield parameters and yield (Table 1). Difference in yield attributes are mainly because of difference in the genetic material of the variety. Of the six promising wheat varieties studied, HD 2967 had the longest and heaviest spike which was remained very close to HD 2687. With respect to sources and methods of Zn fertilization, application of 1.25 kg Zn/ha through EDTA + 0.5% foliar spray (FS) at maximum tillering (MT) and booting stages registered highest LAI, DMA and yield attributes i.e., spike weight and their length and grains/ spike. However, 2.5 kg Zn/ha (ZSHH) + 0.5% FS at MT and booting stages was the next best treatment with respect to yield parameters, indicating foliar fertilization imparting better role for improving growth and yield characteristics. This study shows that the effect of chelated Zn–EDTA was more pronounced than ZSHH, which has more capacity to transport Zn to plant roots. Zn exerts an effect on carbohydrate metabolism which influences photosynthesis, sugar transformations and seed development. Thus, increased Zn content and their uptake resulted in bolder grains, finally improving test weight (Alloway, 2008). Among six wheat varieties, HD 2967

Table 1. Yield attributes, yield and economics of wheat crop as influenced by varieties and Zn fertilization (pooled data of 2 years)

Treatment	Spike length (cm)	Spike wt. (g)	Grains/ spike	1000 grains wt. (g)	Grain yield (t/ha)	Straw yield (t/ha)	Net returns (Rs. ×10^3)	B:C ratio
Varieties								
‘HD 2851’	9.0	2.53	46.21	44.69	4.59	6.47	65.19	2.03
‘HD 2687’	9.56	3.70	60.22	39.87	4.31	7.26	65.23	2.03
‘HD 2967’	9.96	3.81	55.92	44.24	4.89	7.30	73.53	2.30
‘PBW 343’	9.29	3.42	51.27	41.61	4.62	7.87	72.74	2.27
‘HD 2894’	9.29	3.56	54.92	45.17	4.58	7.68	71.10	2.21
‘HD 2932’	9.73	3.01	51.49	45.02	4.50	7.81	70.62	2.20
SEm±	0.080	0.055	1.380	0.440	0.125	0.235	2.055	0.065
CD (P=0.05)	0.260	0.170	4.340	1.390	0.405	0.745	6.485	0.200
Zinc fertilization								
Control {no Zn}	9.37	3.14	48.76	42.85	4.22	7.13	66.78	2.30
5.0 kg Zn {$ZnSO_4.7H_2O$}	9.46	3.33	51.26	43.55	4.62	7.21	72.13	2.42
2.5 kg Zn {$ZnSO_4.7H_2O$} + 0.5 % FS at MT & BS	9.53	3.40	55.71	43.58	4.70	7.56	74.81	2.49
2.5 kg Zn {Zn-EDTA}	9.47	3.36	52.64	43.25	4.63	7.40	65.18	1.72
1.25 kg Zn {Zn-EDTA}+ 0.5 % FS at MT & BS	9.54	3.46	58.33	43.95	4.73	7.69	69.79	1.94
SEm±	0.07	0.045	1.090	0.638	0.060	0.170	0.91	0.03
CD (P=0.05)	NS	0.135	3.105	NS	0.170	0.485	2.570	0.08

FS: Foliar spray, MT: Maximum tillering, BS: Booting stage

produced significantly highest grain yield than rest of the varieties, nevertheless, it was remained at par to PBW 343. The lowest values of 1000 grain weight led to the lowest grain yield of HD 2687. Increase in grain yield due to Zn fertilization varied substantially between 9.4-12.1%. Zn applied through EDTA–chelated Zn remained available to plants for longer time than that with other Zn sources due to lesser transformation of applied Zn through EDTA–chelates into unavailable forms. Because of higher grain yield, HD 2967 was most remunerative and recorded net returns as well as benefit cost ratio (B:C). Due to higher cost of EDTA chelates, the net returns and B:C ratio obtained even lower than control (no Zn) plots. Thus, 2.5 kg Zn/ha (ZSHH) + 0.5% FS or 5 kg Zn/ha (ZSHH) were better choice to realize maximum benefits to the farmers.

CONCLUSION

Cultivar HD 2967 in conjunction with than 1.25 kg Zn/ha (EDTA) + 0.5% foliar spray (FS) or 2.5 kg Zn/ha (ZSHH) + 0.5% FS at MT and booting stages proved as an alternate viable option in realizing higher productivity and profitability of wheat. PBW 343 was found second better alternative cultivar with respect to above production parameters and benefit earned. Overall, varietal selection coupled with Zn fertilization may prove as best for enhancing productivity and profitability of wheat in irrigated plain zone of northern India.

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Nutrient management antecedently enhances the productivity of submergence-tolerant rice varieties in Eastern India

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Rice is a staple cereal of India cultivated in about 43.5 m ha area but with relatively low average productivity. India has the largest rainfed lowland rice area (16.5 million ha), which is about 39 % of the total rice area in India. Climate change poses a critical challenge to farmers, as extreme weather patterns increases abiotic factors like drought, flood and salinity affect rice production adversely in more than 50% of this area. The most common flooding stress is the "flash flooding" that occurs during the monsoon season with different intensities and durations. During these episodes, water completely submerges the established rice crop for a short period from several days up to two weeks. If rice plants remain submerged for more than five days, they start to die and do not recover after the water recedes. In flash flood–prone regions, farmers usually cultivate landraces that are tall and moderately tolerant of submergence but that have low yield. Farmers often suffer from crop losses or significant yield reduction caused by flashflood episodes because of high mortality, suppressed tillering, reduced panicle size, and high sterility. Further, crop loss limits the expected benefit from investments in agricultural inputs such as fertilizer. In response, farmers invest less in fertilizer inputs if their fields are prone to flooding (Gautam*et al.,* 2014a). Post-submergence nutrient management can also contribute substantially towards increasing productivity in flood-prone areas (Gautam*et al.,* 2014b). Keeping the above facts in mind the present study is conducted with following objectives (i) to study the response of graded dose of N and P in submergence tolerance of rice, and (ii) to validate the results of our first study *i.e.* basal phosphorus and post-flood nitrogen enhances the submergence tolerance in rice at Farmers' field in Cuttack, Odisha.

METHODOLOGY

The experiment was conducted to move one step ahead from our previous study i.e. basal phosphorus and post-flood nitrogen enhances the submergence tolerance in rice at National Rice Research Institute, Cuttack (20° 27′ N, 85° 56′ E; elevation 24 m above mean sea level) and at farmers field during 2013-15 under natural conditions. 15 days old seedlings of IR64, Swarna, IR64-Sub1 and Swarna-Sub1 were transplanted. Graded dose of N and P was used, i.e. 100 and 150% P of recommended fertilizer dose (RDF), 100 and 125% N of RDF, K was kept constant, applied in all the treatments except control. Total seven NPK combinations were used viz., control (0), 0-40-40, 0-60-40, 80-40-40, 80-60-40, 100-40-40, 100-60-40 kg/ha. P and K were applied as basal at the time of transplanting. Nitrogen was applied in three equal splits at basal, panicle initiation stage and as post-flood, basal dose of N was applied at the time of transplanting and post flood N was applied after 48 hrs of desubmergence as urea foliar spray as per the treatments. Leaves of rice seedlings were sprayed on their ad axial surface with 2.0% (w/v) urea solution through a back-pack sprayer in a water carrier until they were completely wetted. Different agronomic and physiological parameters were recorded.

RESULTS

Survival rate was calculated as the ratio of surviving plants after desubmergence to the plants before submergence. Average survival rates were 37.8, 34.3, 67.1 and 63.1% in IR 64, Swarna, IR 64-Sub1 and Swarna-Sub1 respectively; irrespective of the nutrient application. Higher dose of N and P contributed to better survival; regardless of the cultivars, higher N (100 kg/ha) and P (60 kg/ha) resulted in 18.5% and 7.9% higher plant survival as compared to their recommended doses *i.e.* 80 and 40 kg/ha, respectively. Dry matter weight and leaf area was measured during the recovery after 10 days of desubmergence; as evident in survival, DMW, leaf area and leaf greenness measured in terms of SPAD value was also higher in Sub1 cultivars as compared to non-Sub1. Graded dose of nutrient application resulted in higher grain yield as compared to control; significantly highest grain yield was recorded with 100-60-40 kg NPK/ha and it was around 143 and 30.1% higher as compared to control and 80-40-40 kg NPK/ha, respectively. In the control, grain yield was lowest and therefore % reduction in yield of non-Sub1 cultivars over Sub1 cultivars was highest. Submergence tolerance is related to extent of underwater shoot elongation, shoot carbohydrate storage and extent of chlorophyll retention, all of which are correlated significantly with seedling survival. Non-structural carbohydrates after submergence, which is the outcome of both elongation ability and the initial carbohydrate contents, is a better indicator of tolerance (Das *et al.,* 2005). Time of N fertilization during the post-submergence period might be one of the crucial factors for determining the recovery growth which would be very important when stand establishment was completely destroyed by flash flood submergence.

CONCLUSION

It can be concluded from the results of our study that replacing current farmers' field practices could improve rice production in rainfed lowlands of Eastern India. Further improvement in nutrient management of an improved variety resulted in higher yields and income. The graded dose of both nitrogen and phosphorus helped in tolerating submergence of rice due to better maintenance of carbohydrate content, chlorophyll and reduced chlorosis, senescence, elongation and lodging. These factors were reflected in the higher survival, crop establishment and yield of cultivars.

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Efficient nutrient management for higher cane yield and nutrient use efficiency in sugarcane

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Sugarcane (*Saccharum officinarum* L.) is the world's primary sugar crop. In India, sugarcane is cultivated over an area of 5.31 million hectares with annual production of 361 million tonnes of cane with an average productivity of 66.36 t/ha (Anonymous, 2013). Nutrient management is one of the most important management practices in sugarcane cultivation. Conventional (soil application) method of fertilizer application results in various losses and ultimately the use efficiency is relatively lesser. Subsurface drip fertigation in sugarcane offers an opportunity for placing fertilizers in a soluble form at root zone of the crop along with the irrigation water, it also ensures that essential nutrients are supplied precisely at the area of most intensive root activity according to the specific requirement of sugarcane crop (nutrient applied vs, nutrients removed by crop) and the type of soil, thereby results in higher cane yields and sugar recovery (He and Kang, 2000). Keeping these aspects in view, field investigation was carried out with objective of to study the comparative performance of WSF and NF either alone or in combination under SSDF and SDF on cane yield and nutrient use efficiency of sugarcane

METHODOLOGY

A field experiment was conducted at farmer's field (Iyyar thottam), Puttuvikki, nearer to Tamil Nadu Agricultural University, Coimbatore during January, 2013 to November, 2013. The soil of the experimental field was sandy clay loam in texture. The soil has pH of 7.65 and Electrical conductivity 0.47 dS/m, having organic carbon 0.84%, available N 199 kg/ha (Low), available P 44 kg/ha (High) and available K 676 kg/ha (High). The experiment was laid out in a randomized block design comprising eleven treatments with three replications. The treatments consisted of source of fertilizers and fertigation levels *viz.,* SSDF at 75% RDF with WSF (All 19, Urea Phosphate, Sulphate of Potash & Urea) (T_1), SSDF at 100% RDF with WSF (T_2), SSDF at 75% RDF with WSF (T_3), SSDF at 100% RDF with NF (T_4), SSDF at 75% RDF with NF (T_5), SSDF at 75% RDF with WSF + 25% RDF with NF (T_6), SSDF at 50% RDF with WSF + 50% RDF with NF (T_7), SSDF at 25% RDF with WSF + 75% RDF with NF (T_8), SDF at 100% RDF with WSF (T_9), SSDF at 100% RDF with NF (T_{10}) and surface irrigation with soil application of NF at 100% RDF (T_{11}). The recommended fertilizer of 300: 100: 200 kg N,P&K

Table 1. Effect of WSF and NF under SSDF on cane yield and nutrient use efficiency in sugarcane

Treatments	Cane yield(t/ha)	NUE(kg/kg of NPK applied)
T_1: SSDF at 75% RDF with WSF	167.63	372.5
$T_{2:}$ SSDF at 100% RDF with WSF	193.94	323.2
$T_{3:}$ SSDF at 75% RDF with WSF	172.22	382.7
T_4: SSDF at 100% RDF with NF	148.67	247.8
T_5: SSDF at 75% RDF with NF	132.58	294.6
T_6: SSDF at 75% WSF + 25% NF RDF	184.41	307.4
T_7: SSDF at 50% WSF + 50% NF RDF	163.48	272.5
T_8: SSDF at 25% WSF + 75% NF RDF	156.52	260.9
T_9: SDF at 100% RDF with WSF	175.14	291.9
T_{10}: SDF at 100% RDF with NF	139.53	232.5
T_{11}: SI + SA of 100% RDF with NF	98.38	164.0
SEd	8.08	-
CD (P=0.05)	16.86	-

was used for experimentation. Fertigation was done once in a week and irrigation was done once in two days based on 100% crop evapotranspiration (ETc). Transplanting of young bud chip seedlings (Co.86032) with triangular method of planting was done. The laterals (16 mm) were laid out in subsurface at a spacing of 1.65 m with 0.4 m emitter spacing at a discharge rate of 4 lph.

RESULTS

Subsurface drip fertigation with water soluble fertilizers had significant influence on cane yield and data are presented in Table 1. SSDF at 100% RDF with WSF has recorded significantly superior cane yield (193.94 t/ha) which was on par with combination of 75% RDF with WSF + 25% RDF with NF under SSDF (184.41 t/ha). Surface irrigation with soil application of NF at 100% RDF has recorded significantly lesser cane yield (98.38 t/ha). SSDF at 100% RDF with WSF has contributed to a yield increase of 49.27% over surface irrigation with soil application of NF at 100% RDF. This result is in accordance with the findings of Pawar *et al.* (2013).

In the present investigation, fertigation at 75% RDF recorded higher nutrient use efficiency (NUE) compared to 100% RDF under SSDF with WSF and surface irrigation with soil application of 100% RDF with NF (Table 1) . The enhanced NUE was 2.24 times higher under fertigation at 75% RDF with WSF through SSDF than surface irrigation with soil application of 100% RDF with NF. Among WSF and NF, WSF has registered higher NUE of 30.43% under SSDF and 25.55% under SDF. Similar result was reported by Parikh *et al.* (1994) in Banana. Among the treatments, lower NUE was registered in surface irrigation with soil application of NF.

CONCLUSION

From the above results, it can be concluded that subsurface drip fertigation at 75% RDF with WSF was found to be optimized fertilizer level for higher nutrient use efficiency along with higher cane yield.

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Response of nitrogen management through inorganic and organic sources on late sown wheat in eastern Uttar Pradesh

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Wheat (*Triticum aestivum* L.) is widely grown cereal crop of world and is the major staple food crop after rice in South East Asia. Uttar Pradesh ranks first in respect of area (9.25 mha) and production (25.60 mt) but the average productivity is much lower (2.79 t/ha) than Punjab and Haryana. Wheat is an exhaustive feeder and requires substantial amount of nutrients for higher productivity. This resulted in the increase in consumption of chemical fertilizers but the trend of fertilizer use efficiency is not encouraging. These erratic fertilizer use patterns, if continued for years, could cause much greater drain on native soil fertility and the soil may not be able to support high production levels in future. It is, therefore, necessary to develop a sustainable production system with maximum productivity and environmental safety. In this context, integration of inorganic fertilizers and organics like farmyard manure (FYM) assumes greater significance and would be within the approach of Indian farmers. Keeping this in view, a study was undertaken to find out the suitable nitrogen management practice on productivity of wheat under late sown condition and also to explore the possibilities of replacement of inorganics through organic sources in recently reclaimed usar soil condition of eastern plain zone of Uttar Pradesh.

METHODOLOGY

The field experiment was conducted at Agronomy Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad during *Rabi* 2013-14 and 2014-15 in randomized block design having four replications. The experiment constituted of six treatments *viz*, T_1 (recommended dose of N through inorganic source), T_2 (recommended dose of N through organic source), T_3 (75% N through inorganic source + 25% through organic source), T_4 (50% N through inorganic + 50% through organic), T_5 (25% N through inorganic + 75% through organic) and T_6 (N through inorganic source based on soil test value). The soil of the experimental field was silty clay loam in the texture, with low in available nitrogen and available phosphorus and medium in available potassium. The soil was recently reclaimed usar land with pH 8.13, organic carbon 0.34%, electrical conductivity 0.33 dS/m and 146, 16.6 and 245.8 kg/ha available N, P and K respectively. The recommended dose of fertilizer was 120, 60, 60 kg NPK/ha respectively. Wheat variety NW 1014 was sown with a seed rate of 125 kg/ha under late sown condition on 10th and 12th December, 2013 and 2014, respectively. Recommended cultural practices for late sown conditions were adopted.

RESULTS

All the growth parameters such as plant height, number of productive tillers per m row length, leaf area index and total dry matter accumulation under studies were significantly affected by various fertility treatments during both the years and were significantly higher in recommended dose of N through inorganic source based on soil test value and through 100% inorganic source over other treatments. The possible reason for lower yield attributes under the treatments of organic sources might be due to poor availability of nutrients to the crop. Yield attributes viz., spikes per m row length (79.6) and numbers of grains per spike (42.1) were increased significantly with recommended dose of nitrogen through inorganic source based on soil test value which was at par with T_1 and T_3. Grain (3.50 t/ha) yields and net return (Rs. 44211) were maximum and proved significantly superior with recommended dose of nitrogen through inorganic source based on soil test value than all the organic sources treatments, however, it was on par with 100% N through inorganic source (3.43 t/ha and Rs. 40427). This might be due to fact that inorganic sources supply nutrients quickly which resulted in better root system development under recently usar reclaimed conditions. Due to higher sodicity in the beginning, the nutrients might be released with much slower rates from organic sources while the inorganic sources (fertilizers) are immediate nutrient releaser. But in the subsequent year, organic sources will results equal or better responsive. The results are in conformity with Dudhat *et al.* (1997) and Singh and Agarwal (2004). Highest net returns (Rs.44211) and B:C ratio (2.5) were obtained with recommended dose of nitrogen through inorganic source based on soil test value followed by 100% N through

Table 1. Yield attributes and economics of wheat as influenced by inorganic and organic sources of nitrogen management treatments

Treatment	Dry matter (g/m row length)	Spikes /m	Grains/ Spike	Grain yield (t/ha)	Net return (Rs/ha)	B:C ratio
T_1: 100% N through In Os	247.1	78.3	41.5	3.43	40427	2.4
T_2: 100% N through Os	141.8	51.4	32.6	2.19	13417	1.4
T_3: 75% N InOs+25% Os	234.5	66.7	37.9	3.26	32880	2.1
T_4: 50% N InOs+50% Os	200.1	61.1	35.3	2.64	23003	1.7
T_5: 25% N InOs+75% Os	164.2	57.3	34.7	2.24	13769	1.4
T_6: 100% N In Os on soil test value	250.7	79.6	42.1	3.50	44211	2.5
CD (P=0.05)	24.63	6.56	4.03	0.27	-	-

Note: In Os: Inorganic source; Os: Organic source

inorganic source (Rs.40427 & 2.4) followed by 75% N through inorganic sources and 25% with organic sources (Rs. 32880 & 2.1).

CONCLUSION

Grain yield and economics of wheat improved significantly with application of N through inorganic source based on soil test value under recently reclaimed usar soil. Among different combinations of organic and inorganic sources, 75% N through inorganic source + 25% through organic source *i.e.* FYM proved most appropriate. On economic basis, application of recommended dose of N through inorganic fertilizer was better than application of N through organic source.

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Site specific nutrient management for improved and sustained safflower yields under dryland ecosystem of Karnataka

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Safflower is an important oil seed crop of *rabi* season in India mainly grown in semi-arid regions for vegetable and industrial oil purpose, although elsewhere it's seeds are used as bird feed, young plants as forage plant and florets for preparing textile dyes (Dordas and Sioulos, 2008). Safflower seed contains around 28 to 34 per cent of oil with high levels of linoleic acid, which is known to reduce blood cholesterol content (Kadu and Ismail, 2008). Safflower crop, like other crops, requires balanced nutrition, including secondary / micro nutrients, and adequate moisture to realize higher seed and oil yield. Despite the fact that safflower is a drought tolerant crop (Bitarfan *et al*., 2011) this crop often experiences moisture stress due to dry and hot weather prevalent during post-rainy season. Further, non-application of balanced nutrition based on the site-specific soil nutrient status is also another reason for lower safflower yields. Hence there was a need to test if site-specific nutrient management (SSNM) technique in safflower crop help improve yield. In addition application of FYM or organic residues would enhance SOM which in turn, help improve water holding capacity of soils. Therefore, combined application of organic and chemical nutrient elements based on site-specific nutrient status may not only enhance safflower yields but also help build drought resilience in the soil in the long-run. In this context, a long-term field experiment on SSNM in safflower was started during *rabi* 2014-15 and this extended summary includes result from two years (2014-16).

Table 1. Growth and yield of safflower as influenced by the organic manure and fertilization based on SSNM (pooled data of two years)

Treatment	Plant height (cm)	No of branches per plant	No. of capitula per plant	100 seed weight (g)	Seed yield (kg/ha)
M_1	60.51	7.36	23.27	5.58	1343
M_2	63.38	8.21	25.54	5.78	1461
CD (P=0.05)	2.57	NS	1.05	NS	105.13
F_1	59.21	7.20	21.54	5.51	1293
F_2	62.96	8.10	25.78	5.72	1421
F_3	62.79	7.51	24.49	5.79	1445
F_4	62.93	7.59	24.74	5.83	1462
F_5	63.04	8.50	25.19	5.84	1476
CD (P=0.05)	NS	NS	2.81	0.28	131.00
M_1F_1	58.43	6.89	21.68	5.36	1272
M_1F_2	61.40	7.43	23.40	5.59	1377
M_1F_3	60.90	7.55	21.70	5.62	1296
M_1F_4	60.83	7.65	22.45	5.60	1352
M_1F_5	61.15	7.84	23.15	5.72	1418
M_2F_1	59.99	7.50	23.45	5.67	1345
M_2F_2	64.57	8.27	27.10	5.74	1456
M_2F_3	62.68	7.92	26.33	5.85	1475
M_2F_4	64.63	8.18	26.83	5.87	1480
M_2F_5	65.08	8.20	26.98	5.90	1511
CD (P=0.05)	NS	NS	3.14	0.49	NS

METHODOLOGY

This study was conducted at Agriculture Research Station, Annigeri, University of Agricultural Sciences, Dharwad during *rabi* seasons of 2014-15 and 2015-16 under rainfed condition. The station is located in Northern Dry Zone (Zone-3) of Karnataka at a $15^0 8''$ N, $75^0 7''$ E with an altitude of 624.8 amsl. The soil is clayey in texture (Vertisol) with pH 7.95, bulk density 1.27 dS/m, available nitrogen, phosphorus and potassium of 224, 20.8 and 342 kg per ha, respectively. The experiment included two factors. The main factor had two levels of manure treatments (M_1-no manure and M_2-FYM at 5 t/ha) and the sub-factor had five levels of fertilizers (F_1-no fertilizer, F_2-recommended NPK @ 40:40:12 kg per ha, F_3-SSNM based on STCR equation, F_4- F_3 + micronutrients @ Zn @25 kg/ha+S@10 kg/ha and F_5 - F_3+if soil is deficient add 25 % more than F_2 and if soil is medium apply 25% less than recommended). The experiment was laid out in split-plot design with three replications at fixed site during both the years.

RESULTS

The year 2014-15 received more and uniform distributed rainfall than 2015-16 as the latter year received no rain after sowing, thus crop experienced extremely dry and hot climate. Hence yield in 2015-16 was much lower than in 2014-15. However, pooled data analysis doesn't show this contrast. Application of FYM @ 5 t per ha increased plant height, capitula number per plant and seed yield over non application of FYM (Table 1). Application of fertilizer either based on STCR or NPK combined with micro-nutrients enhanced seed yield by improving test weight of seeds. However interaction between manure and fertilizers were found to be non-significant although combined application of FYM @ 5 t per ha and 100% NPK or NPK application based on STCR or NPK combined with micro-nutrients tended to enhance crop growth and yield.

CONCLUSION

This study is an on-going long-term fixed site experiment, but initial results from two years do suggest the beneficial effect of FYM @ 5 t per ha, and optimized and balanced fertilization on safflower yield. However, actual effect of FYM and balanced nutrition based on STCR can be realized after few more years' of study.

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Balance nutrient management sustained crop productivity in tribal areas in India: Experiences from long term fertilizer experiments

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The long term experiments proved that there is an urgent need to apply nutrients in balance manner to sustain soil fertility and crop productivity at the optimum level. In this context it is well documented that balance nutrient application over the years has improved soil properties that ultimately sustained the yield of different crops in vivid agroecological zones in India (Singh and Wanjari, 2013). Under such circumstances there is a need to create awareness about balance nutrient application amongst farmers through training programmes and field demonstrations in tribal areas. In this context the nutrient management technology emanated from long term fertilizer experiments was transferred to farmers' fields through tribal sub-plan (TSP) fund which enabled to conduct field trials in tribal areas in our country through different centres of All India Coordinated Research Project on Long Term Fertilizer Experiments (AICRP LTFE).

METHODOLOGY

The experimental fieldunder AICRP LTFE consists of nutrient management treatments i.e.Graded doses of NPK (50%, 100%, 150%), NPK + hand weeding, NPK + Zn or lime, NP, N, NPK + FYM, NPK (Sulphur free/sulphur source) and control with a provision of one or two additional treatments that may be of local or regional interest. On the basis of results of these experiments best proven technologies were taken to the farmers' field for demonstrations at different locations. The cluster of village was selected in different tribal areas in the states of Karnataka, Odisha, Himachal Pradesh, and Maharashtra to impart training and conduct field trials on farmers' fields in participatory mode. The representative soil samples were collected from selected farmers' field. These samples were analyzed in the laboratory by adopting standard methodology to assess soil nutrient status. The agricultural knowledge was imparted to the tribal farmers through different modes of extension activities like training programme, farmers' fair, distribution of printed literature, agricultural exhibition, field demonstration etc. The farm inputs like seed, fertilizer and pesticides were provided to the farmers as per recommendation to demonstrate the agricultural technology. The purpose of conducting demonstrations was to create awareness amongst tribal farmers, preparation of soil health cards etc.

RESULTS

Karnataka:In general, majority of soils (90%) were acidic in nature, 96% were low in available N, 65% medium in P and 57% medium in K status in collected from selected tribal beneficiary fields in B.R.Hills andChamarajanagardistricts (Bangalore, Karnataka). Average yield of finger millet (cvGPU - 28) and maize (Hybrid-Hema) on ten farmer's field showed an increase in finger millet by 24.9% compared to 22.7% in maize. The farm inputs and soil health cards were distributed to the beneficiaries in these tribal areas.Odisha:Front line demonstrations (FLDs) conducted in different villages in tribal districts of Odisha (Bhubaneshwar) revealed that in rice an application of recommended NPK dose with splits(25% N, 100% P and 50% K at planting, 50% N at maximum tillering stage and 25% N + 50% K at panicle initiation stage) increased productivity by 26.5% over farmers' practice. Yield further enhanced by 38.48% with conjunctive use of 100% NPK + FYM @ 5 Mg/ha applied before planting. Fertilizer application on the basis of soil test values recorded highest yield of 50.1% more than the farmers' practice. Jharkhand:Intervention in nutrient management resulted increase in yield of maize by 29.8, 44.3, 71.8 and 98.6% with the application of NP, NPK, NPK+lime and NPK+FYM, respectively, as compared to farmers' practice (80:20:0 kg N:P:K & FYM @ 2 Mg/ha). Results showed that about 69-72% yield improved with application of NPK+FYM or NPK + lime as compared to farmers' practice. Maharashtra:Field demonstrations were conducted on tribal farmer's field of Amravati district revealed that application of 100% NPK + FYM @ 5 Mg/harecorded significantly highest yield of soybean (1145 kg /ha), 3221 kg /ha of sorghum, for wheat 2991 kg /ha and 1438 kg /ha for chickpea compared to farmers' practice. Thus, integrated nutrient management (100% NPK + FYM @ 5 Mg/ha) improved the productivity of all the crops grown over the area. Himachal Pradesh:Field demonstrations were conducted to monitor effect of integrated nutrient management (INM) on grain yield of maize on farmers' fields. The INM (N: 120, P: 60, K: 40 kg/ha + FYM @ 5 Mg /ha) enhanced yield to 5030 kg /ha compared to farmers practice (N: 60, P: 24, K: 16 kg/ha + FYM @ 5 Mg /ha) with 2300 kg /ha.

CONCLUSION

Thus, field demonstrations results proved that intervention in nutrient management boost crop productivity in the tribal areas. Higher productivity not only will improve their economic status but also provide strength to nutritional security of the country.

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Effect of nutrient management on growth parameters of maize

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In modern farming system, the nutrient management is based on eco friendly principles of balanced fertilization which not only enhances the fertilizer use efficiency but also helps to sustain the productivity of crops. In recent years the deterioration in soil health associated with global predicament of energy along with escalation in the prices of chemical fertilizers led to emphasize on supplementation of chemical fertilizers with low priced nutrient sources such as organics and bio sources. The aim is to integrate natural and manmade resources of plant nutrients supply so as to increase crop productivity in an efficient and environmentally favorable manner without diminishing soils inherent capacity of plant nutrient supply. Amongst the growth inputs, mineral nutrients play a vital role not only in exploiting the realizable potential of the crop but also to maintain sustainability of soil for agricultural production. Thus, emphasis on mineral nutrition is very essential. Integration approach helps to restore soil fertility and productivity and also supply the essential nutrients to the crop growth including the micronutrient unlike chemical fertilizers which are generally manufactured only to supply one or two macronutrients.

METHODOLOGY

A field experiment was conducted during *kharif* 2011 on clay loam soil of Rajasthan College of Agriculture, Udaipur. The soil of experimental site was sandy clay loam in texture, slightly alkaline in reaction and calcareous in nature. It was medium in available nitrogen and phosphorus and high in potassium, sulphur and DTPA-extractable zinc. The experiment involved 12 treatment combinations consisted of 100% NPK based on soil test values (120 kg N + 60 kg P_2O_5 + 30 kg K_2O /ha), 100% NPK+Zn (5 kg Zn/ha), 100% NPK+Zn +S (40 kg S/ha), 100% NPK+S, 100% NPK + seed treatment with *Azotobacter,* FYM 10 t/ha+100% NPK(-NPK of FYM), 100% NPK+FYM 10 t/ha, FYM 20 t/ha, 150% NPK, 100% NP, 100% N and Control. The sowing of maize cultivar PEHM-2 was done on 3rd November, 2011 with seed rate 25 kg/ha at a spacing of 60 cm X 20 cm following package and practices of Sub-Humid Southern Plain and Aravalli Hills'' of Rajasthan. Various observations were recorded using standard methods.

RESULTS

Nutrient application in various forms and FYM combinations tended to result in significantly higher LAI at 60 DAS which varied from 1.98 to 3.63. The highest LAI (3.63) was recorded by enriching the soil with 100% NPK + FYM 10 t/ha which was closely followed by 150% NPK. The crop under nutrient stress showed minimum crop growth rate. Application of 100% N increased CGR over control, it further increased by addition of P with N over N alone. However, addition of K with NP failed to give significant increase in crop growth rate at 45-60 DAS. Maximum CGR (20.7 g/m^2/day) was obtained by soil fortified with 100% NPK + FYM 10 t/ha. The overall improvement in CGR due to various treatments ranged from 27.6 to 105.7%. The variation in grain yield of maize under different treatments varied from 1.28 to 3.91 t/ha. Significant enhancement in grain yield of maize was recorded by applying various treatments to supply nutrients. The highest grain yield (3.91 t/ha) was recorded by application of 100% NPK + FYM 10 t/ha and its performance was at par with 150% NPK. A faster growth rate in terms of dry matter production in plant parts and total as evinced from higher

LAI, CGR and RGR under the influence of balanced and higher level of fertilization which might have played a significant role in reducing competition for photosynthates and nutrients with other plants resulting in healthy plants. The increased availability of photosynthates might have enhanced number of flowers and their fertilization resulting in higher number of filled grains per cobs. Further, in most of cereals, greater assimilating surface at reproductive development stage results in better grain formation because of adequate production of metabolites and their translocation towards grain as evident from nutrient concentration and their uptake might have resulted in increased weight of individual grain thus highest grain yield was achieved. It can be concluded from the results that application of 100% NPK + FYM 10 t/ha recorded the highest values of LAI, CGR, RGR which ultimately increased grain yield.

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Performance of maize hybrids as influenced by plant population and fertility levels under irrigated ecosystem

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Maize occupies a pride place among the cereals in India. India grows about 8.71 million hectares of maize with total annual production of 22.3 million tonnes of grain giving an average yield of 2.55 tonnes per hectare (*Anon*., 2014) that is tremendously lower than other maize growing countries of the world. There are many reasons for low productivity of maize in India, among them cultivation of impotent genotypes, under planting density and mismanagement of plant nutrition are considered to be the major once. However, today, single cross hybrids are clearly the preferred cultivars of maize for achieving high yield. Because of their hybrid vigour over double cross, three way cross hybrids and composites hence, they are familiar among the farmers year after year. Inspite of this, presently hybrids constitute just 30 per cent of total plantings in a given year. It is estimated that hybrids would constitute 90 per cent of the total area by 2050, this would provide a major boost to the maize production. Further, single cross hybrids are known for their erectophyll leaf orientation and higher leaf area at silking and grain filling stage it made them to be flexible for higher planting density. Panting density is one of the practices that made significant change in productivity of maize. Further, yield gap in maize is due to inadequate and imbalanced fertilization and lack of distinct fertilizer recommendations for high yielding single cross hybrids. Karnataka being a one of the major producer of maize, assessment of most suitable planting density and fertility levels to high yielding single cross hybrids for irrigated ecosystem of Karnataka is the untouched part of maize research. Hence, a field experiment was conducted to exploit the full potentiality of maize under irrigated ecosystem.

METHODOLOGY

A field experiment was conducted during *kharif* 2013 and 2014 at Agriculture Research Station Farm, Mudhol to study the effects of single cross hybrids, plant population and level of fertilization on growth and yield attributes, yield, nutrient use efficiency and economics of maize production. The experiment was laid out in split-split plot design and was replicated thrice. The soil of the experimental site was deep black soil. The soil was alkaline in reaction and low in organic carbon. The soil nutrient status of soil was low in available nitrogen (237 kg/ha) and phosphorous (23 kg/ha) and high in available potassium (427 kg/ha). Well decomposed farm yard manure at the rate of 10 tonnes and 25 kg $ZnSO_4$ and $FeSO_4$/ha was applied uniformly over all the treatments and seeds were treated with phosphorus solibilizing bacteria and *Azospirullam* each at the rate of 750 g/ha. As per the treatments seed rows at 45 cm and 60 cm were opened to accommodate 1, 11, 111 and 83, 333 plants/ha in sub plots. Inter row spacing of 20 cm was maintained for both the populations. Basal dose of nitrogen (15 % of RDN), phosphorous (100 % RDP_2O_5), potassium (RDK_2O) and micronutrients were applied at the time of sowing and reaming quantity nitrogen was applied in four splits. The observations on growth, yield attributes, grain and stover yield were recorded as per the standard procedure and were statistically analyzed.

Table 1. Growth and yield parameters of maize as influenced by hybrids, plant population and fertility levels (Pooled data of two years)

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Net returns (Rs. Lakh/ha)	B:C ratio
Maize hybrids (H)				
H_1-NK-6240	10.14	14.38	87560	2.68
H_2-Super 900-M	9.89	14.33	81856	2.49
H_3-Arjun	7.59	11.84	61088	2.38
SEm±	0.16	0.30	2231	0.05
CD (P=0.05)	0.65	1.17	6698	0.15
Plant population/ha (P)				
P_1-1, 11, 111	9.80	14.68	84563	2.65
P_2-83, 333	8.61	12.36	69107	2.38
SEm±	0.15	0.15	2011	0.04
CD (P=0.05)	0.53	0.52	6030	0.12
Fertility levels kg/ha (F)				
F_1-$N_{(150)}P_2O_{5(65)}K_2O_{(65)}$	7.38	12.57	57514	2.27
F_2- $N_{(187)}$ $P_2O_{5(81)}$ $K_2O_{(81)}$	8.43	13.12	69014	2.44
F_3- $N_{(225)}$ $P_2O_{5(97)}$ $K_2O_{(97)}$	9.69	14.02	83347	2.65
F_4- $N_{(262)}$ $P_2O_{5(114)}$ $K_2O_{(114)}$	10.12	13.81	86439	2.64
F_5- $N_{(300)}$ $P_2O_{5(130)}$ $K_2O_{(130)}$	10.42	14.08	87859	2.59
SEm±	0.22	0.33	2941	0.06
CD (P=0.05)	0.63	0.93	8820	0.18

RESULTS

Among the maize hybrids, significantly higher grain (10.14 t/ha), stover (14.38 t/ha) yield, net return (Rs. 87,560/ha) and benefit cost ratio (BCR) (2.68) was obtained in NK-6240. The superiority of maize hybrid NK-6240 could be attributed to higher combining ability, wider adoptability and stability in hybrid vigour and favorable genotypic basis. Similar type of opinions was earlier reported by Azam *et al.* (2007). Between the plant populations, 1,11,111 plants/ha recorded significantly higher grain (9.80 t/ha), stover (14.68 t/ha) yields, net return (Rs. 84,563/ha) and BCR (2.65) than 83,333 plants/ha. Higher grain yield under higher plant population was observed which may be attributed to more number of harvestable cobs per unit area. Among the fertility levels, $N_{(300)}P_2O_{5(130)}K_2O_{(130)}$ kg/ha recorded significantly higher grain (10.42 t/ha), stover (14.08 t/ha) yield and net return (Rs. 87,859/ha). However, significantly higher BCR was registered with $N_{(225)}P_2O_{5(97)}K_2O_{(97)}$ kg/ha (2.65). The higher of growth attributing parameters with elevated fertility levels could be due to increased availability of nutrients under assured irrigated condition. Maize being a C_4 plant responds to applied fertilizer under adequate moisture condition. Similar reports were earlier reported by Thavaprakaash *et al.* (2005).

CONCLUSION

Maize hybrid NK-6240 or Super 900-M at 1, 11, 111 plants/ha along with application of $N_{(262)}P_2O_{5(114)}K_2O_{(114)}$ kg/ha was more productive and profitable cropping practice for maize under irrigated ecosystem.

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Effect of nitrogen fertilization on grain yield and nitrogen use efficiency of basmati rice

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Basmati rice cultivation is quite common in Punjab, Haryana, Delhi and western Uttar Pradesh. The indiscriminate use of nitrogenous fertilizers in basmati rice cultivation leads to environmental pollution, higher incidence of insect-pests and diseases, reduced profits and lodging of crop. All these losses could be minimized if appropriate amounts of nitrogen are applied in basmati varieties. 'Pusa Basmati-1121' is a very common variety in Bijnor district of Uttar Pradesh, but its optimum N requirement is yet to be worked out.

OBJECTIVES

The objective of the study was to assess the effect of nitrogen fertilization on grain yield and nitrogen use efficiency of basmati rice variety 'Pusa Basmati-1121'.

METHODOLOGY

A field experiment was conducted during two *kharif* seasons of 2013 and 2014 at the Department of Agronomy, R.S.M. P.G. College, Dhampur , Distt. Bijnor, Uttar Pradesh. The treatments comprised of 5 nitrogen levels (0, 30, 60, 90 and 120 kg N/ha) replicated four times in a Randomized Block Design. Prilled urea was used as a source of nitrogen. Rice crop was grown under transplanted and puddled conditions during both the years.

RESULTS AND DISCUSSION

Basmati rice responded significantly to the N application (Table 1). Grain yield increased progressively and significantly up to 90 kg N/ha. Further increase in N level to 120 kg N/ha could not bring a significant improvement in grain yield of basmati rice during both the years of this field study. The increasing levels of nitrogen decreased the agronomic nitrogen use efficiency of basmati rice during both the years.

CONCLUSION

Based upon two years results, the optimum N application for basmati rice variety 'Pusa Basmati-1121' was worked out to be 90 kg/ha. Further, the nitrogen use efficiency declined substantially due to increase in nitrogen levels from 30 to 120 kg N/ha.

Table 1. Grain yield of basmati rice as influenced by nitrogen fertilization

Nitrogen level (kg/ha)	Grain yield (t/ha)		Agronomic nitrogen use efficiency (kg grain increase/kg N)	
	2013	2014	2013	2014
0	2.52^{D}	2.45^{D}	-	-
30	3.45^{C}	3.26^{C}	31.0	27.0
60	4.21^{B}	3.98^{B}	28.1	25.5
90	4.93^{A}	4.68^{A}	26.7	24.7
120	4.96^{A}	4.73^{A}	20.3	19.0

Means followed by the same letter or letters do not differ significantly at $P \leq 0.05$ by Duncan's multiple range test.

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Effect of phosphogypsum on growth and yield of soybean

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Soybean has been introduced as an oilseed crop in India, to increase the edible oil resources due to its high yield potential. The low productivity of soybean is associated with low supplement of N, P, S, Ca and Zn nutrients. Due to their specific role in metabolism these nutrients are directly involved in nodulation, pod formation, oil and protein content thereby increasing yield and maintaining quality of any oilseed crop. Soybean is quite responsive to sulphur and calcium application due to higher quantities of sulphur containing amino acids. These nutrients are to be supplied through independent sources thereby increasing cost of inputs. Thus, the phosphogypsum was identified as a source of these nutrients. Phosphogypsum is available in many states as a by-product of phosphoric acid based fertilizer industry and can be used as a source of nutrients for oilseed crops. Less than 10% of phosphogypsum is being used for agricultural purpose (Somani, 1995). In view of this the present investigation was carried out to study effect of phosphogypsum on growth and yield of soybean.

METHODOLOGY

A field experiment was conducted during *Kharif* season of 2013-14 at Agronomy Farm, College of Agriculture, Nagpur, Maharashtra State. The soil was slightly alkaline (pH 7.9) and clayey in texture. The soil was low in organic carbon, available N, available P_2O_5 and rich in available K_2O. The experiment was laid out in factorial randomized block design with 12 treatment combinations replicated thrice. The factor A comprised of three different fertilizer application treatments viz. F_1- 75% RDF, F_2-100% RDF, F_3-125% RDF and four treatments of phosphogypsum as B factor viz. PG_1-75 kg /haphosphogypsum, PG_2-100 kg /ha phosphogypsum, PG_3-125 kg /ha of phosphogypsum, PG_4-150 kg / haphosphogypsum.Grain yield of soybean was recorded after harvest of the crop from respective treatments and the various economic parameters such as gross monetary returns, net monetary returns and benefit cost ratio were estimated according to prevailing market value of produce and inputs during respective year.

RESULTS

Data in the table revealed that the application of 125% recommended dose of fertilizer (F_3) recorded significantly higher leaf area/plant at 60 DAS and dry matter plant^{-1} at harvest over 75% application of RDF (F_1) and was at par with 100% RDF (F_2). This could be the result of net photosynthesis, partitioning and energy budgeting. Phosphogypsum application of 150 kg/ha (PG_4) recorded significantly more leaf area/plantat 60 DAS and dry matter/plant at harvest over all other treatments except phosphogypsum @ 125 kg/ha (PG_3) which was at par with 150 kg/haphosphogypsum (PG_4). This may be because of increased in chlorophyll synthesis as it is greatly affected by the sulphur content in growing medium thereby increasing number of leaves/plant which enhances the photosynthetic activity producing higher dry matter. Interaction effect was non-significant. Number of nodules/ plant was found significantly higher with application of 125% RDF (F_3) over 75% RDF (F_1) at flowering stage. This is quite logical because nitrogen and phosphorus nutrition leads to extensive root system, effective growth and development of nodule bacteria. Phosphogypsum application of 150 kg/ha (PG_4) recorded significantly higher number of root nodules plant^{-1} at flowering over all other treatments except 125 kg / haphosphogypsum which was at par with 150 kg /ha phosphogypsum.

Number of pods/plant, mean seed yield/plant, seed yield q /ha were reported significantly higher in treatment 125% RDF (F_3) over 75% of RDF (F_1) and was at par with 100 % RDF (F_2). Application of nitrogen, phosphorus and potassium enhanced formation of nodules, better nitrogen fixation and overall development of plant which ultimately resulted in increasing yield attributing characters and yield also. As regards economic returns, also 125% RDF (F_3) recorded significantly higher gross monetary returns and net monetary returns over all other treatments. Also benefit cost ratio was highest with this treatment. Significantly higher number of pods/plant, seed yield/plant and seed yield /ha were recorded with application of 150 kg/ha phophogypsum over all other treatments except 125 kg/ha phosphogypsum (PG_3) which was found at par with 150 kg/haphosphogypsum (PG_4). The increased in seed yield /ha due to application of phospogypsum (sulphur and calcium) might be correlated with significant improvement in morphological parameters, root nodules and increase in yield attributes. Application of 150 kg phosphogypsum (PG_4) recorded significantly higher gross monetary returns (Rs. 76517/ha), net monetary returns (Rs. 56041/ha) and benefit cost ratio over all other treatments. This might be due to the greater availability of sulphur and calcium that increased the grain yield.

CONCLUSION

It can be concluded that application of phosphogypsum @ 150 kg/ha and application of 125% RDF recorded significantly higher growth, yield attributes and yield of soybean thereby increasing monetary returns and B:C ratio amongst all the other treatments.

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Productivity and profitability of direct seeded rice under different nitrogen and zinc levels

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Rice is staple food for more than half of the world's population. India has the world's largest area under rice with 44.0 million ha and is the second largest producer next only to China and contributes 21.5% of global rice production (Viraktamath*et al*., 2011). In Asia, rice is commonly grown by transplanting one month-old seedlings into puddled and continuously flooded soil.Huge water inputs, labour costs and labour requirements for transplanted rice have reduced profit margins. Direct seeded rice is a new rice production technique that avoids all problems relating to transplanted rice in which seeds directly sown in the field rather than by transplanting seedlings from the nursery (Farooq*et al*., 2011). Nitrogen and zinc deficiency are the genuine problems of Indian soil that reduce the productive potential of rice. Nitrogen is an essential element that determine rice grain yield by promoting tillering and increasing spikelet number per panicle.Zinc fertilization also very important for grain production as well as for grain zinc contents. So combine application of nitrogen and zinc are good way to increasing rice productivity and profitability.

METHODOLOGY

The experiment was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, at Varanasi during the *Kharif* (rainy) seasons of 2014, to study the effect of nitrogen levels and zinc application on yield and zinc content of direct seeded rice (DSR). The soil of the experimental site was sandy clay loam (52.20, 21.15, 26.64% sand, silt, clay respectively), organic carbon 0.45%, pH 7.4, available NPK 197.6, 21.22, 220.21 kg/ha respectively, and available zinc 0.51 ppm. The seed of rice cultivar HUR-105 was sown directly under unpuddled condition with 20 cm plant to plant spacing. The field experiment was laid out in a factorial randomized block design, with 3 replications, comprising 4 nitrogen (N) levels (0, 80, 120 and 150 kg N/ha) and 4 zinc application (0, 0.3% $ZnSO_4$.H2O spray at anthesis, at early milking and at dough stage) with constant rates of phosphorus and potassium at 60 and 60 kg/ha respectively. Nitrogen and zinc were applied in the form of urea and zinc sulphate respectively. Data on various yield attributes, grain and straw yields of rice, zinc content in grain and economic return were statistically analysed as per standard statistical procedure.

RESULTS

The data pertaining to rice productivity and profitability are presented in Table 1. The nitrogen levels and zinc application were statistically varied for rice productivity and profitability.Significantly maximum grain(4341 kg/ha) and biological(10086kg/ha) yield of rice was recorded with application of 150 kg N/ha which was 42.47% and 24.55% respectively higher than control. Zinc application had also significant effect and maximum grain (4369 kg/ha) and biological (10273kg/ha) yield of rice recorded with 0.3% ZnSO4 spray at anthesis which was 60.73% and 54.73% respectively higher than control.Data onbiological yield also statistically varied and maximum net return 41.28×10^3 and Rs 3.0×10^3 /ha was obtained with application of 150 kg N/ha and 0.3% ZnSO4 spray at anthesis respectively.Interaction effect of nitrogen and zinc levels in terms of grain yield was give significantly good result while in terms of biological yield and net return was non-significant. Data in Table 2 showed that

Table 1. Rice productivity and profitability under different nitrogen and zinc levels.

Treatment	Grain yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Net returns ($x10^3$ Rs/ha)
N rates				
N_0	3047[d]	7630[d]	40.21	21.17[d]
N_{90}	3627[c]	8686[c]	41.71	29.72[c]
N_{120}	3952[b]	9355[b]	42.48	35.05[b]
N_{180}	4341[a]	10086[a]	43.03	41.28[a]
Zn management/timing of Zn application				
Control	2718[d]	6639[d]	41.04	13.17[d]
0.3% Zn spray at anthesis	4369[a]	10273[a]	42.63	43.01[a]
0.3% Zn spray at early milking	4027[b]	9535[ba]	42.37	36.83[cb]
0.3% Zn spray at dough stage	3853[c]	9310[c]	41.40	34.21[b]
SEm±	98.71	266.69	1.16	1.74
CD (p=0.05)	285.09	770.24	3.35	5.02
NxZn	S	NS	NS	NS

Table 2. Interaction effect of N x Zn on grain yield, zinc content and uptake in grain.

Treatment	Seed yield (kg/ha) N levels (kg/ha)			
	N_0	N_{90}	N_{120}	N_{150}
Zn management				
Control	2271	2753	2867	2981.09
0.3% Zn spray at anthesis	3526	4006	4361	5582.05
0.3% Zn spray at early milking	3305	3880	4321	4601.44
0.3% Zn spray at dough stage	3085	3867	4261	4199.13
SEm± 197.42, CD (P=0.05) NxZn: 570.18				

the interaction effect of nitrogen levels and zinc application was recordedsignificantly in terms of grain yield and maximum grain yield (5582kg/ha) was recorded with combine application of 150 kg N/ha and 0.3% $ZnSO_4$ spray at anthesis, which was 145.81 % higher than absolute control (2270.83kg/ha).

CONCLUSION

Based on present investigation it can be concluded that the grain yield,biological yields and net returns of the rice have significantly maximum withapplication of 150 kg N/ha and 0.3% ZnSO4 spray at anthesis than control. This might be due to rapid growth and development of plant cells due to adequate nitrogen and zinc was supply at early growing stage of plants.

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Effect of phosphorus and sulphur fertilization on yield and economics of fenugreek

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Fenugreek (*Trigonellafoenum-graecum* L.) popularly known by its vernacular name "methi" is an important condiment legume crop grown mainly in India. Legumes have generally higher P requirement because the process of symbiotic nitrogen (N) fixation consumes a lot of energy. In addition to P, sulphur is also becoming deficient in our soil due to use of high grade S-free fertilizers, cultivation of high yielding varieties and lack of industrial activity/deposition. Growing of sulphur responsive crops, high intensive cropping and use of sulphur free fertilizers caused S deficiency in soils of India (Tandon and Tiwari, 2007). Thus, P and S need of the crop should essentially be met through supplementation of these to soils or other feasible means. Therefore, the current investigation is aimed at ascertaining the required P & S response of fenugreek through soil application.

METHODOLOGY

A field experiment was conducted during *Rabi* on clay loam soil at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipurduring year 2010-11. The experimental soil was slightly alkaline in reaction (*p*H 8.2), low in available nitrogen (247 kg /ha), medium in available P (20.1 kg P /ha), high in potassium (326 kg /ha), low in available S (8.7 kg /ha) and clay loam in texture. The experiment was laid out in a factorial RBD consisting of a combination of four levels of phosphorus (0, 20, 40 and 60 kg /ha through diammonium phosphate, DAP) and four levels of sulphur (0, 15, 30 and 45 kg /ha through gypsum) with three replications. Fenugreek 'Rmt-1' was sown using seed rate 25 kg /ha and row spaced at 30 cm apart. Nitrogen was applied as basal dressing @ 25 kg /ha through urea. Grain yield, yield attributes and other biometrics observations were undertaken as per requirement for validation of findings. Other soil and plant analysis were made following standard procedures.

RESULTS

Phosphorus and Sulphur application significantly influenced the grain and straw yield of fenugreek (Table 1). Among the different levels of phosphorus, application of 60 kg P_2O_5 /ha recorded maximum grain and straw yield of fenugreek, and was closely followed by 40 kg P_2O_5/ha. This treatment recorded 51.9, 17.3 and 4.8 per cent increase over 0, 20 and 40 kg P_2O_5/ha. Phosphorus plays a significant role in growth and development of legume plants. Energy storage and transfer are the most important functions of phosphorus

Table 1. Effect of phosphorus and sulphur on yield and harvest index of fenugreek

Treatment	Yield (kg /ha)			Harvest index
	Seed	Straw	Biological	(%)
Phosphorus (kg P_2O_5 /ha)				
0	1112	4435	5547	19.8
20	1440	4846	6286	22.9
40	1612	5137	6749	23.8
60	1689	53.15	7004	24.1
SEm (±)	25	82	82	0.4
C.D. (P=0.05)	73	238	236	1.2
Sulphur (kg /ha)				
0	1196	4482	5678	20.8
15	1401	4822	6223	22.5
30	1588	5108	6696	23.6
45	1668	5321	6989	23.8
SEm (±)	25	82	82	0.4
C.D. (P=0.05)	73	238	236	1.2

Table 2. Interaction effect of phosphorus and sulphur levels on seed yield (kg /ha) of fenugreek

Sulphur levels(kg S /ha)	Phosphorus levels (kg P_2O_5 /ha)			
	P_0	P_{20}	P_{40}	P_{60}
S_0	756	1244	1330	1454
S_{15}	1113	1389	1507	15.95
S_{30}	1249	1521	1685	1899
S_{45}	1331	1605	1926	1809
SEm (±)	50			
C.D. (P=0.05)	145			

and its adequate availability has been found to have positive impact on growth, yield, nodule formation and activities of symbiotic nitrogen fixing bacteria. Similarly, increasing levels of sulphur increased the grain and straw yield of fenugreek up to 45 kg S /ha. This was 39.5, 19.1 and 5.0 per cent increase over 0, 15 and 30 kg S /ha. This could be due to adequate sulphur supply might have stimulating effect on the synthesis of chloroplast protein resulting in greater photosynthetic efficiency, which in turn increased the yield. This was truer when soil was poor in S status. Sulphur is an important structural constituent of amino acids and vitamins. It is shown to positively affect on plant growth, development and root nodulation which consequently enhances growth, yield attributes and seed yield. Contrary to seed yield, harvest index was enhanced up to 30 kg S/ha Among the different combinations, application of 40 kg P_2O_5 /haand sulphur at 45 kg S /ha significantly increase seed yield (1926 kg/ha), highest net returns (46352 /ha) and highest B/C ratio (3.36) of fenugreek. This was 154.8 per cent increase seed yield over control. This might be due to combined and sustained nutrient supply by phosphorus and Sulphur resulted in enhanced photosynthetic activity by the crop. This in turn resulted in higher values for yield attributes and yield (Table 2).

CONCLUSION

It was inferred from the above study that ona medium fertility clay loam soil, 40 kg P_2O_5 /ha in combination with 45 kg Sulphur /hacould be optimum in realizing higher seed yield (1926 kg/ha), net return(46 352/ha) and B/C ratio (3.36) in fenugreek.

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Response of growth and yield of basmati rice to zinc fertilization under sub-tropical foothill plains of Jammu region

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Rice (*Oryza sativa L.)* is one of the most important cereal crops. In India, rice ranks first among all the crops occupying 43.95 mha and production of 106.54 mt of rice with average productivity of 24.24 q/ha (Anonymous, 2015). Increasing productivity and production are essential to meet the food requirement of the burgeoning population. Zinc has emerged as the one of the plant nutrient limiting rice growth in several parts of the world. India, especially rice-wheat cropping system belt of North India is deficient in available Zinc (Shivay *et al*., 2010). Timely zinc fertilization is a most important to minimize the loss in yield and management of soil fertility through the use of Zn has also been found as effective. Hence, the present study was undertaken with the objective to assess the effect of zinc fertilization on growth and yield of basmati rice.

METHODOLOGY

A field experiment was conducted to study the effect of zinc fertilization on growth and yield of basmati rice at research farm of Division of Agronomy, SKUAST-Jammu (J&K) during the *kharif* season of 2015. The soil of the experimental field was sandy loam in texture, slightly alkaline

Table 1. Effect of zinc fertilization on plant height, dry matter and grain yield of basmati rice

Treatment		Plant height at harvest (cm)	Dry matter at harvest (g/m^2)	Grain yield (t/ha)
T_1:	Recommended N, P_2O_5 and K_2O @ 30, 20 and 10 kg/ha (Control)	123.40	856.95	2.76
T_2:	Control + 20 kg/ha $ZnSO_4.7H_2O$ soil applications	133.62	910.26	3.34
T_3:	2% Zn through ZnO coated urea + recommended P_2O_5 and K_2O	127.59	876.79	2.99
T_4:	2% Zn through $ZnSO_4.7H_2O$ coated urea + recommended P_2O_5 and K_2O	129.48	884.87	3.05
T_5:	4% Zn through ZnO coated urea + recommended P_2O_5 and K_2O	130.37	894.78	3.08
T_6:	4% Zn through $ZnSO_4.7H_2O$ coated urea + recommended P_2O_5 and K_2O	131.73	903.45	3.13
T_7:	0.2% Zn foliar spray (ZnO) + recommended dose N, P_2O_5 and K_2O	129.69	889.06	3.08
T_8:	0.2% Zn foliar spray ($ZnSO_4.7H_2O$) + recommended dose N, P_2O_5 and K_2O	130.58	898.23	3.11
T_9:	2% Zn through ZnO coated urea + 0.2% Zn foliar spray (ZnO) + Recommended P_2O_5 and K_2O	132.02	906.54	3.22
T_{10}:	2% Zn through $ZnSO_4.7H_2O$ coated urea + 0.2% Zn foliar spray ($ZnSO_4.7H_2O$) + recommended P_2O_5 and K_2O	132.97	908.57	3.33
T_{11}:	4% Zn through ZnO coated urea + 0.2% Zn foliar spray (ZnO) + recommended P_2O_5 and K_2O	133.90	913.39	3.38
T_{12}:	4% Zn through $ZnSO_4.7H_2O$ coated urea + 0.2% Zn foliar spray ($ZnSO_4.7H_2O$) + recommended P_2O_5 and K_2O	135.30	919.61	3.46
	SEm±	1.96	10.69	0.13
	CD (P= 0.05)	5.76	31.36	0.38

in reaction, low in organic carbon, available nitrogen and zinc and medium in available phosphorous and potassium. The experiment was laid out in randomized block design, replicated thrice with 12 treatments (Table 1). The source of fertilizers was urea, zinc coated urea ($ZnSo_4.7H_2O$ & ZnO), DAP, SSP and MOP. Full dose of phosphorus, potassium, soil applied zinc along with 1/2 dose of nitrogen fertilizers were applied as per treatments after the puddling and remaining dose of nitrogen fertilizer was broadcasted in one split at 30 DAT. Zinc was also applied as foliar spray (600 litre water + zinc) through zinc sulphate @ 0.2 % $ZnSO_{4.}7H_2O$ and zinc oxide @ 0.2 % ZnO at 40 DAT as per treatments. The rice variety 'Basmati-370' was used in the experiment. All recommended agronomic practices were followed throughout the crop period. The grain yield was recorded from the net plot area and expressed as t/ha.

RESULTS AND DISCUSSION

All the zinc fortification treatments significantly influenced the growth parameters and yield of basmati rice. Amongst the Zn fertilization treatments, significantly highest plant height of 135.30 cm was recorded where application of T_{12} (4% Zn through $ZnSO_4.7H_2O$ coated urea + 0.2% Zn foliar spray ($ZnSO_4.7H_2O$) + recommended P_2O_5 and K_2O) which was at par with T_{11}, T_2, T_{10}, T_9, T_6, T_8, T_5 and T_7. Almost a similar trend was also observed with respect to dry matter accumulation and yield in basmati rice. Highest basmati rice grain yield was observed to the tune of 3.46 t/ha with zinc application of 4% Zn through $ZnSO_4.7H_2O$ coated urea + 0.2% Zn foliar spray ($ZnSO_4.7H_2O$) + recommended P_2O_5 and K_2O. Which was might be due to increase in N availability through synchronized release from zinc coated urea which increased number of leaves, resulting in higher photosynthesis, metabolic activity and cell division, which consequently increased growth and hence yield (Jat *et al.*, 2011).

CONCLUSION

It was concluded that the application of 4% Zn through $ZnSO_4.7H_2O$ coated urea + 0.2% Zn foliar spray ($ZnSO_4.7H_2O$) + recommended P_2O_5 and K_2O owing to improved growth and yield of basmati rice (Basmati-370).

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Participatory nutrients management in *jhum* maize for enhancingcrop and soil productivity

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Jhum (shifting cultivation) is an agricultural system in which land is cultivated temporarily (3-5 years) and then abandoned for building soil fertility. Livelihood of the farmers is largely dependent on jhum cultivation as most of the agricultural produces for household comes from jhum area (Ramakrishna, 1984). Due to reduction of *jhum* cycle from 20-30 years in past to 3–5 years at present, land degradation in the form of soil erosion and soil fertility depletion is taking place at a massive scale in the region.The burning of biomass on jhum land releases huge CO_2 in to the atmosphere which is the major component in greenhouse gas and cause for climate change (Rastogi *et al.,* 2002). Maize occupies an important place in shifting cultivation. Maize crop is used as food for human and feed for animals, and cultivated entirely under rainfed condition. Growing local varieties, no fertilizer or manure application, improper crop establishment practices, soil erosion due to along the slopes cultivation and lack of pest and disease management practices are the major constraints of maize production under shifting cultivation. As a result, productivity of maize in jhuming hardly goes beyond 1 t/ha. The objectives of the present study were to identify efficient cultivars and soil fertility management practices for maize production in *jhum* condition.

METHEDOLOGY

The field experiment was conducted in the village Sonidan, District Ri Bhoi, Meghalaya during the *kharif* season of 2014 and 2015. The experimental field had pH 4.65, high in organic carbon (2.61 %), available nitrogen (313kg/ha) and low in phosphorus (31 kg P/ha) and medium in potassium (241kg K/ha).The experiment was laid out in a factorial randomized block design with treatment combination of three cultivars

Table 1. Effect of different cultivars and nutrient management practices on maize grain equivalent yield (MGEY) and soil available N, P and K at harvest

Treatment	System productivity (MGEY, t/ha)		Available N (kg/ha)		Available P (kg/ha)		Available K (kg/ha)	
	2014	2015	2014	2015	2014	2015	2014	2015
Cultivar								
JKMH 502 (Hybrid)	2.75	2.56	307.1	292.5	28.6	28.3	238.6	236.6
DA 61A (Composite)	3.07	2.86	301.5	291.1	28.4	28.6	238.2	236.2
Saru Bhoi (Local)	2.43	2.23	306.1	299.0	30.7	30.6	239.0	237.2
SEm±	0.09	0.08	4.06	5.03	0.34	0.30	2.34	3.09
CD (P=0.05)	0.27	0.23	NS	NS	0.98	0.88	NS	NS
Nutrient Management practice								
N1	2.13	1.91	291.7	274.6	28.1	28.0	230.6	228.1
N2	3.08	2.89	306.7	299.9	29.8	29.4	244.0	244.3
N3	2.77	2.59	315.1	309.9	30.0	29.8	240.5	239.0
N4	3.51	3.32	316.1	310.5	29.1	29.4	242.0	240.6
N5	2.26	2.03	294.9	276.3	29.1	29.1	235.8	231.5
SEm±	0.12	0.10	5.24	6.49	0.44	0.39	3.02	3.99
CD (P=0.05)	0.35	0.30	15.17	18.80	1.27	1.13	8.75	11.57

N_1-Farmers' practice (no manure or fertilizer application), N_2-Fertilizer application(40:13.1:16.7 kg N, P, K /ha+500 kg lime+2 t/ha FYM), N_3-Fertilizer+FYM (50% N from each for total supply of 40:13.1:16.7 kg N, P, K /ha+500 kg lime), N_4-Maize+groundnut intercropping (4:2 ratio) with N_3 and N_5-Foliar spray of DAP @ 2% on 30 and 60 DAS.

viz.,JKMH 502 (Hybrid), DA 61A (Composite) and Saru Bhoi (Local)] and five nutrient management practices *viz.,* N_1-Farmers' practice (no manure or fertilizer application), N_2-Fertilizer application(40:13.1:16.7 kg N, P, K /ha+500 kg lime+2 t/ha FYM), N_3-Fertilizer + FYM (50% N from each for total supply of 40:13.1:16.7 kg N, P, K /ha+500 kg lime), N_4-Maize+Groundnut intercropping (4:2 ratio) with N_3 and N_5-Foliar spray of DAP @ 2 % on 30 and 60 days after sowing (DAS). Entire dose of phosphorus (as single super phosphate) and potassium (as Muriate of potash) were applied as basal. Fertilizer N in the form of urea was applied in three equal splits *i.e.,* 1/3rd as basal, 1/3rd at knee height stage, and 1/3rd at tasseling stage. Two hand weedings were given at 20 and 45 DAS. All other recommended cultural practices for achieving maximum grain yield were followed. Observations on yield of maize recorded as per the standard procedures. Surface soil samples (0–30 cm) were collected from individual plots after the harvesting of crop. N, P and K content in soilwere analysed for following standard procedures. Similarly, maize grain equivalentyield(MGEY) was calculated as per the following formula.MGEY (t/ha) = Productivity of the component crop (kg/ha) x Price of component crop (Rs/kg)/Price of maize (Rs/kg).

RESULTS

Among the tested maize cultivars, the composite cultivar DA 61A recorded higher values of yield attributing characters as compared to hybrid and local cultivars during both years. This might be due to better adoptability of particular cultivars under jhum lands. Whereas, under nutrient management practices, application of fertilizer (40:30:20 kg N, P_2O_5, K_2O /ha along with 500 kg lime and 2 t/ha FYM) resulted in higher yield attributing parameters as compared to other nutrient management practices during both years of experimentation. The grain yield was obtained significantly higher under composite variety DA 61A (2.95 and 2.74 t/ha) as compared to hybrid (2.62 and 2.44 t/ha) and local (2.29 and 2.10 t/ha) cultivars during 2014 and 2015, respectively. MGEY was also recorded significantly higher under composite variety as compared to other cultivars for both the seasons of experiment (Table 1). With regards nutrients management practices, adoption of maize+groundnut intercropping (4:2 ratio) along with fertilizer+FYM (50% N from each for total supply of 40:13.1:16.7 kg N, P, K /ha+500 kg lime) recorded 64.9% and 73.8% higher MGEY over farmers practices during2014 and 2015, respectively.The effect of cultivars and nutrient management practices on post-harvest soil fertility (after harvest of maize) was significant on available P of soil. Whereas, the available P and K content in soil was recorded higher under cultivation of local cultivars as compared to cultivation of hybrid and composite for both the year of experiment. This might be due to poor yield of local cultivar, resulted in less mining of N, P and K from the soil. Among the nutrient management practices, the available N was recorded significantly higher under maize+groundnut intercropping (4:2 ratio) along with fertilizer + FYM (50% N from each for total supply of 40:13.1:16.7 kg N, P, K /ha+500 kg lime)as compared to farmers' practice during 2014 and 2015. The application of fertilizer+FYM (50% N from each for total supply of 40:13.1:16.7 kg N, P, K /ha, 500 kg lime, 2 t/ha FYM) recorded significantly higher available soil P as compared to other nutrient management practices during both the years. Thus, it is concluded that, cultivation of maize composite (DA 61A) and adoption of maize+groundnut intercropping (4:2 ratio) along with fertilizer +FYM (50% N from each for total supply of 40:13.1:16.7 kg N, P, K /ha, 500 kg lime, 2 t/ha FYM) is profitable practices for improving maize productivity in jhum lands. Therefore, cultivation of maize composite (DA 61 A) and groundnut in 4:1 ratio along with fertilizer +FYM (50% N from each for total supply of 40:13.1:16.7 kg N, P, K /ha, 500 kg lime, 2 t/ha FYM) is recommended for achieving better economic returns and enhancing fertility status of Jhum land in north East India.

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Extended Summaries Vol. 2 : 4th International Agronomy Congress, Nov. 22–26, 2016, New Delhi, India

Efficient nitrogen management in wheat (*Triticumaestivum*)using leaf colour chart and chlorophyll meter for optimizing growth and yield

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Nitrogen is essential primary nutrient and important limiting factordetermining the yield of wheat and together with rice; these two crops consume huge amount of nitrogenous fertilizers. However nitrogen use efficiency in rice and wheat is low.A world-wide evaluation shows that the fertilizer N recovery efficiency is around 30% in wheat with current practices (Krupnik*et al.,* 2004). The major reason of low N-use efficiency is fixed time splitting of N applications advocated in current recommendation, or N application is not synchronized with crop demand, as well as the use of nitrogen in excess to the requirement. A potential solution has been tried to regulate the timing of nitrogen application in rice and wheat using a chlorophyll meter or a LCC to determine the plant N needs (Singh *etal*., 2002). The concept is based on the result that show close link between leaf chlorophyll and nitrogen content. Study was carried out to standardize nitrogen management practices in wheat by using LCC and SPAD value, to investigate the effect of LCC and SPAD base nitrogen management practices on growth and yield of wheat, nitrogenuptake, nitrogen use efficiency and economics.

METHODOLOGY

A field experiment was conducted atGovindBallabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhandduring*rabi*season of 2014-15 in randomized block design (RBD) having 3 replications. Treatment consisted of different nitrogen management practices including control (no N), recommended N(50 kg at basal+50 kg at crown root initiation+50 kg at maximum tillering), 25 kg at basal+ 30 kg (at LCC 4,5 and SPAD 35, 40), 25 kg at basal+40 kg (at LCC 4,5 and SPAD 35, 40), 25 kg at basal+30 kg at CRI+30 kg at SPAD 40 and 25 kg at basal+40 kg at CRI+40 kg at SPAD 40. Wheat crop (var. HD2967) was sown on 14 November,2014.Normal package and practice was practiced for successful raising of the crop.The SPAD meter and LCC were used for measurements of ten topmost fullyexpanded leaves at 7 days interval at a specified time and averaged for each plot.

RESULT

Data pertaining to crop dry matter at 60, 90 DAS,grain yield, N uptake, recovery efficiency and net return is presented in Table 1.Crop dry matter, grain yield and total N uptake werehighest in recommended nitrogen (150 kg N/ha) management,however they were *at par* with nitrogen management included applicationof N as 25 kg at basal+40 kg(at LCC 4, 5 and SPAD 35, 40) and 25 kg at basal+40 Kg at CRI+40 kg at SPAD 40 (total 105 kg N/ha) with the saving of 30 percent (45kg/ha) nitrogen. This might be because of nitrogen application based on LCC and SPAD was done as per the crop need rather than at fixed time leads to synchronization of nitrogen supply with demand of crop and causedfavorable effect of N on cell division, tissue organization and photosynthetic rate that ultimately improved dry matter accumulationand grain yield.Treatment comprised of application of N as 25 kg at basal+40 Kg at CRI+40 kg at SPAD 40 statistically similar with N as 25 kg at basal+40 kg (at LCC 4, 5 and SPAD 35, 40) and recommended N management indicated that crop requires 40 kg N/ha at CRI stage under current season and situation and that can be applied as prescriptive dose without looking into the SPAD or LCC values for nitrogen application. However, this might change with time and cropping system followed. The total N uptake in SPAD and LCC-based N plot was slightly lower compared to the highest level of fixed-timing N plot, which might be attributed to less N application through the use of SPAD and LCC which also preserved N without any yield reduction.It was found that numerical value of recovery efficiencywas higher (22.1 percent) in treatments of application of N as 25 kg at basal+40 kg (at LCC 4,5 and SPAD35, 40), 25 kg at basal+40 Kg at CRI+40 kg at SPAD 40 (total 105 kg N/ha) than recommended nitrogen management treatment.Net returns was found highest (57986 Rs/ha) in recommended nitrogen management followed by treatment of N application as 25 kg at basal +40 kg at SPAD 40 (105 kg/ha).

CONCLUSION

It is thus concluded that 25 kg N as basal +40 kgN at SPAD 40 (105 kg/ha)resulted at *par* grain yield and higher recovery efficiency compared to recommended N (150kg N/ha), although higher net returns was obtained in the recommended N practice. There could be substantial fertilizer saving with use of real time N management.

Table 1. Effect of different treatments on crop dry matter, grain yield, N uptake, recovery efficiency and net returns in wheat

Treatment	Total dose of N (kg/ha)	Dry matter 60 DAS	Dry matter 90 DAS	Grain yield (t/ha)	Total N uptake (kg/ha)	Recovery efficiency	Net return (Rs/ ha)
Control (no N)	0	38	238	1.29	25.2	-	3558
Recommended	150	182	700	4.33	106.1	53.9	57986
*30 kg at LCC 4	85	116	578	2.63	59.0	39.7	32482
*40 kg at LCC 4	105	160	660	3.80	98.4	69.8	50299
*30 kg at LCC 5	85	120	581	2.73	64.0	45.6	34182
*40 kg at LCC 5	105	163	673	4.06	101.8	73.0	53819
*30 kg at SPAD 40	85	122	590	2.78	68.0	50.2	35132
*40 kg at SPAD 40	105	168	676	4.11	105.1	76.0	54694
*30 kg at SPAD 35	85	118	565	2.66	66.0	47.9	33267
*40 kg at SPAD 35	105	162	664	3.93	97.6	68.9	52034
*30 Kg at CRI+30 kg at SPAD 40	85	124	585	2.74	63.5	45.0	34377
*40 Kg at CRI+40 kg at SPAD 40	105	169	674	4.06	104.4	75.5	53894
SEm.±		11.0	22.2	0.19	5.52	-	-
CD (P=0.05)		32.2	65.3	0.57	16.19	-	-

*25 kg N/ha was applied as basal, recommended N 150 kg N/ha in 3 equal splits i.e. 50 kg/ha as basal, 50 kg/ha at crown root initiation (CRI) stage and 50 kg/ha at maximum tillering stage

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Extended Summaries Vol. 2 : 4th International Agronomy Congress, Nov. 22–26, 2016, New Delhi, India

Density and nitrogen effects on the interference and economic threshold of little seed canary grass (*Phalaris minor*) in wheat

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The major wheat producing countries are China, India, USA, France, Russia, Canada, Australia, Pakistan, Turkey, UK, Argentina, Iran and Italy. These countries contribute about 76% of the total world wheat production.India is the second largest producer of wheat after china and produced 94.5millontonnes ofwheat from 31.2 million ha acreage of land during 2014-15 (FAOSTAT, 2016).Wheat contributes major portion of food and nutritional security for vast population of India. Weed infestation is one of the major biotic constraints in wheat production. Growing high-yielding dwarf varieties of wheat has led to a shift in weed flora from broad-leaved weed dominance in 1960s to grass weed menace in early 1970sandlittleseed canarygrass (*Phalaris minor* Retz.) dominance in late 1970s. Littleseed canarygrasshas developed resistanceto isoproturon (Malik and Singh, 1993). The yield losses due to weeds vary depending on the weed species, their density and environment. Littleseed canarygrassis single most dominant grassy weed in northern Indian plains causing significant yield losses (Chhokar*et al.,* 2012).Heavy infestation of this weed might incur a complete crop failure.The longer and higher amount of herbicides application to control littleseed canarygrasslead to the development of resistance and create ground water pollutions as well as residues in crop produce. The use of herbicides can be minimised if the prediction of threshold level of littleseed canarygrass is possible. On the other handclimate change is anticipated to trigger differential growth in crops and weeds and may have more implications for weed management in crops and cropping systems.The growth factors, particularly, N may affect the interference and economic threshold (ET) of littleseed canarygrassin wheat but less studied in the context of climate change.The effect of littleseed canarygrassdensities on wheat in response to nitrogen (N) application may alter the crop-weed balance but hardly documented.

METHODOLOGY

The field experiment was conducted at Indian Agricultural Research Institute, New Delhi, India, during winter of 2015. The experiment was laid out in a split plot design with 3 replications consisting of 21 treatment combinations:3 N doses (100 kg N/ha, 150 kg N/ha and 180 kg N/ha) in main plotand4 little seed canary grass densities (10, 20, 40 and 80 plants/m^2) and 3 controls (unweeded control without little seed canary grass, unweeded control having mixed population and weed free check) in sub plots. The wheat variety HD 2967 was sown with seed-cum fertilizer drill by using 100 kg seed/ha at row spacing of 22.5 cm. The seed of little seed canary grass was broadcasted at the time of sowing to maintain the desired densities. The herbicide metsulfuron at 5 g /ha was used at 20 DAS of wheat in little seed canary grass plots to remove the broad-leaved weeds. All recommended package of practices were used to grow wheat crop including recommended dose of P and K. The data on little seed canary grass tillers and dry weight of weeds, and yield and yield attributes of wheat were recorded and analyzed statistically using the F-test as per the standard procedure. Weed density data were transformed with square-root transformation [“(x + 1.0)] before analysis.

RESULTS

All yield attributing characteristics of wheat viz., effective tillers, grains/spike and grain yield were significantly improved asthe doses of N increased from 100 to 180 kg /ha (Table 1). Significantly higher grain yield of wheat was observed with the application of 180 kg N/ha followed by 150 kg and 100 kg N/ha. Similarly littleseed canarygrassdensities also influenced yield and yield attributing characters of wheat. Increase in the density of littleseed canarygrassfrom10 plants/m^{2}to80 plants/m^2, the yield of wheat was reduced considerably. Theyield reduction was 2.3 to 21.3 % respectively over weedfree check. Tillers and dry weight of littleseed canarygrasswere also influenced by N doses and density. Higher number of tillers and dry weight of littleseed canarygrasswere observed under lower doses of nitrogen during harvest of wheat over higher dose of 150 and 180 kg N/ha. Significantly higher tillers and dry weight were observed under littleseed canarygrass density of 80 plants/ m^2. Several studies revealed that littleseed canarygrass competition with wheat was decreased at 120 and 160 kg N/ ha due to vigorous crop growth.Babu and Jain (2012) reported that at higher levels of nitrogen wheat suppressed the population of *Phalaris minor* and this weed become less competitive than wheat. The economic threshold (ET) of littleseed canarygrass determined using the quadratic equationwas ~ 6 to 11 plants/m^2 across the N doses (Table 2). The variations in growth of crop and weed, cost of control, products price, and herbicide efficiency across N-doses are

Table 1. Yield and yield attributes of wheat and dry weight and tillers of littleseedcanarygrass as influenced by N-doses and densities.

Treatment	Effective tillers/ m^2	Grains/ spike (Nos.)	Grain yield (t/ha)	Littleseed canary grass tillers/ m^2 at harvest	Dry weight of weeds (g/m^2) at harvest
Nitrogen dose					
100 kg N/ha	332^c	42^c	3.67^c	8.8(89)*	137.0
150 kg N/ha	398^b	46^b	5.00^b	7.5(63)	102.1
180 kg N/ha	450^a	50^a	5.74^a	6.2(43)	78.1
CD(P=0.05)	15	3.0	0.23	0.8(13)	24.0
Littleseed canarygrassdensity					
10 plants/m^2	429^{ab}	48^{ab}	5.46^a	5.1(26)	28.6
20 plants/m^2	411^{bc}	47^{bc}	5.20^b	6.8(47)	51.9
40 plants/m^2	389^{cd}	45^{bcd}	4.80^c	8.9(82)	84.7
80 plants/m^2	371de	44^{cde}	4.40^d	12.1(149)	134.4
Unweeded control without *littleseed canarygrass*	357^{ef}	42de	4.17^e	-	152.0
Unweeded control having mixed population	345^f	42de	4.02^e	4.5(20)	182.8
Weed free check	451^a	51^a	5.59^a	-	0
CD(P=0.05)	25	3.0	0.22	0.9(18)	19.9

Table 2. The economic threshold (ET) level of littleseedcanarygrassas influenced by nitrogen doses.

N-dose (kg/ha)	Regression equation	Economic Threshold level (plants/m^2)
100	$0.00000735T^2 – 0. 16365T – 1 = 0$	6.11
150	$0.00000997T^2 – 0. 1167T – 1 = 0$	8.56
180	$0.00000466T^2 – 0. 09181T – 1 = 0$	10.89

responsible for this variation in ET. Economic threshold based weed management can provide certain benefits like reduction in future weed populations and herbicide use.

CONCLUSION

Results of present study can be concluded that the higher dose of 180 and 150 kg N/ha proved beneficial towards reduction of little seed canary grass interference, however, higher density of little seed canary grass reduce the effect of N. The ET of little seed canary grass was 6, 9 and 11 plants/m^2 at 100, 150 and 180 kg N/ha respectively.

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Integrated nutrient management in rice-wheat cropping system

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Responsible application of chemical fertilizers in combination of organics, residue recycling, bio-fertilizers etc. is the focal aim at integrated nutrient management (INM) system. Long term fertilizer experiments involving intensive cereal based cropping systems reveal a declining trend in productivity even with the application of recommended levels of N, P and K fertilizers (Mahajan and Sharma, 2005). Such combination in INM is not only augmenting the crop productivity but also improves the physical, chemical and biological properties of soil. Thus, the system will become more sustainable in terms of productivity as well as environmental point of view. Addition of green manure or FYM with inorganic fertilizers to soil is proved to increase the efficiency of applied fertilizers resulting in higher removal of nutrients by the crops as compared to chemical fertilizers and build up of soil N, P, K, Zn and organic carbon. Keeping this in view, the present study was conducted to develop suitable integrated nutrient supply system for rice-wheat sequence involving more efficient use of fertilizer in conjunction with a judicious combination of organic manure by effective recycling techniques without detrimental effect on long term soil fertility and for improving crop productivity.

METHODOLOGY

The experiment was conducted at Norman E. Borlaug Crop Research centre (29°N, 79°E and altitude is 244 m above MSL), GBPUA&T, Pantnagar during 2014-15. The soil was sandy loam in texture having pH (7.3), organic carbon (0.67%), available N (296 kg/ha), available P_2O_5 (29 kg/ha) and available K_2O (185 kg/ha). The experiment following rice-wheat cropping system comprised of 12 treatments [T_1- Control (without fertilization) in both rice and wheat; T_2- 50% recommended NPK through fertilizersin both rice and wheat; T_3- 50% rec. NPK through fertilizers in rice and 100% rec. NPK through fertilizers in wheat; T_4- 75% rec. NPK through fertilizersin both rice and wheat; T_5- 100% rec. NPK through fertilizersin both rice and wheat; T_6- 50% rec. NPK through fertilizers+ 50% N through FYM in rice and 100 rec. NPK through fertilizer in wheat; T_7- 75% rec. NPK through fertilizers+ 25% N throughFYM in rice and 75% rec. NPK

Table 1. Effect of different treatment in system productivity, production efficiency and economics of the rice-wheat cropping system

Treatment	System Productivity (kg REY/ha/year)	PE kg/ ha/ day	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
T_1	4320	11.83	46560	62637	16077	1.34
T_2	5590	15.32	51560	80667	29107	1.56
T_3	6570	16.62	54060	95257	41197	1.76
T_4	6900	18.91	54060	100067	46007	1.85
T_5	8420	23.08	56560	121419	64859	2.14
T_6	9440	25.86	58060	136895	78835	2.36
T_7	9940	27.23	54810	144134	89324	2.63
T_8	8760	24.01	66060	127102	61042	1.92
T_9	8750	23.98	59560	126940	67380	2.13
T_{10}	9550	26.16	58060	138551	80491	2.39
T_{11}	9520	26.10	54810	146068	91258	2.66
T_{12}	8210	22.50	56560	119109	62549	2.11
SEm±	1410	0.39	-	362	363	0.007
CD (p=0.05)	4205	1.15	-	1042	1046	0.02

through fertilizer in wheat; T_8- 50% rec. NPK through fertilizers+ 50% through wheat straw in rice and 100% rec. NPK through fertilizer in wheat; T_9- 75% rec. NPK through fertilizers+ 25% N throughwheat straw in rice and 75% rec. NPK through fertilizer in wheat; T_{10}- 50% rec. NPK through fertilizers+ 50% N by green manure in rice and 100% rec. NPK through fertilizer in wheat; T_{11}- 75% rec. NPK through fertilizers+ 25% N by green manure in rice and 75% rec. NPK through fertilizer in wheat; T_{12}- Farmers' practice in both rice and wheat) was laid out in a randomized block design system with four replications. Recommended dose of $N:P_2O_5:K_2O$ was 120:60:40 kg/ha, whereas, in case of farmers' practice, dose of $N:P_2O_5:K_2O$ was 120:48:24 kg/ha respectively.Green manuring was donethroughgreengramstover. System productivity in terms of rice equivalent yield (REY), production efficiency (PE) and economics of the experiment were calculated.The experimental data were statistically analysed for the differential effect of treatments by applying 'Analysis of Variance' (ANOVA) technique for randomized block design as per the standard procedures.

RESULTS

Effect of different levels of nitrogen and its substitution by different organic sources on total productivity and production efficiency of the system are presented in table 1showing that the total system productivity (TSP) was the maximum when the recommended dose of fertilizers was substituted with 25% FYM followed by 50% substitution through greenmanuring, while, the minimum value of TSP was found when no fertilizer or organic manure was added. TSP increased with increasing doses of fertilizers and addition of organic manure. Similar trend of observation was recorded with production efficiency of the system as well. Addition of different organicmaterials like greengram green manure, FYM, wheat strawetc. enhanced the organic matter percentage of the soil thatplayed a key role for improving cropproductivity. These results corroborated the findings of Parmer and Sharma (2002) and Zaka*etal*. (2003). Economics of the experiment presented in table 1 representing that the gross return was highest in treatment getting 25% nitrogen through FYM followed by the treatment receiving 50% nitrogen through green manure. Cost of cultivation in general increased significantly when the recommended dose of fertilizer was substituted with organic sources and was reported to be highest in case of T_8 and T_9 receiving 50% and 25% nutrients through wheat straw. Net return and benefit: cost ration were the maximum in treatment receiving 25% nutrients through green manuring, followed by treatment receiving 25% nutrition through FYM.

CONCLUSION

From the experiment it can be concluded that substitution of chemical fertilizers to the tune of 25% through FYM or green gram straw has resulted into higher productivity of the rice-wheat cropping systemand makes the system most economic through retuning more net monetary values.

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Influence of preceding legumes, N levels and irrigation schedules on the performance of *rabi* sorghum

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Sorghum is considered as the king of millets and extensively grown both for grain as food, animal feed and stalks as animal fodder. *Rabi* sorghum is gaining popularity in Andhra Pradesh from the recent past. However, development of agrotechnology for *rabi* sorghum is at infancy stage. The low yield potential of *rabi* sorghum is attributed mainly due to moisture stress cycles, during the flowering and grain formation stages. Application of one or two supplemental irrigations during such stress cycles gives a manifold increase in the grain yield of *rabi* sorghum (Bhoi and Jadhav, 1986).

METHODOLOGY

The field experiment was conducted during *rabi* 2013-14 at Indian Institute of Millet Research, Rajendranagar, Hyderabad, India. The soil was clay loam in texture with pH of 7.7 and EC of 0.38 dS/m, low in organic carbon (0.23%), low in available N (162 kg /ha), medium in available phosphorus (29.1 kg P_2O_5 /ha) and available potassium (282.8 kg K_2O /ha). The experiment was laid out in strip-split plot design with three replications. There were four strips of legumes in *kharif viz.*, dhaincha, green gram, cowpea and fallow. Sorghum was sown in split plot layout in each strip in the following *rabi* with four main plots of irrigation and four sub-sub plots of nitrogen levels. Dhaincha was grown till the commencement of flowering and then incorporated. The greengram pods were picked for grain and haulms were then turned down into the soil. The cowpea foliage was harvested for fodder and the stubbles turned down into the soil for decomposition. The irrigations were scheduled at critical stages *viz.*, panicle initiation, boot leaf stages anthesis and milk stage of grain sorghum. The levels of nitrogen were 0, 30, 60 and 90 kg /ha.

Table 1. Performance of *rabi* sorghum as influenced by preceding legumes, irrigation schedules and nitrogen levels

Treatment	Plant height (cm)	Dry matter (kg/ha)	Panicle length (cm)	1000 grain weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)
Preceding legume in kharif						
Sorghum preceded by Dhaincha	217.2	9151	18.2	25.9	3024	6127
Sorghum preceded by Greengram for seed	217.3	9005	17.8	25.8	2942	6063
Sorghum preceded by Cowpea for fodder	213.3	8946	18.5	26.1	2947	5999
Sorghum preceded by Fallow	208.3	8949	17.9	25.6	2930	6019
CD (P=0.05)	6.8	236	0.2	NS	85	29
Irrigation schedule						
Panicle initiation	201.1	8700	16.6	24.4	2870	5830
PI and booting	209.9	8882	17.6	25.3	2929	5953
PI, booting and anthesis	217.5	9138	18.7	26.5	2997	6141
PI, booting, anthesis and milk stage	227.6	9333	19.5	27.2	3047	6286
CD (P=0.05)	5.8	47	0.2	2.4	22	131
N level (kg/ha)						
No Nitrogen	190.1	7777	15.9	22.8	2466	5311
30	210.6	8719	17.5	25.1	2886	5833
60	222.5	9560	18.7	27.0	3222	6338
90	232.8	9995	20.3	28.5	3269	6726
CD (P=0.05)	13.0	619	1.4	4.1	199	484

The test varieties of dhaincha as green manure, greengram for seed and cowpea for fodder were *Sesbania cannabina*, LGG-407 and EC - 4216 respectively, while the test variety of sorghum was SPV-2048 (Phule Suchitra).

RESULTS

Significantly higher grain (3024 kg /ha) and stover yields (6127 kg /ha) were recorded in the treatment where *in-situ* incorporation of *dhaincha* was done (Table 1). This was mainly owing to significantly higher dry matter production. However, this treatment was found to be at par with that of greengram (seed) and cowpea (fodder). Dhaincha harvested at the beginning of flowering was succulent with high moisture content, maximum nutrient accumulation in the foliage and expected optimum C: N ratio of about 25. This was ideal for early decomposition. The haulms of greengram were less succulent and more lignified because of their incorporation late at maturity when the pods were harvested. The stubbles of cowpea added least biomass to the soil. Confirming the positive role of residual effect of legumes, Mahadkar and Saraf (1988) recorded significant improvement in the dry matter production of sorghum by the incorporation of blackgram haulms in the preceding season. Further, scheduling irrigation at critical stages *viz.,* panicle initiation, booting, anthesis and milk stage produced significantly taller plants with higher dry matter, longer panicles and 1000 grain weight. Additional mean grain yield of 67, 133 and 184 kg /ha was obtained due to 2, 3 and 4 irrigations over 1. Maximum stover yield of 6286 kg /ha was obtained when the soil was not deprived of moisture stress at panicle initiation, boot leaf, anthesis and milk stage of grains. Kambale (1983) reported that irrigation at grand growth stage increased the plant height and dry matter of the crop. Nitrogen improved the yield components remarkably. A low dose of 30 kg /ha N increased the yield attributes. These components showed further improvement to high level of nitrogen and the maximum response was at 90 kg /ha N. All the growth parameters and yield attributes thus seed (3269 kg /ha) and stover yields (6726 kg /ha) significantly higher due to application of 90 kg N /ha. However, it was at par with that of 60 kg N /ha. These both were significantly superior to 30 kg N /ha and control. Control was found to significantly inferior to all three N doses.

CONCLUSION

It is inferred that *in situ* incorporation of *dhaincha* age in and application of irrigation at critical stages along with 60 kg N /ha to *rabi* sorghum can be advocated for achieving higher seed and stover yields.

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Optimizing manurial requirement for greengram under system of pulse intensification (SPI)

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Planting geometry has influence on canopy development as well as light interception. Ideal plant geometry is precious and important for better and efficient utilization of available plant growth resources in order to get maximum productivity in crops. Vermicompost is known to play an important role in improving the fertility and productivity of soils through its positive effects on soil physical, chemical and biological properties and balanced plant nutrient. Foliar spray of TNAU pulse wonder helps to decrease the flower shedding and increases the drought tolerance along with 20 per cent yield increases. Spraying Pink-pigmented facultative methylotrophs (PPFM) is also said to influence the crop growth by producing plant growth regulators like zeatin and related cytokinins and auxins. The yield and economics were increased by optimization of plant geometry and nutrient management under irrigated condition.

MEHTODOLOGY

The field experiments were conducted during 2014-15 and 2015-16 at research farm of Agricultural College and Research Institute, Madurai to assess the effect of Integrated Nutrient Management (INM) on the performance of green gram (*Vigna radiata)* under System of Pulse Intensification (SPI). The experiment comprised of nine treatments of three plant geometry *viz.,* 25 x 25 cm, 30 x 30 cm and 30 x 10 cm and four INM package viz. STCR based fertilizer application alone and in combination with $ZnSo_4$, pulse wonder, PPFM spray and RDF + vermicompost + $ZnSo_{4.}$

RESULTS

Results showed that the application of STCR based fertilizer (33:30:25 kg/ha) + $ZnSO_4$ (25 kg/ha) + Pulse wonder (5 kg/ha) + PPFM (500ma/ha) under plant geometry of 25 x 25 cm recorded significantly higher seed yield (846 kg/ha), net income of Rs. 24055 per ha along with maximum BCR of 2.58. Whereas conventional method of 30 x10 cm spacing with application of RDF + Vermicompost + $ZnSo_4$ registered lower seed yield (563 kg/ ha) and BCR (2.01).

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Growth and yield of specialty corn as influenced by zinc fertilisation

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Maize (*Zea mays L.*) is emerging as third important cereal crop in the world after wheat and rice. It is called as "Queen of cereals", due to the high productiveness, ease to process, low cost than other cereals (Jaliya *et al.*, 2008), besides serving as human food and animal feed with wide industrial application. Specialty corn like Pop corn and Sweet corn are popular snack foods whereas Quality protein maize (QPM) is important since it was enriched with tryptophan and lysine which provide nutritious food and feed for poultry, cattle and to poor people particularly for those with maize as staple food, thereby providing food and nutritional security. Continuous intensive cropping of high yielding crop varieties has further aggravated the depletion of soil zinc leading to low zinc concentration in edible grains. Biofortification is a process in which plants are allowed to take up the minerals (Zn) from the soils and immobilize them in the grains so as to produce nutritionally rich grains that support dietary requirement of humans. A field experiment was carried out to study the influence of biofortification with zinc in specialty corn at Agricultural Research Institute (ARI), Rajendranagar during *kharif* 2013 to study the influence of soil and foliar applied zinc on growth and yield of specialty corn and to evaluate the concentration of zinc in leaves and grains of specialty corn.

METHDOLOGY

A field experiment entitled "Biofortification with zinc in Specialty corn" was conducted during *Kharif*, 2013 at ARI, Maize Research Centre, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad, Andhra Pradesh. The experimental soil was sandy loam in texture with pH (8.2), EC (0.56 dS/m) and OC (0.42%). The soil was low in available nitrogen (196 kg /ha), high in phosphorus (31.21 kg /ha) and potassium (201 kg /ha). The experiment was laid out in a Randomized Block Design and replicated thrice, treatments comprised of three Speciality corns like Pop corn, Sweet corn, QPM and six zinc levels like Zn_0: Control (Only Recommended dose of fertilizer), Zn_1: 12.5 kg $ZnSO_4$ /ha as Soil application, Zn_2: 25 kg $ZnSO_4$/ha as Soil application, Zn_3: Zn_1 + 2 Foliar sprays at tasseling and milking stage ($ZnSO_4$ application @ 2g/l of water), Zn_4: Zn_2 + 2 Foliar sprays at tasseling and milking stage ($ZnSO_4$ application @ 2g/l of water), Zn_5: 2 Foliar sprays ($ZnSO_4$ application @ 2g/l of water) at tasseling and milking stage. A uniform dose of NPK (180 kg N – 60 kg P_2O_5 – 50 kg K_2O /ha) as per the recommendation was applied to all the treatments.

RESULTS

Among the three types of corn (Pop corn, Sweet corn and QPM) the growth parameters (plant height, leaf area index) linearly increased at all the growth stages. Dry matter production is high in Sweet corn as this is harvested in green cob stage. Similarly, soil application of 25 kg $ZnSO_4$/ha along with 2 foliar sprays at tasseling and milking stage (Zn_4) had significantly improved plant height, leaf area index and dry matter production followed by all other Zn treatments. In case of yield (grain/green cob yield and stover/green fodder yield), green cob yield of Sweet corn was significantly high due to high moisture content while the higher and lower grain yield was recorded with QPM and Pop corn respectively. Likewise among three Specialty corn, Sweet corn produced maximum

Table1. Growth parameters and yield of specialty corn as influenced by soil and foliar application of zinc

Treatment	Plant height (cm)	Leaf area index (LAI)	Dry matter production (kg/ha)	Grains/green cob yield (kg/ha)	Stover yield (kg/ha)
Specialty corn type					
Pop corn	184.11	1.701	7842	3114	4875
Sweet corn	181.52	2.028	9372	4459*	5657*
QPM	199.43	4.133	8703	3681	5077
SEm±	3.98	0.052	97	73	53
CD (P=0.05)	11.44	0.151	279	210	153
Zinc level					
Zn_0 (Control, only recommended dose of fertilizer)	180.44	2.177	8122	3451	4847
Zn_1 (12.5 kg $ZnSO_4$ /ha as Soil application)	185.94	2.272	8464	3631	5064
Zn_2 (25 kg $ZnSO_4$ /ha as Soil application)	195.86	2.891	9176	4015	5409
Zn_3 (Zn_1 + 2 Foliar sprays at tasseling and milking stage)	187.42	2.783	8553	3787	5249
Zn_4 (Zn_2 + 2 Foliar sprays at tasseling and milking stage)	197.24	3.416	9255	4101	5677
Zn_5 (2 Foliar sprays at tasseling and milking stage)	183.23	2.184	8264	3522	4972
SEm±	5.63	0.074	137	103	75
CD (P=0.05)	NS	0.214	394	297	217
Interaction (C × Zn)	NS	NS	NS	NS	NS

*Fresh weight was recorded as it is harvested for green cobs purpose.

green fodder yield compared to QPM and Pop corn. Soil application of 25 kg $ZnSO_4$/ha along with 2 foliar sprays at tasseling and milking stage (Zn_4) recorded significantly higher yield attributes and yield followed by other graded levels and control. Green cob yield of Sweet corn increased significantly due to increased moisture content. Maximum green cob yield of 4459 kg/ha was recorded with Sweet corn, while the higher and lower grain yield of 3681 and 3114 kg/ha was recorded with QPM and Pop corn respectively. The higher yield 4101 kg/ha was produced with Zn_4, while lower yield of 3451 kg/ha was recorded with Zn_0(Table 1). Zinc has beneficial effect on physiological process, plant metabolism, growth, there by leading to higher grain or green cob yield. The nutrients also enhance the carbohydrates supply to kernels, increasing yield components like cob length, cob girth and number of grains row^{-1}, which have direct influence on grain yield and green cob yield. The interaction effect in growth parameters and yield was not found significant by graded levels of Zn in three types of corn.

CONCLUSION

Soil and foliar applied zinc significantly influenced the growth parameters and yield. Soil application of 25 kg $ZnSO_4$ /ha along with 2 foliar sprays at tasseling and milking stage (Zn_4) recorded higher growth and yield but it was on par with soil applied 25 kg $ZnSO_4$/ha (Zn_2) alone. Among the three types of corn (Pop corn, Sweet corn and QPM) tested, Sweet corn registered higher growth and yield compared to other two types QPM and popcorn.

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Integrated nitrogen management in ramie (*Boehmeria nivea*) in Indo-Gangetic plain of West Bengal

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Ramie is an important perennial herbaceous bast fibre crop largely grown in the north-eastern states of India. Due to a small area under cultivation in the north-east, production of ramie fibre is insufficient to meet the domestic demand and India has to depend largely on import of this fibre. Therefore, the area under ramie cultivation in the country needs expansion. For normal growth, ramie plants annually remove large amount of nutrients from the soil and leave considerable quantity of waste material following extraction of the fibre (Mitra *et al*., 2013). If the waste is composted and added back to soil, nutrients present in it may be utilized by the following ramie crop. A field experiment was conducted at the research farm of ICAR-CRIJAF, Barrackpore for three years to study growth and fibre production potential of ramie in the Indo-gangetic plain of West Bengal and to examine response of ramie to application of N through chemical fertilizers and organic manures (farm yard manure and ramie compost).

METHODOLOGY

The experiment was conducted in the Research Farm of ICAR-CRIJAF, Barrackpore, West Bengal during 2011 to 2013. Soil of the experimental site was sandy loam in texture with 0.6% organic C, 243 kg/ha available N, 32.5 kg/ha Olsen P, and 162 kg/ha neutral (N) ammonium acetate extractable K. Ramie crop was established by planting rhizome cuttings of ramie cultivar R-67-34 at 0.6 m x 0.3 m spacing. Ramie stalks were harvested 3 to 4 times a year by cutting the 1 to 1.5 m long stems just above the lateral roots (just before or at start of flowering). A uniform dose of 6.6 kg P and 12.5 kg K/ ha was applied to all the plots after each cutting of ramie while nitrogen was applied as per the treatments of the experiment. The experiment was conducted on fixed plots with 6 nitrogen management treatments laid out in a randomized block design with four replications. The nitrogen management treatments were: T_1: 100% recommended dose of nitrogen (RDN) supplied through chemical fertilizer (30 kg N/cut/ha); T_2: 150% RDN with 25% of N supplied through farm yard manure (FYM); T_3: 150% RDN with 25% of N supplied through ramie compost (RC); T_4: 150% RDN with 50% of N supplied through FYM; T_5: 150% RDN with 50% of N supplied through RC and T_6: 150% RDN supplied through chemical fertilizer (45 kg N/cut/ha). The waste biomass generated during fibre extraction of ramie was used to prepare ramie compost. Total N, P and K content of the ramie compost (on oven-dry weight basis) prepared was 1.50-2.50, 0.20-0.35 and 0.70-0.80%, respectively. Total N, P and K content of the FYM (on oven-dry weight basis) used in the experiment was 0.70-0.80, 0.25-0.32 and 0.75-0.87%, respectively. Fibre was extracted from the defoliated stems using a decorticator machine and raw fibre was then washed with clean water to remove gum to certain extent. The plant and soil samples were analyzed following standard procedures.

RESULTS

At recommended level of fertilizer nitrogen application (30 kg N/ha/cut), mean annual fibre yield of ramie at Barrackpore was 1.23 t/ha which significantly increased to 1.79 t/ha when the dose of fertilizer nitrogen application was raised by 50%. Substitution of 25% fertilizer nitrogen either by farm yard manure (FYM) or ramie compost (RC) did not have significant adverse effect on annual fibre yield of ramie while substitution of 50% fertilizer nitrogen with organics reduced the fibre yield of ramie. Maximum fibre yield of ramie was recorded with 150% recommended fertilizer nitrogen (45 kg N/ha/cut) treatment in all the three years though the yield was statistically at par with that of the integrated nitrogen management treatments where 25% of the fertilizer nitrogen was substituted with either FYM or ramie compost (in 2012 and 2013, and also when three years data were pooled). As the source of nitrogen for ramie, no significant difference was observed between farm yard manure and ramie compost. Compared with recommended dose, application of 150% recommended dose of nitrogen fertilizer to ramie resulted in significant increase in availability of N in the soil. Available N in the soil receiving integrated nitrogen management treatments T_4 and T_5 (50% of N supplied through FYM or ramie compost) were statistically comparable with that of sole fertilizer nitrogen treatment T_6.

CONCLUSION

Application of 45 kg nitrogen/ha/cut to ramie, with 25% of this nitrogen supplied through farm yard manure or ramie compost, produced mean annual fibre yield of 1.79 t/ha and sustained soil nitrogen fertility in Indo gangetic plain of West Bengal.

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Growth and yield of specialty corn as influenced by zinc fertilisation

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Maize (*Zea mays L.*) is emerging as third important cereal crop in the world after wheat and rice. It is called as "Queen of cereals", due to the high productiveness, ease to process, low cost than other cereals (Jaliya *et al.*, 2008), besides serving as human food and animal feed with wide industrial application. Specialty corn like Pop corn and Sweet corn are popular snack foods whereas Quality protein maize (QPM) is important since it was enriched with tryptophan and lysine which provide nutritious food and feed for poultry, cattle and to poor people particularly for those with maize as staple food, thereby providing food and nutritional security. Continuous intensive cropping of high yielding crop varieties has further aggravated the depletion of soil zinc leading to low zinc concentration in edible grains. Biofortification is a process in which plants are allowed to take up the minerals (Zn) from the soils and immobilize them in the grains so as to produce nutritionally rich grains that support dietary requirement of humans. A field experiment was carried out to study the influence of biofortification with zinc in specialty corn at Agricultural Research Institute (ARI), Rajendranagar during *kharif* 2013 to study the influence of soil and foliar applied zinc on growth and yield of specialty corn and to evaluate the concentration of zinc in leaves and grains of specialty corn.

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RESULTS

Among the three types of corn (Pop corn, Sweet corn and QPM) the growth parameters (plant height, leaf area index) linearly increased at all the growth stages. Dry matter production is high in Sweet corn as this is harvested in green cob stage. Similarly, soil application of 25 kg $ZnSO_4$/ha along with 2 foliar sprays at tasseling and milking stage (Zn_4) had significantly improved plant height, leaf area index and dry matter production followed by all other Zn treatments. In case of yield (grain/green cob yield and stover/green fodder yield), green cob yield of Sweet corn was significantly high due to high moisture content while the higher and lower grain yield was recorded with QPM and Pop corn respectively. Likewise among three Specialty corn, Sweet corn produced maximum

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Effect of different methods of rice cultivation and fertilizer doses vis-à-vis SRI

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More than 90 % of the world's rice production is from Asia. Rice accounts for about 35 to 75 % of the calories consumed by more than 3 billion Asians. In India, rice is grown in area of 44.1mha with a production of 107 mt and a productivity of 3.58 t/ha. To assure food security in the rice consuming areas of the world, rice production should be increased in these countries by 2025. Among the various methods of rice cultivation, the SRI (System of Rice Intensification) method was reported with doubling of rice yields. Keeping the above realities, the present study was planned to evaluate different methods of rice planting methods with various sources and levels of fertilizer application to evaluate the certain methods of rice cultivation to that of SRI.

METHODOLOGY

A field experiment was conducted at Annamalai University Experimental Farm, Annamalainagar with rice variety ADT-43 under split plot design during *kuruvai* season (short season) 2015 (July-October). The soil of the experimental field was clay, low in available N, medium in available P_2O_5 and high in available K_2O.Wet nursery and 'mat' nursery were prepared for conventional and SRI methods respectively. The seed rate adopted were 5 kg /ha, 60 kg /haand 40 kg /ha for SRI, drum seeding and conventional (random) transplanting methods respectively, that constituted the main plot treatments and the sub plot treatments were six (vide Table 1). In SRI method, seedlings were raised in the *dapog* nursery with recommended seed rate and transplanted in the specified plots with 12 days old seedlings @ one seedling/hill under moist soil with a spacing of 25 cm x 25 cm and in drum seeding method, too a similar spacing was adopted whereas 28 days old seedlings were used in conventional method. Recommended dose of N, P and K was applied as urea, SSP and MOP, respectively as per the treatment schedule.

RESULTS

All the growth parameters viz., root volume at flowering stage, plant height at harvest, tiller number as well as yield determining factors *viz.*, panicle number and filled grains number were positively influenced by both the main and sub treatments (Table 1). SRI method recorded the maximum values regardless of the parameter observed while, it was

Table 1. Effect of planting methods and nutrient management practices on growth and yield of rice var. ADT-43

Treatment	Plant height at harvest (cm)	Tiller number /m²	Root volume (cc)	Panicle number /m²	Filled grains/ panicle	Grain yield (kg/ha)	BCR
Planting method							
SRI	89.08[a]	443[a]	23.93[a]	305[a]	128[a]	5934[a]	3.73
Drum seeding	76.34[c]	260[c]	13.19[c]	205[c]	89[c]	2642[c]	1.58
Conventional	82.34[b]	398[b]	19.54[b]	254[b]	102[b]	3778[b]	1.60
SEm±	1.148	10.407	0.279	6.3	2.463	115.79	NA
CD (P=0.05)	3.187	29	0.776	17	6.874	321.5	NA
Nutrient management practice							
100%RDF	87.57[ab]	423[ab]	20.32[ab]	290[ab]	117[ab]	5091[ab]	3.00
100% N through Vermicompost (N-Equivalent basis)	78.63c	364[c]	17.91[c]	248[c]	95[c]	3374[c]	1.50
50% N through vermicompost+ 50% N through fertilizers(N-Equivalent basis)	84.61[b]	397[b]	19.55[b]	276[b]	111[b]	4766[b]	2.62
150%RDF	88.75[a]	430[a]	21.53[a]	303[a]	125[a]	5424[a]	3.19
Control (No fertilizer)	73.38[e]	220[d]	15.13[d]	157[d]	85[d]	1934[d]	1.39
SEm±	1.918	15.906	0.453	10.05	4.23	178.035	NA
CD(P=0.05)	3.959	33	0.935	21	8.74	321.5	NA

NA- NOT STATISTICALLY ANALYSED; Means in a column followed by a same alphabet is not statistically different from one another followed by conventional method and the least was with drum seeding. Among different sources and levels of nutrients tried, irrespective of the parameter, though, 150% RDF recorded the maximum values it was on par with 100% RDF. It is noteworthy to observe that 50% substitution of N with organic source also produced similar effect as that of 100% RDF through fertilizers. Also, application of organic as vermicompost alone could not pull up the yield significantly. SRI increased the grain yield to 5.9 t/ ha which was 56 and 124 % higher than that of random transplanting and *drum* seeding respectively. Similarly, the yield increase with 100% RDF (50% inorganic and 50% organic source) compared to 100% organic source was 41%. The highest BCR was also with SRI method of rice cultivation (3.73). Wide fluctuations in growth attributes among the different methods of sowing were earlier demonstrated by Chandrapala*et al*. (2010). The yield increase with nutrient levels showed a sluggish response, after once, it attained the 100% RDF level. In all, integrated source of nutrients performed satisfactorily in increasing the yield compared to the other sources. The results underline the point that, increasing the dose of fertilizers above 100% RDF was not suggestive and further it was spotted that, within 100% RDF, integration of organics viz., vermicompost with fertilizers at 50% level on N equivalent basis proved to augment the rice yield. JoeliBarison (2002) reported, that, greater nutrient uptake might be due to some increase of available N in the soil as a result of higher mineralization of organic-N in a soil environment that alternates aerobic and anaerobic conditions.

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Effect of various sources of nutrition on yield and yield attributes of rice (*Oryza sativa*)

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Rice (*Oryzasativa* L.) is one of the most important cereal crops of the world as its forms the staple diet of 70 percent of the world's population (Sahu*et al.,*2014). Rice is the premier food crop of India and therefore, national food security system largely relies on the productivity of rice in different agro-ecosystems. The conjunctive application of organics with inorganic sources of nutrient reduces the dependence on chemical inputs and it not only acts as a source of nutrient but also provides micronutrient as well as modifies the soil physical behaviour and increases the efficiency of applied nutrients (Pandey*et al*., 2007). Utilization of indigenous organic sources, *viz*. farmyard manure (FYM), obnoxious weeds and green leaf manures may serve as alternatives or supplements to chemical fertilizers, and help in increasing the productivity of the rice-based cropping system in all zones of the country.Organic manures play a vital role in sustaining higher productivity in intensive agriculture and irrigated rice in particular.Keeping above facts in view, the present investigation was taken to study the effect ofeffect of various sources of nutrition on yield attributes and yield of rice (*Oryzasativa* L.).

METHODOLOGY

The field experiment was conducted during rainy seasons in 2014 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University,Varanasi. The soil of experimental site was sandy clay loam in texture, neutral in reaction (pH7.5), low in organic carbon (0.34%), available nitrogen (198.45 kg/ha), medium in available phosphorus (23.64 kg/ha) and available potassium (206.4 kg/ ha). The experiment was laid out in randomized block design having 12 treatments *viz.* Control (T1),100% RDF (T2), T2 + FYM @ 5 t/ha (T3), T2 + Vermicompost @ 5 t/ha(T4), T2 + Press mud @ 5 t/ha(T5), T3 + *Trichoderma* compost @ 2.5 kg/ha(T6), T3 + *Trichoderma*compost @ 5.0 kg/ha(T7), T3 + *Trichoderma* compost @ 7.5 kg/ha (T8), T4 + *Trichoderma*

Table1. Effect of different organic sources of nutrient on yield attributes and yield of rice.

Treatments	Panicle length (cm)	Panicle weight (g)	Panicles/ m^2	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
T_1	18.18	2.67	107.47	21.50	3900	5800	
T_2	19.33	2.75	111.23	21.63	4000	5990	40.04
T_3	20.00	2.88	116.30	21.90	4130	6100	40.38
T_4	20.33	2.95	118.42	22.00	4200	6160	40.54
T_5	19.62	2.80	113.83	21.80	4083	6045	40.31
T_6	22.03	3.21	124.53	22.43	4617	6530	41.42
T_7	23.00	3.28	125.50	22.53	4820	6600	42.26
T_8	23.80	3.34	127.47	22.63	4900	6767	42.00
T_9	24.03	3.39	129.70	22.73	5185	6820	43.24
T_{10}	24.10	3.45	131.43	22.90	5290	6933	43.28
T_{11}	25.05	3.50	133.20	22.93	5400	7000	43.56
T_{12}	20.95	3.02	120.18	22.10	4333	6250	40.90
T_{13}	21.03	3.08	121.63	22.20	4412	6313	41.13
T_{14}	21.46	3.10	123.04	22.30	4507	6400	41.33
SEm$\pm$	0.54	0.06	0.80	0.08	56	112	0.55
CD (P=0.05)	1.57	0.18	2.31	0.23	163	327	NS

compost @ 2.5 kg/ha(T9), T4 + *Trichoderma* compost @ 5.0 kg/ha (T10), T4 + *Trichoderma* compost @ 7.5 kg/ha (T11), T5 + *Trichoderma* compost @ 2.5 kg/ha (T12), T5 + *Trichoderma* compost @ 5.0 kg/ha (T13), T5 + *Trichoderma*compost @ 7.5 kg/ha (T14) and replicated thrice. Recommended fertilizer 120:60:60 kg/ha of N, P_2O_5 and K_2O, respectively as per recommendation were applied through Urea, DAP and muriate of potash as per treatments. Half dose of nitrogen and full dose of phosphorus and potassium were applied basally. Remaining half dose of N was applied in two equal splits once at tillering stages and rest panicle initiation stages. However, vermicompost, *Trichoderma*compost, FYM and press mud was applied at the time of transplanting.Seedlings of 25 days of 'MTU 7029' Rice were transplanted, keeping 2-3 seedling/hill at 20 X 15 cm spacing on 30 June in 2014 under puddle conditions. The crop was harvested at the mid of November**.**The other agronomic practices were followed as per standard recommendations**.**

RESULTS

Result revealed that the application of organic sources of nutrient increased the yield attributes and yield. Application of 100% RDF + Vermicompost @ 5 t/ha+ Trichoderma compost @ 7.5 kg/ha significantly recorded higher yield attributes viz, number of panicle/m^2 (133.2), panicle length (25.1cm), panicle weight (3.5 g) and 1000 grain weight (22.9 g) and followed by treatment 100% RDF + Vermicompost @ 5 t/ ha+ Trichoderma compost @ 5 kg/haand significantly superior over control. The minimum yield attributes viz, number of panicle/m^2 (107.5), panicle length (18.2 cm), panicle weight (2.67 g) and 1000 grain weight (21.50 g) were recorded in control.Similar finding were also reported by Chaudhary*et al. (*2011). This might be due to organic sources acting as slow release source of N are expected to more closely match with N and supply of other nutrients with demand of rice crop and this could reduce the N losses and also improved the nutrient use efficiency particularly of nitrogen therefore, inorganic fertilizers in combination with organic manures caused the greater translocation of photosynthates from source to sink site that resulted higher yield contributing characters of rice. Significantly higher grain yield (54 q/ha) and straw yield (70q/ha) were recorded under of 100% RDF + Vermicompost @ 5 t/ha+ Trichoderma compost @ 7.5 kg/ha. Integration of organic sources might have increased the N content of the plants which ultimately influenced the protein yield favourably.Minimum grain yield (3.9 t/ha) and straw yield (5.8 t/ha) were recorded under control.

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Response of soybean to foliar application of nutrients and its economics

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Soybean [*Glycine max* (L.) Merrill] is globally cultivated important oilseedand legume crop, containing 18-20% edible oil and high quality protein (38-40%). It is highly adaptable to varying soil and climatic conditions, giving fairly high yield compared to other pulse crops. In India it was cultivated on an area of 11.06 mha with 667 kg/ha productivity. Maharashtra ranks at the second position after Madhya Pradesh in area and production. Hence, in order to obtain the sustainable soybean yield, precise and site specific application of nutrients is necessitated. Soil application of nutrients undergo several changes and vulnerable to losses through leaching and volatilization. In order to avoid or minimize severity of such condition, foliar application of nutrients is imperative. Hence, the crop needs nutrient supplementation to get better yield through foliar application of macro and micro nutrients. Therefore, a field experiment was conducted on effect of foliar application of nutrients on soybean yield.

METHODOLOGY

A field experiment was conducted during *kharif* 2015 in vertisolsoil having7.4 pH at Institute's research farm. The experiment was laid out in randomized block design (RBD)as:T_1: RDF + Water spray, T_2: RDF + Urea 2% spray, T_3: RDF + DAP 2% spray, T_4: RDF + MOP 0.5% spray, T_5: RDF + 19:19:19 (NPK) 2% spray, T_6: RDF + Molybdenum 0.5% spray, T_7: RDF + Boron 0.5% spray, T_8: RDF + Zinc chillated spray and T_9: RDF only and replicated thrice. The seeds of recently released soybean variety 'DSb 21' were sown on 15th July, in plots of size 3.6 X 6 m with 45 cm row to row and 5 cm spacing between the plants. Recommended dose of fertilizers (RDF) 20 kg N + 80 kg P_2O_5 + 20 kg K_2O /ha was supplied through di-ammonium phosphate (DAP), single super phosphate (SSP) and muriate of potash (MOP), respectively at the time of sowing. Foliar spray of nutrient was done as per the treatments at pod initiation stage using the knapsack sprayer. All intercultural operations and plant protection measures were carried out to raise a good crop. The data on yield attributes, seed yield was recorded and economics of treatments was calculated.

RESULTS

Data presented in table 1 reveals that RDF supplemented by foliar application of nutrients had significantly affected the yield and yield attributes viz., pods per plant, seed yield per plant and yield per hectare. Application of RDF + Foliar spray of 2% DAP at pod initiation gave significantly higher soybean seed yield (3.51 t/ha) and was at par with RDF + Zinc chillated (3.35 t/ha), RDF + Boron 0.5% (3.28 t/ha), RDF + MOP 0.5% (3.27 t/ha) and RDF + Molybdenum 0.5% (3.22 t/ha) foliar spray at pod initiation. RDF only (3.03 t/ha) and RDF + water spray (2.99 t/ha) gave significantly lower soybean yield.Vinothkumar *et al*. (2013) and Eman *et al*. (2014) reported that the increase in yield due to foliar application of nutrients might be due to enhanced uptake of nutrients by soybean by effective translocation of nutrients from sink to reproductive area of crop. The differences for seed index and harvest index were non-significant due to foliar application of

Table 1. Effect of foliar nutrition on soybean yield and economics

Treatment	Pods/ plant	Seed index (%)	Harvest index (%)	Seed yield (t/ha)	Net returns (₹ /ha)	B:C ratio	RUE (%)
T_1: RDF + water spray	51.07	12.81	50.46	2.99	62764	1:2.60	11.01
T_2: RDF + Urea 2% spray	61.00	13.35	53.23	3.08	65473	1:2.67	11.31
T_3: RDF + DAP 2% spray	72.53	13.10	61.43	3.51	79724	1:3.02	12.89
T_4: RDF + MOP 0.5% spray	66.73	13.27	53.90	3.27	72048	1:2.84	12.01
T_5: RDF + 19:19:19 (NPK) 2% spray	60.27	12.99	57.02	3.13	65119	1:2.58	11.49
T_6: RDF + Molybdenum 0.5% spray	62.73	12.68	61.55	3.22	58471	1:2.14	11.84
T_7: RDF + Boron 0.5% spray	68.47	13.29	56.43	3.28	72199	1:2.83	12.05
T_8: RDF +Zinc chillated 0.5% spray	69.48	13.05	55.79	3.35	72020	1:2.72	12.31
T_9: RDF only	51.40	12.90	55.10	3.03	64389	1:2.67	11.13
SEm±	4.41	0.19	2.34	0.0991	3368	0.08	0.36
CD (P=0.05)	13.22	NS	NS	0.2969	10096	0.24	1.09

nutrients. Rainfall use efficiency (12.89%) was significantly higher with RDF + DAP 2% followed by Zinc chillated, Boron and Muriate of potash spray at pod initiation. From the data on economics of different treatments in Table 1 shows that, net returns (₹ 79,724 /ha) and benefit: cost ratio (1:3.02) was significantly higher with RDF + DAP 2% spray at pod initiation owing to higher yield followed by RDF + Boron 0.5%, RDF + MOP 0.5% and Zinc chillated 0.5% spray at pod initiation.

CONCLUSION

From the results it can be concluded that application of the nutrients as basal dose through RDF along with the supplementation of nutrients through foliar application at important growth and development stage i.e. pod initiation can help to boost yield of soybean. Application of RDF and foliar application of 2% DAP, 0.5% Zinc chelated, 0.5% Boron, 0.5% MOP and 0.5% Molybdenum at pod initiation stage gave higher soybean yield and net monetary returns than RDF only and water spray.

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Effect of organic and inorganic nutrient management on productivity of soybean based cropping system

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In recent years there has been renewed interest in use of organics in agriculture. The concern is for maintaining sustainable agriculture production system, for better utilization of resources and to produce crops with less expenditure. Addition of organic matter to the soil provides several mechanisms for improved agronomic efficiency, particularly increased retention of soil nutrient and water and better synchronization of nutrient supply with crop demand, and it also improves soil health through increased soil biodiversity and carbon stock (Suryavanshi *et al.,* 2015). The presence of growth promoting substances like enzyme and hormones in organic manures make them essential for improvement in soil fertility and productivity. Oilseeds are energy rich crops and need higher nutrient for realizing high productivity of seed and oil. Integrated nutrient management aims at a judicious combination of inorganic and organic sources for meeting the nutrient needs of crop and cropping system and is of great interest for sustaining high productivity (Hegde, 1998). The combined use of organic and inorganic sources of plant nutrients not only increase the production but also helps in maintaining the fertility status of the soil. Soybean is a rainy season crop and fixes atmospheric nitrogen in the soil to an extent of 200-240 kg/ha through symbiotic association with *Rhizobium* bacteria. Out of nitrogen fixed by soybean, major quantity of nitrogen fixed is utilized by the crop itself and 35-40 kg N/ha is left in the soil for the succeeding crop in *Rabi* season. Therefore the present study was conducted to assess various organic and inorganic management practices on productivity of soybean based cropping system.

METHODOLOGY

A field experiment was carried out at the Crop research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during *Kharif* 2013. The experimental soil belong to Haldi series (coarse loamy, mixed, thermic, Typic Hapludolls) and showed silty clay loam texture, 0.51 per cent in organic carbon, 0.065 per cent total nitrogen, 20.4 kg P_2O_5 per ha available phosphorus, 163.6kg K_2O per ha available potassium with pH of 7.2. The experiment was conducted in Strip plot design, with two cropping system Soybean-wheat and Soybean- Chick pea in vertical strips and five organic and inorganic treatments in horizontal strip with four replications. The sub plot treatment consisted of T-1. 100 per cent organic having nutrient sources like FYM@ 10t/ha, rock phosphate, seed inoculation through rhizobium and phosphorus solublising bacteria and weed control through cultural practices and plant protection measures through bio-agent and bio- pesticides. T-2. 100 per cent Inorganic treatment consisted of application of recommended fertilizer

Table 1. Influence of different cropping system and nutrient management system on soybean yield attributing character, soybean yield, *Rabi* crop yield, soybean equivalent yield, rhizobium count and bulk density.

Treatments	Pods / plant	Seed index (g/100-seeds)	Soybean Seed yield (kg/ha	Harvest index	Rabi-crop yield (kg/ha)	Soybean Equivalent Yield (kg/ha)	*Rhizobium* count (CFU/ soil x 10^5)	Bulk Density (g/cm^3)
Nutrient Management System								
100 % organic	58.3	10.25	2927	27.5	2299	1312	39.7	1.34
100% inorganic	63.1	10.25	3097	28.9	2536	1438	20.6	1.42
50% organic + 50% inorganic	57.3	11.12	3198	29.1	2313	1488	43.0	1.37
INM+ IPM	55.3	10.37	3021	28.4	2459	1394	26.2	1.39
CD (P=0.05)	1.20	0.49	153	0.34	162	136	3.7	0.007
Cropping System								
Soybean-Wheat	56.3	10.87	3069	28.4	4417	2209	37.1	1.43
Soybean-Chickpea	60.7	9.87	3103	28.6	532	608	40.8	1.36
CD(P=0.05)	NS	NS	NS	NS	269	307	1.67	0.004

20:60:40 N: P: K and all other recommended practices for chemical weed and insect control. T-3. Combination of 50 per cent organic and 50 per cent inorganic treatment consisted of FYM @ 5 t/ha and rock phosphate + 50 per cent of recommended fertilizer and plant protection through Integrated pest management practices. T-4 Recommended Integrated nutrient management practices and Integrated Pest management practices.

RESULTS

Treatment 100% inorganic resulted in significantly higher pods per plant over remaining sub- plot treatments. Treatment 50% organic + 50% inorganic resulted in significantly higher seed index over remaining treatments. Highest seed was recorded with the 50% organic+ 50% inorganic treatment and it was significantly higher than all remaining treatments. Significantly higher harvest index was also recorded in 50% organic + 50% inorganic treatment over remaining treatments. During Rabi season treatment 50% organic + 50% inorganic being at par with treatments 100% inorganic and INM+ IPM recorded significantly higher soybean equivalent seed yield over treatment 100 % organic. Treatment 50% organic + 50% inorganic also resulted in significantly higher rhizobium count over treatments 100 % organic, 100% inorganic, and INM+ IPM. Bulk density of soil was also influenced by various organic treatments. It was significantly lower in 100 % organic as compared to remaining treatments. Highest bulk density was recorded in 100 per cent inorganic treatment and it was significantly higher than remaining treatments. Among cropping system soybean-chickpea resulted in higher soybean seed yield in *Kharif* season. In *Rabi* season soybean equivalent yield in soybean –wheat cropping system was significantly higher over soybean-chickpea cropping system. Rhizobium count under soybean-chick pea cropping system was also significantly higher than soybean-wheat cropping system, and bulk density under soybean-chick pea cropping system was significantly lower than soybean- wheat cropping system.

CONCLUSION

Soybean-wheat cropping resulted in higher soybean, wheat and soybean equivalent yield over soybean-chick pea cropping system. Among different organic and inorganic treatments, incorporation of 50% organic and 50% inorganic resulted in higher grain yield of soybean.

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Evaluation of various tillage options in rice-wheat systems and optimization of nitrogen dose in wheat (*Triticum aestivum*)

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During last four decades the growth rates of rice and wheat production in South Asia (2.5% and 5.2% per year, respectively) exceeded the population growth rate (2.22% per year), indicating an increase in the per capita availability of these two cereals that strengthen the food security, reduced rural poverty and increased affordability of food in the region (Pingali and Shah, 1999). In South Asia, rice- wheat crop sequence is the largest production system and occupies approximately 13.5 million hectares area including 10.3 million hectares in India, extending from Indo-Gangetic plain to Himalayan foothills. In India, approximately 23 and 40 % of total rice and wheat area, respectively, is represented by rice-wheat system alone (Timsina and Connor, 2001), which requires contrasting edaphic conditions. Rice is commonly transplanted into puddled soils and gets continued submergence whereas wheat is grown in upland well drained soils having good tilth. Puddling reduces infiltration of water and destroys soil structure. Farmers generally tilled soil 6-8 times after rice harvest to achieve good seed bed for wheat sowing. This excessive tillage results in delayed planting and thus reduced wheat yields. Delaying wheat sowing beyond November decreases yield by 15.5, 32.0, 27.6, 32.9 and 26.8 kg/ha/day under Northern Hill Zone, North Western Plains Zone, North Eastern Plains Zone, Central Zone and Peninsular Zone, respectively for timely sown varieties with corresponding yield losses of 7.6, 18.5, 17.7, 17.0 and 15.5 per cent (Tripathi*et al*., 2005). The turnaround time between rice and wheat crops is 3- 6 weeks. In order to plant wheat timely, many farmers harvest the rice crop with a combine and burn loose residues that lead to greenhouse gas emission and particulate matter in large quantities in sudden spurts and ultimately deteriorating the air quality and loss of nutrients. Direct seeding of rice (DSR) saves energy, labour and water for rice establishment resulting in earlier maturity of rice, which allows timely wheat sowing.

METHODOLOGY

A field study was conducted for four consecutive years commencing from 2012-13 to 2015-16 at Indian Institute of Wheat and Barley Research, Karnal (Latitude 29^0 43' N, longitude 76^0 58' E and altitude 245 m above mean sea level). The experimental soil was sandy clay loam in texture (15 % clay), low in organic carbon (0.36 %) and available N (143 kg/ha), medium in available P (16.7 kg/ha) and available K (168 kg ha^{-1}) content having pH 8.1. Experiment was conducted in split plot design with three main plots viz direct seeded rice in unpuddled, zero till transplanted rice and puddled transplanted rice and four sub plots in wheat i.e. 0, 75, 150 N and LCC based N application after first top dressing with three replications. Recommended 60 kg P_2O_5 /ha (in the form of DAP), 40 kg K_2O /ha (through MOP) and 1/3 nitrogen (through urea) was applied at the time of sowing as basal dose, 1/3 N was applied at first node stage i.e DC 31 and remaining 1/3 N was applied at boot leaf stage as per treatments. Rice variety Gobindand wheat variety DPW 621-50 was grown. Rice was seeded @ 80 kg/ha under direct seed condition in 1st week of June whereas transplanting was done with 25 days old seedlings in other two main plots in first week of July. Transplanting under zero tillage condition was done by irrigating the field 24 hours earlier. Wheat was seeded @ 100 kg/ha, after adjusting the 1000 grain weight at 38 g, during first week of November in each year of the study. Wheat under zero tillage conditionwas sown about 3-4 days earlier than conventional tillage condition. Irrigations were applied as per need of the crop. Weeds in zero till rice were controlled with the application of pendimethalin @1.0 kg ha^{-1} just after seeding whereas in transplanted rice weeds were controlled with the application of butachlor @ 1.0 kg ha^{-1} in 400 liter of water at 3-4 days after rice transplanting. Similarly weeds in wheat were controlled with the application of sulfosulfuron 25 g ha^{-1} in 400 liters of water at 30-35 days after sowing. All the other recommended package and practices were adopted in rice as well as in wheat.

RESULTS

Combined analysis of four years revealed that puddled transplanted rice produced significantly higher grain yield (81.01 q/ha), which was 19.9 and 13.9% higher than zero till direct seeded rice and zero till transplanted rice, respectively. Similar was the case for rice straw yield, however, direct seeded rice recorded significantly higher straw yield than zero till transplanted rice. There was non-significant effect of different N doses applied in wheat on rice grain and straw yield. Conventional till wheat exhibited significantly higher grain and straw yield, which was 10.9 and 22.39 % higher than zero till wheat, respectively. There was significant increase in wheat yield by increasing N levels up to 125 kg/ha (LCC based application). This showed that about 25 kg N/ ha could be saved with use of LCC in wheat (Table 1).

Table 1. Effect of different rice seeding methods and N level in wheat on grain and straw yield of rice and wheat (4 years pooled)

Treatment	Rice		Wheat	
	Grain Yield (t/ha)	Straw yield (t/ha)	Grain Yield(t/ha)	Straw yield (t/ha)
ZT Rice-ZT Wheat	6.76	12.68	3.95	5.88
ZTT Rice- CT Wheat	7.11	11.90	4.28	7.14
CT Rice-CT Wheat	8.10	13.25	4.39	7.20
CD at 5 %	0.33	0.72	0.15	0.42
N (kg/ha) in wheat	0.00	0.00	0.00	0.00
0	7.20	12.47	2.15	4.04
75	7.32	12.72	4.24	6.50
150	7.31	12.63	5.25	8.28
LCC based (125)	7.42	12.63	5.19	8.14
CD (P=0.05)	NS	NS	0.15	0.44

ZT: Zero tillage, ZTT: Zero tillage transplanted, CT: Conventional tillage

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Effect of phosphorus and biofertilizers on productivity of soybean under rainfed conditions (*Glycine max* (L.) Merill)

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There is vast scope for soybean production due to high nutritional quality, more production and short duration (90-110 days), tolerate long dry spell and being leguminous crop helps in improving the fertility and productivity of soil. Hence, it is known as "Gold of Soil". The prices of fertilizers are increasing day by day and therefore, it is necessary to reduce the cost of fertilizers by using *Rhizobium*, PSB and VAM inoculation to increase yield of legume crops. Biofertilizers cannot replace chemical fertilizers, but certainly are capable of reducing their input. Seed inoculation with effective *Rhizobium* inoculants is recommended to ensure adequate nodulation and N_2 fixation for maximum growth and yield of pulse crop. Biofertilizer do not supply nutrients directly to crop plants but have capacity to fix atmospheric nitrogen and convert insoluble phosphate into soluble form. Hence, soil microorganisms play significant role in mobilizing P for the use of plant and large fraction of soil microbial population can dissolve insoluble phosphate in soil. Seed treatment with biofertilizers had their significant effect on microbial population in conjunction with P application in soybean field (Sarawgi *et al*., 2012). The main objective of this study was to assess the effect of phosphorus and

Table 1. Seed yield, straw yield, biological yield and harvest index of soybean as influenced by various treatments

Treatment	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Net monetary returns (Rs/ha)
T_1- No phosphorous application	808	954	1762	45.85	9914
T_2- 45 kg P_2O_5/ha through SSP	884	1084	1968	44.91	10989
T_3- 60 kg P_2O_5/ha through SSP	917	1108	2025	45.28	10612
T_4- 45 kg P_2O_5/ha through SSP + PSB	920	1144	2064	44.57	12268
T_5- 45kg P_2O_5/ha through SSP + *Rhizobium* (R.I.)	959	1189	2147	44.67	13828
T_6- 45 kg P_2O_5/ha through SSP+ VAM	929	1168	2097	44.30	11663
T_7- 45 kg P_2O_5/ha through SSP+PSB+R.I.	979	1284	2263	43.26	14496
T_8- 45 kg P_2O_5/ha through SSP+PSB +VAM	939	1196	2135	43.98	11924
T_9- 45 kg P_2O_5/ha through SSP+R.I.+VAM	1014	1355	2369	42.80	14927
T_{10}- 45 kg P_2O_5/ha through SSP+PSB+R.I.+ VAM	1104	1495	2600	42.46	18381
C.D. (P=0.05)	136	239	246	-	1718

biofertilizers on productivity of soybean under rainfed conditions and to assess microbial population for promoting better growth of soybean.

METHODOLOGY

The experiment was conducted during *kharif* season of 2015 on the Farm of College of Agriculture, Latur. The soil of the experimental site was deep, black in colour with good drainage. The soil was low in available nitrogen (118.86 kg/ha), medium in available phosphorus (20.42 kg/ha), very high in available potassium (385.89 kg/ha) content and alkaline in reaction having pH 8.5. The experiment was laid out by using Randomized Block Design with three replications. The treatments were consisting of *Rhizobium*, PSB and VAM constituting ten treatments viz., T_1**-** No phosphorous application, T_2**-** 45 kg P_2O_5/ha through SSP, T_3**-** 60 kg P_2O_5/ha through SSP**,** T_4**-** 45 kg P_2O_5/ha through SSP + PSB, T_5**-** 45kg P_2O_5/ha through SSP + *Rhizobium* (R.I.)**,** T_6- 45 kg P_2O_5/ha through SSP+ VAM **,** T_7**-** 45 kg P_2O_5/ha through SSP+PSB+R.I.**,** T_8**-** 45 kg P_2O_5/ha through SSP+PSB +VAM, T_9**-** 45 kg P_2O_5/ha through SSP+R.I.+VAM and T_{10}**-**45kg P_2O_5/ha through SSP+PSB+R.I.+ VAM. Sowing was done on 11th August, 2015 at a recommended spacing of 45 cm x 5 cm. The recommended cultural practices and plant protection measures were taken. Fertilizer *viz.,* nitrogen, phosphorus and potassium were applied as per the recommendation by using straight fertilizers urea, SSP and MOP.

RESULTS

The yield of soybean was influenced significantly due to different phosphorus levels and biofertilizers. Application of 45kg P_2O_5/ha through SSP+PSB+R.I. + VAM (T_{10}) recorded higher growth and yield attributes viz., plant height, number of functional leaves, number of branches, leaf area, total dry matter, number of nodules, number of pods/plant, weight of pods, number of seeds/plant seed yield/plant, seed yield kg/ha, straw yield kg/ha, test weight and net monetary returns (Rs/ha) and it was followed by application 45 kg P_2O_5/ha through SSP+R.I.+VAM (T_9) and 45 kg P_2O_5/ha through SSP+PSB+R.I. (T_7) treatments. The application of 45kg P_2O_5/ha through SSP+PSB+R.I. +VAM (T_{10}) recorded higher mean seed yield (1108 kg/ha) and it was followed by application 45 kg P_2O_5/ha through SSP+R.I. +VAM (T_9) (1014 kg/ha) and 45 kg P_2O_5/ha through SSP+PSB+R.I. (T_7) (979 kg/ha). This might be due to the cumulative effect in increasing growth contributing characters which have been clearly exhibited on the final produce i.e. seed and straw yield ha^{-1}. Similar kind of result was reported by Ingle *et al.,* (2001) and Menaria *et al.* (2003). Application of 45kg P_2O_5/ha through SSP+PSB+R.I. + VAM (T_{10}) recorded significantly higher mean straw yield (1495 kg/ha) and biological yield (2600 kg/ha) respectively followed by the application of 45 kg P_2O_5/ha through SSP+R.I. +VAM (T_9). The data on net monetary returns per hectare revealed that the application of 45kg P_2O_5/ha through SSP+PSB+R.I. + VAM (T_{10}) recorded significantly higher net monetary returns (Rs.18381/ha) followed by 45 kg P_2O_5/ha through SSP+R.I. +VAM (T_9).

CONCLUSION

Rainfed soybean responded positively to different phosphorus application treatments. Application of 45 kg P_2O_5/ha through SSP+PSB+R.I.+ VAM (T_{10}) performed the best amongst the various phosphorus treatments evaluated with regards to growth, yield attributing characters and yield of soybean.

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Nitrogen management through neem coated urea and application method further improve rice productivity in coastal flood-prone rainfed lowland

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Nitrogen (N) is the most limiting nutrient in non-legume cropping systems, and also the least predictable one. Recovery of applied fertilizer N in flooded rice soils is very poor due to leaching, volatilization and de-nitrification losses. Mismanagement of this fertilizer can impact both economic and environmental aspects of crop production (Tubana *et al*., 2011). N is conventionally applied to the soil at various stages in splits starting before transplanting to flowering stage. Foliar spray of N is another method of application to the standing crop for better N absorption through leaves and other plant parts. Furthermore, N application through slow release fertilizers results in reduced N losses. Coating urea granules with one of several forms of neem (natural oil from *Azadirachta indica*) to produce Neem Coated Urea (NCU) will delay nitrification and/or have other slow-release properties that will allow it to better feed plant needs, thereby improving N-use efficiency and reducing nitrous oxide emission. NCU often improves grain yield of rice and wheat (compared with uncoated urea), but does not consistently reduce N_2O emissions or improve N-use efficiency. There have been suggestions that it improves insect/pest control in rice fields. GoI has made it mandatory for urea manufacturers to work towards production of 100% NCU (policy support initiated in May 2015). This study was conducted with a hypothesis that application of NCU along with foliar spray through prilled urea (PU) will increase the yield of rainfed low land rice through better fertilizer response.

METHODOLOGY

Experiment was conducted at ICAR-CSSRI, RRS, Canning Town, West Bengal during wet seasons of 2014 and 2015 in randomized block design in three replications with rice variety Amal-Mana having ten treatments of N source, time and method of application [T_1: 50% basal N through PU +50% N through 6 foliar applications with PU (one at maximum tillering (MT), four during panicle primordial initiation (PI) to booting and one at flowering stage), T_2: 50% basal N through NCU + 50% N through foliar application as in T_1, T_3: 50% N one week after transplanting (1 WAT) through PU + 50% N through foliar application as in T_1, T_4: 50% N at 1 WAT through NCU + 50% N through foliar application as T_1, T_5: 50% basal N through PU + topdressing of 25% N through PU at MT + 25% N through 3 foliar applications (one each at PI, booting and flowering), T_6: 50% basal N through NCU + topdressing of 25% N through NCU at MT + 25% N through foliar application as in T_5, T_7: 50% N at 1 WAT through PU + topdressing of 25% N through PU at MT+ 25% N through foliar application as in T_5, T_8: 50% N at 1 WAT through NCU + topdressing of 25% N through NCU at MT + 25% N through foliar application as T_5, T_9: Recommended N for coastal lowland through PU (50% basal, 25% at tillering and 25% at PI), T_{10}: Recommended N through NCU (splitting as in T_9)]. Fertilizer dose of 50-20-10 kg N-P_2O_5-K_20 /ha was applied in all treatments. Foliar spray was done with 1% urea solution (w/v) as per treatment. Experimental soil was heavy textured having top soil pH 5.8 to 7.1, average bulk density 1.49 g/cm^3 and organic carbon concentration 0.48%.

RESULTS

Yield and economics of rice (Table 1) was higher when NCU was used in comparison to PU. Grain yield was 22.9% higher only by replacing PU (3.31t/ha) with NCU (4.07 t/ha). However, 50% N application at 1 WAT+ 25% top dressing with NCU and remaining 25% as foliar application through PU (T_8) produced significantly higher grain yield than other treatments. It implied that simply procrastinating the basal application (T_6-3.64 t/ha) till one week after transplanting (T_8-4.57t/ha) proved an effective N management strategy resulting in 25.5% yield increase. There was no significant difference between soil and foliar application methods. Cost of cultivation was less in the use of NCU, mainly due to less infestation of pests. Gross return, net return and benefit-cost ratio were higher with the use of NCU, however, the economics did not differ with method of application. With NCU applied 75% to soil and PU applied 25% to foliage (T8), the net return was US$ 437/ha, which was at par (US$ 375/ha)

Table 1. Economics of rainfed lowland rice with different nitrogen management practices in *Sundarbans* region, West Bengal (pooled data of 2014 and 2015)

Treatment	Cost of cultivation ($/ha)	Gross return ($/ha)	Net return ($/ha)	BCR
T_1	623	822	199	1.3
T_2	617	836	219	1.4
T_3	623	773	150	1.2
T_4	619	801	182	1.3
T_5	622	786	165	1.3
T_6	614	839	224	1.4
T_7	621	797	175	1.3
T_8	616	1052	437	1.7
T_9	619	841	223	1.4
T_{10}	609	983	375	1.6
CD (P=0.05)	5	137	137	0.2

with application of NCU 100% to soil (T10). The BCR for these two treatments were 1.7 and 1.6, respectively, whereas for other treatments it ranged between 1.2 and 1.4.

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Effect of phosphorus on seed yield of summer mungbean sown after wheat

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Summer mungbean has special importance in intensive crop production due to its short duration period as it can be grown as a catch crop in rice-wheat cropping system in Punjab and Haryana. Inclusion of legumes in cereals sequence not only improves the soil health but enhances the productivity of cropping system. Besides these, nitrogen and phosphorus are both integral components of virtually all the biochemical compounds that make plant life possible. Nitrogen as well as phosphorus (Singh *et al.,* 2008) is essential for normal growth and yield of mungbean. Generally, farmers do not apply phosphorus to mungbean crop. Therefore, the experiment was conducted at CCS Haryana Agricultural University Krishi Vigyan Kendra, Ambala to find out the effect of phosphorus on seed yield of summer mungbean varieties.

METHODOLOGY

A field experiment was conducted at CCS Haryana Agricultural University Krishi Vigyan Kendra, Ambala situated in the sub-tropics at $30^0 23'$ N latitude $76^0 47'$ E longitude and 264 m above mean sea level during summer season of 2014. The soil of the experimental site was sandy loam (pH 7.8), low in available N (143 kg/ha), medium in available P (174 kg/ha) and medium in available K (272 kg/ha). The experiment was laid out in randomized block design with 2 varieties of mungbean *viz*. MH 421 and SML 668 and 4 phosphorus levels viz. control (no fertilizer), 20, 40 and 60 kg P_2O_5/ha with 4 replications. The recommended dose of nitrogen (20 kg/ha) was added along with each phosphorus level. The crop was sown on 17.04.2014 with seed rate of 25 kg/ha and harvested on 23.06.2014.

RESULTS

Mungbean variety MH 421 gave 6.9 per cent higher seed yield than SML 668 with net returns of Rs 21001/- and B:C ratio of 1.60 (Table 1). Application of varying levels of phosphorus significantly increased the seed yield of mungbean over control. However, significant increase was found up to 40 kg P_2O_5/ha. Application of 40 and 60 kg P_2O_5/ha did not differ significantly with respect to seed

Table 1. Effect of varieties and phosphorus levels on seed yield of summer mungbean

Treatment	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Varieties			
MH 421	1158	21001	1.60
SML 668	1083	17546	1.50
CD (P=0.05)	8.4	-	-
Phosphorus levels (kg/ha)			
Control	812	10135	1.34
20	1096	23586	1.79
40	1283	32351	2.08
60	1292	32586	2.08
CD (P=0.05)	11.8	-	-

yield of mungbean. Application of 40 and 60 kg P_2O_5/ha fetched net returns of Rs 32351/- and Rs 32586/- with the same B: C ratio of 2.08.The higher seed yield with higher phosphorus rates was attributable to better nodulation and efficient functioning of nodule bacteria for fixation of N to be utilized by plants during grain development stage in the synthesis of protein which in turn led to increase in seed yield.

CONCLUSION

From the one year investigation it was concluded that MH 421 variety of mungbean with 40 kg P_2O_5/ha produced higher seed yield of mungbean during summer season.

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Effect of fertility level, seaweed sap and its concentration on yield and economics of wheat (*Triticum aestivum* L.)

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Wheat (*Triticum aestivum* L.) is the second most important food crop of India next to rice and demand for wheat in the country is increasing day by day. The greatest demand for wheat in the coming years will have to be met by increasing devotion of land to wheat or increasing yield per unit area. At present, we use chemical fertilizers in large quantities to harvest more and more. The cost of fertilizers has increased tremendously, with existing price of Rs. 15, 58 and 31 per kilogram nitrogen, phosphorus and potassium, respectively. The abundant use of chemical fertilizers adversely affects soil fertility. So, there is need to find some natural resource product which can enhance the soil fertility as well as productivity of the crop. In this context, applications of seaweed fertilizers are of great importance to substitute the commercial chemical fertilizers. Liquid fertilizers derived from seaweeds are rich in organic matter, micro and macro elements, vitamins and fatty acids along with the presence of metabolites similar to plant growth regulators like auxin, gibberellins, vitamins and amino-acids. The beneficial effect of seaweeds extracts on agriculture crops has been reported by several workers (Mostafa *et al.,* 1999 and Singh *et al.,* 2015) and proves to be a useful source of fertilization for achieving higher production.

METHODOLOGY

The field experiment, were conducted during the *Rabi* season of 2012-13 at the Birsa Agriculture University, Ranchi (23º17’ N latitudes, 85º19’ E longitudes and 625 m above altitude)**.** The soil was sandy loam in texture, with pH 5.7 having organic carbon 0.45%, available nitrogen 255.9 kg/ha, phosphorus 14.0 kg/ha and potassium 169.4 kg/ha. The climate of the region is subtropical with hot and dry summer, comparatively cool rainy season followed by moderate winter. Treatment consisted of two fertilizer levels *viz.,* 100 and 50%

Table 1. Effect of seaweed sap on productivity and profitability of wheat

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Net return (Rs./ha)	B: C ratio
Fertilizer level				
100% RDF	4.46	5.41	43238	1.70
50% RDF	3.52	4.40	32045	1.43
SEm±	0.01	0.05	248	0.01
CD (P=0.05)	0.07	0.28	1512	0.07
Sap Source				
K-sap	4.12	5.05	39674	1.65
G-sap	3.85	4.77	35609	1.48
SEm±	0.02	0.04	308	0.01
CD (P=0.05)	0.07	0.15	1210	0.06
Spray concentration (%)				
Water	3.41	4.26	31414	1.46
2.5	3.77	4.61	35804	1.58
5.0	3.96	4.85	37803	1.60
7.5	4.44	5.35	44011	1.80
10.0	4.29	5.23	40873	1.61
15.0	4.07	5.14	35943	1.31
SEm±	0.07	0.07	966	0.04
CD (P=0.05)	0.19	0.19	2762	0.12

recommended fertilizer in main plot, two seaweed sap source *viz., Kappaphycus alvarezii* (K-sap) and *Gracilaria edulis* (G-sap) in sub plot and 6 sap concentration *viz.*, 0 (water), 2.5, 5.0, 7.5, 10.0 and 15.0% in sub-sub plot laid out in a split-split plot design and replicated thrice. The recommended dose of fertilizer was 120:60:40 kg NPK/ha. Half dose of nitrogen and full dose of phosphorus and potash through urea, single super phosphate and muriate of potash, respectively, were applied at sowing and remaining half nitrogen was applied after first irrigation. Three sprays of K-sap and G-sap were applied each at the tillering stage, panicle initiation and boot stage. For proper adherence, extracts were mixed with surfactant (Mazik drop) at the time of spraying. Wheat variety 'K-9107' was sown at row spacing of 20 cm during first fortnight of November.

RESULTS

Application of 100 % recommended dose of fertilizer produced significantly higher grain yield (4.46 t/ha), straw yield (5.41 t/ha), net return (Rs. 44238/ha) and benefit cost ratio (1.70) as compared to 50% recommended dose of fertilizer (Table 1). Among seaweed sap, *Kappaphycus alvarezii* (K-sap) recorded significantly higher grain yield (4.12 t/ha), straw yield (5.05 t/ha), net return (Rs. 39674/ha) and benefit cost ratio (1.65) than *Gracilaria edulis* (G-sap). Irrespective of sap concentration, spraying of 7.5% sap concentration produced significantly higher grain (4.44 t/ha), straw yield (5.35 t/ha), net return (Rs. 44011/ha) and benefit cost ratio (1.80) as compared to lower sap concentration. These results are in accordance with the findings of Singh *et al.* (2015).

CONCLUSION

Application of 100% recommended dose of fertilizer along with 7.5% foliar application of *Kappaphycus alvarezii* enhances the productivity and profitability of wheat.

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Productivity and profitability of maize hybrids under different planting methods and nitrogen levels

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A field experiment was conducted at Agronomy research farm, CCS Haryana Agricultural University, Hisar during *kharif* 2013 and 2014. Results obtained from this experiment indicated that the highest grain yields, stover yields and economics by maize were recorded with FSZT as compared to RBS, FSMT and FSMT. Pooled results shows that FSZT planted maize produced significantly higher grain (5271.4 kg/ha) yield of maize as compared to FSCT and FSMT but the difference between FSZT and RBS was at par with each other. The highest net returns (Rs. 41205/ha), net returns/Re invested (2.05) were recorded with FSZT compared to other planting methods. Cultivation of maize with HQPM-5 maize hybrid recorded maximum net returns as compared to HQPM-1 maize hybrid. Application of 180 kg N/ha had maximum values for net returns (Rs. 38894/ha), net returns Re invested (1.91) compared to other nitrogen levels. Maize crop management involves decision making on several cultural/agronomic practices aimed to maximize grain yields like planting methods (CA based RCTs), improved varieties and proper nutrient management. Interventions in the form of new resource conservation technologies (RCTs) like zero-tillage and furrow irrigated raised bed system (FIRBS) coupled with crop diversification by including maize in place of rice may be a viable solution. Selection of hybrid varieties of maize and different planting methods at suitable dose of nutrients particularly N is a serious problem in north India for quantitative and qualitative production of maize. Utilization and improvement of soil resources is of paramount importance for enhancing crop production. Adequate information is not available on the performance of maize hybrids under different planting methods and varying dose of nutrients particularly N. Proposed investigation is basically aimed to explore possibilities of crop diversification by including maize in the system as an alternate of rice and also to find out optimum dose of N besides suitable planting method. Saving in irrigation water, improvement in soil health and environmental protection will be possible broader outcome besides attaining higher productivity and profitability.

METHODOLOGY

A field experiment was conducted site during the *kharif seasons* of 2013 and 2014 at the Agronomy Research Farm, of CCS Haryana Agricultural University, (situated at 29^0 10' North latitude and 75^0 46' East longitudes at an elevation of 215.2 m above mean sea level) Hisar, India. The experiment consisted of four planting techniques *viz.* Raised bed system (RBS), Flat sowing with Zero tillage (FSZT), Flat sowing with Minimum tillage (FSMT) and Flat sowing with Conventional tillage (FSCT) in main plots and two maize hybrids *viz.* HQPM-1 and HQPM-5 and three nitrogen levels *viz.* 120, 150 and 180 kg N/ha in sub plots with combination. The 24 treatment combinations were tested in split plot design with three replications.

RESULTS

Growth attributes, yield and economics were significantly influenced by the planting methods, maize hybrids and nitrogen levels (Table 1). Pooled data shows that flat sowing with zero tillage (FSZT) maize resulted in significantly higher growth attributes to FSCT and FSMT but the difference between FSZT and RBS was not significant. FSZT planted maize produced significantly higher grain (5271.4 kg/ha) as well as stover (6944.5 kg/ha) yield of maize as compared to FSCT and FSMT but the difference between FSZT and RBS was at par with each other. Among the maize hybrids, HQPM-5 recorded significantly higher grain yield (5224.0 kg/ha) over HQPM-1 maize hybrid. Application of 180 kg N/ha gives significantly higher grain (5363.5 kg/ha) yield, stover (6897.5 kg/ha) yield and economics of maize as compared to 150 and 120 kg N/ha. The maximum net returns (Rs. 41205/ha), net returns Re invested (2.05) were recorded with FSZT compared to other planting methods. Cultivation of maize with HQPM-5 maize hybrid recorded maximum net returns as compared to HQPM-1 maize hybrid. Application of 180 kg N ha^{-1} had maximum values for net returns (Rs. 38894/ha), net returns Re invested (1.91) compared to other nitrogen levels. The ultimate effect of experimental variables is reflected in the final yield of crop and thus, it is a major criterion to identify the efficiency of various treatments in a given situation. FSZT

Table 1. Plants height, total dry matter production at maturity, grain and stover yields and economics of maize as influenced by various planting methods, maize hybrids and nitrogen levels

Treatment	Plant height (cm)	Total dry matter production (g/plant)	Grain yield (kg/ha)	Stover yield (kg/ ha)	Net returns (Rs/ha)	Net returns/ Re invested
Planting method						
Raised bed system	194.3	243.5	5216.0	6447.8	35101	1.80
FSZT	197.9	247.2	5271.4	6944.5	41205	2.05
FSMT	184.1	218.3	5075.5	6520.0	34921	1.82
FSCT	180.5	204.8	4935.2	6163.2	30982	1.70
SEm±	2.81	7.01	30.49	20.51	—	—
CD (P=0.05)	8.44	22.39	97.80	61.54	—	—
Maize hybrid						
HQPM-1	183.7	222.5	4948.5	6392.5	32989	1.78
HQPM-5	187.3	239.9	5224.0	6645.0	37077	1.87
SEm±	0.89	5.37	21.93	12.61	—	—
CD (P=0.05)	2.68	15.80	65.81	38.18	—	—
Nitrogen level (kg/ha)						
120	175.7	203.2	4560.0	6142.3	27677	1.66
150	181.8	236.6	5006.0	6516.0	33888	1.80
180	188.6	244.1	5363.5	6897.5	38894	1.91
SEm±	1.81	6.43	26.82	15.11	—	—
CD (P=0.05)	3.95	18.94	80.59	45.40	—	—

planted maize was able to produce significantly higher growth attributes as well grain and stover yields compared FSCT and FSMT but the difference between RBS and FSZT were only marginal (Table 1). The increase in grain yield of maize under zero tilled (FSZT) maize could be attributed to higher growth and yield attributes whereas; the increase in biological yield was due to higher dry matter production. To some extent it could also attributed to better soil environment in flat sowing with zero tillage (FSZT). Higher grain yield under FSZT also might be due to a longer grain filling duration resulting in bolder grains. There exists a positive correlation between grain yield and better yield components like number of plants, plant highest, LAI, fertile cobs and grains per cob under higher nitrogen levels. FSZT planting of maize at the rate of 180 kg N/ha produced highest yield attributes, and grain and stover yields. This might be due to the favourable soil physical conditions and improved nutrients, moisture availability, deeper root growth and thereby the yield.

CONCLUSION

On the basis of experimental findings, it may concluded that planting of maize under FSZT with HQPM-5 and 180 kg N/ha was found best with respect to growth and yield attributes, grain and stover yield and economics over other treatment combination. The increased dose of fertilization by nitrogen increases the growth, yields as well as it increased net returns and it would be more profitable to farming community.

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Effect of method and time of nitrogen application on growth and yield of sorghum

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A field experiment on method and time of nitrogen application on sorghum genotypes under rainfed condition was conducted during *kharif* season of 2012-2013 at the farm of Sorghum Research Unit (CRS) Dr. PDKV, Akola to find out proper method and time of nitrogen application for enhancing productivity and soil fertility. The experiment was planned in FRBD with the treatments as Factor A: N application methods (5 Nos) as N1: 50% N, at sowing and 50% at 30 DAS, N2: 50% N, at sowing + 25% at 30 DAS +25% at boot-leaf stage (BLS), N3: 25% N, at sowing + 50% at 30 DAS +25% at boot-leaf stage (BLS), N4: 25% N, at sowing + 50% at 30 DAS +15% at BLS 10% at grain filling stage (GFS), N5: 25% N, at sowing + 45% at 30 DAS + 5% foliar spray at 45 DAS +15% at BLS+10% GFS and Factor B two cultivars as G1-CSH 16 and G2-CSV 20. In N application methods the plant height and the yield attributing characters as panicle length (cm), panicle weight (g) and grain weight/panicle were significantly maximum with the application of 50% N at sowing + 25% at 30 DAS +2 5% at boot-leaf stage (BLS). Fodder and grain yield was significantly maximum with the application of 50% N at sowing + 25% at 30 DAS +25% at boot-leaf stage (BLS). Among the cultivar the variety CSV 20 recorded significantly maximum plant height, panicle length (cm), panicle weight (g) and fodder yield than hybrid CSH 16. However the hybrid CSH 16 recorded significantly maximum grain yield but it was at par with the variety.

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Evaluation of mid-late planted sugarcane genotypes under variable fertilizers levels for subtropical conditions

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Sugarcane yield is very low in the sub-tropical condition of country due to low yielding varieties, imbalance nutrition, atmospheric conditions and adaptation of poor management practices. Glaz (2000) reported that sugarcane production can be improved through adaptation of promising varieties and improved technologies. North India, the fertility status is deteriorated gradually due to imbalance and inadequate fertilizer application. In such a situation, evaluations of promising genotypes in different fertility levels are vital for getting higher productivity of cane yield. Higher cane yield is the function of higher genetic potential of the variety evaluated in different locations with different fertility levels (Panwar *et al.,* 2002). Sugarcane yield is directly correlated to yield attributing characters viz. number of millable canes, cane girth, cane length and cane weight as reported by Mahmood *et al*. (1990). It is well known that sugarcane is a C4 plants produces heavy tonnage of biomass and removes large quantity of plant nutrients from soil. Sugarcane has high requirement of macronutrient (N, P and K) that normally exceeds the inherent capacity of soils to supply it by mineralization of organic matter. Imbalance and inadequate use of some macro nutrients results in poor cane yield, deterioration of soil health and multiple nutrient deficiencies. To achieve optimumproductivity of sugarcane, application of inorganic fertilizers (N, P and K) not only increasedthe cost of cultivation but also enhanced the chances of nutrient pollution of the ecosystem and atmosphere. It is essential to assess the nutrient requirement of mid-late promising sugarcane genotypesgrowing in subtropical condition. Therefore, a field experiment was conducted to assess the performance of mid-late promisinggenotypesof sugarcane with different fertility levels on yield attributes, cane yield and juice quality.

METHODOLGY

A field experiment was conducted at Indian Institute of Sugarcane Research, Luckow during 2014-15 and 2015-16 to assess the effect of graded doses of fertilizer application on mid-late planted genotypes of sugarcane (plant and ratoon crop). The soil of experimental field was sandy loam having 7.61 pH, 0.19 dS/m,0.47% organic carbon, 236.3 kg/ha available N, 28.1kg/ha available P and 273.7 kg/ha available K.The experiment consisted 9 treatment combinations with three mid-late genotypes viz. COPb 08217, CoLk 09204 and CoS 0835 and three doses of fertilizers application viz., 75% RDF(112.5:45:45 kg N:P_2O_5:K_2O/ha), 100%RDF(150:60:60 kg N:P_2O_5:K_2O/ha) and 125% RDF (187.5:75:75 kg N:P_2O_5:K_2O / ha). Nitrogen was applied in three equal splitsat the time of planting as basal and top dressing at tillering and grand growth stages through urea in the respective plots. A full dose of phosphorus and potassium fertilizers were applied at time of planting through diammonium phosphate (DAP) and muriate of potash (MOP), respectively. The crop was irrigated as and when required and weeding, earthing up and trash-twist (TT) propping were carried out as per the recommendation. Data on germination per cent at 45 DAP, number of millable canes (NMC), length of cane, canediameter, single cane weight and cane yield per plot were recorded at harvest. Juice sucrose was determined at harvest (12^{th}month) following the standard procedure (Meade and Chen 1977). Estimated commercial cane sugar (CCS) yield was determined based on CCS per cent and cane yield.

RESULTS

The data revealed that growth, yield and its attributes and juice quality affected significantly with different genotypes of sugarcane, except germination. Genotype CoLk 09204 observed significantly higher shoot count and NMC over the CoPb 08217. However, cane yield (69.41 t/ha) was recorded significantly higher with COPb 08217 over the CoS 0835 and CoLk 09204. The genotype CoS 0835 and CoLk 09204 were at par to each other in respect of cane yield, cane length, cane juice (Table 1). Application of fertilizers at different levels showed significant effect on shoot counts, NMC, cane yield and cane length. However, germination, shoot counts, pol (%) and purity (%) were non-significant. Application of 125% RDF showed significant effect on shoot counts, NMC, cane girth, cane yield and CCS (%) over the 75% RDF but no significant

Table 1. Plant growth, yield attributes, cane yield and quality of juice affected under different genotypes and fertilizer doses

Treatment	Shoot counts (000/ha)	NMC (000/ha)	Cane yield (t/ha)	Pol (%)	Purity (%)	CCS (%)	CCS (t /ha)
Genotype							
COPb 08217	130.3	98.21	69.41	17.92	90.10	13.47	8.88
CoLk 09204	138.2	110.3	62.27	16.52	88.29	12.47	7.76
CoS 0835	136.0	100.1	62.31	17.27	88.40	12.99	8.39
CD (P=0.05)	6.39	5.58	3.72	0.91	1.26	0.65	0.60
Fertilizers dose							
75% RDF	131.2	100.7	62.58	17.02	88.85	13.25	8.17
100% RDF	135.5	102.3	64.34	17.04	88.94	12.84	8.28
125%RDF	138.9	105.7	67.08	17.64	89.00	12.83	8.59
CD (P=0.05)	6.39	4.34	3.72	NS	NS	0.65	NS

Table 2. Genotypes and fertilizer doses affected plant growth, yield and juice quality of ratoon

Treatment	Shoot counts	NMC (000 /ha)	Yield (t /ha)	Pol (%)	Purity (%)	CCS (%)	CCS (t/ha)
Genotype							
CoPb 08217	144.48	123.06	79.26	17.98	90.67	13.08	9.78
CoLk 09204	158.63	113.12	73.53	17.41	89.32	12.45	9.10
CoS 0835	157.67	108.70	74.60	17.50	90.10	12.88	9.61
CD (P =0.05)	6.76	4.41	4.32	0.61	0.69	0.49	0.50
Fertilizers dose							
75% RDF	150.62	110.7	72.58	17.40	89.89	12.67	9.22
100% RDF	152.90	113.87	76.03	17.64	89.93	12.74	9.71
125%RDF	157.26	120.51	78.78	17.84	90.27	12.99	9.57
CD (P =0.05)	NS	4.41	4.32	NS	NS	NS	NS

differences were observed between 100% and 125% RDF and 75 and 100% RDF (Table 1). Data on sugarcane ratoon growth, yield attributes and ratoon cane yield had significant effect of sugarcane genotypes and different levels of recommended of fertilizers. Significantly higher ratoon cane length, girth, NMC, yield (79.26 t/ha), pol %, purity, CCS (13.08%) and CCS (9.78 t/ha) were recorded in CoPb 08217 over the CoLk 09204 but genotype CoLk 09204 and CoS0835 were at par to each other in most of the cases (Table 2). Application of 125% RDF showed significant effect on shoot counts, cane length, cane girth, NMC, cane yield and cane length over 75% RDF. However, germination, shoot counts, pol (%), purity, CCS (%) and CCS (t/ha) and purity (%) were non-significant (Table 2).

CONCLUSION

It is concluded that genotype CoPb 08217 was the best suited genotype in respect of cane yield and juice quality of plant and ratoon crop in subtropical condition over CoLk 09204 and CoS 0835. However, application of 125% RDF recorded highest growth, shoot counts, NMC, cane and ratoon yield than 75 and 100% RDF.

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Nutrient use efficiency indices as influenced by N and K in FCV tobacco (*Nicotiana tabacum*) under irrigated Alfisols of Andhra Pradesh

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Export quality FCV tobacco (*Nicotiana tabacum* L.) is cultivated under irrigated Alfisols in an area of 28,850 ha, producing about 64.36 million kg of semi-flavourful to flavourful leaf every year in Northern Light Soil which includes West Godavari and East Godavari districts of AP and Khammam district in Telangana . The cv. Kanchan is being grown to a larger extent due to the higher yield potential and superior leaf quality characters. N and K are key nutrients for FCV tobacco production and have more pronounced effect on productivity and leaf quality parameters of flue-cured tobacco plant than any essential elements (Collins and Hawks Jr, 1993). However, the information on the quantification of N and K use efficiency indices in FCV tobacco is meagre. The present study was undertaken to find out the influence of different N and K doses on FCV tobacco cv. Kanchan productivity and N and K use efficiencies indices in irrigated Alfisols of Andhra Pradesh.

METHODOLOGY

A field experiment was conducted for three consecutive seasons in fixed plots during *rabi* 2009-2012 at the research farm of ICAR-CTRI Research Station, Jeelugumilli, (17° 11' 30" N and 81° 07' 50" E at 150 m above mean sea-level, average annual rainfall 1100 mm), West Godavari district, Andhra Pradesh under semi arid tropical climate. The experiment soils are Typic Haplustalfs with sandy loam soil surface (0-22.5 cm) and sandy clay sub surface (22.5–45.0 cm) with slightly acidic pH (6.35), low electrical conductivity (0.22) dS/m, chlorides 30 mg/kg, organic C (0.21%), available N (115 kg/ha), medium available P (24 kg/ha) and available K (230 kg/ha). The cv. Kanchan is grown with five levels each of N and K (0, 40, 80, 120 and 160 kg/ha) along with 60 kg P_2O_5 and replicated thrice in RBD. The sources of N, P and K are DAP, CAN and SOP, respectively. Different indices for nutrient use efficiencies were computed as per Dobermann and Fairhurst, 2000. Agronomic efficiency (AE) is defined as the economic yield (kg) in nutrient (N/K) treated plot minus leaf yield (kg) in control (N/K=0) plot per unit amount of nutrient applied (kg). Physiological efficiency (PE) is the leaf yield in nutrient (N/K) treated plot (kg) minus leaf yield in control (N/K=0) plot (kg) divided by total nutrient uptake in N/K treated plot (kg) minus total nutrient uptake in control (N/K=0) plot (kg). Internal efficiency (IE) is economic yield (kg) per total nutrient uptake (kg), Partial factor productivity (PFP) or input use efficiency is the leaf yield (kg) per unit amount of nutrient applied (kg) and Recovery efficiency (RE) is the percentage of nutrient uptake in nutrient treated plot (kg) minus nutrient uptake in control (N/K=0) plot (kg) divided by the amount of N/K applied (kg). NHI is proportion of leaf nutrient to total shoot nutrient.

RESULTS

Tobacco cv. Kanchan cured leaf yield increased up to 120 -60-120 kg NPK in individual years and up to 160-60-160 kg NPK in pooled data (Table 1). Use efficiency indices for N and K varied with different levels of N and K. The $AE_{N,}$ $PE_{N,}$ $IE_{N,}$ PFP_{N}, RE_{N} and NHI_{N} values ranged from 8.39 to 15.88 kg/kg, 22.26 to 30.05 kg/kg, 27.30 to 49.07 kg/kg, 14.61 to 37.93 kg/kg, 37.68 to 52.83 and 54.28 to 52.72% respectively. The $AE_{K,}$ $PE_{K,}$ $IE_{K,}$ $PFP_{K,}$ RE_{K} and $NHI_{K,}$ values ranged from 2.58 to 5.90 kg/kg, 8.68 to 9.41 kg/kg, 24.53 to 48.73, kg /kg, 13.88 to 50.85 kg/kg, 29.75 to 62.68, and 71.69 to 75.59%. All these indices except NHI for N were lower at higher levels of N and K and increased with decrease in the level of N and K. The NHI_{N} remained more or less same (52.78 to 54.28%) across all doses of N. This implied that about 52.78 to 54.28% of total N uptake was trans-located to economic part (i.e. leaf) in all the treatments. The AE is a measure of additional yield (kg) produced for each kg of nutrient applied over the control, PE explains the additional yield for each additional kg of nutrient uptake over control, IE of nutrient is the yield produced per kg nutrient taken up from both fertilizer and indigenous (soil) nutrient sources i.e. total nutrient uptake and PFP measures the yield produced for each kg of nutrient applied, RE explains how much percentage of nutrient applied was recovered and taken up by the crop at the end of the cropping season. N and K improved their uptake with each successive increase in dose up to 160 kg N and 160 kg K_2O/ha. But the use efficiencies showed the reverse trend and the maximum values of use efficiencies of both the nutrients were noticed at 40 kg N and 40 kg K_2O/ha. The AE, PE, IE, PFP and RE declined steadily with successive increase in level of both N and K. This is because the leaf yield could not increase in tune with the rate of fertilizer application following the law of diminishing return and low nutrient utilization efficiency which resulted in lower values of N and K use efficiencies.

Table 1. N and K nutrient use efficiencies of FCV tobacco cv. Kanchan (Pooled)

Treatment	Pooled cured leaf yield (kg/ha)	Agronomic use efficiency ($AE_{N/}$ AE_{k}) (kg/kg)	Physiological efficiency (PE_{N}/ PE_{k}) (kg/kg)	Internal efficiency (IE_{N}/ IE_{k}) (kg/kg)	Partial factor productivity (PFP_{N}/ PFP_{k}) (kg/kg)	Nutrient recovery efficiency (RE_{N}/ RE_{k}) (%)	Nutrient harvest index (NHI_{N}/NHI_{k}) (%)
N use efficiency							
N_0 P_{60} K_{120}	645	-	-	49.07	-	-	52.72
N_{40} P_{60} K_{120}	1308	15.88	30.05	37.62	37.93	52.83	54.23
N_{80} P_{60} K_{120}	1689	12.38	26.76	32.87	24.19	46.25	53.92
N_{120} P_{60} K_{120}	1914	10.13	23.97	29.39	18.23	42.24	53.94
N_{160} P_{60} K_{120}	2035	8.39	22.26	27.30	14.61	37.68	54.28
Mean		11.70	25.76	35.25	23.74	44.75	53.82
K use efficiency							
N_{120} P_{60} K_0	1513	-	-	48.73	-	-	75.59
N_{120} P_{60} K_{40}	1756	5.90	9.41	31.21	50.85	62.68	74.93
N_{120} P_{60} K_{80}	1857	4.11	8.66	26.71	26.78	47.51	72.65
N_{120} P_{60} K_{120}	1914	3.18	8.83	25.57	18.23	35.94	73.65
N_{120} P_{60} K_{160}	1945	2.58	8.68	24.53	13.88	29.75	71.69
Mean	1629	3.94	8.89	31.35	26.69	43.97	73.7

CONCLUSION

It was concluded that the cured leaf yield increased with increase in N and K up to 160 kg/ha. All the indices except NHI_{N} were lower at higher levels of N and K and increased with decrease in the level of N and K in FCV tobacco cv. Kanchan under irrigated Alfisols of Andhra Pradesh.

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Biochemical and phenological parameters of Indian mustard [*Brassica juncea* (L.) Czern and Coss.] as affected by weed management and nitrogen levels

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Among oilseeds, rapeseed and mustard is the second major oilseed crop after groundnut in India. Crop is severely infested both by monocot as well as dicot weeds especially under irrigated conditions and causes yield reduction to the tune of 68% (Degra *et al.*, 2011). This yield reduction is resulted from deprivation in nutrient uptake by the crop due to more competitive ability of weeds in using the nutrients available in soil than the crop. Nitrogen is an essential nutrient which has a synergistic effect in uptake of other nutrients. Nitrogen improve photosynthetic ability of crop by improving chlorophyll content in green part of the crop and it was also reported that abscissic acid (ABA) concentration in tissue is affected by nitrogen availability (Gawronska *et al.,* 2004) and thus ultimately increase in crop duration which indirectly contributes to higher yield. Therefore, different nitrogen levels along with weed management practices were tested in Indian mustard to carry out the experiment.

METHODOLOGY

A field experiment was conducted during *rabi* 2014-2015 on clay loam soil of Instructional farm, Rajasthan College of Agriculture, Udaipur (582.17 m above mean sea level, 24°35´ N latitude and 73°42´ E longitude) Rajasthan. The soil of the experimental field was alkaline in reaction, medium in N and P and high in K. The experiment involved 15 treatment combinations consisted of 5 weed management practices (pendimethalin 0.75 kg/ha as pre emergence, oxadiargyl 0.09 kg/ha as pre emergence, quizalofop-ethyl 0.05 kg/ha 25 days after sowing (DAS), hand weeding 25 DAS and weedy check) and 3 nitrogen levels (45, 60 and 75 kg/ha). Indian mustard variety BIO-902 (*Pusa Jaikisan*) was sown with seed rate of 2.5 kg/ha on 2nd November, 2014 at 30 cm × 10 cm spacing using package of practices available for Sub-Humid Southern Plain and Aravalli Hills'' of Rajasthan. Herbicides were sprayed with knapsack sprayer fitted with flat fan nozzle using 500 litres of water per hectare. The required doses of N for different treatments were applied both through urea and DAP after adjusting the quantity of nitrogen supplied by DAP for supplying 35 kg/ha of phosphorus. Observations of the parameters were taken by using standard procedure.

RESULTS

Chlorophyll content of leaves of Indian mustard had been recorded significantly minimum under weedy check as

Table 1. Effect of weed management and nitrogen levels on biochemical and phonological parameters and yield of Indian mustard

Treatment	Chlorophyll content (mg/g fresh weight of leaves)		Phenological characteristics		Seed yield (kg/ha)
	60 DAS	90 DAS	Days to 50 % flowering	Days to maturity	
Weed Management					
Pendimethalin 0.75 kg/ha	2.65	2.17	53.56	122.78	1852
Oxadiargyl 0.09 kg/ha	2.67	2.25	53.00	123.44	2234
Quizalofop-ethyl 0.05 kg/ha	2.66	2.18	54.01	123.89	1655
One Hand weeding 25 DAS	2.75	2.28	52.45	123.33	2240
Weedy Check	2.48	2.04	55.44	124.00	1312
LSD (P=0.05)	0.10	0.08	NS	NS	210
Nitrogen levels (kg/ha)					
45	2.48	2.08	54.87	121.13	1610
60	2.67	2.19	53.13	123.27	1887
75	2.79	2.28	53.07	126.07	2079
LSD (P=0.05)	0.08	0.06	NS	1.58	163

compared to all weed management treatments as under unweeded condition crop was not able to compete for nutrients with weeds. Among different herbicidal treatments oxadiargyl 0.09 kg/ha recorded the highest (2.67 mg/g of fresh leaves) chlorophyll content which was comparable to one hand weeding treatments. On the other hand, among the three levels of nitrogen, application of both 75 and 60 kg N/ha resulted in significant increase in chlorophyll content of plant over 45 kg N/ha (2.48 mg/g of fresh leaves). The per cent increase in chlorophyll content/g of fresh weight of leaves of the crop due to 75 kg N/ha was 12.50 compared to 45 kg N/ha. Addition of each level of nitrogen significantly increased days to maturity however, days to 50% flowering was not affected due to nitrogen fertilization and resulted into lengthening of the period between flowering and maturity. It allowed the crop to harness more photosynthates during reproductive period of crop and thus contributed to the higher seed yield.

CONCLUSION

The research findings reveal that pre emergence application of oxadiargyl 0.09 kg/ha recorded higher chlorophyll content comparable to one hand weeding treatment and application of 75 kg N/ha increased days to maturity by 4.94 days over 45 kg N/ha.

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Effect of fertility levels on growth and yield of hybrid rice (*Oryza sativa* L.) cultivars under sub-tropical irrigated conditions

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Rice (*Oryza Sativa* L.) is a major staple food for more than half of the world's population. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. To meet the demands of increasing population and maintain the self sufficiency, the present production level needs to be increased to 120 million tonnes by 2020. There is no scope for horizontal expansion of cultivable area, therefore cultivation of hybrid rice cultivars with good management practices and efficient use of input resources are necessary for achieving desired level of productivity. The potentiality of high yielding rice varieties depends upon their efficacy in utilizing the available soil nutrients. The proper dose of NPK fertilizer is very important to harness the yield potential of rice with economic efficiency. Considering these facts, the present investigation was conducted with the objective to study the effect of varieties and fertility levels on growth and yield of hybrid rice under the sub-tropical irrigated conditions.

METHODOLOGY

A field experiment was carried out during the *kharif* season of 2014 at research farm, SKUAST-Jammu. The soil of the experimental site was sandy loam, slightly alkaline in reaction and medium in electrical conductivity. The soil was low in organic carbon and available N whereas medium in P and K. The experiment consisting of 4 varieties viz. PRH-10, DRRH-3, Indra Sona and PHB-71 and 4 fertility levels ($N:P_2O_5:K_2O$ kg/ha) viz. 60:30:15, 90:45:23, 120:60:30 and 150:75:38. The experiment was laid out in factorial randomized block design with 3 replications. Full doses of phosphorus and potassium along with 1/3rd nitrogen fertilizers were applied treatment wise after the puddling by broadcasting method and the remaining dose of nitrogen fertilizer was broadcasted in two equal splits one at mid tillering stage and other just before panicle imitation. All recommended agronomic practices were followed throughout the crop period. The grain yield was recorded from the net plot area and expressed as t/ha.

RESULTS AND DISCUSSION

Among the different hybrid varieties, PHB-71 variety recorded the highest plant height at all the growth stages which was statistically superior over DRRH-3, Indra Sona and PRH-10. Variety DRRH-3 was statistically at par with

Table 1. Effect of varieties and fertility levels on growth, yield and economics of hybrid rice

Treatment	Plant height at harvest (cm)	No. of tillers/ m^2 at harvest	Grain Yield (t/ha)	Benefit:cost ratio
Varieties				
PRH-10	95.22	270.97	5.77	1.88
DRRH-3	99.77	340.83	6.40	2.19
Indra Sona	97.40	333.17	6.32	2.16
PHB-71	103.41	357.71	7.20	2.59
SEm±	1.05	3.63	0.08	-
C.D (P=0.05)	3.03	10.49	0.23	-
Fertility Levels (*N:P_2O_5:K_2O kg/ha*)				
60:30:15	92.31	266.34	5.50	1.91
90:45:23	98.46	333.42	6.32	2.21
120:60:30	101.66	347.17	6.87	2.36
150:75:38	103.37	355.75	6.99	2.30
SEm±	1.06	3.63	0.08	-
C.D (P=0.05)	3.03	10.49	0.23	-

Indra Sona in terms of plant height and number of tillers at harvest. The difference in the plant height was due to genetic character of the genotype. The maximum plant height and number of tillers in relation to fertility levels was recorded with the application of N:P_2O_5:K_2O @ 150:75:38 kg/ha which was statistically at par with N:P_2O_5:K_2O @ 120:60:30 kg/ha. Significant increase in plant height at different fertility levels might be due to optimum nutrient availability in accordance with different crop growth phases for better nutrient uptake and vigorous vegetative growth (Bindu and Subramanian, 2008). Among the hybrids, variety PHB-71 recorded significantly higher grain yield over DRRH-3, Indra Sona and PRH-10. The variety 'PHB-71' has better utilization capacity of available nutrients and better nutrient uptake leading to higher grain yield (Virmani, 1996). Application of N:P_2O_5:K_2O @ 150:75:38 kg/ha recorded significantly highest grain yield which was statistically at par with N:P_2O_5:K_2O @ 120:60:30 kg/ha which was due to significant improvement of yield attributes viz. no. of panicles/m^2, no. of grains/panicle and 1000-grain weight under optimum nutrient supply. Among the varieties, PHB-71 recorded highest benefit: cost ratio and proved more remunerative followed by variety DRRH-3, Indra Sona and PRH-10. Application of N:P_2O_5:K_2O @ 120:60:30 kg/ha gave highest benefit: cost ratio. This was resulted due to higher grain yield at this fertility level.

CONCLUSION

On the basis of 1 year study, it can be concluded that variety PHB-71 and fertility level N:P_2O_5:K_2O @ 120:60:30 kg/ha has been found more beneficial for achieving economic yield advantage from hybrid rice with higher economic feasibility.

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Fertigation studies in oil palm

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Oil palm is the highest edible oil yielding crop giving up to 3-6 tonnes of oil per hectare per year. It is the crop that has a greater advantage in the productivity per hectare that is much higher than that of any major oil producing crop, thus cutting the cost of land infrastructure, maintenance and harvesting. It is a crop of the future and source of health and nutrition, value addition, waste utilization, eco-friendly, diversification, import substitution, co-generation and sustainability. The total vegetable oil production has increased from 16.07 million tons in 1960 to 81.83 million tons in 1998 and to 159.43 million tons in 2013 with major contribution from palm oil 56.21 million MT (Rethinam, 2014).

METHODOLOGY

A field experiment was conducted at AICRP on Palms (Oil Palm), ARS Campus, Gangavathi, University of Horticultural Sciences, Bagalkot to study the influence of fertigation on oil palm through micro-irrigation under medium black soils of Tungabhadra Command area of Karnataka. The mean rain fall of the station for a period of 26 years is about 520 mm distributed over 35-36 rainy days. During the year 2012 an amount of 372.27 mm rainfall was received. The maximum temperature was observed in the month of April & May (37.33^{o}C and 36.87^{o}C) and minimum temperature was in the month of January (13.56^{o}C) and Relative humidity was higher in the month of August (84.5%) and lowest in the month of April (58%). The experiment has been laid out in RBD design with seven different fertigation doses in three replications *viz*., T_1: 300:150:300 g NPK through fertigation, T_2: 600:300:600 g NPK through fertigation, T_3: 900:450:900 g NPK through fertigation,T_4: 1200:600:1200 g NPK through fertigation, T_5: 1200:600:1800 g NPK through fertigation, T_6: 1200:600:2700 g NPK through fertigation, T_7:1200:600:2700 g NPK through soil application on 18 years old oil palm garden. The observations recorded during 2012 and 2013 were statistically analyzed and presented and Economics of the two years also calculated. The fertilizers were applied in six equal splits per palm per year.

RESULTS

The FFB yield differed significantly among various treatments. The pooled data of FFB yield differed significantly among various treatments. The treatment T4 through fertigation recorded the significantly higher FFB yield (8.36 t/ha) over all other fertigation and soil application treatments (Table 1). The two years data indicated that the treatment T_4 through fertigation with 6 equal splits recorded higher FFB yield and yield attributes. The gross return differed significantly among the various treatments. The fertigation treatment 1200:600:1200 g NPK/Palm/year recorded significantly higher gross return (Rs.58,535) over all other fertigation and soil application treatments. A significant

Table 1. Effect of fertigation treatments on the number of bunches/palm, bunch weight (kg) and FFB yield (t/ha) and economics of oil palm (Pooled data of two years)

Treatment	Number of bunches/Palm	Bunch weight (kg)	FFB yield (t/ha)	Cost of cultivation (Rs.)	Net return (Rs.)	B:C ratio
T_1	2.58	14.23	5.25	17,441	19309	2.11
T_2	2.46	15.48	5.45	20,347	17772	1.87
T_3	2.73	15.60	6.09	23,251	19380	1.83
T_4	3.06	19.11	8.36	26,157	32378	2.24
T_5	2.69	18.20	7.00	28,622	20385	1.71
T_6	2.38	16.23	5.52	32,321	6345	1.20
T_7	2.99	15.74	6.73	32,321	16285	1.46
SEm$\pm$	0.26	1.40	0.52		2875	0.16
CD (P= 0.05)	NS	4.26	1.53		8457	0.48

difference in the net return was observed for different fertigation treatments. Application of 1200:600:1200 g NPK/ palm/year through fertigation recorded higher net return (Rs.32,378) over all other treatments except T1:300:150:300 g NPK/Palm/year through fertigation. The fertigation treatments 1200:600:1200 g NPK/Palm/year recorded significantly higher BC Ratio (2.24) over all other fertigation and soil application treatments except 300:150:300 g NPK/Palm/year (2.11). The treatment T_4 recorded higher gross return and net returns and appeared to have better prospects for adaptation under Tungabhadra command area and can be recommended on farmers fields.

CONCLUSION

The study over the years indicated that Fertigation in Oil palm with 1200:600:1200 g $N:P_2O_5:K_2O$ /palm/year in six equal splits at bi-monthly interval recorded higher FFB yield and good monetary returns.

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Productivity of field pea (*Pisum sativum*) as influenced by biofertilizers in conjunction with chemical fertilizers

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Field pea (*Pisum sativum* L.) is a high yielding, input responsive and relatively stable pulse crop of *rabi* season. In India, area under field pea is 0.96 million hectare and production is 0.92 million tonnes with the productivity of 960 kg/ha (Anonymous, 2014-15). Though India is the world's largest producer of pulses and second largest producer of field pea in the world yet it imports a large amount of pulses (3.8 million tonnes) to meet the growing domestic need. The scope of increasing the area under pulses is very limited due to their low productivity in comparison to high yielding dwarf varieties of cereal and millet crops. One of the possible ways is to increase the productivity per unit area by integrating the use of chemical with bio-fertilizers. Seed inoculation with *Rhizobium*, phosphate solublizing bacteria (PSB) and plant growth promoting rhizobacteria (PGPR) prior to sowing is the cheapest means to improve the productivity of grain legumes, as it influences the nodulation, biological nitrogen fixation, produced growth hormones and ultimately increases grain yield. Keeping this in view, a field experiment was carried out to find out the effect of biofertilizers in conjunction with chemical fertilizers on productivity in field pea.

METHODOLOGY

The field experiment was conducted during rabi season of 2013-14 at Research Area, CCS Haryana Agricultural University, Hisar The soil of the experimental field was sandy loam, slightly alkaline in pH (7.9), low in nitrogen (140 kg/ha), medium in phosphorous (30.2 kg/ha) and high in potassium (311 kg/ha). The experiment was conducted in randomized block design with nine treatments *viz.*, Control, seed inoculation with *Rhizobium*, *Rhizobium* + PSB, *Rhizobium* + PSB + PGPR, Recommended dose of fertilizers (RDF, 20 kg N and 40 kg P_2O_5/ha), RDF + Rhizobium, RDF + Rhizobium + PSB, RDF + Rhizobium + PSB + PGPR, RDF + $ZnSO_4$ @ 25 kg/ ha.The seed of variety HFP 8909 / *uttera* was drilled at spacing of 30 cm X 15 cm. Weeds were managed manually by two hand hoeing at 25 and 45 days after sowing. Seed was treated with biofertilizers @ 10 g/kg seed as per treatments. At maturity, data on pods per plant, seeds per pod, 100 grain weight, grain and biological yield were recorded.

RESULTS

Combined application of RDF + *Rhizobium* + PSB + PGPR significantly improved the yield attributing characters of field pea *i.e*. number of pods/plant; grains/pod and 100-grain weight (Table 1). The application of RDF + *Rhizobium* + PSB + PGPR produced significantly more number of pods $plant^{-1}$ (23.3), which was statistically at par with RDF (19.9), RDF + *Rhizobium* (21.2), RDF + *Rhizobium* + PSB (22.2) and RDF + $ZnSO_4$ (20.3). The number of grains pod^{-1} was improved significantly with the combined application of RDF + *Rhizobium* + PSB + PGPR (5.70), which did not differ significantly from RDF (5.23), RDF + *Rhizobium* (5.40), RDF + *Rhizobium* + PSB (5.50) and RDF + $ZnSO_4$ (5.30) treatments.

Table 1. Effect of bio-fertilizers and their combination with chemical fertilizers on yield attributes and yields of field pea

Treatment	No. of pods/ plant	No. of grains/ pod	100 grain wt. (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
Control	12.0	4.20	13.3	1595	2798
Rhizobium	13.3	4.26	15.1	1727	3012
Rhizobium + PSB	14.5	4.26	15.3	1802	2873
Rhizobium + PSB + PGPR	16.1	4.50	15.5	2116	3136
RDF (20 N + 40 P_2O_5 kg/ha)	19.9	5.23	16.3	2499	2925
RDF + *Rhizobium*	21.2	5.40	16.6	2577	3019
RDF + *Rhizobium* + PSB	22.2	5.50	16.7	2731	3025
RDF+ *Rhizobium* + PSB + PGPR	23.3	5.70	16.9	2931	3095
RDF + $ZnSO_4$ @ 25 kg/ha	20.3	5.30	16.5	2549	3058
CD (P=0.05)	4.3	0.51	NS	137	NS

The various treatments did not differ significantly in 100 grain weight however, a numerical increase in 100 grain weight was observed in treatment RDF + *Rhizobium* + PSB + PGPR.

CONCLUSION

Biofertilizers application *viz. Rhizobium,* PSB and PGPR along with recommended dose of fertilizers (20 kg N and 40 kg P_2O_5/ha) improved the yield attributes and yield of field pea over recommended dose of fertilizers

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Response of late sown wheat cultivars to integrated nitrogen management under lowland rice–wheat cropping system

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Rice-wheat system is the backbone of India's food security. This system occupies an area of 10.5 million hectare in the Indo-Gangetic plains (IGP) of India, out of which majority of area in the north-eastern and north-western plain zone. A sizable area of the wheat of NEPZ falls under low lying where late harvest of preceding crops (rice) delays wheat sowing. After harvest of the preceding rice crop, the soil remainwet and it is very difficult to prepare the field for wheat sowing. It takes 15-20 days for any cultural operation for sowing as field remains fallow due to high soil moisture. High temperature prevailing during the reproductive phase of the late planted wheat crop affects the grain yield adversely. In all for these areas, early maturing and high yielding varieties of wheat are required that can fit into prominent crop rotations and suitable for sowing during mid to late December. Understanding the response of very late sown wheat to high temperature stress during grain filling will assist to identify short duration cultivars and development of best agronomic management practices *viz.* advancing planting time, cultivars choices, mulching, and fertigation for mitigating high temperature stress. An optimum dose of nitrogen fertilizer can be effective in boosting the productivity of late sown wheat crop. Therefore, efforts ought to be made to minimize the effect of heat stress due to delayed sowing by choosing appropriate wheat varieties and the optimum nitrogen requirement to wheat cultivars for mitigating the high temperature stress.

METHODOLOGY

The field experiment was conducted at Agronomy Research Farm, N.D.U.A.T., Kumarganj, Faizabadduring winter (*rabi*) season of 2012-13 and 2013-14in randomized block design with three replications. The soil was silty loam having pH 8.4, organic carbon 0.31%, CEC16.30me per 100 g soil and 203, 15 and 265 kg /ha available N, P and K respectively. Zinc status was in lower range. The soil was

Table 1. Effect of late sown wheat cultivars and nitrogen level on growth, yield attributes and yields of underlowland rice-late wheat cropping system

Treatment	No. of tillers/m	LAI	No. of ears /m	Ear length (cm)	No. of grains /ear	1000 grain wt. (g)	Grain yield (t/ha)	Straw yield (t/ha)
Variety								
HUW 234	97	3.35	52	9.5	43	36.7	3.19	4.57
HP 1633	93	3.18	48	8.8	40	34.9	2.70	4.38
NW 1014	100	3.25	53	9.6	44	37.1	3.29	4.75
Raj 3077	94	3.04	51	9.3	43	35.3	3.06	4.57
CD (P=0.05)	2.4	0.24	3.1	0.4	2.3	0.3	0.15	0.19
Nitrogen level								
90 kg/ha	85	3.46	55	9.7	44	37.5	3.01	4.21
120 kg/ha	91	3.51	56	9.5	47	37.9	3.24	4.36
90 kg/ha + 25 % through FYM	93	3.57	58	9.8	46	37.9	3.26	4.38
120 kg/ha + 25 % through FYM	99	3.68	61	9.9	48	38.1	3.61	4.35
150 kg/ha	98	3.64	61	9.9	48	38.0	3.63	4.36
CD (P=0.05)	1.2	0.1	1.4	0.1	3.2	0.2	0.21	0.16

slightly alkaline in nature which was partially reclaimed during *kharif* season through gypsum supplementation. The experiment constituted of 18 treatment combinations comprising fourvarieties of wheat (HUW 234, HP 1633, NW 1014 and Raj 3077) and five doses of nitrogen levels (90 kg N/ha, 120 kg N/ha, 90 kg N/ha + 25% N through FYM, 120 kg N/ha + 25% N through FYM and 150kg N/ha). The NP&K fertilizers were applied through urea, DAP and MOP respectively. One third of N (as per treatments)and full dose of P_2O_5 (50 kg/ha), K_2O (30 kg/ha)and $ZnSO_4$ (20 kg/ha) were applied at sowing and the remaining N was applied in two splits at first and second irrigation. The FYM were applied at the time of field preparation. The wheat varieties were sown on third week of December in lowland condition under lowland rice–late wheat cropping system during both the years under partial sodic reclaimed conditions. The crop was drilled with 22 cm inter-row spacing through seed drill at the seed rate of 125 kg/ha. Recommended cultural practices were also adopted as per need of crop.

RESULTS

Significant differences were observed with varieties and nitrogen levels on growth, yield and economics of wheat under late sown condition of partially reclaimed soils in rice-wheat cropping system. Among wheat varieties, NW 1014recorded significantly higher number of tillers/m (100), leaf area index (3.25), number of ears/m (53), ear length (9.6 cm), grains/ear (44) and 1000 grain weight (37.1 g) than that of other late sown varieties under studies, except HUW 234 which was at par with all the characters under studies (Table 1). Similarly, NW 1014 was the highest yielding cultivar (3.29 t/ha) with significant yield advantage under very late sown condition in partial reclaimed soils over other cultivars under study except HUW 234 that reflects its better tolerance to terminal heat stress. This endows NW 1014 as more suitable for different crop rotations followed in the zone, such as rice-wheat, sugarcane-wheat, potato-wheat, vegetable pea-wheat. Similarly, with each increment in nitrogen level resulted in significant increase in yield attributes and grain yield up to 150 kg/ha. However, incorporation of nitrogen through FYM showed significant improvement in growth and yield towards its succeeding higher doses. Nitrogen level with 120 kg/ha + 25 % through FYM found significantly higher grains and straw yields and proved significantly superior to lower N levels doses, but was at par with 150 kg N/ha. The increase in grain yield due to incremental dose of N was mainly due to increase in number of effective tillers, grains/ear and weight of grains/ear. Interaction effect between variety and nitrogen levels was not found significant. This might be due to the fact that short statured high yielding wheat varieties performed equally well to optimum level of nitrogen.

CONCLUSION

On the basis of results obtained, it may be concluded that wheat cultivar Raj 3765 was found most suitable for cultivation under very late sown condition of north eastern plain zone to avoid terminal heat stress during grain development stage. The optimum dose of N was computed 160 kg/ha for the higher yield potential under such type of conditions.

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Effect of organic and inorganic resources of nutrients on yield of paddy

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Rice (*Oryza sativa*) forms staple food for more than half of the world population. In India, rice the most important and extremely grown food crop, occupied 42.5 million hectare and produced 152.6 million tonnes paddy with a productivity of 3.59 t/ha on against the world's average yield of 4.39 t/ha, however India remain first in area and second in production in the world (Anonymous, 2012).The post-green revolution period, however, showed a decline in yield trend, mostly because of imbalanced use of fertilizers and pesticides. These led to yield stagnation, causing concern about the future potential for productivity growth and long-term sustainability. Excessive fertilizer application may lead to wastage of nutrients and reduction in yield and quality of crop. In view of these facts organic nutrient management has significant role in improving productivity of crop and soil fertility. Organic manures provide regulated supply of N by releasing it slowly resulting in increased yields of rice and nutrient use efficiency.

METHODOLOGY

The experiment was conducted at the research farm of Department of Organic Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *kharif* 2014 consisted of eight treatments comprising of combinations of four nutrient management treatments *viz.,* Organic nutrient management (soil & seed treatment, vermicompost (VC) 10 t/ha and 3 sprays of vermiwash at 15, 30, 45 days after sowing), Inorganic nutrient management (recommended NPK), Integrated nutrient management (5 tonnes VC + 50% of recommended NPK), control (farmer's practices) (2.5 tonnes VC + 25% of recommended NPK) with two ecosystems *i.e.* transplanted and direct seeded paddy were tested in split plot design, replicated thrice.

RESULTS

Transplanted conditions significantly delayed the physiological maturity by 3 days as compared to direct seeded condition. The different nutrient management treatments failed to influence the numbers of days taken to physiological maturity. Transplanted ecosystem took significantly more number of days to attain maturity, whereas, the nutrient management treatments failed to influence the number of days taken to attain maturity. Rice crop in transplanted ecosystem produced significantly higher grain and straw yield as compared to direct seeded (Table 1). Among nutrient management treatments, integrated nutrient management being at par with organic produced significantly higher grain yield as compared to other treatments. Farmer's practice produced significantly lowest grain yield over all other treatments. Integrated and organic nutrient management treatments produced 41.84 and 35.07% more grain yield over farmer's practice, respectively. Higher growth due to integrated and organic nutrient management owing to improvement in physical, chemical and biological properties resulted in higher assimilation area and more leaf area duration better nutrient supply and better translocation of

Table 1. Effect of treatments on days taken to maturity, grain, straw yield and harvest Index

Treatment	Days taken to maturity	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index
Ecosystems				
Transplanted	128	4.40	6.47	0.404
Direct seeded	125	3.71	5.54	0.401
CD (P=0.05)	2	0.39	0.26	NS
Nutrient Management				
Organic	127	4.39	6.54	0.401
Inorganic	126	3.96	5.88	0.406
Integrated	126	4.61	6.81	0.402
Farmer's practice	126	3.25	4.86	0.401
CD (P=0.05)	NS	0.25	0.33	NS

photosynthates to storage organs might have improved the yield attributes and ultimately grain yield. Moreover, organics besides supplying macro and micronutrient have also solubilizing effect on native soil nutrients due to the action of organic acids produced during decomposition. Among nutrient management, statistically identical straw yield was obtained from integrated and organic treatments which were significantly higher than the remaining treatments. The data regarding the effect of ecosystems and nutrient management on harvest index revealed that the ecosystems and nutrient management could not exhibit any significant influence on harvest index.

CONCLUSION

Transplanted ecosystem in organic (soil treatment with jeevamrit, seed treatment with *Azospirillum* + PSB, vermicompost 10 t/ha and 3 sprays of vermiwash) and integrated nutrient management (VC 5 t/ha + 50% recommended NPK) practices in paddy cultivation proved to be significantly higher yield than other treatments.

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Effect of Chromium on yield attributes of leafy vegetables: cabbage and spinach

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Chromium (Cr) is one of the toxic heavy metals found abundantly in the earth's crust, and now as a consequence of its wide industrial use, it has become a serious environmental pollutant. However, contamination of soil and water by chromium (Cr) is of recent concern. The leather industry is the major cause for the high influx of Cr to the biosphere, accounting for 40% of the total industrial use. In India, about 2000–32,000 tons of elemental Cr annually escapes into the environment from tanning industries only (Dey *et al*., 2009). Nearly 60,000 metric tonnes of chromium containing solid waste is generated by tanneries alone per annum in the US (Cabeza *et al.,* 1998), whereas Indian tanneries produce 54 kg of chromium as waste per day (Sekaran *et al.,* 1998). Most of the tanneries present here are located in the outskirts of several major cities such as Delhi, Kanpur, Mumbai, Calcutta, Chennai *etc.* The tanning industries significantly impact the groundwater quality, especially chromium contamination. Additionally, Cr transport to the aerial part of plant can have a direct impact on the cellular metabolism of shoots, thus it contributing to the reduction in plant height, reduction in germination of Cr-treated seeds.

METHODOLOGY

The study was conducted at ICAR - Central Soil Salinity Research Institute, Karnal, Haryana. Twenty seeds of each individual variety of *Brassica oleracea* L. (Cabbage), variety Golden Acre and *Spinacia oleracea* L. (Spinach), variety Pusa Bharti were taken in three replicates in petri plates. Petri plates were arranged in completely randomized block design (CRD) and contained a layer of moistened germinating filter paper spiked with different concentrations of chromium (Chromium sulphate) *i.e.,* 0, 0.1, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 mg/L, and kept in a germinator at 20^0C for 15 days. The seed germination, plumule length and radicle length (cm), fresh weight and dry weight (gm) of seedling were recorded (Cokkizgin and Cokkizgin, 2010).

RESULTS

The results of seedlings of spinach (*Spinacia oleracea)* and cabbage (*Brassica oleracea)* exposed to increasing Cr concentrations have revealed that there were reduction in seed germination, plumule length, radical length, fresh weight and dry weight. The average effects of Cr doses were found to be significant on these parameters for both the crops. When the Cr concentration increased from 0 to 5.0 mg/L, the germination percentage, plumule and radical length, fresh and dry weight decreased in spinach from 100 to 33.33%, 5.41 to 2.42 cm, 5.08 to 2.58 cm, 26.33 to 11.75 mg and 2.54 to 1.80 mg, respectively and their inhibition increased from 5.0 to 66.67%, 4.19 to 55.27%, 0.85 to 49.24%, 4.30 to 55.39% and 4.33 to

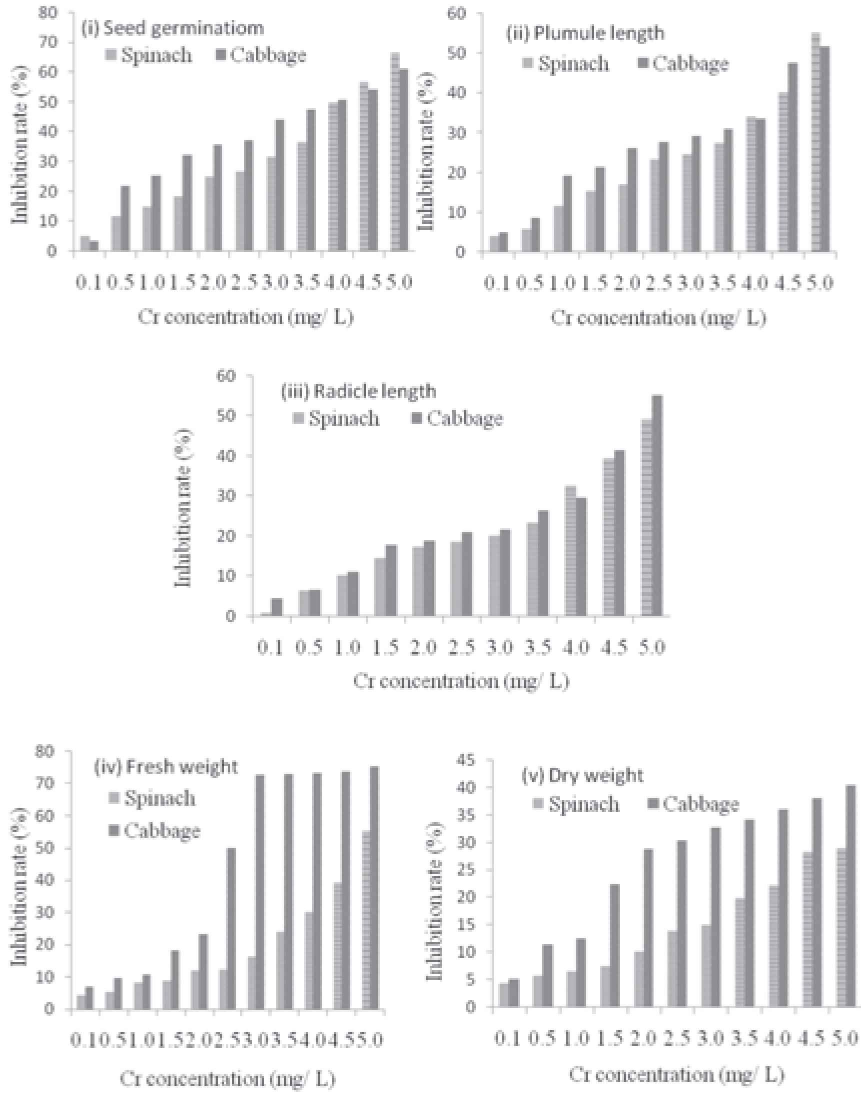

Fig. 1. (i-v). Inhibition rate for seedling growth attributes and germination of spinach and cabbage at different Cr concentration as compared to control

29.00%, respectively, in 0.1 to 5.0 mg/L Cr concentration (as compared to control). In case of cabbage, the decrease for the corresponding parameters was from 98.33 to 38.33%, 5.87 to 2.84 cm, 5.05 to 2.33 cm, 68.48 to 16.95 mg and 2.54 to 1.80 mg, respectively and their inhibition increased from 3.4 to 61%, 5.03 to 51.7%, 4.38 to 55.11%, 7.10 to 75.24% and 5.09 to 40.43%, in same order at 0.1 to 5.0 mg/L Cr concentration (as compared to control) (Fig. 1, i-v).

CONCLUSION

It was concluded that the data which is generated through this study will be helpful in detecting the lethal levels of heavy metals to tolerance and accumulation capacity in vegetables. Spinach and cabbage both being leafy vegetables are not advised to be grown in Cr heavy metal contaminated water as the consumption of these vegetables could cause food chain contamination in long term.

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Nutrient management for sorghum based intercropping

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A field experiment on nutrient management and sorgum based intercropping under rainfed condition was conducted during *kharif* season of 2010-2012 at the farm of Sorghum Research Unit (CRS) Dr. PDKV, Akola to find out suitable nutrient application level and intercrop for enhancing productivity and soil fertility. The experiment was planned in FRBD with the treatments as factor A is two nutrient levels as 1) RDF (80:40:40 NPK kg/ha) and 2) soil test basis and factor B is nine intercropping (sorghum+soybean, sorghum+greengram, sorghum+ blackgram and sorghum+pigeonpea and their sole cropping) in three replications. Microbial colony count, Sorghum equivalent yield and pooled GMR, NMR and B:C ratio of three years was found to be non significant due to nutrient levels however among the nine intercropping Microbial colony count(23.13 and 21.38 fungi10^8/g soil at flowering and at harvesting respectively, 55.11 and 52.90 bacteria 10^6/g soil at flowering and at harvesting respectively and actinomycetes 1.92 and 1.47 10^9/g soil at flowering and at harvesting respectively), Sorghum equivalent yield (52.60 kg/ha pooled) and pooled GMR, NMR and B:C ratio was significantly maximum with Sorghum + pigeon pea (B:C ratio 3.67) intercropping fallowed by sorghum + green gram (B:C ratio 3.26) intercropping. As compare to sole cropping productivity of all the intercropping was more.

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Effect of STCR technology on yield and nutrient uptake of maize in acid Alfisol of Himachal Pradesh

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India's fertilizer consumption increased from 1.1 million tonnes (1967-68) to 26 million tonnes (2014-15). Degradation of soil health has also been reported due to imbalanced use of fertilizers, overall nutrient use ratio (N: P_2O_5: K_2O) of 4:2:1 is considered ideal for Indian soils, whereas the present ratio of 6.7:2.4:1 is far off the mark. This imbalanced nutrient use has resulted in wide gap between crop removal and fertilizer application. Thus, balanced NPK fertilization has received considerable attention in India (Ghosh*et al*., 2004). To ensure balanced fertilizer application soil testing is the key.However to judiciously use nutrients from organic as well as inorganics, target yield approach employing soil testing and crop correlationhas evolved as one of the most efficient nutrient management approaches. The experiment was conducted to study the effect of prescription based fertilizers and FYM application on yield and nutrient uptake of maize.

METHODOLOGY

The study was conducted in an ongoing long-term experiment initiated during *Kharif,* 2007 with maize-wheat cropping system at the research farm of Himachal Pradesh Krishi Vishvavidyalya, Palampur. The soil of the experimental site was acidic in reaction, silty clay loam in texture and is situated at 32° 6' N and latitude, 76° 3' E longitude and an altitude of 1290 m. The investigation comprised 8 treatments over the years. Fertilizer doses in case of target yield treatments were worked out using equations given below:

Table 1. Effect of prescription based fertilizers and FYM application on yield of maize (pooled data *Kharif*, 2013 & 14)

Treatment	Nutrient Dose (kg /ha)			Grain yield (t /ha)	Stover yield (t /ha)
	N	P_2O_5	K_2O		
T_1-Control	0	0	0	1.14	2.34
T_2-Farmers' Practice (FP)	35	0	0	1.96	3.44
T_3-General recommended dose (GRD)	120	60	40	2.77	4.53
T_4-Soil test based (STB)	150	45	35	2.80	4.71
T_5-Target yield 30 q /ha(T_{30})	119	89	10	2.87	5.17
T_6-Target yield 30 q /ha with FYM @ 5 t /ha(T_{30} IPNS)	88	57	10	3.13	5.42
T_7-Target yield 40 q /ha(T_{40})	176	77	10	3.68	5.79
T_8-Target yield 40 q /ha with FYM @ 5 t /ha (T_{40} IPNS)	144	100	10	3.90	6.37
CD (P=0.05)				0.79	1.8

Table 2. Effect of prescription based fertilizers and FYM application on nutrient uptake by maize (pooled data *Kharif*, 2013 & 14)

Treatment	Nutrient uptake (kg /ha)					
	N		P		K	
	Grain	Stover	Grain	Stover	Grain	Stover
T_1-Control	16.16	32.31	3.80	3.72	4.15	40.66
T_2-Farmers' Practice (FP)	29.02	44.31	7.77	5.80	8.38	55.09
T_3-General recommended dose (GRD)	48.52	53.96	11.10	6.47	13.25	67.21
T_4-Soil test based (STB)	49.40	57.28	11.87	7.25	13.84	71.60
T_5-Target yield 30 q /ha(T_{30})	50.35	71.14	12.11	8.55	13.88	81.25
T_6-Target yield 30 q /ha with FYM @ 5 t /ha(T_{30} IPNS)	52.11	75.92	13.17	9.31	14.83	86.48
T_7-Target yield 40 q /ha(T_{40})	63.77	80.23	16.16	8.82	17.60	91.30
T_8-Target yield 40 q /ha with FYM @ 5 t /ha (T_{40} IPNS)	67.34	83.07	17.97	10.31	18.41	94.12
CD (P=0.05)	4.94	8.34	2.92	2.10	1.27	10.44

IPNS- Integrated Plant Nutrient Supply

$FN = 5.88\,T - 0.23\,SN - 0.93\,ON$; $FP_2O_5 = 4.87\,T - 1.22\,SP - 0.81\,OP$

$FK_2O = 3.66\,T - 0.49\,SK - 0.51\,OK$

In above equations, FN, FP_2O_5, FK_2O are doses of N, P_2O_5 and K_2O, respectively in kg /ha. T is the yield target (q ha^{-1}), SN, SP and SK are soil available N, P and K contents before sowing of the crop, respectively in kg ha^{-1}.Whereas ON, OP and OK are N, P and K supplied by FYM, respectively in kg ha^{-1}.

RESULTS

Soil test based fertilizer application (T_4) enhanced the grain yield over farmers' practice (T_2). As far as the effect of nutrients application based on STCR concept for specific yield targets is concerned, treatments corresponding to 40 q / ha with and without FYM (T_8 and T_7), were found significantly better as compared to soil test based and general recommended dose for grain yield of maize. The higher grain and stover yields of the crop in targeted yield treatments both with and without FYM over general recommended dose and soil test based treatments might be due to balanced and judicious use of the NPK fertilizers. The higher grain and stover yield and hence nutrient uptake (NPK) in case of targeted yield treatment with FYM might be due addition of FYM. FYM might have improved physical properties like bulk density, water retention, better aggregation that might have helped in better development of roots and proper use of native and applied nutrients and also known to enhance microbial activities. Similar results have also reported by Verma*et al.* (2002).

CONCLUSION

Soil test based nutrient application along with FYM based on STCR approach significantly enhanced the productivity as well nutrients uptake by maize. The prescription based application of fertilizers along with FYM proved superior to conventional general recommended dose as well as soil test based fertilizer application for yield as well as nutrient uptake.

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Effect of STCR technology on yield and nutrient uptake of maize in acid alfisol of Himachal Pradesh

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India's fertilizer consumption increased from 1.1 million tonnes (1967-68) to 26 million tonnes (2014-15). Degradation of soil health has also been reported due to imbalanced use of fertilizers, overall nutrient use ratio (N: P_2O_5: K_2O) of 4:2:1 is considered ideal for Indian soils, whereas the present ratio of 6.7:2.4:1 is far off the mark. This imbalanced nutrient use has resulted in wide gap between crop removal and fertilizer application. To ensure balanced fertilizer application soil testing is the key. However to judiciously use nutrients from organic as well as inorganics, target yield approach (Ramamoorthy *et al*., 1967) employing soil testing and crop correlation has evolved as one of the most efficient nutrient management approaches. This approach takes into account the absolute content of available nutrients present in soil for realizing the desired yield. An attempt has been made in this study to evaluate the effect of targeted yield approach of fertilizer application with and without FYM on yield and nutrient uptake of maize in comparison to the conventional approaches of fertilizer recommendations. To study the effect of prescription based fertilizers and FYM application on yield and nutrient uptake of maize

METHODOLOGY

The study was conducted in an ongoing long-term experiment initiated during *Kharif*, 2007 with maize-wheat cropping system at the research farm of Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The soil of the experimental site was acidic in reaction, silty clay loam in texture and is situated at 32° 6' N and latitude, 76° 3' E longitude and an altitude of 1290 m. The investigation comprised 8 treatments over the years. Fertilizer doses in case of target yield treatments were worked out using equations given below: (i) FN = 5.88 T- 0.23 SN - 0.93 ON (ii) FP_2O_5 = 4.87 T- 1.22 SP - 0.81 OP (iii) FK_2O = 3.66 T- 0.49 SK - 0.51 OK. In these equations, FN, FP_2O_5, FK_2O are doses of N, P_2O_5 and K_2O, respectively in kg/ha. T is the yield target (q/ha), SN, SP and SK are soil available N, P and K contents before sowing of the crop, respectively in kg/ ha.Whereas ON, OP and OK are N, P and K supplied by FYM, respectively in kg/ ha .

RESULTS

Soil test based fertilizer application (T_4) enhanced the grain yield over farmers' practice (T_2). As far as the effect of nutrients application based on STCR concept for specific yield targets is concerned, treatments corresponding to 40 q ha^{-1} with and without FYM (T_8 and T_7), were found significantly better as compared to soil test based and general recommended dose for grain yield of maize. The higher grain and stover yields of the crop in targeted yield treatments both with and without FYM over general recommended dose and soil test based treatments might be due to balanced and judicious use of the NPK fertilizers. The

Table 1. Effect of prescription based fertilizers and FYM application on yield of maize (pooled data *kharif*, 2013 and 14)

Treatment	Nutrient Dose (kg/ha)			Grain yield (t/ha)	Stover yield (t/ha)
	N	P_2O_5	K_2O		
T_1-Control	0	0	0	1.14	2.34
T_2-Farmers' Practice (FP)	35	0	0	1.96	3.44
T_3-General recommended dose (GRD)	120	60	40	2.77	4.53
T_4-Soil test based (STB)	150	45	35	2.80	4.71
T_5-Target yield 30 q/ha(T_{30})	119	89	10	2.87	5.17
T_6-Target yield 30 q/ha with FYM @ 5 t/ha (T_{30} IPNS)	88	57	10	3.13	5.42
T_7-Target yield 40 q/ha (T_{40})	176	77	10	3.68	5.79
T_8-Target yield 40 q ha-1 with FYM @ 5 t/ha (T_{40} IPNS)	144	100	10	3.90	6.37
CD (P=0.05)				0.79	1.8

Table 2. Effect of prescription based fertilizers and FYM application on nutrient uptake by maize (pooled data *kharif*, 2013 and 14)

Treatment	Nutrient uptake (kg/ha)					
	N		P		K	
	Grain	Stover	Grain	Stover	Grain	Stover
T_1-Control	16.16	32.31	3.80	3.72	4.15	40.66
T_2-Farmers' Practice (FP)	29.02	44.31	7.77	5.80	8.38	55.09
T_3-General recommended dose (GRD)	48.52	53.96	11.10	6.47	13.25	67.21
T_4-Soil test based (STB)	49.40	57.28	11.87	7.25	13.84	71.60
T_5-Target yield 30 q/ha(T_{30})	50.35	71.14	12.11	8.55	13.88	81.25
T_6-Target yield 30 q/ha with FYM @ 5 t/ha (T_{30} IPNS)	52.11	75.92	13.17	9.31	14.83	86.48
T_7-Target yield 40 q/ha (T_{40})	63.77	80.23	16.16	8.82	17.60	91.30
T_8-Target yield 40 q/ha with FYM @ 5 t/ha (T_{40} IPNS)	67.34	83.07	17.97	10.31	18.41	94.12
CD (P=0.05)	4.94	8.34	2.92	2.10	1.27	10.44

IPNS- Integrated Plant Nutrient Supply

higher grain and stover yield and hence nutrient uptake (NPK) in case of targeted yield treatment with FYM might be due addition of FYM. FYM might have improved physical properties like bulk density, water retention, better aggregation that might have helped in better development of roots and proper use of native and applied nutrients and also known to enhance microbial activities.

CONCLUSION

Soil test based nutrient application along with FYM based on STCR approach significantly enhanced the productivity as well nutrients uptake by maize. The prescription based application of fertilizers along with FYM proved superior to conventional general recommended dose as well as soil test based fertilizer application for yield as well as nutrient uptake.

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Yield and uptake of nutrients by fodder maize (*Zea mays*) as influenced by soil and foliar applications of zinc

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India, possessing the largest livestock population of 529.7 million heads the performance of livestock is deplorably low due to the poor nourishment, which is primarily ascribed to the fluctuating and inconsistent supply of quality green fodder. Against the projected need of 1025 million tonnes of green fodder in the country, the present availability is to the tune of 390 million tonnes only. The productivity and availability of good quality fodder is most important to fulfill the requirement of feeding cattle. Fertilizer management is the most important aspect to achieve the goal which includes application of micronutrients along with macronutrients to get maximum yield and maximum uptake of nutrients (Shivay *et al.,* 2014). Maize is the ideal fodder crop because of its high production potential, wider adaptability, quick growing nature, succulency, palatability and excellent fodder quality. Maize fodder is free from toxicants and can be safely fed to milch animals at any stage of the crop growth. Keeping these points in view, a field experiment was conducted to study the effect of zinc on yield and nutrient uptake of fodder maize.

METHODOLOGY

The present investigation was carried out in sandy loam soils of Dryland Farm of Sri Venkateswara Agricultural College, Tirupati campus of Acharya N. G. Ranga Agricultural University, during *kharif,* 2014. The farm is geographically situated at 13Ú N latitude, 79.5Ú E longitude and at an altitude of 182.9 m above mean sea level, comes under Southern Agro-climatic Zone of Andhra Pradesh and according to Trolls

Table 1. Green fodder yield, nutrient (N, P, K and Zn) uptake at harvest by fodder maize as influenced by soil and foliar applications of zinc.

Treatment	Green fodder yield (t/ha)	N uptake (kg /ha)	P uptake (kg/ha)	K uptake (kg/ha)	Zinc uptake (g/ha)
T_1 - Recommended dose of fertilizers (120 kg N -50 kg P_2O_5 - 40 kg K_2O /ha)	32.4	61.2	5.13	64.6	9.35
T_2 - T_1 + Soil application of 25 kg $ZnSO_4$ /ha	36.8	71.2	6.36	79.5	10.78
T_3 - T_1 + Soil application of 50 kg $ZnSO_4$ /ha	38.0	76.3	6.76	82.2	12.02
T_4 - T_1 + Foliar application of 0.2% $ZnSO_4$ at 30 DAS	35.4	63.7	5.60	68.4	9.77
T_5 - T_1 + Foliar application of 0.2% $ZnSO_4$ at 45 DAS	35.6	65.5	5.76	73.5	10.18
T_6 - T_1 + Foliar application of 0.2% $ZnSO_4$ at 30 and 45 DAS	36.0	67.9	6.16	76.5	11.09
T_7 - T_2 + Foliar application of 0.2% $ZnSO_4$ at 30 DAS	40.6	77.7	6.96	84.1	11.83
T_8 - T_2 + Foliar application of 0.2% $ZnSO_4$ at 45 DAS	40.8	78.8	7.26	86.1	12.18
T_9 - T_2 + Foliar application of 0.2% $ZnSO_4$ at 30 and 45 DAS	41.1	79.9	7.60	87.5	12.49
T_{10} - T_3 + Foliar application of 0.2% $ZnSO_4$ at 30 DAS	41.7	86.1	8.20	93.1	13.35
T_{11} - T_3 + Foliar application of 0.2% $ZnSO_4$ at 45 DAS	42.1	93.3	8.60	98.5	14.04
T_{12} - T_3 + Foliar application of 0.2% $ZnSO_4$ at 30 and 45 DAS	42.4	103.2	9.20	109.7	15.10
SEm±	0.885	0.71	0.17	0.68	0.100
CD (P=0.05)	2.6	2.1	0.31	2.0	0.29

classification, it is under Semi-Arid Tropics (SAT). Soil was sandy loam in texture, near neutral in soil reaction (pH 6.4), low in organic carbon (0.48 per cent), available nitrogen (174 kg/ha) and available zinc (0.49 ppm), high in available phosphorus (44 kg/ha) and medium in available potassium (165 kg/ ha). The total rainfall received during the crop growth period was 441 mm. The experiment was laid-out in a randomized block design with twelve treatments comprised of soil and foliar applications of zinc and replicated thrice. The recommended dose of fertilizers was 120 kg N, 50 kg P_2O_5 and 40 kg K_2O/ha applied to all the treatments. Nitrogen was applied through urea in two equal splits *viz.,* first half at the time of sowing as basal and remaining half as top dressing at 30 DAS. Entire quantity of phosphorous and potassium was applied as basal through single super phosphate and muriate of potash, respectively in furrows at 5 cm away from the seed rows. Zinc sulphate was applied as per the treatments (soil application of $ZnSO_4$ at two days after basal application of N, P and K and foliar application of 0.2% $ZnSO_4$ at 30 and 45 DAS as per the treatments) on fodder maize variety 'African Tall'. Fodder maize was sown on 12th July 2014 at a spacing of 45 × 10 cm and harvested on 29th September 2014 at milky stage.

RESULTS

The highest green fodder yield of maize (42.4 t/ha) was recorded with soil application of $ZnSO_4$ @ 50 kg /ha + foliar application of $ZnSO_4$ @ 0.2% twice at 30 and 45 DAS along with RDF (T_{12}), which was however comparable with soil application of either 25 or 50 kg $ZnSO_4$/ha + foliar application of 0.2% $ZnSO_4$ once or twice at 30 and 45 DAS along with RDF (T_{11}, T_{10}, T_9, T_8 and T_7). The percentage increase in green fodder yield under these treatments over T_1 (no zinc application) ranged from 13.5 to 30%. Application of only RDF without zinc application (T_1) resulted in significantly the lowest green fodder yield (32.4 t/ha) (Table 1). The increase in green fodder yield might be due to the role of zinc in various growth processes like photosynthesis, nitrogen metabolism, protein synthesis, harmone production and regulation of auxin concentration in the plants. These favourable impacts of zinc resulted in taller plants, increase in leaf area, leaf to stem ratio and dry matter production which might have reflected in terms of higher green fodder yields. Application of zinc enhanced the uptake of nitrogen, phosphorous, potassium and zinc significantly (Table 1). The highest nitrogen (103.3 kg/ha), phosphorous (9.2 kg/ha), potassium (109.7 kg/ha) and zinc (15.10 g/ha) uptake was recorded with soil application of ZnSO4 @ 50 kg/ha + foliar application of ZnSO4 @ 0.2% twice at 30 and 45 DAS along with RDF (T_{12}), followed by soil application of ZnSO4 @ 50 kg/ha + foliar application of ZnSO4 @ 0.2% at 45 DAS along with RDF (T_{11}) and differed significantly from all other treatments. Nutrient uptake (N, P, K and Zn) is vital in enhancing the yield and nutrient content (Table 1). The lowest uptake of nutrients, nitrogen (61.2 kg/ha), phosphorous (5.13 kg/ha), potassium (64.6 kg/ha) and zinc (9.35 g/ha) was recorded with the application of only RDF (120 kg N - 50 kg P2O5 - 40 kg K2O /ha) without zinc (T_1) which differed significantly from other treatments.

CONCLUSION

From the above study, it can be concluded that application of zinc significantly influenced the yield and uptake of nutrients by fodder maize and the best treatment was soil application of ZnSO4 @ 50 kg/ha + foliar application of ZnSO4 @ 0.2 % twice at 30 and 45 DAS along with RDF.

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Effect of sowing time and nutrient management on grain yield and harvest index of heat tolerant cultivars of wheat under Jabalpur condition of Madhya Pradesh

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In Madhya Pradesh wheat (*Triticum aestivum* L.) is generally grown after the harvesting of *kharif* crops. Thus the delay in harvesting of *kharif* crops forces to grow wheat in late upto middle of January. As a result the crop is subjected to low temperature (<10^0 C) during early growth stages and above (>25^0C) during reproductive and grain filling stages which disturb the phenology, growth and development and finally reduce the yield. Temperature beyond optimum reduces the length of crop growing season, so less radiations are intercepted resulting in less photo-assimilation and ultimately lowered grain yield (Fahad *et al*., 2014).Growing of suitable cultivars according to prevailing environmental conditions is essential for ensuring optimum crop productivity. Some improved wheat cultivars have the capability to fill their grains quickly even under prevailing heat stress condition during grain filling period. Inclusion of such cultivars in farming after proper evaluation for particular region and sowing window may improve the productivity of the area. Appropriate fertilization is also the key for the productivity of high yielding wheat cultivars. Keeping this in view, an experiment was conducted with the objective to identify suitable time of sowing, nutrient levels and suitable cultivars of wheat under era of climate change for Jabalpur, Madhya Pradesh.

METHODOLOGY

The experiment was conducted during *rabi* season of 2014-15 and 2015-16 at Research farm, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh). The soil is classified as clay soil which was medium in N, P and K with neutral pH. The experiment was laid out in split plot design with 3 replications. The main plot received 3 dates of sowing (30thNovember, 20thDecember and 10thJanuary) and 3 nutrient levels (RDF, 20% higher dose of RDF & 20% lesser dose of RDF) while 3 heat tolerant cultivars were allotted to subplots. The crop received all the recommended package of practices of the region for raising the wheat.

Table 1. Effect of sowing time and nutrient management on grain yield and harvest index of heat tolerant cultivars of wheat

Treatment	Pooled data (2014-15 and 2015-16)			
	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Date of sowing				
30th November	4.20	5.04	9.24	45.32
20thDecember	3.76	4.78	8.54	43.96
10th January	3.05	4.07	7.12	42.77
SEm±	0.30	0.31	0.50	0.19
CD (P=0.05)	0.89	0.92	1.50	0.56
Nutrient management				
RDF(100:60:40 NPK Kg/ha)	3.64	4.63	8.28	43.93
20% higher dose of RDF	4.01	4.84	8.85	45.08
20% lesser dose of RDF	3.35	4.42	7.77	43.08
SEm±	0.30	0.31	0.50	0.19
CD (P=0.05)	0.89	0.92	1.50	0.56
Wheat cultivars				
MP 3336	3.59	4.53	8.13	43.97
MP 1203	4.05	4.93	8.98	44.96
GW 173	3.36	4.43	7.79	43.11
SEm±	0.25	0.21	0.40	0.15
CD (P=0.05)	0.71	0.60	1.14	0.43

RESULTS

The significant difference in grain as well as in biological yield was exhibited with different date of sowing, nutrient levels and wheat cultivars. The highest yield of grain (4.20t/ha) and straw (5.04 t/ha) as well as harvest index (45.32%) were recorded in timely sown (30^{th} November) wheat followed by 20^{th}December and 10^{th} January (Table 1.). A significant decrease in grain yield was recorded with successive delay in sowing. This might be due to less availability of favorable period to late and very late sown wheat. The similar finding was given by Pal *et.al*.(1996).Amongst the nutrient levels 20% higher dose of RDF (recommended dose of fertilizer, i.e. 120: 60:40 NPK Kg/ha) recorded significant effect with respect to grain and straw yield and found superior over RDF (recommended dose of fertilizer) and 20% lesser dose of RDF. The treatment received 20% lesser dose of RDF registered lowest yield (3.35t/ha). This might be due to the proper nutrition of crop during growth and reproductive phases (Amrawat *et. al*.,2013). As regards heat tolerant cultivars, MP 3336 was found significantly superior over MP 1203 and GW-173 under all the sowing windows. Wheat cultivar GW 173 registered significantly lowest grain yield.This might be due to the inherent ability of MP 3336 cultivar to perform well in normal as well as in stress environment in comparison to rest of cultivars. Highest harvest index was noticed with 30^{th} November sowing and was significantly superior to 20^{th} December and 10^{th}January. Amongst the cultivars MP 3336 recorded significantly higher harvest index (4.4%) than MP 1203 (4,39%) and GW 173 (4.31%). This might be due to genotypic variation in yield and harvest index (Deswal et,al., 1996 and Mukherjee, 2012).

CONCLUSION

On the basis of experimental results it can be concluded that; sowing of wheat cultivar MP 3336 on 30^{th} November along with 20% higher dose of NPK gave the higher yields. The cultivar MP 3336 was most suitable for all sowing windows.

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Evaluation of conventional and fortified phosphatic fertilizers for enhancing productivity of dry season rice

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Rice (*Oryza sativa* L.) is an important staple food for more than half of the global population. Today, major concern for rice cultivation is slowdown in growth of productivity due to the imbalanced use of plant nutrients. Declining fertilizer use efficiency is one of the factors for low productivity as well as poor crop response ratio (Prasad, 2012). Some of the value added (fortified) complex and straight fertilizers are being commercially available to combat the deficiencies of micronutrients (such as zinc) and secondary nutrients (such as sulphur), especially in the areas of intensive cultivation. Recent trends in their usage need an assessment to ensure balanced nutrition through primary, secondary and micro nutrients in optimum quantities by the farmers and simultaneously enhance the productivity of dry season rice. Hence, the present study was undertaken to evaluate certain conventional and fortified phosphatic fertilizers for sustainable rice production in West Bengal.

METHODOLOGY

A field experiment was conducted at Rice Research Station, Chinsurah, Bengal in clay loam soil during dry (*boro*) season of 2014-15 and 2015-16. The rice variety Satabdi (IET

Table 1. Effect of treatments on growth, yield attributes and grain yield of dry season rice (pooled data of 2014-15 and 2015-16)

Treatment	Plant height (cm)	No. of tillers / m^2	No. of panicles / m^2	Panicle weight (g)	Grain yield (t/ha)
SSP	97.18	414.50	324.17	2.85	5.88
SSP fortified with 0.5% Zn	98.15	448.17	368.67	3.28	5.98
10:26:26 (NPK)	95.80	378.00	283.17	2.54	5.73
10:26:26 fortified with 0.5% Zn	99.32	480.17	403.33	3.76	6.12
28:28:0 (UAP)	95.83	382.17	278.83	2.61	5.73
24:24:0:8 (UAP fortified with 0.8% S)	96.61	417.00	318.83	2.84	5.88
18:46:0 (DAP)	93.05	334.50	236.17	2.31	4.85
DAP fortified with 0.5% Zn	95.90	405.00	308.17	2.78	5.63
20:20:0:13 (APS)	99.37	481.83	399.67	3.74	6.12
20:20:0 (Nitrophosphate)	97.57	421.17	327.50	3.10	5.89
14:35:14 (NPK)	93.73	356.17	256.17	2.44	5.27
Control (No fertilizer)	79.16	224.50	132.00	1.54	2.29
CD (P=0.05)	3.51	39.95	36.51	0.22	0.37

APS: Ammonium phosphate sulphate; DAP: Di-ammonium phosphate; SSP: Single super phosphate; UAP: Urea ammonium phosphate

4786) was taken for the study. Twelve treatments including different conventional and fortified fertilizers were assigned in a randomized complete block design with three replications. Conventional fertilizers were single super phosphate (SSP: 16% P_2O_5 and 12% S), 10:26:26 (10% N, 26% P_2O_5 and 26% K_2O), urea ammonium phosphate (UAP: 28% N and 28% P_2O_5), di-ammonium phosphate (DAP: 18% N and 46% P_2O_5), ammonium phosphate sulphate (APS: 20% N, 20% P_2O_5 and 13% S), nitrophosphate (20% N and 20% P_2O_5) and 14:35:14 (14% N, 35% P_2O_5 and 14% K_2O), whereas fortified ones included zincated SSP (SSP + 0.5% Zn), 10:26:26 + 0.5% Zn, S-fortified UAP (24% N, 24% P_2O_5 and 8% S) and zincated DAP (DAP + 0.5% Zn). A common nutrient dose of 130-65-65 kg N-P_2O_5-K_2O/ha was applied in all the treated plots. Additional requirements of N and K_2O, if any, were supplemented through urea (46% N) and muriate of potash (MOP: 60% K_2O), respectively. Major growth parameters (plant height and number of tillers m^{-2} at 60 days after transplanting), yield attributes (number of panicles m^{-2} and panicle weight) and grain yield at harvest were recorded in both the years, and subjected to pooled analysis.

RESULTS

A perusal of pooled data in Table 1 revealed significantly higher grain yields with Zn-fortified 10:26:26 (6.12 t/ha), APS (6.12 t/ha), zincated SSP (5.98 t/ha) and S-fortified UAP (5.88 t/ha). Of the fortified fertilizers, comparatively less yield was recorded in the case of zincated DAP (5.63 t/ha), which might be due to contribution of less quantum of Zn (0.71 kg/ha) to the crop than the other Zn-fortified fertilizers (1.25-2.03 kg Zn/ha). All the fortified fertilizers excluding zincated DAP possibly could fulfill the crop demand for secondary (S) and/or micronutrients (Zn) other than three primary nutrients (NPK). The conventional complex fertilizer APS (20:20:0:13) was found as good as Zn-fortified 10-26-26 in terms of maximum grain productivity level (6.12 t/ha), which was ascribed to higher values of growth and yield attributes (Table 1). It was earlier reported that the addition of Zn and S to the crop would not only improve crop quality and nutritional value, but also increased crop productivity and resilience to stress situations. Deficiencies of secondary and micronutrients could be overcome by fortified N/P/NP/NPK fertilizers (NAAS, 2012). Even the application of SSP as a source of P proved to record higher productivity (5.88 t/ha) for the additional supply of S, whereas comparatively lower levels of grain yields were recorded in the plots treated with other conventional phosphatic fertilizers *viz*. 10:26:26 (5.73 t/ha), 28:28:0 (5.73 t/ha), 14:35:14 (5.27 t/ha) and 18:46:0 (4.85 t/ha). The lowest grain yield (2.29 t/ha) was in control plots because of the dearth of plant nutrients.

CONCLUSION

It might be concluded that zincated SSP, Zn fortified 10-26-26 and S-fortified UAP among fortified fertilizers, and APS (20-20-0-13) among conventional fertilizers proved to be promising from the view point of balanced nutrition, leading to enhanced productivity of dry season rice. These fertilizer materials would also be very effective for the farmers who are often reluctant to apply any secondary and micronutrients.

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Effect of method of tillage, nutrient management and mulch practices on different cropping systems

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The success of any cropping system depends upon the appropriate management of resources including balanced use of manures and fertilizers. Soil tillage systems can be able to influence soil compaction, water dynamics, and Soil temperature and crop yield. Soil compaction is a major cause of soil degradation inmost agricultural soils. Tillage changes of soil microbiological activity, soil respiration and sustainability of agriculture. The selection of an appropriate tillage practice for the production of crops is very important for optimum growth, yield and profitable outcome and allows increase of organic matter. Compaction can be caused by the use of heavy machinery, ploughing at the same depth for many years and trampling by animals, reduced use of organic matter, frequent use of chemical fertilizers. Degraded soils are usually characterized by low organic matter contents, superficial effective rooting depth, high bulk densities and compaction and exposed subsoil (Agele, 2007). Human efforts to produce ever greater amounts of food leave their mark on our environment. Persistent use of conventional farming practiced based on extensive tillage, and especially combined with in situ burning of crop residue, have modified soil erosion losses and soil resources based has been steadily degraded. Hence, this study was carried out with the objective to find out the best treatment combination for higher yield of crops and to evaluate the economic viability of different treatments.

METHODOLOGY

A field experiment was conducted At all India Coordinated Research Project on Integrated Farming System, College of Agriculture, Indore during the *kharif* season 2014 with the objective to find out the effect of methods of tillage, nutrient management and mulch practices on yield of different crops and cropping system and their effect on economic viability Experiment was laid out in split plot design with three replication and total thirty two treatment combinationswas done. In the treatments of minimum tillage (T_1) one harrowing was done and 2 harrowing in conventional tillage (T_2), four cropping systems sole soybean (CS_1), soybean + maize (CS_2), soybean + sorghum(CS_3), arhar + fodder sorghum(CS_4). Under fertility level (F_1) is the 100% RDF and (F_2) is the 75% RDF + 25% vermi-compost and mulch (M_1) treatments wheat straw was used as a mulch material.

RESULTS

The productivity of different crops under study was evaluated after converting the yield of different crops into soybean equivalent grain yield in kg/ha. All, crops yield converted into soybean seed yield in kg/ha as per market price of different crops. The soybean equivalent seed yield in kg/ha as affected by various treatments was presented in table 1 Tillage significantly influenced the soybean equivalent seed yield. Minimum tillage recorded significantly higher soybean equivalent seed yield (1.48 t/ha) than conventional tillage (1.17t/ha) .Among the different cropping system, soybean + maize found significantly higher soybean equivalent seed yield (1.76 t/ha) followed by sole soybean (1.54t/ha), soybean + sorghum (1.28 t/ha) and Arhar + fodder(0.743t/ha).Soybean equivalent grain yield was significantly influenced by integrated nutrient management treatments. Application of 75 % RDF +25 % vermi-compost significantly increased the soybean equivalent seed yield (1.46 t/ha) over 100% RDF (1.16 t/ha) as well as the maximum soybean equivalent seed yield (1.33 t/ha) was registered with mulch treatment than no mulch (1.15 t/ha). Similar results were reported by Khatri*et al.*(2014). The tillage significantly influenced the net return.. Minimum tillage found significantly superior net return (₹ 45521/ha) than conventional tillage(₹ 25544/ha). Cropping systems significantly influenced the net Return.(Soybean + maize) cropping system recorded significantly maximum profit (₹ 52694/ ha) than arhar+ fodder (₹ 39487/ha), soybean +sorghum (₹ 25519/ha), and sole soybean (₹ 24430/ha).Net return of INM treatmentF2: (75% RDF + 25% vermi-compost)was recorded significantly higher net return(₹ 35535/ha) than F1 treatment (₹ 29376/ha).Mulch treatment found significantly more profit (₹ 40195/ha) than no mulch treatment (₹ 30870/ha).The data presented in table 1, further revealed that tillage significantly affect the benefit-cost ratio. In minimum tillage significantly higher benefit cost ratio (2.41)

Table 1. Effect of different tillage, cropping system, INM and mulch on Soybean equivalent seed yield, net returns and B:C ratio

Treatment	Soybeanequivalent seed yield (t/ha)	Net return (Rs./ha)	B:C ratio
Tillage			
Minimum	1.48	45521	2.41
Conventional	1.17	25544	1.72
CD(P=0.05)	.0030	1597.71	0.045
Cropping system			
Soybean sole	1.54	24430	1.78
Soybean +Maize	1.76	52694	2.56
Soybean +Sorghum	1.28	25519	1.77
Arhar + Fodder sorghum	0.743	39487	2.18
CD(P=0.05)	.0068	1119.97	0.031
INM			
100% RDF	1.16	29376	2.64
75%RDF+25%vermi-compost	1.46	35535	3.67
CD(P=0.05)	.0048	791.93	0.022
Mulch			
No mulch	1.15	30870	1.97
Mulch with wheat Straw	1.33	40195	2.17
CD(P=0.05)	.0048	791.93	0.022

observed than conventional tillage (1.72). Cropping systems significantly influenced benefit cost ratio (soybean + maize) intercropping found significantly higher benefit cost Ratio (2.56) followed by Arhar + sorghum fodder (2.18), sole soybean (1.78) and soybean + sorghum (1.77). The treatment F2: (75% RDF + 25 % vermi-compost) recorded significantly higher benefit cost ratio (3.67) than F1 treatment (2.64). In mulch treatment found significantly higher benefit cost ratio (2.17) than no mulch treatment (1.97). The analysis of variance showed that INM and mulch interactions significantly affected the B:C ratio Similar result reported by Nandni *et al.*, (2013).

CONCLUSION

On the basis of results obtained from the experiment it is concluded that minimum tillage was identified as the suitable tillage practice. Maximum soybean equivalent yield, net return and benefit cost ratio were observed under minimum tillage, intercropping combinationsoybean + maize with 75 % RDF + 25 % vermi-compost and mulching.

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Precision nutrient management in groundnut (*Arachis hypogaea* L.)

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Groundnut is the world's fourth most important source of edible oil and third most important source of vegetable protein (El-Habbasha, 2015). In India it is cultivated over an area of 52.54 lakh hectares with a total production of 94.72 lakh tones with an average productivity of 1804 kg/ha (Anon., 2014). There is a growing demand for edible oil in the country which can be matched by enhancing the productivity. One of the strategies to enhance productivity of groundnut is through precise management of nutrients. The quantity of supplemental nutrients needed by crops to achieve high cash value of harvested product per unit of nutrient input can vary within fields as well as among fields, growing seasons and years. The balanced recommendation of fertilizer dose is a challenge to scientists as it should meet both nutrient demand of the crop and sustain the production system (Shankar and Umesh, 2008). In this backdrop a field study for developing precision nutrient management technology for achieving targeted yield of groundnut was conducted at the Zonal Agricultural Research Station, G.K.V.K, Bengaluru during *rabi* - summer 2015-16.

METHODOLOGY

A field study was conducted during *rabi* - summer 2015-16 at the Zonal Agricultural Research Station, Gandhi Krishi Vignana Kendra, Bengaluru. The experimental site is located at 13^o 05' 22" N latitude, 77^o 34' 04" E longitude with an altitude of 933 m above mean sea level. The experimental field has been delineated into 36 grids with a size of 9 m x 9 m using geospatial technology and also DGPS. Soil samples from each grid were collected from the four equidistant places and at the centre of the grid in 0 - 15 cm depth, composited, air dried, crushed to pass through 2 mm sieve and analysed by following alkaline permanganate, Bray's and Flame photometric method to know the spatial variability of available N, P_2O_5 and K_2O status of soil. Based on the spatial variability for available soil N, P_2O_5 and K_2O, twelve treatment combinations comprising of three methods of fertilizer application (M_1: Application of NPK as per UASB package of practice, M_2: Application of fertilizer in 12 equal splits at weekly interval through drip, M_3: Application of NPK in 6 equal splits at fortnightly interval through drip) and four fertilizer levels for targeted yield levels *viz.* Y_1: 1.5 t/ha, Y_2 :2.0 t/ha, Y_3:2.5 t/ha and Y_4: Recommended dose of fertilizer for UASB package yield were selected. The experiment was laid out in split plot design with methods of application in main plots and fertilizer levels in sub plots. The treatments were replicated thrice. The seeds of groundnut variety ICGV-91114 were sown on 13th December, 2015 with a spacing of 30 cm X 10 cm. The fertilizer nutrients needed for targeted yields were calculated using Soil Test Crop Response (STCR) formulae; F.N = 6.39 T – 0.48 S.N (KM_nO_4-N), F. P_2O_5 = 15.50 T - 10.20 S. P_2O_5 (Bray's P_2O_5) and F. K_2O = 8.68 T - 0.80 S. K_2O (Amm. Acetate K_2O) (Where, T: Targeted yield, F.N: Fertilizer nitrogen requirement, F. P_2O_5: Fertilizer phosphorous requirement and F. K_2O - Fertilizer potassium requirement, S.N / S. P_2O_5 / S. K_2O –Soil Nitrogen / phosphorus / potassium content). The average quantity of nitrogen, phosphorous and potassium applied for the targeted yield levels of 1.5, 2.0 and 2.5 t/ha and package yield were 15:36:20, 26:67:29, 50:86:42 and 25:75:38 kg N: P_2O_5: K_2O/ha, respectively. The nutrients were supplied through Urea, water soluble monoammonium phosphate (MAP) and muriate of potash (MOP). Except the treatments the routine agronomic practices were followed as per UASB package for raising the groundnut crop. The experimental data was recorded and statistically analysed by adopting the standard procedures.

RESULTS

The status of soil available nitrogen, phosphorus and potassium during November 2015 is depicted in Fig. 1. The variability is from 74 to 462, 12.3 to 64.0 and 109 to 301 kg for N, P_2O_5 and K_2O/ha respectively.

There is large variability in soil NPK which necessitates nutrient management either through yield based or grid based management concept for precise fertilizer management as compared to the blanket recommendation. Significantly higher pod yield of groundnut (2.61 t/ha) was obtained with the application of fertilizers through drip irrigation in 6 equal splits at fortnightly interval over soil application as per UASB package of practice (2.25 t/ha) and fertilizer application through

Table 1: Productivity of groundnut as influenced by precision nutrient management practices and targeted yield levels

Treatments	SPAD values at 90 DAS	No. of pods/plant	100 kernel weight (g)	Pod yield (t/ha)	Haulm yield (t/ha)	Shelling (%)
A. Main plots (Methods of fertilizer application)						
M_1	41.6	27.8	28.2	2.25	3.08	65.8
M_2	43.0	48.2	29.3	2.40	3.29	65.4
M_3	44.2	43.0	29.9	2.61	3.24	70.1
SEm±	0.6	0.5	0.4	0.05	0.07	1.0
CD (P=0.05)	2.5	2.1	1.6	0.20	0.29	3.9
B. Sub-plots (Targeted yield levels)						
Y_1	41.3	34.4	28.9	2.15	3.02	65.1
Y_2	43.4	36.6	29.7	2.41	3.25	67.0
Y_3	44.2	50.4	30.7	2.90	3.47	70.2
Y_4	42.8	37.3	27.3	2.21	3.08	66.1
SEm±	0.6	1.7	0.5	0.06	0.09	0.8
CD (P=0.05)	1.9	5.0	1.5	0.17	0.28	2.4

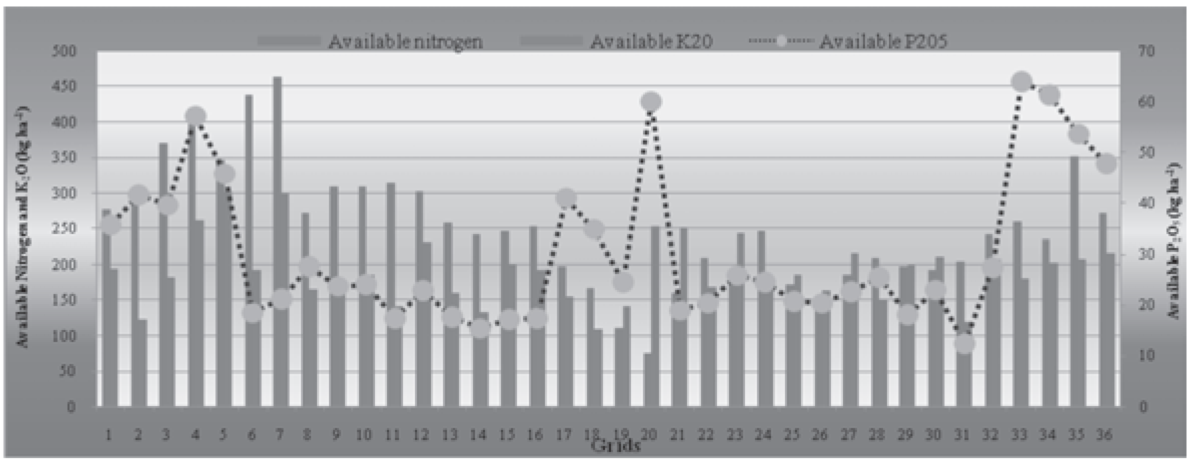

Fig. 1. Spatial variability of soil available nitrogen, phosphorus and potassium during November 2015

drip irrigation in 12 equal splits at weekly interval (2.40 t/ha). Among the yield targets, fertilizers applied for the targeted yield of 2.50 t/ha recorded significantly higher pod yield (2.90 t/ha) over rest of the targeted yields (Table 1). The actual yields (2.15, 2.41 and 2.90 t/ha) were higher than the targeted yields of 1.50, 2.0 and 2.50 t/ha respectively, by 43.3, 20.5 and 16.0% while 2.21 q/ha was recorded with the application of recommended fertilizer dose as per UASB package. The haulm yield also followed the trend of pod yield. Significantly higher pod yield of groundnut in precision nutrient management through drip irrigation was attributed to more number of pods/ plant, higher test weight and higher shelling per cent and (Table 1). The improvement in the yield attributes was due to higher availability of nutrients as indicated by higher SPAD values throughout the crop growth period.

CONCLUSION

Fertilizers applied through drip irrigation in six equal splits at fortnightly interval enhanced the pod yield of groundnut to an extent of 16.0 % as compared to UASB package method.

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Response of micronutrients on hybrid rice production under boro cultivation in lower Gangetic alluvial zone

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Rice (*Oryza sativa L.*) is the premier food crop for the majority population in the world. It contributes 80% of the calories in the daily diet. Almost 90% of the rice is produced and consumed in Asia, and 96% in developing countries. In West Bengal, rice is grown in about 5.84 mha contributing 14.50% share of the India's rice area and ranks first producing 14.39 mt i.e. 19.81% of India's total production and average yield comes to 2.50 t/ha. Micronutrients like Zinc, molybdenumand boron has synergistic effect with N in rice. In view of this, a field experiment entitled "Influence of micronutrients on yield and yield attributes of hybrid rice production under boro cultivation in lower Gangetic alluvial zone"was conducted to evaluate the hybrid rice productivity in *boro* season under various combinations of molybdenum and boron micro nutrients as foliar spray and to find out the optimum doses of micronutrients along with recommended dose of fertilizers for maximizing hybrid *boro* rice yield under lower Gangetic alluvial soil condition.

METHODOLOGY

The field experiment was conducted at the Agricultural Experimental Farm of Calcutta University at Baraipur, 24-Paraganas (south) during 2013-2014 which comprises of eight treatment combinations T_1 (NPK (120 : 60 : 60)), T_2 NPK (40/120 : 60 : 60)+ ZnSo4 (25kg/ha), T_3 NPK (40/120 : 60 : 60) + Ammonium molibdate 0.2%, T_4 NPK (40/120 : 60 : 60) +Di-sodium-tetrahydrateoctaborate 0.2%, T_5 NPK (40/120 : 60 : 60) +$ZnSo_4$+ Ammonium molybdate , T_6 NPK (40/120 : 60 : 60) +$ZnSo_4$ + Di-sodium-tetrahydrateoctaborate , T_7 NPK (40/120 : 60 : 60) + Ammonium molybdate + Di-sodium-tetrahydrateoctaborate, T_8 NPK (40/120 : 60 : 60) + $ZnSo_4$ + Ammonium molybdate + Di-sodium-tetrahydrateoctaborate were replicated three times in Randomized Block Design.

RESULTS

Application of micro nutrients viz. molybdenum and boron as foliar spray at active tillering stage and panicle initiation stage respectively of rice had profound effect on yield attributing characters i.e. grain yield and straw yield of hybrid rice under Table. Highest grain yield (6.543 t/ha)was recorded with NPK (40/120: 60 : 60) + $ZnSo_4$ + Ammonium molybdate + Di-sodium-tetrahydrateoctaborate and harvest index (49.07) was higher in NPK (40/120 : 60 : 60) + Ammonium molybdate + Di-sodium-tetrahydrateoctaborate. This may be attributed mainly due to increased no. of Panicle per metre (346.66), Length of panicle (27.50 cm), total grains (120.33 /panicle), filled grains (99.00/panicle) and Test weight (22.35

Table 1. Effect of molybdenum and Boron on yield and yield attributes of Hybrid rice cv.KRH-2.

Treatments	Panicle (no/ m)	Length of panicle (cm)	Total grains (No/panicle)	Filled grains (No/panicle)	Test weight (g)	Grain yield (t/ha)
T_1	266.67	26.76	110.00	88.00	21.44	5.055
T_2	280.00	27.12	110.67	88.68	21.14	5.232
T_3	280.00	27.43	120.00	95.00	21.94	5.420
T_4	293.33	27.65	118.00	97.00	21.83	5.443
T_5	303.66	27.95	123.00	97.00	22.48	5.770
T_6	320.00	27.82	116.00	98.00	22.67	6.181
T_7	320.00	27.90	117.00	98.00	22.29	6.403
T_8	346.66	27.50	120.33	99.00	22.35	6.543
SEm±	10.838	0.276	2.212	2.270	0.247	0.060
CD (P=0.05)	32.770	0.836 (NS)	6.712	6.884	0.750	1.053

Test weight -(g/1000 grains); t-Tonnes, ha-Hectare NS-Not significant g). This is in confirmation with earlier workers Keram *et al.* (2014)and Praneeth *et al.* (2015).

CONCLUSION

Based on this experiment it can be concluded that NPK (40/120 : 60 : 60) + $ZnSO_4$ + Ammonium molybdate + Di-sodium-tetrahydrateoctaborate as foliar application at active tillering stage and panicle initiation stage respectively of hybrid rice crop growth have profound influence on the yield and yield attributing characters.

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Effect of integrated nutrient management on growth, yield and quality of cauliflower

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Cauliflower is one of the most important winter vegetable crop and being grown for its white curds. Growing cauliflower with low chemical fertilizers is now a day gaining popularity particularly in peri-urban areas.

METHODOLOGY

To suggest suitable nutrient management modules in integrated nutrient management (INM), an experiment was conducted using cauliflower var. Snowball 16 in Randomized Block Design with three replications at Main Experiment Station, Udai Pratap Autonomous College, Bhojubeer, Varanasi during 2013-14. Plant growth, yield and curd quality traits were recorded using standard measures and procedures.

RESULTS

The height of plant (59.25 cm; 58.79 cm) and length of leaves (50.50 cm; 50.34 cm) showed significant response to INM which were highest with T_{11} (half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha + *Azospirillium* @ 5 kg/ha + *Vesicular Arbascular Mycorrhiza* @ 5 kg/ha), respectively. Maximum curd weight (g) (943.55 g; 912.72g) and curd yield (t/ha) (26.5 t/ha; 25.9 t/ha) were also recorded with application of T_{11} followed by T_9 (half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha + *Azospirillium* @ 5 kg/ha), respectively. Total soluble solids (4.40 °B) and ascorbic acid content (58.57 mg/100g) were increased, by the application of treatment of T_{11} (half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha + *Azospirillium* @ 5 kg/ha + *Vesicular Arbascular Mycorrhiza* @ 5 kg/ha) during the year.

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Yield and quality of Pusa Basmati-1509 as influenced by transplanting dates and nitrogen levels under temperate conditions

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In Jammu and Kashmir, the agriculture in general and rice is particular, is facing tremendous challenge for its survival from the horticulture crops, especially apple. So it is need of the hour that the revenue earning potential of the rice be improved through cultivation and popularization of the high value scented rice varieties. Basmati rice is essentially a subtropical crop and its varieties either do not mature or mature very late under temperate conditions of Kashmir valley. But, Pusa Basmati 1509 released in 2013 is superior to others with respect to yield, grain quality, earliness, non-shattering at maturity, non-lodging habit and reduced height and matures timely under Kashmir valley conditions. Kashmir valley has a short growing season ranging from 140- 150 days and therefore timely transplanting assumes a greater significance. Excessive N results in delayed maturity and sterility and sub optimal N may reduce the yields. Since the variety is a new introduction for Kashmir valley, optimization of its transplanting date and N level is very important to harness maximum benefits from it. Therefore, a field experiment was conducted to evaluate its response to varied transplanting dates and N levels.

METHODOLOGY

A field experiment entitled "Yield and quality of Pusa Basmati-1509 as influenced by transplanting dates and nitrogen levels under temperate conditions" was conducted at Mountain Research Centre for Field Crops, Khudwani, SKUAST-K during *Kharif* 2014. The soil of the experimental field was silty clay loam in texture with neutral pH, low in available nitrogen, medium in available phosphorus, potassium and organic carbon. The treatments included *viz*. four planting dates (20^{th} May, 30^{th} May and 10^{th} June) and nitrogen levels (0, 30, 60, 90 and 120 kg N/ha). The experiment comprised of 15 treatment combinations, laid in split-plot design with three replications, with planting dates in main plots and nitrogen levels in sub plots.

Table 1. Effect of transplanting dates and nitrogen levels on yield attributes, yield and quality of Pusa Basmati 1509

Treatment	Panicle/ m^2	Panicle weight (g)	Spikele/ panicle	Filled grains/ panicle	Sterility (%)	Grain yield (t/ha)	Straw yield (t/ha)	Grade 1 grain (%)	Head ricerecovery (%)	Kernel elongation ratio
Transplanting dates										
20^{th} May	337.69	1.58	94.88	72.70	23.23	4.15	6.72	45.35	44.16	1.71
30^{th} May	323.90	1.53	88.52	63.80	28.06	3.63	6.48	25.32	43.67	1.72
10^{th} June	304.22	1.46	76.62	51.09	33.23	3.05	6.180	13.27	41.40	1.66
SEm±	2.29	0.02	0.73	0.61	0.68	0.097	0.55	0.89	0.18	0.05
CD (P=0.05)	9.24	0.06	2.93	2.37	2.66	0.39	2.31	3.48	0.68	N S
Nitrogen levels (kg/ha)										
Control	279.30	1.32	77.68	57.03	26.53	1.90	6.01	24.25	41.96	1.62
30	310.98	1.41	81.86	60.84	26.82	2.91	6.22	26.97	42.56	1.66
60	332.40	1.53	86.36	62.48	27.60	3.90	6.30	30.28	43.20	1.70
90	341.39	1.67	93.19	65.99	28.63	4.55	6.83	32.84	43.09	1.73
120	345.60	1.69	94.27	66.32	29.47	4.23	7.42	28.92	44.06	1.76
SEm±	1.70	0.01	0.47	0.54	0.64	0.059	0.033	0.43	0.14	0.01
CD (P=0.05)	5.09	0.04	1.42	1.56	1.87	0.17	0.10	1.29	0.43	0.03

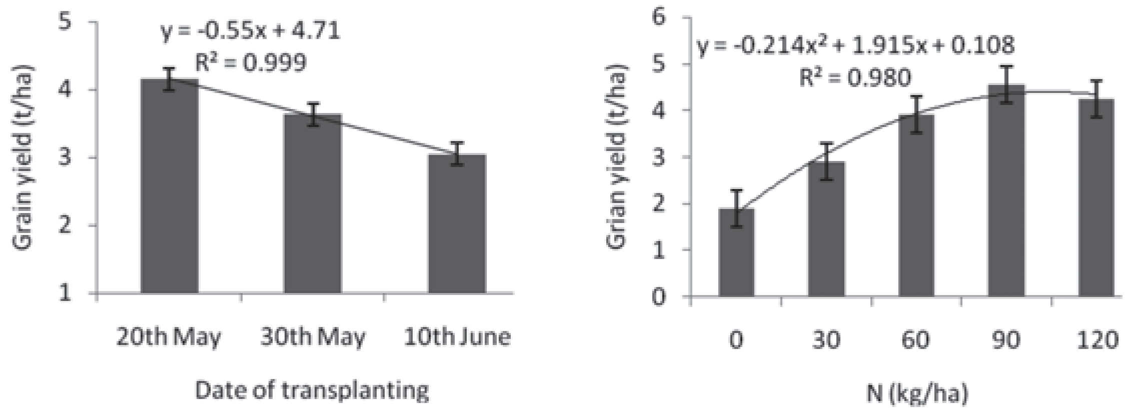

Fig. 1. Response of grain yield to transplanting dates and nitrogen levels

RESULTS

Yield attributes like panicles/m^2, spikelets/ panicle and filled grains/ panicle were higher for the 20th May, which resulted in highest grain (4.15 t/ha) and straw (6.72 t/ha) (Table1). Also quality parameters like head rice recovery (45.88%), grain grade 1 (45.35%), kernal length (9.22 mm) and breadth (1.72 mm), kernal length after cooking (15.74 mm) was improved in 20th May transplanted crop. However, sterility per cent a negative yield attribute was highest for the late planted crop, and was in the order of 23.23, 28.06 and 33.23 per cent for 20th May, 30th May and 10th June transplanted crop, respectively. The yield contributing characters *viz*. panicles/m^2 (345.6), spikelets/panicle (94.27) and were highest for the nitrogen level of 120 kg/ha but the same were at par with 90 kg/ha. Filled grains/panicle (66.32), grain yield (4.63 t/ha), straw yield (7.42 t/ha) were for highest dose of nitrogen *i.e.* 90 kg/ha but decreased significantly at 120 kg N/ha. Earlier transplanting resulted in synchronization of critical phenophases with optimum environmental conditions that resulted in higher no. of yield attributes and yield. Late transplanting resulted in delayed flowering and exposure of the crop to low temperature during resulting in sterility during floods in the first week of September that reduced the yields drastically. Low temperature affects fertilization and grain filling adversely (Yoshida 1981.) This might be due to better environmental factors during the critical growth stages like panicle initiation, flowering and grain filling periods which caused less tiller mortality in the earlier sowing dates, and consequently increased panicles m^{-2}. The results were in accordance Singh (2003). Quality parameters like head rice recovery, kernal length and kernal length after cooking was highest for the 120 kg N/ha. However, sterility % (29.47 %) was also highest for the treatments receiving 120 kg N/ha. Grain yield decreased linearly with the delay in transplanting (Fig 1). However, grain yield responded quadratically to increased N levels. Economic optimum N dose worked out at 104 kg/ha.

CONCLUSION

Transplanting on 20th May and application also recorded highest grain yield and B: C ratio (3.84). Among the N levels of 90 kg N /ha recorded highest grain yield which decreased significantly at 120 kg N/ha.

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Nutrient management in soybean-based cropping system

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Soybean is an important *kharif* crop in Chhattisgarh grown under upland unbunded heavy black soil (*Vertisols*) conditions. The total productivity of this crop in the state is 1250 kg/ha from an area of 153.40 thousand ha. It has been reported that soybean crop producing 6.7 t/habiomass removes about 614 kg N, 148 kg P and 486 kg K/ha (Nelson, 1989). The use of manures from livestock is an important way of recycling or out-turning nutrients to the soil. Hence, soybean can be an ideal option for using farm derived organic sources which not only reduces the expenditure on fertilizers but also improves the fertility of the soil and helps to increase the income of the farmers by raising their produce, which is important for small farm holders whose income is not enough to feed his family.The farmers need more yield with optimum resources without disturbance of the physical condition of soil. Oilseed, pulses and vegetables are receiving more attention owing to higher prices in the market due to increased demands. Inclusion of these crops in the sequence changes the economics of cropping system. Therefore, a balanced nutrient application is must to harness the productivity and sustainability of these crops.

METHODOLOGY

Field experiment was conducted at Raipur, Chhattisgarh in *Vertisols* for 2 years (2013-14 and 2014-15) to investigate the effect of organic, inorganic and integrated nutrient management in different soybean based cropping systems on system productivity and soil quality. The soil of experimental field was low (208 kg/ha) in available N, medium in available P_2O_5(13.0kg/ha) and K_2O (274 kg/ha), respectively. The experiment was laid out in strip plot design with three replications. The treatments consisted of 6 nutrient schedules *viz.* 100% N through organic, 75% N through organic, 50% N through organic + 50% N through inorganic, 75% N through organic + 50% N through inorganic, 100% N through inorganic and 100% N through inorganic + 5 t FYM/ha in hori-

Table 1. Productivity and economics of soybean based cropping systems as affected by nutrient management

Treatment	Soybean yield (t/ha)	Rabi crop yield in terms of soybean equivalent yield (t/ha)	Total productivity (t/ha)	Net return (Rs/ha)	B:C ratio
Nutrient Management					
100% Organic	1.51	4.78	6.29	88416	1.87
75% Organic	1.32	4.07	5.43	71059	1.52
50:50% Integrated	1.56	4.77	6.32	77123	1.58
75:25% Integrated	1.56	4.80	6.35	80953	1.68
100% Inorganic	1.55	5.04	6.58	84658	1.69
100% Inorganic + 5t FYM	1.69	5.76	7.45	97005	1.83
SEm±	0.03	0.09	0.11	2129	-
CD (P=0.05)	0.09	0.29	0.33	6708	-
Cropping system					
Soybean-Maize	1.52	4.90	6.41	96968	1.72
Soybean-Pea	1.53	3.88	5.41	65491	1.57
Soybean-Chilli	1.55	5.78	7.32	81232	1.68
Soybean-Onion	1.54	4.94	6.47	89118	1.79
SEm±	0.02	0.05	0.06	1564	-
CD (P=0.05)	NS	0.15	0.18	4716	-

zontal strips and followed by four different soybean based succeeding *rabi* crops in vertical strips *viz.*soybean'JS-335'-maize 'Sugar-75', soybean – table-pea 'PSM-3', soybean-chilli 'Agnirekha' and soybean – onion 'Nasik Red'.NPK levels for different crops were for soybean -30:60:30; maize-120:60:60; pea- 20:50:20, chilli- 125:75:60 and for onion – 75:60:100 kg N: P_2O_5: K_2O/ha respectively.Price of produce were considered as soybean 25000, maize 12000/-, pea 20000/-, chilli 20000/- and onion 10000/- for normal produce and soybean 31250/-, maize 15000/-, table pea 25000, chilli 25000/- and onion 12500/t, respectively for organic produce by giving 25% premium price to them.

RESULTS

The maximum pooled soybean seed yield of two years (1.69 t/ha) was recorded in the application of 100% inorganic + 5 t FYM/ha which was significantly higher than rest of the other treatments, followed by 100% inorganic). The seed yield attained under integrated nutrient management options of (50:50% integrated) and 75:25% inorganic fertilizer + organic manure and also in purely organic (100% organic) was found statistically similar to 100% inorganic. The statistically lowest seed yield (1.36 t/ha) was recorded under suboptimal dose of 75% organic. The availability of adequate amount of both organic and inorganic fertilizers provides sufficient amount of both macro and micro nutrient available in root zone which might have helped crop growth and yield attributing characters (Behera *et al*., 2007). No significant difference was recorded in soybean yield under different cropping systems. Under different nutrient management practices, highest equivalent yield (5.77 t/ha) and total productivity(7.45 t/ha) was recorded under the treatment 100% inorganic + 5 t FYM while, under different soybean based systems, soybean-chilli produced maximum SYE of *rabi* crop (5.78 t/ha) and total productivity (7.32 t/ha) followed by soybean–onion (4.94 t/ha SYE and 6.48 t/ha of total productivity). Application of 100% N through inorganic+ 5 t FYM/ha in soybean-maize also generated significantly highest economic returns (Rs 97,005/ha)and higher benefit cost ratio of 1.83 as compared to the other organic or inorganic treatments even after giving premium prices to organic one due to the sustainability in yield and lesser cost of cultivation. Among different cropping systems, highest net return of Rs 96,968/ha with B:C ratio of 1.72 in soybean-maize cropping sequence followed by soybean-onion cropping sequence (Rs 89,118/ha and B:C ratio 1.79). Total dry matter production in a plant often reflects its potentiality for its biomass production, whereas, mobilization towards the seed development is an important factor for realization of economic yield and serves as the yard stick for the acceptance and rejection of treatment hypothesis.

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Response of pearl millet under pearl millet -wheat system to various sources of nutrients

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In India pearl millet is the fourth most important cereal crop after rice, wheat and maize. It is dry land crop but responds to fertilizers (Kumar *et al.,* 2015). The continuous use of only chemical fertilizers may deteriorate soil health, environment and hence, crop productivity may not remain sustainable. Moreover, the indiscriminate use of high analysis chemical fertilizers results in the deficiency of nutrients other than applied and causes decline in organic carbon in soil (Yadav *et al*., 2014).

METHODOLOGY

The field experiment was conducted to study the effect of different sources of fertilizers/manures on the crops during 2014-15 and 2015-16 on pearl millet-wheat cropping system at Research Farm of Department of Agronomy, CCS Haryana Agricultural University, Hisar. The field experiment was carried out in permanent laid out research plots in Agronomy Research Area at CCS Haryana Agricultural University, Hisar during the year 2014-15 and 2015-16. The experiment was laid out in randomized block design with twelve treatments replicated thrice. The twelve treatments of integrated nutrient management (INM) were comprisingof chemical fertilizers alone or in combination with organic sources (FYM, green manuringand wheat straw) in pearl millet-wheat cropping system (Table 1).

Table 1. Treatments details

Treatment	*Kharif* (Pearl millet)	*Rabi* (Wheat)
T_1	Control (no fertilizer)	Control (no fertilizer)
T_2	50% recommended NPK dose through fertilizers	50% recommended NPK dose through fertilizers
T_3	50% recommended NPK dose through fertilizers	100% recommended NPK dose through fertilizers
T_4	75% recommended NPK dose through fertilizers	75% recommended NPK dose through fertilizers
T_5	100% recommended NPK dose through fertilizers	100% recommended NPK dose through fertilizers
T_6	50% recommended NPK dose through fertilizers + 50% N through farmyard manure	100% recommended NPK dose through fertilizers
T_7	75% recommended NPK dose through fertilizers + 25% N through farmyard manure	75% recommended NPK dose through fertilizers
T_8	50% recommended NPK dose through fertilizers + 50% N through wheat straw	100% recommended NPK dose through fertilizers
T_9	75% recommended NPK dose through fertilizers + 25% N through wheat straw	75% recommended NPK dose through fertilizers
T_{10}	50% recommended NPK dose through fertilizers + 50% N through green manure	100% recommended NPK dose through fertilizers
T_{11}	75% recommended NPK dose through fertilizers + 25% N through green manure	75% recommended NPK dose through fertilizers
T_{12}	Farmer's practice	Farmer's practice

Table 2. Effect of different nutrient treatments on yield attributing characters and yield of pearl millet

Treatment	2014			2015			Mean of Two years		
	Effective tillers per m	1000-grain weight (g)	Yield (kg/ha)	Effective tillers per m	1000-grain weight (g)	Yield (kg/ha)	Effective tillers per mr l	1000-grain weight (g)	Yield (kg/ha)
T_1	16.6	6.60	976	9.42	6.22	931.25	13.01	6.41	953.63
T_2	17.4	7.00	2132	11.76	7.12	1656.25	14.58	7.06	1894.13
T_3	18.5	7.12	2316	12.81	7.24	1869.5	15.66	7.18	2092.75
T_4	20.6	7.34	2770	13.19	7.46	2325.25	16.90	7.40	2547.63
T_5	20.8	8.54	3242	24.16	8.59	2876.25	22.48	8.57	3059.13
T_6	21.4	8.92	3465	26.04	8.72	2997.5	23.72	8.82	3231.25
T_7	19.7	7.96	3110	16.24	7.78	2600.25	17.97	7.87	2855.13
T_8	20.2	8.62	2814	20.01	8.13	2702.75	20.11	8.38	2758.38
T_9	19.8	7.40	2646	14.14	7.52	2342.5	16.97	7.46	2494.25
T_{10}	20.8	8.90	3230	22.82	8.46	2729.5	21.81	8.68	2979.75
T_{11}	19.8	7.92	3156	15.22	7.67	2518.5	17.51	7.80	2837.25
T_{12}	18.4	7.42	2804	18.03	8.09	2681.25	18.22	7.76	2742.63
CD (P=0.05)	NS	0.47	443	2.906	0.36	132.19	-	-	-

RESULTS

Yield attributing characters viz. effective tillers and 1000-grain weight of pearl millet was highest in 50% recommended NPK dose through fertilizers + 50% N through farmyard manure, which led towards highest pearl millet yield. Pearl millet yield was highest where 50 % recommended NPK dose through fertilizer + 50 % N through FYM in *kharif*and 100 % rec. NPK dose through fertilizer in *rabi* were applied. In this treatment the grain yield of pearl millet was 3465 kg/ha and 2997.5 kg/ha during 2014 and 2015, respectively and followed by application of 100 % recommended NPK dose through fertilizers both to pearl millet and wheat where yield of pearl millet was recorded 3242 kg/ha and 2876.25 kg/ha, respectively during 2015 and 2016 (Table 2). FYM application to replace 50 per cent nitrogen in pearl millet along with 50 per cent recommended NPK produced 172 kg/ha higher grain yield of pearl millet as to recommended NPK (mean value of two years) (Table 2).

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Effect of different fertility levels on growth parameters and yield of quality protein maize (*Zea mays*) varieties

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Maize is an important cereal crop of India and is grown on 8.67 m ha with the production and productivity of 21.75 m t and 2566 kg/ha, respectively. In recent past high yielding single cross hybrids of quality protein maize were developed by addition of opaque-2 mutant gene, which improve lysine and tryptophane and reduce leucine and isoleucine contents and produce quality protein with balanced composition of amino acids (Parsanna *et al.*, 2011). With development of high yielding varieties and hybrids which are competitive to other cereals with respect to farm profitability and resource use efficiency under diverse climatic conditions (Pooniya *et al.*, 2015), therefore maize gaining importance now a days. The QPM varieties have slow initial growth and thereafter vigorous growth, thus its N and P requirement is high compared to other hybrids. In quality protein maize nitrogen stress during flowering stage results in kernel and ear abortion and stress during grain filling accelerates leaf senescence reduce photosynthesis and kernel weight. Our most of the soils are having medium to low status of nitrogen and phosphorus, hence, adequate nitrogen and phosphorus fertilization is considered to be one of the most important prerequisites for increasing productivity of quality protein maize. Considering these facts the experiment was conducted for evaluation of quality protein maize varieties under different fertility doses.

METHODOLOGY

A field experiment was carried out during *kharif* 2014 at RCA, Udaipur (Rajasthan) which is situated at 23°34'N latitude and 72°42'E longitude. The soil of the experimental field was clay loam having organic carbon 0.81, available N 295.8 kg/ha, available P 18.8 kg/ha and available K 309.6 kg/ha in the plough layer with soil pH 7.8. Treatment consisted four quality protein maize varieties (HQPM 1, HQPM 5, Pratap QPM hybrid 1 and Vivek QPM 9) and four fertility fertilizer levels (90 + 12.9, 110 + 17.2, 130 + 21.5, 150 + 25.8 kg N + P_2O_5 /ha) and replicated four times in factorial randomized block design. Phosphorus as per treatments was applied as basal, whereas nitrogen was applied in three equal splits *viz.*, 1/3 as basal, 1/3 at knee high stage and remaining 1/3 at initiation of tassel. Pre-emergence application of atrazine at 0.5 kg/ha followed by one hoeing and earthing up at 20 days after sowing was carried out. Net returns and B:C ratio were

Table 1. Effect of varieties and fertility levels on yield and economics of maize

Treatment	Grain weight/ plant (g)	Grain (kg/ha)	Stover (kg/ha)	Net returns (Rs/ha)	B:C ratio
Variety					
Pratap QPM hybrid-1	58.45	3874	5630	39117	2.09
Vivek QPM-9	35.21	2415	3452	17246	0.92
HQPM-1	66.96	4262	6334	45176	2.42
HQPM-5	59.09	3904	5858	39933	2.14
SEm±	0.34	21	27	298	0.02
CD (P= 0.05)	0.96	60	78	849	0.05
Fertility level (kg/ha)					
90 kg N + 30 kg P_2O_5	44.37	2948	4308	25996	1.45
110 kg N + 40 kg P_2O_5	51.41	3454	5004	33036	1.79
130 kg N + 50 kg P_2O_5	58.90	3881	5709	39137	2.08
150 kg N + 60 kg P_2O_5	65.04	4173	6253	43302	2.25
SEm±	0.34	21	27	298	0.02
CD (P= 0.05)	0.96	60	78	849	0.05

calculated on basis of prevailing market prices of inputs and produce. Leaf area indexes (LAI), crop growth rate (CGR) and relative growth rate (RGR) were worked out by using standard methods.

RESULTS

Highest CGR was recorded in HQPM 1 which was significantly higher over rest of the varieties. However, the highest RGR was recorded in Pratap hybrid QPM 1 which was superior than rest of the varieties. HQPM 1 has the tallest plant, highest dry matter, LAI, grain weight/plant, grains/cob, cob length and shelling per cent which were significantly higher over rest of the varieties. The highest grain (4.2 t/ha) and stover (6.3 t/ha) yield were recorded with HQPM 1 which was significantly higher over rest of the varieties (Table 1). The highest net returns and B:C ratio was recorded with HQPM 1 and proves economically profitable variety. HQPM 5 and Pratap QPM 1 were the next best varieties. Similarly least yield was recorded in Vivek QPM 9, it has due to stalk rot at post flowering stage. Application of 150 kg N + 25.8 P/ha significantly enhanced growth and yield attributing parameters of QPM varieties over 130 kg N + 25.8 P/ha. Days to 50 per cent silking and plant population did not vary significantly under different fertility levels. The significant response up to 150 kg N + 25.8 kg P/ha might be on account of enrichment of soil with these 2 major nutrients N and P to the level of sufficiency which in turn promoted growth of plant right from early stage.

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Variability in Indian mustard (*Brassica juncea*) cultivars for response to phosphorus application

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Field investigation entitled "Variability in Indian mustard (*Brassica juncea* L.) cultivars for response to phosphorus" was carried out during *rabi* 2012-13 at research farm of Oilseeds Section, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana. Soil of the experimental field was loamy sand in texture, neutral in reaction (pH 7.8), free from salts (EC 0.10 dS/m), low in organic carbon (0.37%), nitrogen (245 kg/ha), Olsen's available phosphorus (11.7 kg/ha) and rich in potassium (165 kg/ha). The study comprised 42 treatments with three doses of phosphorus (0, 15 and 30 kg P_2O_5/ha) in the main plots and fourteen cultivars (RLC 1, PBR 210, PBR 91, RLM 619, RL 1359, PBR 357, ELM 123, NRCDR 2, NRCHB 601, Pusa Bold, Varuna, MLM 19, NPJ 79 and PLM 2) in the sub plots. Treatments were replicated thrice as per split plot design of experimentation. The study revealed that application of 15 kg P_2O_5/ha of significantly increased main shoot length, number of siliquae on main shoot and phosphorus concentration up to 120 DAS whereas application of 30 kg/ha of P_2O_5 significantly increased number of siliquae/plant, seeds/siliqua, 1000 seed weight and oil content. Increase in seed yield (1723 kg/ha), stover yield (6269 kg/ha), oil yield (674 kg/ha) and protein yield (313 kg/ha) with application of 15 kg/ha of P_2O_5 over control (1607 kg/ha, 5712 kg/ha, 625 kg/ha and 291 kg/ha, respectively) was significant whereas such increase with further increase in dose of phosphorus to 30 kg/ha of P_2O_5 (1766 kg/ha, 6576 kg/ha, 695 kg/ha and 317 kg/ha, respectively) was inconspicuous.

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Precision nutrient management in cereal crops through using the novel fertilizer decision support tool: The accrued benefits

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South Asia, especially India, is one of the most populous and intensively cultivated regions in the world. Smallholder farmers of the region however have low resource availability, and profitability from predominantly cereal-based cropping system. At present, cereal based systems such as –rice, wheat, and maize based cropping systems are major in terms of acreage and number of farmers associated. However, the fertilizer recommendations for cereals available to farmers are "blanket" in nature and do not take into account the spatial variability in indigenous nutrient supplying capacity of different farms and the variable resource endowment of farmers. Such recommendations often fail to supply required amount of nutrients to crops, leading to loss of productivity and farm profit. Studies have reported that there is a yield loss of 0.5 to 1 t/ha on an average for most of the cereals due to imbalanced nutrient management. A farm specific 4R Nutrient Stewardship compliant precision nutrient management is a need for farm profitability. Precision nutrient management plays a significant role in yield improvement with better nutrient use efficiency, ensuring better environment stewardship of agricultural nutrients across different groups of farmers with varied typologies. The present paper discusses the current advances in precision nutrient management strategies to improve productivity and profit in smallholder systems while reducing environmental footprint of agricultural practices.

The *Nutrient Expert*®for rice, wheat, and maize, developed and validated by IPNI and its partners such as CIMMYT, NARES, SAUs, and Industry Associates, is a recent innovation for developing field specific precision fertilizer recommendation tool for individual farmers. The tool is based on the principles of site-specific nutrient management (SSNM). It utilizes information provided by a farmer or a local expert to suggest a meaningful yield goal for his location and formulates a fertilizer management strategy required to attain the yield goal. The required information about the production system is gathered through a set of simple, easily answerable questions that analyses the current nutrient management practices and develops guidelines on fertilizer management that are tailored for a particular location, cropping system, farmer resource availability and considers the organic inputs as a part of the system nutrient balance. This decision support system is an easy-to-use, interactive computer-based tool that can rapidly provide nutrient recommendation for individual farmers' field in presence or absence of soil testing data.

METHODOLOGY

Experimental treatments include comparison of Nutrient Expert based recommendation with farmers' fertilizer application practice as well as state recommendation. In the case of maize, on-farm experiments evaluating the performance of NE over SR (official fertilizer recommendations by respective states) and FP (farmers' fertilizer application practice) were conducted at 191 major maize growing sites across Andhra Pradesh, Karnataka, Tamil Nadu and Odisha (Satyanarayana, *et al.,* 2014). The comparative experiments were distributed in both the *kharif* (monsoon) and *rabi* (winter) seasons, and were conducted in varying maize growing environments, under rainfed and assured irrigated conditions. In the case of wheat on-farm validation trials (n=109) were conducted across major wheat growing states of India that included Bihar, Haryana, and Punjab in the year 2010-11 and 2011-12. The current study reports the data from 53 trials conducted in 2010-11 that included 10 in Bihar, 21 in Haryana, and 22 in Punjab, and 56 trials in 2011-12 in Bihar (n=11), Haryana (n=26), and Punjab (n=19). Among these 109 trials a total of 65 trials were conducted under conventional tillage (CT) and 44 trials (22 trials each year) were conducted under zero tillage (ZT) condition (Dutta *et al.,*2014).Nutrient Expert® – rice validation trials were conducted in collaboration with Indian Institute of Framing System Research (ICAR – IIFSR) across ten locations across the country, in 324 locations of West Bengal, and in 22 location of Bihar as IPNI study

RESULTS

Farmers' field validation showed that nutrient recommendation from Nutrient Expert® achieved higher yields and profit over existing practices, with lesser environmental footprint than the existing practices.Present study highlights that the maize yield on NE based recommendations were significantly (p d” 0.05) higher compared to that of farmers’ fertilizer practice (FFP) in across 191 locations across four different states – Andhra Pradesh, Karnataka, Tamil Nadu and Odisha. Similarly, the Nutrient Expert® – Wheat fertilizer decision support tool-based fertilizer recommendation was compared with existing fertilizer management practices in 109 on-farm sites in Punjab, Haryana and Bihar over a period of two years. The present study showed a significant (p d” 0.01) increase in wheat yield through NE nutrient management treatments over FFP and state recommendation (SR) in both the years. Nutrient Expert®– rice validation trials also highlight that the grain yield in NE recommended plots were significantly (p d” 0.05) higher than FFP and SR.

CONCLUSION

The present study suggests that large-scale implementation of this precision nutrient management tool will provide the opportunity to bridge nutrient-related yield gaps in wheat and increase farm profitability in an environmentally sustainable manner.

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Effect of fertility level, seaweed sap and its concentration on yield and economics of wheat (*Triticum aestivum* L.)

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Wheat (*Triticum aestivum* L.) is the second most important food crop of India next to rice and demand for wheat in the country is increasing day by day. The greatest demand for wheat in the coming years will have to be met by increasing devotion of land to wheat or increasing yield per unit area. At present, we use chemical fertilizers in large quantities to harvest more and more. The cost of fertilizers has increased tremendously, with existing price of Rs. 15, 58 and 31 per kilogram nitrogen, phosphorus and potassium, respectively. The abundant use of chemical fertilizers adversely affects soil fertility. So, there is need to find some natural resource product which can enhance the soil fertility as well as productivity of the crop. In this context, applications of seaweed fertilizers are of great importance to substitute the commercial chemical fertilizers. Liquid fertilizers derived from seaweeds are rich in organic matter, micro and macro elements, vitamins and fatty acids along with the presence of metabolites similar to plant growth regulators like auxin, gibberellins, vitamins and amino-acids. The beneficial effect of seaweeds extracts on agriculture crops has been reported by several workers (Mostafa *et al.* 1999 and Singh *et al.* 2015) and proves to be a useful source of fertilization for achieving higher production.

METHODOLOGY

The field experiment, were conducted during the *Rabi* season of 2012-13 at the Birsa Agriculture University, Ranchi (23º17’ N latitudes, 85º19’ E longitudes and 625 m above altitude)**.** The soil was sandy loam in texture, with pH 5.7 having organic carbon 0.45%, available nitrogen 255.9 kg/ha, phosphorus 14.0 kg/ha and potassium 169.4 kg/ha. The climate of the region is subtropical with hot and dry summer, comparatively cool rainy season followed by moderate winter. Treatment consisted of two fertilizer levels *viz.,* 100 and 50% recommended fertilizer in main plot, two seaweed sap source *viz., Kappaphycus alvarezii* (K-sap) and *Gracilaria edulis* (G-sap) in sub plot and 6 sap concentration *viz.*, 0 (water), 2.5, 5.0, 7.5, 10.0 and 15.0% in sub-sub plot laid out in a split-split plot design and replicated thrice. The recommended dose of fertilizer was 120:60:40 kg NPK/ha. Half

Table 1. Effect of seaweed sap on productivity and profitability of wheat

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Net return (Rs./ha)	B: C ratio
Fertilizer level				
100% RDF	4.46	5.41	43238	1.70
50% RDF	3.52	4.40	32045	1.43
SEm±	0.01	0.05	248	0.01
CD (P=0.05)	0.07	0.28	1512	0.07
Sap Source				
K-sap	4.12	5.05	39674	1.65
G-sap	3.85	4.77	35609	1.48
SEm±	0.02	0.04	308	0.01
CD (P=0.05)	0.07	0.15	1210	0.06
Spray concentration (%)				
Water	3.41	4.26	31414	1.46
2.5	3.77	4.61	35804	1.58
5.0	3.96	4.85	37803	1.60
7.5	4.44	5.35	44011	1.80
10.0	4.29	5.23	40873	1.61
15.0	4.07	5.14	35943	1.31
SEm±	0.07	0.07	966	0.04
CD (P=0.05)	0.19	0.19	2762	0.12

dose of nitrogen and full dose of phosphorus and potash through urea, single super phosphate and muriate of potash, respectively, were applied at sowing and remaining half nitrogen was applied after first irrigation. Three sprays of K-sap and G-sap were applied each at the tillering stage, panicle initiation and boot stage. For proper adherence, extracts were mixed with surfactant (Mazik drop) at the time of spraying. Wheat variety ‘K-9107’ was sown at row spacing of 20 cm during first fortnight of November.

RESULTS

Application of 100 % recommended dose of fertilizer produced significantly higher grain yield (4.46 t/ha), straw yield (5.41 t/ha), net return (44238/ha) and benefit cost ratio (1.70) as compared to 50% recommended dose of fertilizer (Table 1). Among seaweed sap, *Kappaphycus alvarezii* (K-sap) recorded significantly higher grain yield (4.12 t/ha), straw yield (5.05 t/ha), net return (39674/ha) and benefit cost ratio (1.65) than *Gracilaria edulis* (G-sap). Irrespective of sap concentration, spraying of 7.5% sap concentration produced significantly higher grain (4.44 t/ha), straw yield (5.35 t/ha), net return (44011/ha) and benefit cost ratio (1.80) as compared to lower sap concentration. These results are in accordance with the findings of Singh *et al.* (2015).

CONCLUSION

Application of 100% recommended dose of fertilizer along with 7.5% foliar application of *Kappaphycus alvarezii* enhances the productivity and profitability of wheat.

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Effect of varieties and fertilizer levels on yield and yield components of lentil (*Lens culinaris*) under rice-lentil relay system in Gangetic Alluvial Zone of West Bengal

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The lentil (*Lens culinaris* M.) is a lens-shaped grain legume well known as a nutritious food, rich sources of carbohydrates, protein, vitamins, minerals, dietary fiber, high energetic value. But if we put on focus on population in our country then we can see population increasing day by day at constant rate but production of lentil is constant in last few years. Relay cropping is one of the productive ways to increase the area and production of lentil. The aberrant onset and withdrawal of monsoons often poses problem in the land preparation of the winter crops (Parya *et al.,* 2010). In West Bengal, lentil seeds are often broadcasted (as relay crop) in the standing crop of rice 15-20 days before harvesting to capitalize on residual moisture and ensure timely sowing as well as to get assured germination and skipping off the tillage operations during lentil growing.

METHODOLOGY

A field experiment was conducted during *kharif* (rainy) and subsequent *rabi* season of 2014-15 and 2015-16 at the District Seed Farm, AB block, Kalyani, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India to identify the ideal lentil varieties and standardize the fertilizer combination to get optimum yield under relay cropping with long duration (MTU 7029) rice in new alluvial zone of West Bengal. The experiment was laid down in split plot design with 6m × 2m plot size in three replications taking three varieties (V1: PL 6, V2: Moitri and V3: Subrata) placed in the main plot and four fertilizer levels (F1: 20 kg N, 40 kg P_2O_5 and 40 kg K_2O per ha at basal, F2: 2% Urea foliar spray at 45 DAS and 65 DAS, F3: 20 kg N, 40 kg P_2O_5 and 40 kg K_2O per ha at basal + 2% Urea foliar spray at 45 DAS and 65 DAS, F4: Control plot) was in the sub-plot. Rice seedling was transplanted on 27.07.2014 and 22.07.2015 with 80 kg N, 40 kg P_2O_5 and 40 kg K_2O were applied with three splits doses of N ($1/4^{th}$, 1/2, $1/4^{th}$), full P_2O_5 and K_2O at basal and harvested on 26.11.2014 and 23.11.2015. Lentil was sown on 11.11.2014 and 09.11.2015 during *rabi* (winter) season with 70 kg/ha seed rate.

RESULTS

Results of two years pooled analysis of the experiment revealed that all the three cultivars performed better as well as the yield attributing characters with combination of F3 fertilizer level (20 kg N, 40 kg P_2O_5, 40 K_2O and 2% Urea foliar spray at 45 DAS & 65 DAS). Subrata produced highest pods/plant (69) and plant population/m (178) followed by Moitri and PL 6 irrespective of fertilizer levels. F3 and F1 fertilizer levels gave maximum pods plant^{-1} (74) and plant population m^{-2} (152) irrespective of cultivars. Highest seed yield (1355.5 kg/ha), biological yield (4966.7 kg/ha) and harvest index (30.6 %) were recorded in Moitri irrespective of fertilizer levels. Maximum seed yield (1559.2 kg/ha) and harvest index (33.0 %) were attained in F3 fertilizer level irrespective of cultivars. F1 (5130.0 kg/ha) fertilizer level gave highest biological yield among the different fertilizer levels. Interaction effect between cultivars and fertilizer levels was found significant in all parameters.

CONCLUSION

Thus it could be concluded that farmers of Gangetic Alluvial Zone of West Bengal can adopt Moitri or Subrata cultivars under rice- lentil relay system with the application of 20 kg N, 40 kg P_2O_5, and 40 kg K_2O/ha along with 2% foliar spray of Urea at 45 DAS and 65 DAS.

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Table 1. Yield and yield attributing characters of Lentil as influenced by cultivar and fertilizer level and interaction effect (Cultivar × Fertilizer level).

Treatment	Pod/Plant	Plant population/m	Biological yield (kg/ha)	Seed yield (kg/ha)	Harvest index (%)
Cultivar					
V1	64	104	4783.4	1276.1	29.28
V2	65	168	4966.7	1355.5	30.66
V3	69	178	4563.7	1310.1	29.55
SEm(±)	1.6	3.3	50.8	15.0	0.57
CD (P=0.05)	NS	10.6	165.6	49.0	NS
Fertilizer level					
F1	69	152	5130.0	1398.0	29.36
F2	66	150	4965.8	1292.5	29.57
F3	74	149	4935.8	1559.2	33.01
F4	55	149	4053.5	1006.6	27.38
SEm±	1.7	2.6	93.40	19.8	0.61
CD (P=0.05)	4.9	NS	268.20	56.7	1.76
Variety × Fertilizer level					
V1F1	71	98	5431.9	1432.3	27.27
V1F2	62	100	4365.3	1181.8	30.97
V1F3	74	112	5221.9	1555.6	32.04
V1F4	49	108	4114.7	932.5	26.85
V2F1	64	165	5399.5	1379.7	28.98
V2F2	66	175	5348.9	1356.5	29.70
V2F3	66	160	4836.1	1603.8	33.91
V2F4	64	172	4282.3	1081.8	30.05
V3F1	71	192	4558.5	1382.1	31.83
V3F2	69	176	5183.2	1337.2	28.05
V3F3	81	176	4749.5	1518.3	33.08
V3F4	54	167	3763.5	1005.6	25.23
SEm±	3.0	4.59	161.9	34.2	1.06
CD (P=0.05)	8.6	13.17	464.5	98.2	3.04

V1, PL6; V2, Moitri; V3, Subrata; F1, 20 kg 40 kg and 40 kg N, P_2O_5 and K_2O respectively as basal; F2, 2 % foliar spray at 45 DAS and 65 DAS; F3, 20 kg, 40 kg and 40 kg N, P_2O_5 and K_2O respectively as basal + 2 % foliar spray at 45 DAS and 65 DAS; F4, Control plot and NS, non-significant.

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Nitrogen requirement of potato variety Kufri Surya

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Potato (*Solanum tuberosum* L.) is regarded as "Future Food Crop" by Food and Agriculture Organization owing to its remarkable potential of producing highest food, energy and protein per unit area and time.In order to sustain higher production of potato of good quality, balance supply of N to plants are indispensible forexcessive application of N affect yield and quality of the tuber due to excessive vegetative growth, while polluting environment and increasing production cost. Also, sub-optimal dose of N to potato may lead to premature senescence in plants due to early mobilisation of N from leaves to tubers. Kufri Surya, a newly released heat tolerant variety by Central Potato Research Station, Shimla (India), is a promising variety for sustaining high potato production at advent of global warming. As a new variety its nitrogen demand needs to be assessed for different agro-climatic conditions. So, the present investigation was planned to find out the response of Kufri Surya on growth, yield, nutrient and water use efficiencies and economics.

METHODOLOGY

A field study was conducted at Potato Research Station, SDAU, Deesa (Gujarat)in *rabi* season for three years (2011-12, 2012-13 and 2014-15) to evaluate N requirement of potato variety on Kufri Surya. The experimental site hadloamy sand soil with low organic carbon (0.33%), available nitrogen (178.12 kg/ha), medium in available phosphorus (15.20 kg P/ha) and available potassium (235.11 kg K_2O/ha). Five treatments on N levels namely 0, 75, 150, 225 and 300 kg N/hawere laid out in randomized block design and replicated four times. Recommended doses of phosphorus (P) and potassium (K) for potato crop are 140-275 kg P_2O_5-K_2O/ha using, respectively. Well sprouted seed tubers of potato variety Kufri Surya at the rate of 3000 kg/ha were planted at the second week of November with spacing of 50 cm x 20 cm, during all years of experimentation. 50% of N dose was applied through ammonium sulphate at the time of planting and remaining N dose as top dressing at 30 days after planting (DAP) during earthing up. Recommended package of practices were followed for management of potato crop. Grade-wise(0-25 g, 25-50 g, 50-75 g and >75 g grade)tuber yields and total tuber yield per plot were recorded and then converted in terms of t/ha.Agronomic N use efficiency (AUE_N) and Partial factor productivity (PFP) of P and K were calculated by using formulae as given by Dobermann (2005). Benefit-cost ratio (BCR) was worked out by dividing net return (₹/ha) with total cost of cultivation (/ha). Three years data were pooled and then subjected to statistical analysis using the software OPSTAT developed by HAU, Hisar.

Table 1. Tuber yields, nutrient use efficiency and benefit-cost ratio of each treatment as influenced by different levels of N in potato

Treatment	Tuber yield (t/ha)					AUE_N (kg increase in total yield/kg of fertilizer applied)	PFP (kg of total yield/kg of fertilizer applied)		BCR
	0-25g	25-50g	50-75g	>75g	Total		P	K	
0 kg N/ha	1.42	4.84	9.16	11.05	26.46	-	189.0	96.2	0.55
75 kg N/ha	1.59	4.06	10.14	17.91	33.69	96.41	240.7	122.5	0.93
150 kg N/ha	1.46	3.28	11.26	21.76	37.77	75.38	269.8	137.3	1.12
225 kg N/ha	1.21	3.22	12.26	22.61	39.29	57.04	280.7	142.9	1.16
300 kg N/ha	1.18	4.05	12.27	22.45	39.96	44.98	285.4	145.3	1.15
SEm±	0.15	0.31	0.52	0.88	0.89	-	-	-	0.05
CD (P=0.05)	NS	0.98	1.61	2.74	2.77	-	-	-	0.15

RESULTS

Tuber yield of potato was markedly influenced by different levels of N, except for 0-25 g grade (Table 1). Increasing levels of N reduced tuber yield under 25-50 g grade, highest being recorded under 0 kg N/ha, which was statistically at par with 75 kg N/ha. However, in case of 50-75 g and >75 g and total tuber yields, increasing levels of N significantly enhanced tuber yield up to 150 kg N/ha, and highest tuber yields being recorded under 300 kg N/ha. The increment in total tuber yield over control ranged from 27.32% to 51.02%, when the N levels were increased from 75 to 300 kg N/ha. Improvement in tuberization as well as extension of tuber bulking duration under higher dose of N could have led to higher yield, but only up to certain levels. In our study, the total tuber yield improved statistically only up to 150 kg N/ha. Agronomic N use efficiency (AUE_N) of the crop decreased with subsequent increase in levels of N, lowest being recorded at 300 kg N/ha (Table 1) On the contrary, partial factor productivity (PFP) of P and K increased with increasing level of N, their maximum values being registered under 300 kg N/ha (Table 1). This shows the positive correlations between higher N levels and utilization of P and K by potato crop. BCR increased statistically up to 150 kg N/ha, while its highest value being recorded at 225 kg N/ha. These could be ascribed to efficient use of water and nutrient under 150 kg N/ha, which ultimately resulted in higher tuber yield and net return.

CONCLUSION

Based on the above findings, it may be inferred that potato growers should apply 150 kg N/ha in Kufri Surya for achieving higher tuber yield with more economic profits and efficient use of nutrients. This will also ensure prevention for excessive N application, thus reducing chance of environmental pollution.

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Effect of long term application of organics and inorganics on productivity and quality of *Motihari* tobacco in *Terai* region of West Bengal

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Motihari tobacco (*Nicotiana rustica*) characterized by chewing type occupies >70% of the area under tobacco and grown in the Northern districts of West Bengal like Cooch Behar, Jalpaiguri, Malda and Murshidabad. This tobacco is also grown in Southern districts of West Bengal i.e. Midnapore, Birbhum and Nadia in small pockets. Total area under Motihari tobacco constitutes 14, 000 ha. Tobacco farmers apply heavy doses of fertiliser for getting more yield and also net returns which in turn effect quality and harmful to environment. Proper management of fertiliser application is essential for getting optimum quantity and quality tobacco leaf. The present study was carried out tostudy the effect of long term application of organic manures and inorganic fertilizers on productivity and quality of *Motihari* tobacco in *Terai* region of West Bengal.

METHODOLOGY

Yield data of 24 years i.e. 1991-92 to 2014-15 was collected from field experiment which has been started in 1961-62. The experiment was conducted with 10 treatments to study the effect of organic manures and inorganic fertilizers on long term productivity of *Motihari* tobacco with 10tretments viz. 10 t FYM (Control) and N, P, K, NP, NK, PK, NPK with 10 t FYM/ha applied to all above treatments and 25 & 50 t FYM/ha in RBD replicated thrice. All the fertilizers applied in the form of Urea, SSP and MOP to supply 112 kg/ha kg of NPK. Well rotten FYM applied one month before planting. Half dose of nitrogen along with full doses phosphorus and potassium applied as basal and remaining half doseof nitrogen at the time of irrigation (45 days after planting). After crop maturity leaves were cured and yield was recorded. Nicotine

Table 1. Long term effect of various treatments on cured and first grade leaf yield, nitrogen, nicotine and reducing sugar content of *Motihari* tobacco

Treatments	Cured leaf yield (kg/ha)	First grade leaf yield (kg/ha)	% quality leaf out turn	Nicotine (%)	Reducing Sugar (%)
Control	1190.33	220.90	18.56	2.286	0.824
N	1889.93	845.40	44.73	3.346	0.780
P	1254.20	258.77	20.63	2.170	0.768
K	1387.69	254.88	18.37	2.120	0.914
NP	2021.70	920.16	45.51	3.612	0.740
NK	1990.98	970.80	48.78	3.306	0.848
PK	1313.62	272.92	20.78	2.084	0.712
NPK	2252.26	1136.65	50.47	4.000	0.724
25t FYM /ha	1417.06	292.49	20.64	2.330	0.758
50t FYM /ha	1572.12	351.42	22.35	2.298	0.868
CD (P=0.05)	116.16	89.67	-	0.535	NS

Note: Treatment 2 to 8 applied @112 Kg /ha of respective nutrients along with 10t FYM /ha; in control plot applied only 10t FYM /ha.

and reducing sugars in the cured leaf was determined as per the standard procedures. The data has been calculated in RBD using online software WASP- Web AgriStata Package to find significance difference among treatments.

RESULTS

The application of NPK recorded significantly highest cured leaf (2252.26 kg/ha) and first grade leaf yields (1136.65 kg/ha) of *Motihari* tobacco as compared to rest of the treatments (Table 1). Application of phosphorus and potassium alone or in combination with each other and 25 or 50 t F Y M applied plots gave lower cured and first grade leaf yield as compared to application of nitrogen alone or in combination of phosphorus or potassium. However, application of 50 t F Y M/ha recorded significantly higher yield than 25 t and 10 t FYM/ha. Here interesting fact is that continuous application 25t or 50 t F Y M/ha for 54 years recorded loweryields when compare with NPK, NK and NP combination. It may be due to only single crop has been taken every year where crop has taken nutrient on same layers and little nutrient was added with crop stem left after tobacco harvesting. Here data clearly revealed that NPK combination with FYM or Nitrogen alone recorded higher quantity and quality leaf. Sharma *et.al* (2014) recorded application of farmyard manure (FYM) and lime along with NPK fertilizers increased the crop yield. The integrated use of optimal dose of NPK and FYM give better and more sustainable yields. Nicotine and Reducing sugar content determines the quality of leaf and are in the desirable levels. Nicotine content in the leaves of *Motihari* tobacco was significantly higher in N applied plots either alone or in combination.FYM @ 50 t/ha also recorded nicotine content at a par to FYM @ 25 t/ha. Significant differences were not observed in reducing sugar content among various treatments.

CONCLUSION

It may be concluded that balanced fertilization sustain crop productivity with highest quality outturn. However nitrogen application in *Motihari* tobacco fertilization play important role for higher yield and quality of tobacco leaf and more Nicotine content in leaves.

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Response of pearl millet advance hybrids and population entries to nitrogen levels

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Pearl millet is a major food, feed and fodder crop for feeding the world population. The growing conditions of pearl millet vary from near optimum with high external inputs to highly draught prone environments. This allows for prioritization of research in cognizance of production constraints and different requirements of various crop growing regions. The pearl millet improvement resulted in development of pearl millet hybrids with grain yield potential of 4-5 t/ha. However, the national average of pearl millet productivity is about 1100 kg/ha. Thus, there is a big gap in potential and realized productivity. Less adoption of production technology, timely in availability of quality seed and illiterate farming community are the major reasons for this gap in potential and realized productivity. At present, in addition to providing suitable genotypes for various cropping systems emphasis is also being given towards developing nutritionally rich hybrids with proper fertilization to meet the demand of fodder in animal supported suitable agriculture system of traditional Pearl Millet growing region. Hence, the present experiment was designed to study response of advance Pearl Millet hybrids and population entries to nitrogen levels.

METHODOLOGY

The present investigation was carried out at National Agriculture Research Project, Aurangabad in kharif-2009. The experiment was laid out in factorial randomized block design with three replications and plot size of the experiment was 4.4 x 2.7 sq.m. The treatment consisted of three nitrogen levels, viz., N_1- 30 kg/ha, N_2- 60 kg/ha, N_3- 90 kg/ha and thirteen advance hybrid and population entries viz., E_1-MH 1570, E_2-MH 1578, E_3-MH 1580, E_4-MH 1587, E_5-MH 1600, E_6-MH 1605, E_7-MH 1606, E_8-MH 1610, E_9-MH 1616, E_{10}-MH 1617, E_{11}-GHB 558, E_{12}-MP 501, E_{13}-Raj 171. The sowing of experiment was done on 07.07.2010. All intercultural operations were carried out as per the recommendation.

RESULTS

Response of pearl millet hybrids and population entries to nitrogen levels was observed. The data on grain and fodder yield of pearl millet hybrids and population as influenced by nitrogen levels are presented in table 1.The pearl millet hybrid MH 1605 recorded highest grain yield (3805 kg/ha) which was at par with MH-1610 and MH-1617 and found significantly superior over rest of the hybrids. The highest fodder yield was recorded with hybrid MH-1587 (5638 kg/ha) and found at par with MH-1600, MH-1605 and MH-1610 and significantly superior over rest of the hybrids. Application of 90 kg N/ha to Pearl Millet recorded maximum grain yield (3779 kg/ha) and fodder yield (5464 kg/ha) which was significantly superior over rest of the treatments.

Table 1. Response of Pearl Millet advance hybrids and population entries to nitrogen levels.

Treatment	Grain yield (kg/ha)	Fodder yield (kg/ha)
Hybrid & Population entry		
E_1-MH 1570	3372	5201
E_2-MH 1578	2876	4675
E_3-MH 1580	2946	4510
E_4-MH 1587	3441	5638
E_5-MH 1600	3294	5235
E_6-MH 160	3805	5490
E_7-MH 1606	2600	4057
E_8-MH 1610	3756	5448
E_9-MH 1616	3240	4815
E_{10}-MH 1617	3750	5037
E_{11}-GHB 558	2687	4387
E_{12}-MP 501	2677	4123
E_{13}-Raj 171	2708	4427
SEm±	108	146
CD (P=0.05)	302	405
Nitrogen level		
N_1 – 30 kg/ha	3491	4013
N_2 – 60 kg/ha	3226	5071
N_3 – 90 kg/ha	3779	5464
SEm±	52	70
CD (P=0.05)	145	194
Interaction H x N		
SEm±	189	253
CD (P=0.05)	522	701

CONCLUSION

Based on present investigation, it is concluded that to get maximum benefit pearl millet hybrid MH-1605should be sown with application of 90 kg N/ha.

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Growth and yield of mungbean (*Vigna radiata*) as influenced by sulphur and zinc in partially reclaimed saline-sodic soils

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This study was conducted at the Instructional Farm of N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.), during summer season of 2008-09 and 2009-10, to study the growth and yield of Mungbean as influenced by sulphur (S) and zinc (Zn). Four levels of S (0, 20, 40 and 60 kg/ha) and four levels of Zn (0, 5, 7.5 and 10 kg/ha) were used in the study. The results revealed that seed and stover yield of mungbean increased with increasing levels of sulphur and zinc. The maximum significant seed and stover yield were obtained with the treatment combinations S_3Zn_4 (40 kg S/ha + 10 kg Zn/ha) and the same treatments combinations gave the highest plant height, number of branches/plant, yield attributes like number of pods/plant, number of grains/pod, weight of 1000 seeds, respectively.

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Effect of integrated application of inorganic and organic sources on yield and nutrient uptake by pearlmillet

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Integrated nutrient supply system aimed at sustainable crop production level with minimum deleterious effect of chemical fertilizers on soil health and least disturbance to pearl millet-mustard ecosystem by orchestrating the combined use of inorganic fertilizers and organic manures. The best of inorganic could be obtained in the presence of adequate organic manure and that maximum pearl millet and mustard yield could be obtained through complementary use of organics with inorganic fertilizers. This approach restores and sustains soil health and productivity in the long run besides meeting the nutritional deficiencies.The result of the long-term field.Experiment/demonstration at farmers field indicated that the technology of the combined use (15t FYM/ha/year with recommended dose of NPK) increased the productivity of pearl millet-wheat, cotton-wheat, cotton-mustard, mustard-sorghum and rice-wheat cropping system.

METHODOLOGY

Field study was conducted at the Crop Research Farm of RajmataVijayarajeScindia Agriculture University, Gwalior (M.P.) in Kharif season 2014 with Pearlmillet as a test crop. The experimental soil having p H (1:2) 7.5, electrical conductivity (E.C.) 0.43dS/m, organic carbon (O.C.) 4.53 g kg^{-1}, available N (172.96) kg /ha, Olsen-P (11.79) kg /ha, available K (198.24) kg /ha and available S (6.88) mg kg^{-1}. The 100% NPK recommended dose of fertilizer for Pearlmillet was 80 kg N, 40 kg P_2O_5 and 20 kg K_2O /ha respectively. The experiment consisted of nine treatments replicated three times in a randomized block design viz., FYM @ 16 t/ha (T_1), N_{40} P_{20} K_{10} + FYM @ 8 t/ha: T_2, N_{20} P_{10} K_5 + FYM@12 t/ha: T_3, N_{60} $P_{30}K_{15}$ + FYM@ 4 t/ha: T_4, Vermicompost 5334 kg /ha: T_5, $N_{40}P_{20}K_{10}$ +Vermocompost @ 2667 kg /ha: T_6, $N_{20}P_{10}K_5$ + Vermicompost @ 4000 kg /ha: T_7, $N_{60}P_{30}K_{15}$ + Vermicompost @ 1334 kg /ha: T_8, $N_{80}P_{40}K_{20}$: T_9. The farmyard manure (FYM) was obtained from small dairy holders. The FYM @ 16 t/ha was incorporated one month before sowing as per treatments. Total N, P, and K contents of the FYM were 0.50, 0.25 and 0.50 % respectively. Half of the N and entire dose of P, K were applied at the basal dose and remaining quantity of N was top dressed after 35 days, in the form of urea, di-ammonium phosphate, murate of potash. Grain and straw yields were recorded after harvest of crop. The grain and straw samples were digested in H_2SO_4 for determination of N and di-acid mixture of HNO_3 and $HClO_4$ (2:5) for P, K and S estimation. Plant uptake of N, P, K and S were computed by multiplying the yield with the respective nutrient content. After harvest of the crop, the composite surface (0-15 cm) soil samples from each plot of the experimental field were analyzed for p H , EC, OC, available N, P, K by following standard procedures.

RESULTS

The organic carbon of soil increased significantly with the application of FYM and vermicompost along with graded dose of fertilizers (table 1). The highest build-up of OC in the soil was recorded in 100% NPK, which was at par with 25% vermicompost + 75% NPK and 75% vermicompost + 25% NPK.Thus, integrated application of organics with chemical fertilizers (vermicompost + NPK) resulted in significantly higher organic carbon content in soil. The increase in OC content in the manorial treatment combinations is attributed to direct addition of organic manure in the soil which stimulated the growth and activity of microorganisms and also due to better root growth, resulting in the higher production of biomass, crop stubbles and residues. Higher yield in comparison to 100% FYM and 100% vermicompost were recorded with 50% vermicompost + 50% NPK (table 2). There was a significant response of different treatments as compared to organic sources. Grain yield varied from 3044.73 to 4192.46 kg /ha under different treatments which were in T_5 (100% vermicompost) and T_6 (50% vermicompost +50% NPK) respectively. Application of P along with N considerably increased yield of pearlmillet compared to the application of FYM alone. A better supply of phosphorus has been associated with prolific root growth resulting in enhanced water and nutrient absorption. The application of K along with NP significantly increased the grain and straw yield of pearlmillet over FYM and vermicompost alone, emphasizing on the essentiality of balanced fertilization to obtain higher pearlmillet productivity. As K play a number of indispensable roles in a wide range of function. Increasing fertility levels increased the yield of pearlmillet in different combination of NPK + vermicompost.Application of balanced fertilization of N, P and K led to significantly higher NPK uptake in comparison to FYM and vermicompost alone (table 2). Nutrient uptake was influenced significantly by the application of chemical

Table 1. Influence of integrated application of inorganic and organic sources on soil chemical properties of post-harvest soil and yield.

Treatment	pH(1:2)	EC (dS/m)	OC (g/kg)	Grain yield (kg/ha)	Straw yield (kg/ha)
100% FYM	7.4	0.42	4.24	3170.66	9723
50% FYM + 50% NPK	7.7	0.42	4.36	3549.3	12038
75% FYM +25% NPK	7.7	0.43	4.49	3468.23	12038
25% FYM + 75% NPK	7.5	0.44	4.46	3693.43	12346
100% Vermicompost	7.7	0.42	4.34	3044.73	11575
50% Vermi +50% NPK	7.6	0.45	4.5	4192.46	11266
75% Vermi + 25% NPK	7.5	0.45	4.5	3450.16	10957
25% Vermi + 75% NPK	7.6	0.46	4.59	3774.46	12964
100% NPK	7.4	0.46	4.61	3891.6	14507
CD (P=0.05)	NS	0.016	0.17	646.271	1814.04

Table 2. Influence of integrated application of inorganic and organic sources on nutrient uptake

Treatment	Total nutrient uptake (kg /ha)			(ppm)
	N	P	K	S
100% FYM	64.79	10.05	142.27	8.18
50% FYM +50% NPK	114.89	23.00	199.45	11.63
75% FYM + 25% NPK	97.35	23.47	207.02	11.11
25%FYM + 75% NPK	85.62	72.26	221.03	12.86
100% Vermicompost	84.07	26.09	207.32	10.34
% 50Vermicompost + 50% NPK	116.11	37.83	225.92	15.08
% Vermicompost 75+ 25% NPK	96.1	25.24	213.67	14.85
25% Vermicompost + 75% NPK	137.39	33.29	245.54	19.95
100% NPK	180.78	38.81	303.05	23.06
CD (P=0.05)	27.48	6.79	35.36	2.95

fertilizers alone or in combination with FYM and vermicompost. The highest total uptake (grain + straw) of NPKS (180, 38.81, 303.05 and 23.06 kg/ha respectively) was recorded with the incorporation of 100% NPK. It is obvious as from inorganic fertilizer release of NPK is faster in the solute form, whereas NPK availability from organics is after its mineralization which depends on soil conditions.

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Nutrient uptake of rice as affected by different levels and sources of zinc under temperate conditions

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Zinc deficiency is prevalent worldwide both in temperate and tropical climate. Soil low in CEC does not bind Zn well, leaving a relatively greater proportion of fertilizer Zn in the plant available form, thus allowing for a considerable increase in grain Zn concentration with an increase in Zn fertilization to 3.2 mg Zn/kg soil (up to 145 mg Zn/kg grain). Zinc can be directly applied to soil as both organic and inorganic compounds. Zinc sulfate ($ZnSO_4$) is the most widely applied inorganic source of Zn due to its high solubility and low cost. Keeping in view the importance of zinc fertilization, a field experiment was conducted to study the nutrient uptake of rice as affected by different levels and sources of zinc under temperate Kashmir conditions.

METHODOLOGY

A field experiment was conducted at Mountain Research Centre for Field Crops, Khudwani of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during kharief 2011 and 2012. The experimental site is situated in temperate zone of Jammu and Kashmir State between 34^o N latitude and 74^o E longitude at an altitude of 1560 m above mean sea level. The experiment comprised of two factors viz. 3 levels of zinc(3,6 and 9kg Zn/ha) and 5 sources of zinc (Zinc sulphate ,Zinc oxide, Zinc enriched urea, Zinc FYM incubated and Zn-EDTA and one absolute control (*i.e.* no zinc) laid out in a Randomized Complete Block Design with three replications. Recommended packages of practices were

Table 1. Nutrient up- take of rice as effected by different levels and sources of zinc (pooled data)

Treatment	NPK uptake (kg/ha)					
	Grain			Straw		
	N	P	K	N	P	K
Zinc levels (kg/ha)						
3	78.20	14.72	13.76	46.62	11.47	117.5
6	86.20	14.88	16.40	55.51	11.73	128.7
9	87.00	14.21	16.75	57.28	11.87	129.2
SEm±	1.66	0.62	0.63	2.14	0.49	3.55
CD (P=0.05)	3.35	1.21	1.28	4.38	NS	7.24
Zinc sources						
Zinc sulphate	81.05	13.87	14.61	48.33	11.23	119.9
Zinc oxide	79.95	13.25	14.18	50.85	10.95	120.2
Zinc enriched urea	86.11	14.54	15.92	53.67	11.99	127.8
Zinc-FYM incubated	85.81	14.26	16.32	55.75	12.13	126.9
Zn-EDTA	86.83	14.62	16.69	53.27	12.81	130.0
SEm±	2.14	0.8	0.80	2.77	0.63	4.58
CD (P=0.05)	4.37	1.33	1.65	5.65	NS	9.36
Control	62.54	13.52	10.65	36.65	11.25	99.17
SEm±	2.87	1.07	1.08	3.71	0.15	6.14
CD (Control vs Zn)	5.87	1.36	2.22	7.59	NS	12.55

fallowed. As per the treatments wherever zinc was to supplied through Zn enriched urea, the entire dose of N and Zn was supplied through the same. In the rest of the plots the N was supplied through urea. In the plots wherever the Zn was supplied through Zn incubated FYM, the recommended dose of FYM and Zn as per the treatments was applied through Zn incubated FYM. Recommended dose of FYM was applied in rest of the plots. After recording the dry weight of pant samples collected from each plot, oven dried samples were grounded in Wileys mill and passed through 32 mesh sieve, both of grain and straw were grounded and subsequently used for chemical analysis. The data were statistically analysed for critical difference as per method described by Cochran and Cox (1963).

RESULTS

The pooled data (Table 1) on N and K up-take of grain and straw revealed that Zn levels significantly increased N and K uptake in grain and straw over control. 6kg Zn/ha increased N and K uptake over 3kg Zn/ha and control though at par with 9kg Zn/ha. Zinc sources recorded a significant difference with respect to N and K uptake in grain as well as straw. Zn-EDTA recorded highest N uptake though it was at par with zinc enriched urea and Zn-FYM incubated but significantly higher than ZnO and $ZnSO_4$. The results are in line with Swami and Shekhawat (2009). In spite of the fact that P content in grain and straw got decreased due to the increasing Zn levels but P uptake increased over control due to overwhelming effect of increase in grain and straw yield. These findings confirm the findings of Shivay *et al*. (2008). Zn-EDTA recorded highest P uptake though it was at par with zinc enriched urea and Zn-FYM incubated but significantly higher than ZnO and $ZnSO_4$. Zn-EDTA, Zn enriched urea and Zn-FYM incubated was more efficient in increasing the K uptake than the ZnO and $ZnSO_4$. Zn-EDTA has been reported to posses highest "zinc-mobilization efficiency" compared to the other zinc sources Srivastava *et al*. (1999).

CONCLUSION

From this study it is concluded that 6 kg Zn/ha significantly increase N and k up-take in grain and straw over 3kg Zn/ha and control and highest uptake was recorded with 9 kg Zn/ha. However, P up-take was significant only upto 3kg Zn/ha beyond which it started decreasing significantly upto 9 kg Zn/ha. Among different zinc sources Zn-EDTA recorded the highest macronutrient uptake in grain as well as straw though at par with Zn enriched urea and Zn-incubated FYM.

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Performance of single node seedlings of sugarcane under wider and paired row planting at graded levels of nitrogen

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Sugarcane is an important commercial crop of India. In sugarcane, cost of cultivation is increasing day by day and 15 % of the total cost of cultivation is going towards seed material. Hence, farmers are preferring seedling cultivation owing to its own advantages in getting higher cane yields along with reduction in cost of seed. In this context there appeared a need to evolve new agronomic technologies like planting methods and nitrogen management for further improvement in yield and quality of sugarcane raised with single node seedlings. Hence, the experiment was laid out at RARS, Anakapalle, Andhra Pradesh, India.

METHODOLOGY

A field experiment was conducted at Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, India. for three consecutive years from 2013-14 to 2015-16 on sandy loam soil. The experimental soil was neutral in reaction (pH 7.2), low in available nitrogen (197.8 kg N/ha),medium in available phosphorus (34.2 kg P_2O_5/ha) and high in available potassium (358 kg K_2O /ha). An early maturing sugarcane variety 2001A63 (Kanaka Mahalakshmi) was planted during spring season in all the three years of experimentation. The treatments consisted of three methods of planting (paired row-60/120X60 cm, wider row planting-150X45 cm and normal planting-90X60 cm) and three nitrogen levels (100 % RDN, 150% RDN and 175 % RDN) The experiment was laid out in split plot design keeping methods of planting as main plots and nitrogen levels as sub plots. Irrigations were accorded once in 3 days up to 15 days after planting and there after once in six days during formative phase and once in three weeks during maturity phase i.e. from November to harvest. Seedlings were planted in treatments plots by letting water into the furrows. FYM @ 25 t/ha and phosphorus @ 100 kg P_2O_5/ha were applied uniformly in furrows before transplanting of singlebud seedlings potassium @ 120 kg K_2O/ha was applied in split doses along with nitrogen. Nitrogen was applied in split doses at 15 days interval upto earthing up (90-100 days) in the treatmental plots.

RESULTS

Number of millable canes/ha: Millable cane number varied significantly due to different planting methods and nitrogen levels during all the three years of experimentation (Table 1). Single node seedlings planted in paired rows of 60 / 120 X 60 cm registered higher number of millable canes of

Table 1. Number of millable canes and quality of sugarcane raised with seedlings as influenced by methods of planting and levels of nitrogen

Treatment	Number of millable canes/ha				Per cent Juice sucrose				Commercial cane sugar (%)			
	2013-14	2014-15	2015-16	Mean	2013-14	2014-15	2015-16	Mean	2013-14	2014-15	2015-16	Mean
Methods of planting:												
Paired row planting(60/120X60 cm)	57229	52085	67293	58869	15.40	17.61	18.97	17.32	11.01	12.80	13.93	12.58
Wider row planting(150X45 cm)	48995	42471	55450	48972	14.86	17.68	18.80	17.11	10.23	13.01	13.70	12.31
Normal planting(90X60 cm)	51973	50506	68905	57128	15.83	17.41	18.90	17.38	10.90	12.53	13.93	12.45
SEm±	450	852	1207	-	.06	0.11	0.21	-	0.09	0.13	1.3	-
CD (P=0.05)	1348	2378	3485	-	NS	NS	NS	-	NS	NS	NS	-
N Levels(Rec. dose of N-112 Kg/ha):												
112 Kg N/ha (100% RDN)	49193	45807	60255	51752	15.11	17.52	19.31	17.31	11.20	13.10	14.30	12.86
168 Kg N/ha (150% RDN)	51747	48502	64803	55017	15.72	17.63	18.84	17.39	11.50	12.72	13.87	12.70
196 Kg N/ha (175% RDN)	57257	52758	59184	59733	15.44	17.54	18.50	17.16	11.51	12.41	13.39	12.44
SEm±	450	807	1315	-	0.04	0.08	0.08	—	0.15	0.09	0.11	-
CD (P=0.05)	1348	2251	3809	-	NS	NS	0.22	-	NS	NS	0.31	-
Interaction	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS	-

Table 2. Cane and sugar yield of sugarcane raised with seedlings as influenced by methods of planting and levels of nitrogen

Treatment	Cane yield (t/ha)				Sugar yield (t/ha)			
	2013-14	2014-15	2015-16	Mean	2013-14	2014-15	2015-16	Mean
Method of Planting								
Paired row planting (60/120 X 60 cm)	85.5	70.3	84.8	80.2	9.5	9.0	11.8	10.1
Wider row planting (150X45 cm)	76.1	54.8	67.1	66.0	7.9	7.1	9.2	8.1
Normal planting (90X60 cm)	79.2	67.3	83.4	76.9	8.6	8.4	11.6	9.5
SEm±	1.0	1.7	1.4	-	-	-	-	-
CD (P=0.05)	3.9	4.8	4.1	-	-	-	-	-
N Levels (Rec. dose of N-112 Kg/ha)								
112 Kg N/ha (100% RDN)	73.4	58.6	74.0	68.7	8.2	7.7	10.6	8.8
168 Kg N/ha (150% RDN)	80.7	62.8	77.7	73.7	9.3	8.0	10.8	9.4
196 Kg N/ha (175% RDN)	86.9	69.1	83.7	79.9	10.0	8.6	11.2	9.9
SEm±	0.9	1.5	1.7	-	-	-	-	-
CD (P=0.05)	2.8	4.3	5.0	-	-	-	-	-
Interaction	NS	NS	NS	-	-	-	-	-

58,869/ha (mean over three years) than wider row planting (48,972/ha) but found comparable to normal spacing at 90 X 60 cm (57,128/ha). Similar results were also reported by Chitkala Devi *et al*., 2014. Significant differences in number of millable canes were observed with different nitrogen levels. Application of nitrogen fertilizer at 175% recommended dose (196 kg N/ha) recorded significantly higher number of miilable canes of 59,733 /ha as compared to lower levels of 100% RDN (51,752/ha) or 150% RDN (55017/ha). Interaction effects were found to be non significant.

Percent Juice Sucrose(%) : Juice sucrose values did not vary significantly due to different planting methods during three years of experimentation. However, the mean sucrose values varied between 17.11 and 17.38 %. Per cent sucrose differed significantly due to graded levels of nitrogen during 2015-16 season only. Application of nitrogen at 150% recommended dose registered slightly higher mean juice sucrose percent (17.39%) than 175% recommended dose of nitrogen (17.16%). Similar findings were also reported by Chitkala Devi *et. al.*, 2014.

Commercial Cane Sugar (%): Significant variation in Commercial Cane Sugar per cent was not obsereved due to different planting methods during all the three years of experimentation (Table 1). During 2015-16 application of nitrogen at 100 % RDN registered significantly higher CCS % of 14.30 % and found superior to 175 % RDN (13.39). This might be due to higher juice sucrose values recorded at lower level of nitrogen.

Cane yield (t/ha): Cane yield varied significantly due to different planting methods and nitrogen levels (Table 2) during all the three years of experimentation. Planting of single bud seedlings in paired rows (60/120 x 60cm) gave higher mean cane yield (80.2 t/ha) than wider row planting i.e. 150 cm x 45cm (66.0 t/ha) but found on par with normal row planting at 90 x 60 cm (76.9 t/ha). The yield improvement in paired row or normal planting might be due to the improved millable cane number under these two methods of planting. These results are in corroboration with findings of Chitkala Devi *et. al*., 2014 and Gouri *et. al*., 2014. Application of 175% recommended nitrogen (79.9 t/ha) improved the cane yield (mean over 3 years) as compared to 100 % nitrogen (68.7 t/ha) or 150% recommended level of nitrogen (73.7 t/ha). Similar yield increase with higher dose of nitrogen application to seedlings was also reported by Chitkala Devi *et. al.*, 2014.

Sugar yield (t/ha): Sugar yield was computed treatmentwise and data are presented in Table 2. Sugar yields followed the same trend as that of cane yield.

CONCLUSION

From three years of experimentation it can be recommended that, single node seedlings could be planted in paired rows of 60/120X60 cm or normal planting of 90X60 cm in order to realise higher cane and sugar yields. For cane crop raised with single node seedlings higher level of 175 % recommended dose of nitrogen can be applied to obtain higher cane and sugar yields.

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Enzyme activity in Bt cotton soils influenced by bio-fertilizers and foliar nutrition under rainfed condition

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Cotton (*Gossypium hirsutum* L.) is the most important commercial crop of India. Cotton contributes to 80 % of the raw material to the textile industry and provides employment to nearly 60 million people. Although there are diverse benefits of Bt cotton, public concern also exist because both *in vitro* and *in vivo* studies on Bt cotton showed that Bt toxin produced in leaves, stems and roots of Bt cotton plants are introduced into soil. Bt-toxin from Bt cotton plants introduced into the soil through two pathways, i.e., biomass incorporation and root exudates. Soil enzyme activity is known to be significantly influenced by the soil/climatic conditions as well as plant nutrition through bio-fertilizers and foliar applied fertilizers(Mastero*et al*., 2006 and Sarkar*et al.,* 2009). Studies on impact of soil applied microbial consortia alone or in combination with foliar nutrition of N, P and K on soil important soils enzyme activity in Bt cotton growing soils, under rainfed condition, is scanty. With this view the experiment was conducted to study the influence of microbial consortia of Phosphate solubilizing Bacteria (PSB) + Potassium solubilizing Bacteria (KSB) + *Azotobacter* +Vesicular Arbusular Mycorrhizha (VAM) fungi and foliar nutrition on the soil enzyme activity.

MRTHODOLOGY

Afield experimentwas conducted at College Farm, Rajendranagar during rainy season (*kharif*) 2014on a sandy clay loam soil with neutral pH (7.4) and loworganic carbon (0.34 %). The soil was low, medium and high in the available N (174.8 kg/ha), P_2O_5(49.3kg/ha)and K_2O (422.4 kg/ha), respectively. The experiment was laid out in a randomized block design (RBD) with 10 treatments replicated thrice with a net plot area of 5.4 m X 3.6 m. An intra hirsutum cotton hybrid Jadhu (Boll-Gaurd II) having semi determinate plant type was used as a test cultivar. Treatments in the experiment included T_1- Control (RDF-150:60:60 N, P_2O_5 and K_2O kg/ha), T_2- Consortia of microbes (PSB+KSB+VAM+*Azotobactor*) to soil @ 1 L/ha, T_3- Foliar application of urea @ 2&, T_4- Foliar application of KNO_3 @ 2%, T_5- Consortia of microbes + Foliar application of urea @ 2%, T_6- Consortia of microbes + foliar application of KNO_3 @ 2%, T_7- Foliar application of 18:18:18 @ 1.5%, T8- Foliar application of 17:44:0 @ 2%, T9- Consortia of microbes + foliar application of 18:18:18 @ 1.5% and T10- Consortia of microbes + foliar application of 17:44:0 @ 2 %. Consortia (PSB and *Azotobactor* are in the form of liquid@ 250 ml/L and KSB and VAM in the form of powder @ 250 g) were mixed well and the mixture was spread uniformly on well decomposed FYM (100 kg/ha) one day before application. FYM was incubated overnight by maintaining optimum moisture and applied to the soil at the time of sowing along with the seed. Foliar sprays were applied at 60, 90 and 120 DAS. Enzymatic activity v*iz.,* dehydrogenase, phosphatases and urease in rhizosphere soils was studied by employing standard procedures at the time of flowering (60, 120 DAS) and harvest (153 DAS).

RESULTS

Dehydrogenase activity during the crop growth period varied from 3.2 to 11.3 µg TPF/g/day. Highest soil dehydrogenase activity was observed during the flowering stage and reduced as the crop reached maturity.Significantly higher dehydrogenase activity at 60 DAS was recorded with consortia of microbes applied to soil with foliar application of 18:18:18 @ 1.5 %which was atpar with consortia + foliar application of KNO_3@ 2% and sole consortia of microbes applied to soil than other treatments. At final harvest also significantly higher dehydrogenase activity was recorded with consortia of microbes with foliar application of18:18:18 @ 1.5 % than all the treatments. Similar results were reported by Sarkar*et al.*(2009).Activity of acid and alkaline phosphatase was significantly higher at 60 DAS, recorded with microbial consortia applied to soil and foliar application of 18:18:18 @ 1.5%than all other treatments. Significantly lower acid and alkaline phosphatase activity in soils was recorded with control.At final harvest, significantly higher acid phosphatase activity was recorded with application of microbial consortia with foliar application of 18:18:18 @ 1.5 %which wasat par with combination of microbial consortia and foliar application of KNO_3 @ 2 %. Phosphatase activity in these treatments was significantly superior to other treatments. Significantly lower acid and alkaline phosphatase activity than the remaining

Table 1. Soil enzyme activity as influenced by soil application of Microbial consortia and foliar nutrition in rainfed Bt cotton.

Treatment	Dehydrogenase (µg TPF/g/day)		Phosphatase (µg PNP released/g/h)			
			Acid phosphatase		Alkaline phosphatase	
	Flowering	Harvest	Flowering	Harvest	Flowering	Harvest
Control (150:60:60)	7.4	3.2	99.5	73.2	54.9	50.0
Consortia of microbes @ 1 L/ ha	10.4	4.4	122.3	83.5	85.3	62.6
FA of 2% Urea	9.8	3.7	111.5	84.0	57.1	49.3
FA of 2% KNO_3	9.1	3.5	109.7	95.7	60.1	52.6
Consortia of microbes + FA of 2% Urea	10.8	4.1	109.0	100.1	78.6	68.2
Consortia of microbes + FA of 2% KNO_3	9.3	4.0	119.9	106.8	82.8	62.1
FA of 1.5% 18:18:18 WSF	9.9	3.6	110.9	95.6	67.5	53.3
FA of 2% 17:44:0 WSF	9.9	3.8	110.2	94.9	63.2	51.0
Consortia of microbes + FA of 1.5 % 18:18:18 WSF	11.3	5.4	142.2	116.0	101.3	82.6
Consortia of microbes + FA of 2 % 17:44:0 WSF	9.3	4.1	116.5	102.3	81.9	61.2
SEm±	0.4	0.3	3.7	5.6	2.6	3.0
CD (P=0.05)	1.2	0.8	11.1	16.8	7.6	8.9

FA-foliar application

treatments in soils was recorded with control.This might be due to large quantity of phosphorus fertilizer addition to soil as well as foliar application to meet the crop demand andlow initial soilavailable P. Insect-resistant Bt crops have the potential to change the microbial dynamics, biodiversity and essential ecosystem functions in soil, because they usually produce *cry* protein through all parts of the plant, similar reports given by Gregory *et al.* (2009).

CONCLUSION

Consortia of microbes applied to soil and foliar application of macro nutrients in *Bt* cotton showed remarkable influence on soil enzyme activity both at flowering and harvesting stages and activity of dehydrogenase, phosphatases and urease enzymes.These enzymes' activitieswere recorded higher during the flowering period (60DAS) and thereafter decreased with the age of the crop and lowest activity was recorded at final harvest.

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Performance of coconut-based cropping system under different nutrient management practices

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The coconut palm does not fully utilize soil space and solar radiation available in the garden due to its rooting pattern and canopy structure (Kushwah *et al.*, 1973; Nair and Balakrishnan, 1977). Underutilized soil space and solar radiation in monocrop stands can be utilized by growing a variety of crops having different stature, canopy shape and size and rooting habits in compatible combinations. In recent years, the farmers are experiencing the non profitability of coconut cultivation due to fluctuating prices of coconut and increasing incidence of pests and diseases in addition to low and erratic rainfall. Hence, there is need for crop diversification and intensification in coconut gardens with compatible crops to increase the productivity and income by ensuring effective and efficient utilization of soil space and solar radiation.

METHODOLOGY

In coconut garden, a large quantity of waste biomass is available in the form of leaves and spathe of coconut and the quantity will further increase with the planting of intercrops (Thomas *et al*., 2001). This biomass could be recycled by converting into vermicompost and thereby the quantity of fertilizer application can be reduced. The coir pith from coir industries can be converted into compost and used as source of nutrients to coconut as well as intercrops. Therefore, an experiment was laid out at Horticulture Research Station, Arsikere, Karnataka, to elucidate the possibility of supplementing nutrients to coconut and intercrops by recycling waste biomass in coconut garden and by other possible means like green manuring and green leaf manuring. Three nutrient management treatments were imposed in the cropping system during 2012 and compared with monocrop of coconut as detailed by T_1: 75% of Rec. NPK + organic recycling with vermicompost. T_2: 50% of Rec. NPK + organic recycling with vermicompost + vermiwash application + biofertilizer application and *in situ* green manuring. T_3: Fully organic: Organic recycling with vermicompost + vermiwash application + biofertilizer application, *in situ* green manuring & green leaf manuring (Glyricidia loppings) + Composted coir pith and mulching with coconut leaves. T_4: Control (Monocrop of coconut with recommended NPK and organic manure). Cocoa, lime and drumstick were planted during 2008 in a 40 year old coconut garden of Tiptur Tall cultivar planted at a spacing of 10 m x 10 m (100 palms/ha). Cocoa was planted at a spacing of 3.3 m x 5 m in two rows in the interspaces of coconut (300 plants/ha), lime was planted at 10 m x 10 m spacing in between two palms in a row (100 plants/ha) and drumstick was planted at 10 m x 5 m spacing in the interspaces of coconut (150 plants/ha). Banana was planted during 2012 in the space available between intercrops (500 plants/ha). Irrigation was given through drip irrigation system as per recommendation for each crop. The weathered leaves and spathe of coconut were used for vermicomposting. Fresh glyricidia leaves harvested from the plants raised in the boundary were used for green leaf manuring. The vermicompost produced was utilized for manuring coconut and intercrops. Vermiwash was collected from vermicompost pits and applied to coconut and intercrops twice a year after diluting with water in the ratio of 1:10. Sunhemp was grown as green manure crop in the basins of coconut, cocoa, lime, drumstick and banana and incorporated in to the soil every year during *Kharif* season. Mulching was done in the basins of coconut and intercrops during summer months.

RESULTS

The mean data over three years from 2012-13 to 2014-15 showed that the productivity of the cropping system was higher than the monocrop of coconut due to additional yield from the intercrops. The nut yield of coconut in the cropping system was unaffected in T-1 treatment (9903 nuts/ha/yr) whereas in T-2 (10860 nuts/ha/yr) and T-3 (10350 nuts/ha/yr) treatments, the nut yield was increased compared to monocrop of coconut (9943 nuts/ha/yr). The dry beans yield of cocoa, fruit yield of lime, pod yield of drumstick and fruit yield of banana were higher in T-2 and T-3 compared to T-1. The earthworm and microbial population were higher in the crop-

Table 1. Yield of coconut and intercrops in the coconut based cropping system during 2012-13 to 2014-15

Treatment		Crop components		Yield of coconut and intercrops	
		2012-13	2013-14	2014-15	Mean
T_1	Coconut (Nuts/ha)	10830	9880	9000	9903
	Cocoa (kg/ha)	157	171	236	188
	Lime (kg/ha)	1025	868	965	953
	Drumstick (kg/ha)	1886	948	785	1206
	Banana (kg/ha)	-	12642	8692	7111
T_2	Coconut (Nuts/ha)	11770	11210	9600	10860
	Cocoa (kg/ha)	158	190	276	208
	Lime (kg/ha)	1061	966	986	1004
	Drumstick (kg/ha)	1963	1082	829	1291
	Banana (kg/ha)	-	12508	9033	7180
T_3	Coconut (Nuts/ha)	11200	10420	9430	10350
	Cocoa (kg/ha)	170	195	288	218
	Lime (kg/ha)	1170	986	1116	1091
	Drumstick (kg/ha)	1944	988	862	1265
	Banana (kg/ha)	-	13800	9825	7875
T_4	Coconut (Nuts/ha)	10930	9730	9170	9943

Table 2. Economics of coconut based cropping system (Mean of three years: 2012-13 to 2014-15).

Treatment	Gross returns (Rs./ha)	Cost of production (Rs./ha)	Net returns (Rs./ha)
T_1	282415	74900	207515
T_2	298843	83367	215477
T_3	306645	82567	224078
T_4	105547	30800	74747

ping system compared to monocrop of coconut. Among the cropping systems, the earthworm population in the interspace of coconut at 0-30 cm depth recorded at the end of third year of imposition of nutrient management treatments was higher in T-3 (66.7 worms/m^2) followed by T-2 (64.8 worms/m^2) and T-1 (53.7 worms/m^2). Similarly, the microbial population recorded at 0 -30 cm depth in the interspace of coconut was also higher in T-3 (Bacteria: 130 x 10^6, fungi: 29 x 10^3 and actinomycetes: 28 x 10^3 CFU per g of soil) followed by T-2 (Bacteria: 121.5 x 10^6, fungi: 28.5 x 10^4 and actinomycetes: 24 x 10^3 CFU per g of soil) and T-1 (Bacteria: 112 x 10^6, fungi: 25.5 x 10^4 and actinomycetes: 19.5 x 10^3 CFU per g of soil). The monocrop of coconut recorded lowest earthworm (7.4 worms/m^2) and microbial population (Bacteria: 101 x 10^6, fungi: 21.5 x 10^4 and actinomycetes: 17 x 10^3 CFU per g of soil). The increase in earthworm and microbial population in the cropping system is attributed to addition of organic matter from the intercrops, application of vermicompost, shade of intercrops and continuous moisture availability in the interspaces due to irrigation to intercrops. The soil enzyme activities (urease and dehydogenase) and soil microbial biomass were higher in coconut based mixed farming system as compared coconut monocropping. The light interception was higher in the cropping system with different nutrient management practices (67.7- 71.2 % of PAR) compared to monocrop of coconut (16.9 % of PAR). The economic analysis of cropping system considering the mean data of three years showed that the net returns were higher in the cropping system under all the three nutrient management practices compared to monocrop of coconut. Among the nutrient management practices, the net returns were higher in T-3 (Rs. 224078/ha) followed by T-2 (Rs. 215477/ha) and T-1 (Rs. 207515/ha). The monocrop of coconut recorded the lowest net returns of only Rs. 74747 per ha.

CONCLUSION

Thus, the present study has indicated the possibility of achieving higher productivity and income in coconut based cropping system by recycling the waste biomass of coconut garden and by adopting organic or integrated nutrient management practices.

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Sugarcane productivity in relation to initial soil organic carbon content and nutrient management in sub-tropics

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Sugarcane (*Saccharum officinarum* L.), a long duration high biomass producing crop occupies 5.0 m ha area in India about 50% of which falls in the northern sub-tropical states with average cane yield of 65 t/ha against the national average of 70 t/ha and around 90 t/ha in tropical region (Srivastava *et al*., 2012). Besides the climatic factors like very high temperatures during summer and frost like conditions during winter months, poor soil health often restricts the crop productivity. Intensive cultivation, imbalanced nutrient application and burning of crop residues led wide spread deficiency of secondary and micro-nutrients and poor status of available N and P along with medium to low soil organic carbon insugarcane growing soils of the region make it imperative to develop and adopt agro-techniques that can effectively improve the soil health and ensure remunerative cane productivity. Since the nutrient management need to be based on intrinsic soil properties and soil organic carbon content is an important and dependable soil quality indicator.

METHODOLOGY

A field experiment to assess the influence of initial soil

Table 1. Effect of initial soil organic carbon content (SOC) and nutrient management on growth and yield of sugarcane

Treatment	Germination (%)	Tiller no. (₹000/ha)		NMC (₹000/ha) (m)	Cane length (t/ha)	Cane yield
		70 DAP	160 DAP			
Initial SOC level						
0.45-0.55	29.3	124.5	122.5	85.7	1.86	62.1
0.56-0.65	34.2	143.6	127.2	103.3	1.91	64.1
0.66-0.75	35.7	158.0	137.8	110.2	1.92	70.9
≥ 0.76	31.4	149.1	137.0	111.6	1.96	70.2
CD (P=0.05)	NS	18.6	11.4	6.6	NS	4.6
Nutrient management						
RDF (150, 60, 60 kg NPK/ha)	32.1	132.8	125.0	100.1	1.79	63.0
RDF + FYM (10 t/ha)	36.4	152.8	139.4	107.6	1.98	69.5
RDF + $ZnSO_4$ 25 kg + S 20 kg/ha	29.3	145.8	128.9	100.4	1.96	67.9
CD (P= 0.05)	NS	16.1	9.7	5.7	0.16	4.0

organic carbon (SOC) content and nutrient management on sugarcane growth and yield was carried out during 2015-16. The experimental field consisted of plots (8x6 m) with varying SOC content as a result of adding variable rates of different bio-manures continuously for 10 years in a plant ratoon system followed by a fallow year. Four initial SOC levels (0.45-0.55, 0.56-0.65, 0.66-0.75 and above 0.75 %) and three nutrient management packages (recommended dose of fertilizers (RDF): 150, 60, 60 kg NPK; RDF + farmyard manure 10 t/ha; RDF + zinc sulphate 25 kg/ha + S 20 kg/ha) were evaluated in all combinations (12) following randomized block design with three replications. Land in all the plots was separately prepared to avoid any possible mixing. Farmyard manure was added in the stipulated plots at the time of final ploughing for land preparation. Sugarcane (Co Pk 05191) was planted in furrows 75 cm apart using 3-bud setts in overlapping manner. Soil and plant samples were drawn at different intervals to record different growth and yield parameters.

RESULTS

Findings evince that varying initial SOC levels did not influence the germination nor was it affected by the different management practices. Higher initial SOC content (0.66-0.75%) ensured significantly higher sugarcane germination (40.4%) over that under lowest SOC (24.4%) when only RDF was applied. Effect of treatments on tillering was conspicuous as the highest number of tillers (000/ha) at 70 and 160 DAP was recorded (158 and 137.8, respectively) under initial SOC level of 0.66-0.75% that were significantly higher over the number of tillers obtained with 0.45-0.55% initial SOC level, further there was no increase in tiller population for SOC content beyond 0.76%. Addition of 10 t/ha FYM along with RDF caused significant improvement in tiller density over the RDF alone at both the stages across different initial SOC levels. Addition of zinc sulphate and sulphur could not evince significant influence (Table 1). Among the yield attributing characters as observed at harvest, the number of millable canes (NMC) was significantly affected due to varying initial SOC content. Significant increase in NMC (110.2 thousand/ha) was recorded up to initial SOC content of 0.66-0.75 % with no further increase with increasing initial SOC. The cane length and thickness was not influenced by initial SOC levels, however, there was significant enhancement in cane length and thickness owing to farmyard manure or zinc sulphate and sulphur application along with RDF over that of RDF alone. Sugarcane yield was recorded highest (70.9 t/ha) under SOC level of 0.66-0.75 % which was significantly higher than that recorded with SOC levels of 0.56-0.65 % (64.1 t/ha) and 0.45-0.55 % (62.1 t/ha). Significant effect of initial SOC on growth and yield parameters may be ascribed to the release of plant nutrients in a slow but steady rate suiting to nutrient uptake pattern of sugarcane crop (Murphy *et al*., 2007) as the SOC stock functions as reservoir of nutrients because of high negative charge and resultant cation exchange capacity. Interaction effect was not found significant on yield attributes and cane yield. Juice quality also remained unchanged due to various treatments.

CONCLUSION

The findings strongly indicate significant role of initial soil organic carbon content on sugarcane growth and yield. It may be inferred that sugarcane soils should contain a minimum of 0.65 % SOC to ensure effective response of applied inputs and adequate cane yield.

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Productivity and profitability of rice-based cropping system under green manuring, rice residue and fertility level

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With the present growth rate of rice production (1.82%), India will be able to produce sufficient rice but a plateauing or even a negative yield trend has been reported in rice-wheat cropping system (Prasad, 2005), which is the backbone of the India's food security. The productivity of rice and rice based cropping system is low may be due to declining soil fertility and poor organic carbon in the soils. Green manures (Singh *et al*., 2011) and rice residue incorporation in rice helps to improve soil nutrient status and promotes soil microbial activity. These alternative practices are known to exert positive effects on chemical, physical and biological soil properties. Keeping above facts in view, the present study was carried out to assess the impact of green manuring, rice residue incorporation and fertility level on the productivity, profitability and sustainability of rice based cropping system.

METHODOLOGY

An experimental was conducted two consecutive years during *kharif* and winter season of 2014-15 and 2015-16 at Research Farm of Regional Rainfed Lowland Rice Research Station (ICAR-NRRI), Gerua, Assam to assess the productivity and profitability of rice based cropping system under green manuring, rice residue incorporation and fertility level in rainfed lowland conditions. The treatment consists of 24 treatment combinations *viz*., Green manuring and Rice residue incorporation in main plots and four fertility levels (control, 50, 75 and 100% recommended doses of fertilizer (RDF) in sub plots for rice and three succeeding *rabi* crops (lentil, linseed and rapeseed) in sub subplots where 100% RDF contained 80:40:40 kg N-P_2O_5-K_2O/ha. Green manure crop (*Sesbania*) and rice residue @ 5 t/ha was buried in the soil one month before transplanting during last week of June during

Table 1. Productivity, production efficiency and profitability of rice based cropping system as influenced by green manuring, rice residue and fertility levels

Treatment	Rice equivalent yield (t/ha)	Production efficiency (kg/day/ha)	Sustainability yield index	Net return (₹/ha)	B:C
Main plot					
Green Manuring	5.90	31.71	0.82	42522	1.91
Rice Residue Incorporation	5.60	30.15	0.81	36416	1.75
CD (P=0.05)	0.11	0.58		2077	0.04
Fertility level					
Control	4.94	26.58	0.82	29245	1.64
50% RDF (40:20:20)	5.78	31.13	0.82	39941	1.85
75% RDF (60:30:30)	6.11	32.84	0.85	44153	1.92
100% RDF (80:40:40)	6.17	33.18	0.85	44538	1.91
CD (P=0.05)	0.55	3.01		7968	0.17
Rabi Crops					
Sole Rice	5.08	42.35	0.80	30420	1.64
Rice-Lentil	6.00	26.66	0.82	41961	1.86
Rice-Linseed	6.11	26.31	0.84	43742	1.90
Rice-Rape seed	5.81	28.40	0.86	41754	1.91
CD (P=0.05)	0.05	0.36		794	0.02

both the years. Rice variety Naveen was used in the study with common package of practice was followed for raising seedling to harvest of the crop during *kharif* season and three*rabi* crops (lentil, linseed and rapeseed) were grown after harvesting rice without any fertilizer application. The data were subjected to analysis of variance (ANOVA) and results were presented at 5% level of significance (P = 0.05).

RESULTS

Green manuring produced significantly higher rice equivalent yield (REY), production efficiency, net return and B:C with slightly higher sustainability yield index (SYI) as compared to rice residue incorporation (Table 1). REY, production efficiency, net return and B:C ratio of rice based cropping system was favourably and significantly influenced by fertility level applied to rice.All three fertility level found significantly superior over control in terms of REY, production efficiency, net return and B:C but remained at with each other. Increment in fertility level 50%, 75% and 100% RDF increased REY by 17%, 23.7% and 24.9% over control, respectively. The highest SYI was obtained with 75% and 100% RDF, whereas, minimum with control. Among the rice based cropping sequences, rice-linseed cropping system resulted the maximum REY and net returnand found significant over other cropping sequences whereas, maximum SYI and B:C was obtained from rice-rapeseed cropping sequence. However, the lowest values of REY, net return, SYI and B:C were recorded with sole rice crop.Pulses and oilseeds reported the benefit towards the net return of cropping systems (Mishra *et al.*, 2013). The study further revealed that rice productivity could be enhanced by 18.1% and 20.3% through inclusion of pulses and oilseeds, respectively than that of its sole crop.

CONCLUSION

Based on the above findingsrevealed that green manuring with 50% RDF was found sufficient to sustain the productivity and profitability of rice based cropping system while linseed and lentil are better options to further increase the productivity.

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Nutrient Expert® (NE) in wheat: its effect on productivity and nutrient use efficiency

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Wheat is the second most important cereal crop next to rice in India occupying about 29 million hectare area and contributing 37% to the total national food grain production. It has been projected that the demand of wheat in India by 2020 has been projected to be between 105 to 109 million tonnes as against 94 million tonnes production of present day for which balanced nutrition holds the key. Existing fertilizer recommendations for wheat are mostly blanket application which often consists of predetermined rates of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) for vast areas. But the management of nutrients for cereals like wheat requires an approach that enables adjustments in N, P_2O_5 and K_2O applications to accommodate the field-specific needs of the crop for supplemental nutrients. The modern approach of fertilizer recommendation is site specific nutrient management (SSNM) which provides the scientific principles for determining the amounts of N, P_2O_5 and K_2O that best match the field-specific needs of a cereal crop for supplemental nutrients. Nutrient Expert® (NE) is a nutrient decision support software that uses the principles of site specific nutrient management (SSNM) and enables farm advisors to develop fertilizer recommendations tailored to a specific field or growing environment (Dobermann and Witt, 2004). In this backdrop, an experiment was conducted to assess the performance of Nutrient Expert®

Table 1. Effect of tillage and nutrient management options on grain yield, agronomic and economic nitrogen use efficiencies

Tillage practices	Nutrients Management practices	Grain yield (kg/ha)		ANUE (kg grain/kg N)		ENUE*(kg grain/Rs invested in N)	
		2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
CT	N_1	3460	3543	10.93	15.89	1.78	1.82
	N_2	3293	3627	9.82	16.44	1.70	1.87
	$SSNM_1$	3920	4013	15.00	20.38	2.16	2.21
	$SSNM_2$	3863	3147	20.85	18.92	3.04	2.64
	N_{rich}	3012	3653	5.30	11.08	1.03	1.25
ZT	N_1	3227	3537	9.38	16.04	1.66	1.82
	N_2	3123	3593	8.69	16.42	1.61	1.85
	$SSNM_1$	3660	3710	13.14	18.43	2.02	2.05
	$SSNM_2$	3450	3137	16.63	19.11	2.72	2.47
	N_{rich}	2920	3360	4.89	9.91	1.00	1.15
CD (P=0.05)	231	274	-	-	-	-	

*Rupees invested per kg of Nitrogen is 12.95 (Urea price-Rs 298.00 per 50 kg bag)

software following the principle of SSNM guidelines on wheat under both zero and conventional tillage.

METHODOLOGY

The field experiment was conducted during *rabi*, 2014-15 and 2015-16. The experiment was laid out in a split plot design having 10 treatments in 3 replicates. Two levels of tillage practices (conventional tillage and zero tillage) in main plot and five levels of nutrient management options {recommended NPK (150-26.3-33.3) with top-dressing before irrigation; recommended NPK (150-26.3-33.3) with top-dressing after irrigation; SSNM based on Nutrient Expert (140-32.9-65); SSNM based on Nutrient Expert with 70% N and full P & K (98-32.9-65) + LCC guided N & 150% N and full P & K as per recommendation (225-26.3-33.3)} in sub plots were allocated randomly. The wheat variety used in the experiment was DBW 39.

RESULTS

The crop raised with conventional tillage (CT) produced significantly higher grain yield during both the years of experimentation (Table 1). It was probably due to better crop stand as reflected by higher number of spikes/m^2 with increased number of grains/spike. In zero till plots, there was some problem with respect to seed germination, seedling emergence as well as weed management. Hand weeding was practiced in CT plots which resulted in better weed control particularly against *Polygonum spp,* the dominant weed flora of this region. The results further showed that $SSNM_1$, *i.e.*, 100% of nutrient expert software dose resulted in highest grain yield. It was revealed that through balanced dose of nutrient application coming from nutrient expert (NE) software ($SSNM_1$), 9 to 18% yield increment was achieved over recommended dose of nutrient application (N_1 and N_2). SSNM has a potential to reduce the yield gaps due to nutrient management limitations and use of NE software for nutrient recommendation was able to approximate yield through more optimal rates of fertilizer application. Perusal of data indicated the superiority of SSNM treatments towards greater agronomic nitrogen use efficiency (ANUE) and economic nitrogen use efficiency (ENUE) under both the tillage options. During both the years of experimentation, higher ANUE and ENUE values were obtained with the stated treatments under both conventional tillage (CT) and zero tillage (ZT) practices. This was probably because of more uniform and more even spreading of nitrogen throughout the growing season as well as avoiding excess single application at early stages, the most common practice.

CONCLUSION

It can be concluded that Nutrient Expert® (NE) was very effective tool for nutrient recommendation of wheat for this zone based on the principle of Site Specific Nutrient Management (SSNM). This easy-to-use computer based decision tool could rapidly provide nutrient recommendations bringing more balance towards fertilization and wheat grown under both zero tillage and conventional tillage responded well to Nutrient Expert® (NE) based recommendation.

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Effect of nitrogen application rate and its scheduling on productivity and economics of a newly introduced biofuel crop *Camelina sativa* L. in Malwa plateau region of Madhya Pradesh, India

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The world is now caught between two growing problems arising out of rapid depletion of fossil fuel reserves as well as environmental degradation due to exhaust emission. Biodiesel, an efficient and 100% clean natural energy alternative to petroleum fuels, is one such fuel, which is capable of providing a ready solution to these twin problems. Oilseed crops are the efficient way to produce biofuel, with a net energy gain of up to 93% after all production process is completed. C*amelinasativa*L. is an ancient oilseed crop that has not been exploited to its full potential; however, there is currently a renewed interest in its production due to its unique agronomic qualities and potential uses. *Camelinasativa* reportedly grows well on marginal soils, is drought tolerant, early maturing and requires fewer inputs than other oilseed species. Presence of high cholesterol (200 mg/kg) and eicosenoic acid (15%) pose a hurdle for its approval as food oil and is recently introduced in India from Austria as a potential biodiesel crop that does not interfere the edible oil trade and compete for available resources (Agarwal*et al.,* 2010). Nitrogen (N) is one of the most important nutrients involved in the production of oilseed crops. There are inconclusive and varying results in reference to *Camelinasativa* production in different regions of the world.It is well established fact that absorption of nutrients by plants, particularly nitrogen increases at various critical physiological growth stages. Being a highly mobile element, losses of N in soil takes place through various paths. Therefore, it is necessary to apply this vital element at critical physiological growth stages by appropriate scheduling of total nitrogen required by plants. Thus, scheduling of nitrogen at sowing, 25 and 50 DAS may have positive influence in increasing productivity of this crop. This suggests that research evaluating rate and time of N application is pertinent in determining the success of this crop in a particular area. Hence, keeping the above facts in view, an experiment was conducted to determine nitrogen dose and its splitting for higher productivity of *Camelinasativa*L. in Malwa plateau region of Madhya Pradesh, India.

METHODOLOGY

A field experiment was conducted at Defence Institute of Bio-Energy Research (DRDO) HQ Haldwani Project Site Military Farm - Mhow, Indore (22.55°N and 75.76°E;556 m altitude)during the winter (*rabi*) seasons of 2010–11 and 2011–12. The soil was medium black with pH-7.0, organic carbon-0.71%, nitrogen-266.0 kg/ha, phosphorus-11.2 kg/ha and potassium-700.0 kg/ha. Twelve treatment combinations comprising 4 nitrogen application rates (60, 90, 120 and 150 kg/ha) and 3 nitrogen scheduling (½ N as basal + ½ N at 25 DAS, ½ N as basal + ¼ N at 25 DAS + ¼ N at 50 DAS and ¹Dç N as basal + ¹DçN at 25 DAS + ¹DçN at 50 DAS) were replicated thrice in factorial randomized block design with plot size of 2.5 × 3.0 m. The *Camelinasativa* cv. calena (EC-643910) was sown in rows, 20 cm apart, with seed rate of 4 kg/ha on 7 November 2010 and 27 October 2011. The crop was fertilized as per treatment combinations with a uniform basal dose of phosphorus and potassium @ 60 and 30 kg/ha, respectively. The crop was grown with 3 protective irrigations and harvested on 18 February 2011 and 10 February 2012. At maturity, data on plant height, primary branches/plant, dry matter accumulation/plant, pods/plant, seeds/pod, 1000-seed weight, biological yield and seed yield were recorded, and plant samples collected at harvest were analysed for oil content in seed and N content in seed and straw. The data collected on growth, yield and quality parameters were statistically analysed as per analysis of variance procedure outlined for factorial randomized block design (Gomez and Gomez, 1984).

RESULTS

A perusal of pooled data of 2 years (Tables 1 and 2) revealed that application of 150 kg N/ha, being at par with 120 kg N/ha, recorded highest values for plant height, days to flowering, pod formation and maturity, dry matter accumulation/plant, pods/plant, 1000-seed weight, seed yield and oil yield of *Camelina sativa*. Seeds/pod was also found significantly higher with 150 kg N/ha, being at par with 90 and 120 kg N/ha. However, application of 150 kg N/ha recorded significantly highest number of primary branches/plant, biological yield and total N uptake over 60, 90 and 120 kg N/ha. Harvest index and oil content did not exhibit any marked difference due to varying N levels. Gross return (40111), gross expenditure (22288) and net return (17823) were also recorded highest with 150 kg N/ha but benefit-cost ratio was found 0.8 either with 120 or 150 kg N/ha. Further in most of the oilseeds, greater assimilating surface at reproductive stage resulted in better grain formation because adequate production of metabolites and their translocation towards grain was evident from nutrient concentration and their uptake. This might have resulted in increased weight of individual grain expressed in terms of test weight and ultimately increased seed yield. The results are in close conformity with the findings of Urbaniak*et al.* (2008) andMalhi*et al.* (2014).Averaged over 2 years (Tables 1 and 2) the crop under three equal splitting (¹Dç as basal + ¹Dç at 25 DAS + ¹Dç at 50 DAS) of nitrogen significantly improved plant height, primary branches/ plant, dry matter accumulation/plant, seeds/pod, seed yield, biological yield, oil yield and total N uptake over other splits viz., ½ N as basal + ½ N at 25 DAS, ½ N as basal + ¼ N at 25 DAS + ¼ N at 50 DAS. However, scheduling of nitrogen

Table 1. Growth and yield attributes of false flax (*Camelina sativa* L.) as affected by nitrogen application rate and its scheduling(pooled data of 2 years)

Treatment	Plant height (cm)	Branches/ plant	Days to flowering	Pod formation	Days to maturity	Dry matter accumulation/ plant (g)	Pods/ plant	Seeds/ pod	Test weight (g)
Nitrogen application rate (kg/ha)									
60	73.0	8.3	39.3	53.8	96.5	6.0	203.1	7.9	1.10
90	79.3	10.4	42.6	57.3	99.9	7.4	246.4	8.6	1.19
120	84.3	11.7	46.0	60.5	102.9	8.1	283.9	8.9	1.25
150	87.5	12.4	47.8	62.2	104.8	8.4	294.2	9.0	1.26
CD (P=0.05)	3.8	0.5	2.2	3.9	4.0	0.4	10.9	0.6	0.07
Nitrogen scheduling									
½ N as basal + ½ N at 25 DAS	75.8	10.0	43.1	57.6	99.3	6.9	237.7	8.3	1.17
½ N as basal + ¼ N at 25 DAS + ¼ N at 50 DAS	81.5	10.7	44.1	58.6	101.3	7.5	260.4	8.6	1.20
¹Dç N as basal + ¹DçN at 25 DAS + ¹ DçN at 50 DAS	85.9	11.9	44.5	59.2	102.5	8.0	272.5	8.9	1.23
CD (P=0.05)	3.3	0.6	NS	NS	NS	0.4	9.4	NS	NS

DAS, Days after sowing

Table 2. Productivity and economics of false flax (*Camelina sativa* L.) as influenced by nitrogen application rate and its scheduling (pooled data of 2 years)

Treatment	Seed yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Oil content (%)	Oil yield (kg/ha)	Total N uptake (kg/ha)	Gross return (/ha)	Cost of cultivation (/ha)	Net return (/ha)	Benefit cost ratio
Nitrogen application rate (kg/ha)										
60	600	599	10.01	35.7	214	58.5	28246	21064	7183	0.3
90	741	749	9.91	35.3	262	71.1	34897	21453	13453	0.6
120	827	809	10.24	35.2	291	84.2	38730	21914	16816	0.8
150	858	849	10.04	34.9	292	88.3	40111	22288	17823	0.8
CD (P=0.05)	37	392	NS	NS	14	3.8	-	-	-	-
Nitrogen scheduling										
½ N as basal + ½ N at 25 DAS	705	699	10.07	35.1	248	70.5	33125	21638	11488	0.5
½ N as basal + ¼ N at 25 DAS + ¼ N at 50 DAS	749	756	9.90	35.3	264	74.9	35308	21701	13614	0.6
¹Dç N as basal + ¹DçN at 25 DAS + ¹DçN at 50 DAS	812	799	10.16	35.4	288	81.2	38055	21701	16355	0.8
CD (P=0.05)	32	340	NS	NS	12	3.3	-	-	-	-

The price of seed was taken 35000/t in 2011 and 40000/t in 2012 while the price of straw was considered 1000/tin 2011 and 1100/t in 2012.

did not influence days to flowering, pod formation and maturity, seeds/pod, test weight, harvest index and oil content significantly. Gross return (38055), net return (16355) and benefit-cost ratio (0.8) were recorded highest with the crop under three equal splitting (¹Dç as basal + ¹Dç at 25 DAS + ¹Dç at 50 DAS) of nitrogen but gross expenditure was found equal (¹ Å– #Å– 21701) with ½ N as basal + ¼ N at 25 DAS + ¼ N at 50 DAS.Application of three equal splitting of nitrogen recorded 15.1 and 8.4 % increase in yield over other splits viz. ½ N as basal + ½ N at 25 DAS, ½ N as basal + ¼ N at 25 DAS + ¼ N at 50 DAS, respectively.

CONCLUSION

The findings of the present study elucidates that application of 120 kg N/ha in three equal splitting (¹Dç as basal + ¹Dç at 25 DAS + ¹Dç at 50 DAS) proved effective in yield enhancement and economical for growing *Camelina sativa* L. in Malwa plateau region of Madhya Pradesh, India.

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Yield and uptake of nutrients by fodder maize as influenced by soil and foliar applications of zinc

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India, possessing the largest livestock population of 529.7 million heads the performance of livestock is deplorably low due to the poor nourishment, which is primarily ascribed to the fluctuating and inconsistent supply of quality green fodder. Against the projected need of 1025 million tonnes of green fodder in the country, the present availability is to the tune of 390 million tonnes only. The productivity and availability of good quality fodder is most important to fulfill the requirement of feeding cattle. Fertilizer management is the most important aspect to achieve the goal which includes application of micronutrients along with macronutrients to get maximum yield and maximum uptake of nutrients. Maize is the ideal fodder crop because of its high production potential, wider adaptability, quick growing nature, succulency, palatability and excellent fodder quality. Maize fodder is free from toxicants and can be safely fed to milch animals at any stage of the crop growth. Keeping these points in view, a field experiment was conducted to study the effect of zinc on yield and nutrient uptake of fodder maize.

METHODOLOGY

The present investigation was carried out in sandy loam soils of Dryland Farm of Sri Venkateswara Agricultural College, Tirupati campus of Acharya N. G. Ranga Agricultural University, during *kharif,* 2014. The farm is geographically situated at 13ˆ N latitude, 79.5ˆ E longitude and at an altitude of 182.9 m above mean sea level, comes under Southern Agro- climatic Zone of Andhra Pradesh and according to Trolls classification, it is under Semi-Arid Tropics (SAT). Soil was sandy loam in texture, near neutral in soil reaction (pH 6.4), low in organic carbon (0.48 per cent), available nitrogen (174 kg/ha) and available zinc (0.49 ppm), high in available phosphorus (44 kg/ha) and medium in available potassium (165 kg/ ha). The total rainfall received during the crop growth period was 441 mm. The experiment was laid-out in a randomized block design with twelve treatments comprised of soil and foliar applications of zinc and replicated thrice. The recommended dose of fertilizers was 120 kg N, 50 kg P_2O_5 and 40 kg K_2O/ha applied to all the treatments. Nitrogen

Table 1. Green fodder yield, nutrient (N, P, K and Zn) uptake at harvest by fodder maize as influenced by soil and foliar applications of zinc.

Treatment	Green fodder yield (t/ha)	N uptake (kg /ha)	P uptake (kg/ha)	K uptake (kg/ha)	Zinc uptake (g/ha)
T_1 - Recommended dose of fertilizers (120 kg N -50 kg P_2O_5 40 kg K_2O/ha)	32.4	61.2	5.13	64.6	9.35
T_2 - T_1 + Soil application of 25 kg $ZnSO_4$ /ha	36.8	71.2	6.36	79.5	10.78
T_3 - T_1 + Soil application of 50 kg $ZnSO_4$ /ha	38	76.3	6.76	82.2	12.02
T_4 - T_1 + Foliar application of 0.2% $ZnSO_4$ at 30 DAS	35.4	63.7	5.60	68.4	9.77
T_5 - T_1 + Foliar application of 0.2% $ZnSO_4$ at 45 DAS	35.6	65.5	5.76	73.5	10.18
T_6 - T_1 + Foliar application of 0.2% $ZnSO_4$ at 30 and 45 DAS	36	67.9	6.16	76.5	11.09
T_7 - T_2 + Foliar application of 0.2% $ZnSO_4$ at 30 DAS	40.6	77.7	6.96	84.1	11.83
T_8 - T_2 + Foliar application of 0.2% $ZnSO_4$ at 45 DAS	40.8	78.8	7.26	86.1	12.18
T_9 - T_2 + Foliar application of 0.2% $ZnSO_4$ at 30 and 45 DAS	41.1	79.9	7.60	87.5	12.49
T_{10} - T_3 + Foliar application of 0.2% $ZnSO_4$ at 30 DAS	41.7	86.1	8.20	93.1	13.35
T_{11} - T_3 + Foliar application of 0.2% $ZnSO_4$ at 45 DAS	42.1	93.3	8.60	98.5	14.04
T_{12} - T_3 + Foliar application of 0.2% $ZnSO_4$ at 30 and 45 DAS	42.4	103.2	9.20	109.7	15.10
CD (P=0.05)	2.6	2.1	0.31	2.0	0.29

was applied through urea in two equal splits *viz.,* first half at the time of sowing as basal and remaining half as top dressing at 30 DAS. phosphate and muriate of potash, respectively in furrows at 5 cm away from the seed rows. Zinc sulphate was applied as per the treatments (soil application of $ZnSO_4$ at two days after basal application of N, P and K and foliar application of 0.2 % $ZnSO_4$ at 30 and 45 DAS as per the treatments) on fodder maize variety 'African Tall'. Fodder maize was sown on 12th July 2014 at a spacing of 45 × 10 cm and harvested on 29th September 2014 at milky stage.

RESULTS

The highest green fodder yield of maize was recorded with soil application of $ZnSO_4$ @ 50 kg /ha + foliar application of $ZnSO_4$ @ 0.2 % twice at 30 and 45 DAS along with RDF (T_{12}), which was however comparable with soil application of either 25 or 50 kg $ZnSO_4$/ha + foliar application of 0.2 % $ZnSO_4$ once or twice at 30 and 45 DAS along with RDF (T_{11}, T_{10}, T_9, T_8 and T_7). The percentage increase in green fodder yield under these treatments over T_1 (no zinc application) ranged from 13.5 to 30 per cent. Application of only RDF without zinc application (T_1) resulted in significantly the lowest green fodder yield (Table 1).The increase in green fodder yield might be due to the role of zinc in various growth processes like photosynthesis, nitrogen metabolism, protein synthesis, harmone production and regulation of auxin concentration in the plants. These favourable impacts of zinc resulted in taller plants, increase in leaf area, leaf to stem ratio and dry matter production which might have reflected in terms of higher green fodder yields. These results are in line with those of Kumar *et al.,* (2012) and Patel *et al.,* (2007).Application of zinc enhanced the uptake of nitrogen, phosphorous, potassium and zinc significantly (Table 1). The highest nitrogen (103.3 kg/ha), phosphorous (9.2 kg/ha), potassium (109.7 kg/ha) and zinc (15.10 g/ha) uptake was recorded with soil application of ZnSO4 @ 50 kg/ha + foliar application of ZnSO4 @ 0.2 % twice at 30 and 45 DAS along with RDF (T_{12}), followed by soil application of ZnSO4 @ 50 kg/ha + foliar application of ZnSO4 @ 0.2 % at 45 DAS along with RDF (T_{11}) and differed significantly from all other treatments. Nutrient uptake (N, P, K and Zn) is vital in enhancing the yield and nutrient content (Table 1). This might be due to higher concentration of Zn accumulated in the plant which received foliar feeding as well as available zinc through soil application. Zinc nutrition is an important component of various enzymes that are responsible for driving many metabolic reactions in fodder maize. Activation of enzymes leads to metabolic reactions as well as improvement in nutrient uptake that produce more biomass. The lowest uptake of nutrients, nitrogen (61.2 kg/ha), phosphorous (5.13 kg/ha), potassium (64.6 kg/ha) and zinc (9.35 g/ha) was recorded with the application of only RDF (120 kg N - 50 kg P2O5 - 40 kg K2O /ha) without zinc (T_1) which differed significantly from other treatments.

CONCLUSION

From the above study, it can be concluded that application of zinc significantly influenced the yield and uptake of nutrients by fodder maize and the best treatment was soil application of ZnSO4 @ 50 kg/ha + foliar application of ZnSO4 @ 0.2 % twice at 30 and 45 DAS along with RDF (T_{12}).

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Nutrient expert decision support system based SSNM practices for enhancing productivity, profitability, nutritional quality of maize (*Zea mays* L.) hybrids under conservation agriculture

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Large knowledge gap with respect to nutrient management in conservation agriculture hamperits wide scale adoption. The Nutrient Expert™ (NE) for Hybrid Maize is a new, computer based decision support tool developed to assist local experts to quickly formulate fertilizer guidelines for tropical hybrid maize based on the principles of site-specific nutrient management(Pampolino *et al*., 2012). Thus, this study was carried out to validate NE under conservation agriculture using different maize hybrids.

METHODOLOGY

A field experiment was carried out from July to November, 2013at theresearch farm of the Indian Agricultural Research Institute. The experiment waslaid out in afactorial randomized block design (FRBD) with twenty treatments combinations having four nutrient management practices and five genotypes, replicated thrice. The five genotypes were; PMH 1, PMH 3, HQPM 1, CMH 08-292 and S-6217. In order to evaluate current nutrient management practices and farmer practices the general recommended dose of fertilizer (RDF) for Central Delhi region and half of the recommended dose of fertilizer was taken respectively. The nutrient management practices were: Absolute control, 100% RDF (150:60:40 kg/ha $N:P_2O_5:K_2O$), 50% RDF (75:30:20 kg/ha $N:P_2O_5:K_2O$), NE-DSS (170:40:48 kg/ha $N:P_2O_5:K_2O$) for hybrids PMH 1, PMH 3, CMH 08-292 and S 6217, NE-DSS (170:33:40 kg/ha $N:P_2O_5:K_2O$) for HQPM 1. This experiment was taken inthe permanent conservation agriculture trial in maize-wheat-mungbean cropping system, initiated during *kharif* 2012 in which mungbean straw @ 1.5 tonnes/ha was retained before the maize planting.

RESULTS

Dry-matter accumulation at 90 days after sowing was significantly increased by NE based field specific recommendation, followed by 100% RDF, 50% RDF and significantly lowest was recorded with absolute control (Table 1). Of the different genotypes, 'CMH 08-292' recorded significantly highest and 'S 6217' recorded significantly lowest dry-matter accumulation. Balancedfertilization using NE leads to a sig-

Table1.Effect of nutrient management practices and genotypes on growth, yield, economics of maize under conservation agriculture

Treatment	Dry matterat 90 DAS (g/plant)	Grains/row (no./row)	Grain yield (t/ha)	B:C ratio	Zn uptake (g/ha)
Nutrient management practice					
Absolute control	246^{c}	30.33^{b}	3.03^{d}	1.41^{ba}	94.8^{c}
100% RDF	317^{b}	30.44^{b}	4.03^{b}	1.25^{bc}	132.1^{b}
50% RDF	256^{c}	30.36^{b}	3.65^{c}	1.20^{c}	139.8^{ba}
NE DSS	345^{a}	31.87^{a}	4.62^{a}	1.57^{a}	154.6^{a}
CD (P=0.05)	12.30	1.29	0.337	0.202	16.56
Genotype					
PMH 1	291^{b}	30.08^{c}	3.81^{b}	1.39^{a}	130.7^{b}
PMH 3	304^{b}	33.24^{a}	4.25^{a}	1.56^{a}	143.8^{ba}
HQPM 1	261^{c}	31.54^{b}	2.98^{c}	0.86^{b}	97.0^{c}
S 6217	248^{c}	29.85^{c}	4.18^{ba}	1.52^{a}	150.3^{a}
CMH 08-292	351^{a}	29.04^{c}	3.95^{ba}	1.45^{a}	129.8^{b}
CD (P=0.05)	13.70	1.263	0.377	0.225	18.52

nificantly higher leaf area and dry matter production which intern influence grain yield. Significantly higher grains/row recorded by NE based SSNM over rest of the treatments. With regards to genotypes, 'PMH 3' recorded significantly higher grains/row, cob yield, 1,000-grain weight and grain yield. Maize hybrids and nutrient management practices had a significant effect on grain yield (Table 1). The grain yield increased significantly by NE-DSS based nutrient management over 100% RDF. Hybrid S 6217 gave a significantly higher grain yield over allother hybrids at absolute control (no nutrient application). Thus S 6217 is efficient genotype for low fertile soils. However, at 100% RDF, hybrid CMH 08-292 produced a much higher grain yield as compared to all other hybrids. At 50% RDF, PMH 3 gave a significantly higher grain yield over other hybrids. Further, at NE-DSS treatments maize hybrid PMH 3 produced a higher grain yield, which was statistically equivalent to S 6217, but significantly higher over other treatments. Significant increase in yield due to NE based SSNM may have occurred due to the fact that the fertilizer requirement for afield is estimated from the expected yield response to each fertilizer nutrient, which is the difference between the attainable yield and the nutrient-limited yield. Significantly higher gross return (Rs 67312), net return (Rs 41137) and B:C ratio (1.57) was obtained with NE based field specific fertilizer recommendation over 100% RDF, 50% RDF and absolute control (Table 1). Amongst genotypes, PMH 3 gave significantly higher return and B:C ratio (1.56) over HQPM 1, however, it remained at par with PMH 1, S 6217 and CMH 08-292. This was due to higher yield as compared with hybrid HQPM 1 which resulted in higher net income and net return/rupee invested. Total zinc uptake by grain was increased significantly by NE-DSS treatment and it remained at par with 50% RDF. Amongst genotypes, zinc uptake in grain was significantly higher by S-6217. It is inferred from the results that theNE-DSS based balance fertilization, not only increase yield, and income of farmers but it also provides nutritional security. Hence it is a wise tool for fertilizer recommendation to conservation agriculture. It also overcomes the practical difficulties in adapting SSNM.

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Utilization of weed plant biomass as an organic macro and micronutrient source on growth, productivity and quality of hybrid Chilli (*Capsicum annuum*)

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A pot experiment was conducted during the summer season of 2014 in red sandy clay loamy soil in farmer's field at Talaku Village of Chitradurga Karnataka to assess utilization of weed plant biomass as an organic macro and micronutrient source on growth, productivity and quality of hybrid Chilli (*Capsicum annuum* L.). The pot experiment comprised of 12 treatments laid out in a complete randomized design and replicated thrice. The results revealed that application of *Hyptis suaveolens* BDLM at 150 kg N equivalent/ha recorded significantly higher plant height (84.1 cm), number of branches per plant (30.7), total biomass (166.4 g/plant) and fruit yield (55.1 g/plant) followed by *Cassia tora/ sida cordifolia*/ *Cassia spectabilis*/ *Crotalaria juncea* BDLM at 150 kg N equivalent/ha and RDF at 150, 75 & 75 kg N, P_2O_5 & K_2O per ha (80.1 cm, 28.0, 160.8 and 52.2 g/plant, respectively) which were at par with each other. Among the different biodigested liquid manures, application of *Hyptis suaveolen s*BDLM at 150 kg N equivalent ha^{-1} recorded significantly higher ascorbic acid (134.77 mg 100/g), capsaicin (1.76%), oleoresin (12.43%) and total extractable colour (129.43 ASTA units) which was at par with *Cassia tora*/ *Sida cordifolia*/*Cassia spectabilis* and *Crotalaria juncea* BDLM at 150 kg N equivalent/ha. However, significantly lower ascorbic acid (118.93 mg/100 g), capsaicin (1.54%), oleoresin (11.60%) and total extractable colour value (108.50 ASTA units) were noticed with control treatment. Similar trend was observed with respect uptake of macro and micronutrients. Therefore we can effectively utilize the *Hyptis suaveolens*/ *Cassia tora*/*Sida cordifolia*/ *Cassia spectabilis* and *Crotalaria juncea* BDLM as a source of macro and micro nutrients in organic farming.

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Agronomic biofortification of zinc and iron nutrition in wheat

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Wheat crop is the first important and strategic cereal crop for the majority of world's population. Micronutrient malnutrition i.e, inadequate dietary intake of iron (Fe), zinc (zn), vitamin A and iodine threatens more than 2 billion people, predominantly in developing countries (Stein 2010).High consumption of cereal based foods with low concentration of Zn and Fe is the major reason of Zn and Fe deficiency in human population. Traditional interventions to address mineral nutrition have focused on supplementation, food fortification and dietary diversification. None of these are successful as they require safe delivery systems, stable political policies, appropriate social infrastructure, and continued investment. Recently, a complementary solution to mineral nutrition termed 'Biofortification' has been proposed where in the nutritional quality of food crops is improved through seed treatment, soil application and foliar application. In this context, the investigation was carried out to study the effect of agronomic biofortification of Zinc and Iron on yield and yield parameters, economics and concentration of micronutrients in the grain.

METHODOLOGY

A field experiment was conducted during the *rabi* season of 2015 at Main Agricultural Research Station, Dharwad, Karnataka. Soil of the study site was medium black in texture, neutral in reaction, low in available N, medium in available P, high in available K, low in available Zn and Fe. The trial was laid out in RBD with three replications. There were 15 treatments viz; T1: Soil application of $FeSO_4.7H_2O$ at 20 kg /ha T2: Foliar application of $FeSO_4.7H_2O$ at 0.5% during heading stage. T3: Foliar application of $FeSO_4.7H_2O$ at 0.5% during milking stage. T4: Foliar application of $FeSO_4.7H_2O$ at 0.5% during heading and milking stage. T5: Soil and foliar application of $FeSO_4.7H_2O$ at 20 kg /ha and 0.5% respectively during heading stage T6: Soil and foliar application of $FeSO_4.7H_2O$ at 20 kg /ha and 0.5% respectively during milking stage. T7: Soil and foliar application of $FeSO_4.7H_2O$ at 20 kg /ha and 0.5% respectively during heading and milking stage. T8: Soil application of $ZnSO_4.7H_2O$ at 20 kg /ha. T9: Foliar application of $ZnSO_4.7H_2O$ at 0.5% during heading stage.T10: Foliar application of $ZnSO_4.7H_2O$ at 0.5% during milking stage. T11: Foliar application of $ZnSO_4.7H_2O$ at 0.5% during heading and milking stage. T12: Soil and foliar application of $ZnSO_4.7H_2O$ at 20 kg /ha and 0.5% respectively during heading stage. T13: Soil and foliar application of $ZnSO_4.7H_2O$ at 20 kg /ha and 0.5% respectively during milking stage. T14: Soil and foliar application of $ZnSO_4.7H_2O$ at 20 kg /ha and 0.5% respectively during heading and milking stage. T15: RDF (water spray). The common dose of nutrition was applied at 50:75:50:20:20 kg N P_20_5 K_20 $FeS0_4$ $ZnS0_4$ as basal dose and remaining 50 kg N was applied after 30DAS.Two foliar application of $ZnS0_4$ and $FeS0_4$ each at 0.5 per cent were sprayed at heading and milking stages. The yield and yield parameters were recorded at harvesting. The economics was worked out .Zinc and Iron content was determined by AAS and the uptake per hectare was computed in grain and straw.

RESULTS

Combined soil and foliar application of zinc at both stages recorded significantly higher grain and biomass yield (38.01 q /ha and100.66 q /ha) which is on par with soil and foliar application of iron at both stages (37.57 q /ha and 98.25 q / ha), soil and foliar application of zinc at milking stage (36.69 q /ha and 97.07 q /ha), soil and foliar application of iron at milking stage (36.15 q /ha and 95.54 q /ha) and recorded significantly higher grain and biomass yield over control (32.25 q /ha and 88.80 q /ha). Similar results also reported by Chaudry *et al.* (2007) where micronutrients (Zn and Fe) significantly increased the wheat yield over control. Also, Chowdhury *et al.* (2008) revealed that application of micronutrients (soil + foliar) was the best method to increase grain yield of wheat. 1000 grain weight was found non-significant. Soil and foliar application of zinc at both stages recorded higher zinc concentration (27.43 ppm), uptake in grain (104.29 g /ha), straw (61 g/ha) while lower content was recorded in control. Soil and foliar application of iron at both stages significantly recorded higher iron concentration (75.10 ppm) uptake in grain (282.28 g/ha), straw (1281.31 g /ha) while lower content was recorded in control. The most effective method for increasing grain Zn is the soil + foliar application method, which may result in an about 3-fold increase in grain Zn concentration (Cakmak *et al.,* 2010). Similar trend was observed for grain and straw uptake.

CONCLUSION

Combined soil and foliar application of zinc at both stages recorded significantly higher grain yield, B: C and concentration in grain over control and found on par with soil and foliar application of iron at both stages

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Long term effect of integrated nutrient management on productivity of rice - wheat cropping system

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Integrated nutrient management system is an important component of sustainable agricultural intensification. The goal of INM is to integrate the use of all natural and man-made sources of plant nutrients, so as to increase crop productivity in an efficient and environmentally benign manner without diminishing the capacity of the soil to be productive for present and future generations. It seeks to maintain or improve soil fertility for sustaining the desired level of crop production and crop productivity through optimization of the benefit from all possible sources of plant nutrients in an integrated manner. Hence, there was an urgent need to develop region specific integrated nutrient management strategies with emphasis on increasing nutrient use efficiencies. Under such conditions, there was a need to explore the possibilities of using the expanding native sources of plant nutrition to find out the optimum combination of fertilizers and FYM or wheat straw or green manure to rice and their residual effect on wheat grown after rice. Since, it is not possible to conclude the findings of investigations on INM in any crop or cropping system within a short-duration, such studies need planning for long-term experimentation.

METHODOLOGY

The present investigation was consisted with a field experiment conducted at Live stock Farm, JNKVV, Jabalpur (M.P.) during the year 1984-85 to 2014-15 under irrigated production system. Thus, the present study was a part of continuous studies pertaining to the 31st crop-cycle without changing the treatments, site and layout plan. Twelve treatments were consisted with T1 – no application of any manure/fertilizer, T2 - 50% NPK to both crops, T3 - 50% NPK to rice followed by 100% NPK to wheat, T4 - 75% NPK to both crops, T5 - 100% NPK to both crops, T6 - 50% NPK + 50% N through FYM to rice followed by 100% NPK to wheat, T7 - 75% NPK + 25% N through FYM to rice followed by 75% NPK to wheat, T8 - 50% NPK + 50% N through wheat straw to rice followed by 100% NPK to wheat, T9 - 75% NPK + 25% N through wheat straw to rice followed by 75% NPK to wheat, T10 - 50% NPK + 50% N through green manure as sunnhemp to rice followed by 100% NPK to wheat, T11 - 75% NPK + 25% N through green manure to rice followed by 75% NPK to wheat; and T12 – fertilizer and manure as per farmers' practice to both crops (40:20 kg NP + 3 t FYM/ha to rice and 40:20 kg NP/ha to wheat). These treatments were tested in randomized block design with four replications. The 100% recommended dose of NPK was 120 kg N + 60 kg P2O5 + 40 kg K_2O/ha to both crops.

RESULTS

Both grain and straw yields of rice as well as wheat grown in a sequence significantly varied due to the effect of different nutrient management including IPNS during 31st crop cycles. The control plot (T1) produced minimum grain and straw yields of individual crop and entire cropping system as well. These yields significantly increased due to application of 50 (T2), 75 (T4) and 100% (T5) recommended NPK through fertilizers to both crops. Consequently, the combined yields in terms of WEY was also minimum (3.84 t/ha/year) with T1, which increased as 6.72, 7.55, 8.46 t/ha/year due to higher rates of fertilizer application under T2, T4 and T5 treatments, respectively. The treatment T3 (50% NPK to rice followed by 100% NPK to wheat) and T4 (75% NPK to both crops) received the same quantity of nutrients. But former led to record significantly lower WEY (7.25 t/ha/year) than later (7.55 t/ha/year). It reveals that application of higher dose of fertilizers to rice was more efficient than wheat. The farmers' practice of plant nutrient management (T12) also produced significantly higher WEY (5.90 t/ha/year) than T1. Although T12 and T2 treatments supply nearly same quantity of nutrients to crops, but former had lesser WEY than later. Among different INM treatments, application of 50% NPK + 50% N through green manure to rice followed by 100% NPK to wheat (T10) produced maximum WEY (9.09 t/ha/year), closely followed by T6 – 50% NPK + 50% N through FYM to rice followed by 100% NPK to wheat (8.78 t/ha/year). These two INM treatments led to record significantly higher WEY than T5 (100% NPK to both crops). Other INM treatments viz. T11 – 75% NPK + 25% N through green manure to rice followed by 75% NPK to wheat, T8 - 50% NPK + 50% N through wheat straw to rice followed by 100% NPK to wheat, T7 - 75% NPK + 25% N through FYM to rice followed by 75% NPK to wheat gave almost comparable WEY to T5, while T9 - 75% NPK + 25% N through wheat straw to rice followed by 75% NPK to wheat gave significantly lesser yields in terms of WEY than T5.The superiority in growth parameters and yield attributes of both crops due to different INM treatments viz. T10, T6, T11, T8 and T7 over T5 as a result of efficient nutrient supply to crops may be the reasons for increased WEYs. Among different organic sources, green manuring of sunnhemp proved superior over FYM and wheat straw at the same level of nutrient supply. However, differences were not much between green manure and FYM. The wheat straw although became at par to T5 for WEY upto end of 17th crop cycle, but it was low yielder during the beginning 5 years, which successively improved till the end of 28th crop cycle. The poor mineralization due to wide C:N ratio of wheat straw may be the reason for low yields during the early years.

CONCLUSION

The integrated use of green manuring with sunnhemp or FYM or wheat straw to meet 50 or 25% N requirement of rice alongwith 50 or 75% NPK through fertilizers followed by 100 or 75% NPK to wheat was comparable to application of 100% NPK to both crops in terms of productivity of individual crop as well as cropping system as whole on long run basis.

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Nutrient management through fertigation and its impact on growth and yield of *hirsutum* improved cotton (*Gossypium hirsutum* L.)

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Combined application of water and fertilizers in splits through advanced method of drip irrigation (drip fertigation) accentuate the scope for increasing the productivity and efficient use of water and nutrients. In general, injection of fertilizers into irrigation water gives a better crop response than either band or broadcasting in furrow irrigation system by minimizing the losses due to leaching, denitrification and volatilization. Fertilization must always supply and maintain an optimum level of nutrients within the root zone for good growth and harvesting of potential yield of crops (Sivanappan, 2004). Fertigationgives flexibility of fertilization, which enables the specific nutritional requirement of the crop to be met at different growth stages of its growth. Split application of fertilizers ensures required nutrients in right time and in right quantity for getting higher yield with minimum loss of nutrients. With this background, an effort was made to study the response of *hirsutum* improved cotton to different doses and split application of nitrogen and potassium through fertigation.

METHODOLOGY

The experiment was laid out in randomised block design with four replications and eight treatments imposed for cotton crop having three deferent level of fertigation in five and seven splits at 75 per cent, 100 per cent and 125 per cent of recommended dose of N and K given through fertigation and P as basal compared with 100 per cent RDNK /ha as conventional soil application in furrow and drip irrigation. The recommended dose of fertilizer for cotton was 90:45:45 NPK Kg/ha.The total rainfall received during the cropgrowth period was 646.5 mm in 28 rainy days. The experimental site was established with inline drip irrigation system (16 mm) lateral laid out at 90 cm with 60 cm dripper spacing. The recommended dose of fertilizer was applied as per the treatments through fertigation tank of 90 lit capacities P was applied as basal and N as urea and K as murate of potash through irrigation water in five and seven splits as per the treatments and growth stages of crop.

RESULTS

The data presented in Table revealed that all the growth parameters and yield attributes were significantly influenced by different doses of N and K fertilizers applied through fertigation. Plant height, sympodial branches per plant, dry weight per plant at harvest was maximum with 125 per cent recommended N and K and was significantly superior over all

Table 1. Growth, Yield attributes, seed cotton yield and economics of *hirsutum* cotton as influenced by different treatments

Treatment	Plant height (cm)	Sympodial branches/ plant	Dry matter/ plant	Bolls picked/ plant	Seed cotton yield/ plant	Seed cotton yield (kg /ha)	Netmonetary returns (Rs/ha)	B:C ratio
T_1 : FI with100% RDNK soil application	90.63	19.16	135.62	22.60	91.20	1496	26812	1.74
T_2 : DI with100% RDNK soil application	101.33	25.94	157.62	28.01	107.02	1981	37434	1.83
T_3 : DF with 75% RDNK five splits	105.51	27.84	166.34	30.44	118.98	2143	45578	2.04
T_4 : DF with75% RDNK seven splits	109.03	28.93	170.56	32.38	122.15	2215	48300	2.09
T_5 : DF with100% RDNK five splits	117.73	32.84	185.27	37.13	134.05	2560	60333	2.34
T_6: DF with100% RDNK seven splits	120.43	34.19	190.43	37.90	141.00	2652	63903	2.37
T_7 : DF with125% RDNK five splits	122.05	35.50	193.23	39.15	143.19	2702	64479	2.33
T_8 : DF with125% RDNK seven splits	124.32	36.11	196.11	40.75	145.92	2745	65379	2.33
CD (P=0.05)	7.70	3.76	8.94	3.84	12.37	209	8755	–

FI –Furrow irrigation,DI- Drip irrigation, DF-Drip fertigation, RDNK- Recommended dose of N & K other treatments except 100 per cent fertigation given in five and seven splits. The conventional method of fertilizer application (100 per cent RDF as soil application) was found at par with 75 per cent recommended dose of N and K through fertigation. Similar trend was observed in case of yield attributing characters like bolls picked per plant and yield of seed cotton per plant.There was a significant response to seed cotton yield by application of 125 per cent RDNK through drip in seven splits through fertigation. Maximum seed cotton yield (2745kg /ha) was recorded where 125 per cent RDNK was applied through fertigation and was significantly superior than 75 per cent fertigation given in five and seven splits, but was at par with 100 per cent fertigation in both splits. However, 75 per cent RDNK in seven splits through drip recorded higher seed cotton yield (2215kg /ha) than 100 per cent RDF through soil application. (1981kg /ha) but was found at par with five splits indicating 25 per cent saving in fertilizers through fertigation.

CONCLUSION

Among different fertigation treatments given in seven splits at 125 percent recommended dose of fertilizer (112.5:56.25: 56.25 NPK/ha) as N and K through drip and P fertilizer as soil application enhanced the growth and yield attributes, however based on the B: C ratio, application of 100 per cent recommended dose of N and K in seven splits found to be beneficial in increasing the economic returns of cotton.

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Growth and yield of zero tilled cowpea (*Vigna unguiculata* L.) as influenced by irrigations and levels of fertilizer application

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Cowpea is a broadly adapted and highly variable crop, cultivated around the world primarily as a pulse, vegetable, a cover crop, and for fodder. Pulses are considered to be an important group of crops in conserving natural resources such as soil, water and nutrients. The reason for the low yield of the pulse crop may be many but the important one is that the pulse crop hardly receives any irrigation and fertilizer. The diverse climatic and soil conditions prevailing in India make it possible to grow a wide variety of crops. It also results in a variety of fertilizer management problems. Therefore, it is essential to improve water as well as fertilizer use efficiency. The efficient utilization of these two key inputs would not only enhance food production but also reduce the cost of food production. To exploit high yielding potential of cowpea on residual moisture, better management of these aspects needs to be emphasis. Therefore experiment was conducted to study the effect of irrigation and levels of fertilizer application on zero tilled cowpea.

METHODOLOGY

A field experiment was conducted at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra during *rabi* season of 2011-2014. The soil of experimental plot was sandy clay loam in texture and was medium in available nitrogen and low in available phosphorus and moderately high in available potassium with pH 5.8. The experiment was laid out in a split plot design with three replications. The main plot treatments were three irrigation levels, *viz.,* no irrigation, one irrigation at branching and two irrigations at branching and pod filling stage. The sub plot treatments comprised six fertilizer levels *viz.,* no fertilizer, 25% RDF, 50% RDF, 75% RDF, 100% RDF below seed placement and 100% RDF through line application. Thus, there were in all 18 treatment combinations. The treatments were randomized in the experimental units. Whole quantity of fertilizers (RDF 25:50:00 kg NPK ha^{-1}) was uniformly mixed and it was applied 3-4 cm below the seed to avoid the direct contact of seed with fertilizers as

Table 1. Effect of irrigation and fertilizer levels on growth and yield of cowpea

Treatment	Plant Height (cm)	Dry matter (g)	Number of pods per plant	Grain yield (q/ha)	Stover yield (q/ha)
Irrigation levels					
Control	13.68	3.67	8.86	7.51	15.05
One irrigation (At Branching)	14.77	5.01	10.14	8.86	17.78
I_2: Two irrigation (At Branching and Pod filling)	15.89	5.62	11.47	10.59	20.40
SEm±	0.14	0.09	0.09	0.09	0.23
CD (P=0.05)	0.42	0.27	0.29	0.28	0.71
Fertilizer levels					
Control	12.86	3.16	6.46	6.94	13.54
F_1: 25% RDF below seed placement.	13.71	3.77	8.50	8.09	15.39
F_2: 50% RDF below seed placement.	14.45	4.61	10.34	8.86	17.30
F_3: 75% RDF below seed placement.	15.39	5.24	11.27	9.45	18.87
F_4: 100% RDF below seed placement.	16.34	6.07	12.57	10.58	21.20
F_5: 100% RDF through line application	15.92	5.74	11.80	10.01	20.17
SEm±	0.11	0.10	0.13	0.17	0.27
CD (P=0.05)	0.32	0.28	0.37	0.48	0.76
General mean	14.77	4.76	10.15	8.98	17.73

per treatments. After fertilizer application the cowpea seed of variety ‘Konkan Sadabahar’ were sown in the holes dibbled. In the present investigation, irrigations were applied as per treatments at branching and pod filling stage to the respective plots, for that purpose irrigations were given to respective treatment plots by flexi pipe, as small bunds were raised around each respective plot. In order to assess the effect of different treatments on the growth and yield of cowpea crop biometrical observations were recorded.

RESULTS

Effect of irrigation: From the data presented in Table 1 it is revealed that application of two irrigation at branching and pod filling stage recorded maximum plant height, dry matter production per plant, number of pods per plant which results in to maximum grain and straw yield which was significantly superior over treatments provided with one irrigation and control. Two irrigations at critical stages of the crop resulted in very good cell turgidity there by increasing the cell elongation resulting in higher growth and development of crop. Similar increase in growth characters under application of irrigation at branching stage and pod development stage which was also observed by Shersingh *et al*. (2004) and Asaduzzaman *et al*. (2008).

Effect of fertilizer application: Data revealed in Table 1 implies that 100% RDF below seed placement recorded the highest growth and yield followed by treatment application of 100% RDF through line application which was at par with each other but found significantly superior over treatment 75 % RDF , 50 % RDF, 25 % RDF and control below seed placement.in that descending order of significance. After supplying ample amount of N, P_2O_5 and K_2O contributed probably higher chlorophyll content which enables the crops photosynthetically more active which has reflected in recording of superior values of growth and yield. Interaction effect was non significant. Availability of optimum amount of essential plant nutrients resulted in a production of superior yield attributes. These results conoborates the findings of Reddy and Ahlawat (1998), Baboo and Mishra (2001). Interaction effect was non-significant.

CONCLUSION

From this experiment it can be concluded that, during rabi hot weather season cowpea crop grown under zero tilled condition should be provided with two irrigations (at branching and pod filling stage) along with 100% recommended dose of fertilizer (25:50:00 NPK Kg ha^{-1}) applied below seed placement for obtaining higher growth and yield.

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Response of soil application and foliar spray of fertilizers on yield of American cotton H 1117 (*Gossypium hirsutum*)

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Cotton (*Gossypium hirsutum* L.) is considered as one of the most important commercial crops in textile industry. Therefore, increasing its productivity as well as the cultivated area is highly recommended. Cotton plants require a specific amount of certain nutrients in specific format applied at an appropriate time for their growth and development (Oosterhuis, 2001; Sajid *et al*., 2008). Now a days, soil application of nutrients (*i.e.,* N, P, K and Zn) is found to be very expensive. In addition, the availability of these nutrients will be affected by several environmental factors, that is, antagonism, element deposition, leaching etc. In contrast, foliar feeding technique as a particular way to supply these nutrients could avoid these factors and results in a rapid absorption. Foliar feeding is more effective and less costly (Jamal *et al*., 2006) in most cases. Therefore, to study the effect of soil and foliar application of fertilizers with different rate of recommended doses of Nitrogen, Phosphorous, Potassium and Zinc (NPK & Zn) and together with foliar spray of different fertilizers on productivity of American cotton H1117 plants.

METHODOLOGY

An experiment was conducted during *kharif,* 2013 and 2014 at Cotton Research Station-Sirsa, CCS Haryana Agricultural University, Hisar on American cotton H1117 in a randomized block design with 3 replications. Effect of various treatments on yield (at maturity) of cotton with 16 treatments of different soil application of fertilizers as basal and top dress in combination with foliar spray of fertilizer (F.S.) applied at flower initiation, boll formation and boll development stages (three sprays) *i.e.,* T_1: 75% RDF, T_2: 100% RDF, T_3: 75% RDF + F.S. of Water, T_4: 75% RDF + F.S. of Urea (2.5%), T_5: 75% RDF + F.S. of DAP (2.0%),T_6: 75% RDF + F.S. of KNO_3 (2.0%), T_7: 75% RDF + F.S. of NPK (19:19:19) (2.0%), T_8: 75% RDF + F.S. of Urea (2.5%) & $ZnSO_4$ (0.5%), T_9: 75% RDF + 1 F.S. of Urea (2.5%) at flower initiation stage + 1 F.S. of DAP (2.0%) at boll formation stage + 1 F.S. of NPK (19:19:19) (2.0%) at boll development stage, T_{10}: 100% RDF + F.S. of Water, T_{11}: 100% RDF + F.S. of Urea (2.5%), T_{12}: 100% RDF + F.S. of DAP (2.0%), T_{13}: 100% RDF + F.S. of KNO_3 (2.0%), T_{14}: 100% RDF + F.S. of NPK (19:19:19) (2.0%), T_{15}: 100% RDF + F.S. of Urea (2.5%) & $ZnSO_4$ (0.5%), T_{16}: 100% RDF + 1 F.S. of Urea (2.5%) at flower initiation stage + 1 F.S. of DAP (2.0%) at boll formation stage + 1 F.S. of NPK (19:19:19) (2.0%) at boll development stage.

RESULTS

The experiments results revealed that there was significantly higher pooled seed cotton yield and total number of bolls/plant in soil application of 100% RDF + foliar spray of

Table 1. Total number of bolls per plant and yield (kg/ha) of cotton as influenced by soil application and foliar spray of fertilizers (Pooled data of 2013 and 2014)

Treatment	Total number of bolls per plant	Seed cotton yield (kg/ha)	Stick yield (kg/ha)	Biological yield (kg/ha)
T1	22	1754	5278	7015
T2	24	2179	6168	8326
T3	22	1803	5413	7197
T4	22	1867	5567	7415
T5	22	1841	5546	7370
T6	24	2076	5171	7227
T7	24	2138	5281	7398
T8	22	1903	5499	7383
T9	22	1907	5453	7341
T10	24	2234	6305	8517
T11	25	2312	6353	8643
T12	25	2272	6339	8589
T13	27	2528	6241	8745
T14	27	2607	6287	8868
T15	25	2337	6553	8867
T16	25	2341	6486	8804
SEm±	0	52	278	290
CD (P=0.05)	1	150	803	837

NPK (19:19:19) (2.0%) as compared to other treatments but the difference between soil application of 100% RDF + foliar spray of NPK (19:19:19) (2.0%) and soil application of 100% RDF + foliar spray of KNO_3 (2.0%) at flower initiation stage, boll formation stage and boll development stage was statistically at par with each other (Table 1). The highest pooled stick yield was recorded with soil application of 100% RDF + foliar spray of Urea (2.5%) & $ZnSO_4$ (0.5%), where as pooled biological yield was significantly higher with soil application of 100% RDF + foliar spray of NPK (19:19:19) (2.0%) as compared to other treatments but the difference between soil application of 100% RDF + foliar spray of NPK (19:19:19) (2.0%) and soil application of 100% RDF + all foliar sprays at flower initiation stage, boll formation stage and boll development stage was statistically at par with each other. There was significant difference in responses to soil application of fertilizer in combination with different foliar spray of fertilizers.

CONCLUSION

It can be concluded that the higher seed cotton yield obtained due to higher number of bolls per plant in soil application of 100% RDF + foliar spray of NPK (19:19:19) (2.0%) or foliar spray of KNO_3 (2.0%) at flower initiation stage, boll formation stage and boll development stage.

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Studies on phosphorus management and its effect on growth, yield and quality of soybean

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Soybean is major oilseed crop of our country next only to groundnut, rapeseed and mustard. India ranks fifth in world in area and production but the productivity is very low. Decline in soil fertility is the main cause of low productivity. Phosphorus is one of the major plant nutrients. It is an indispensable element and plays a unique role in several plant metabolic and energy transformation process. Phosphorus is of major importance as it is a constituent of phospholipids, nucleic acids, protein, co-enzymes. Phosphorus promotes early maturity of crops and helps in translocation of starch and sugar. The main problem of phosphorus fertilizer is its low availability. Phosphorus is quite immobile and major hurdle in the management is its fixation and reversion making it unavailable to plant.

METHODLOGY

The soil samples were drawn for studying the soil properties and then the experiment was laid out at Agronomy Section Farm of College of Agriculture, Nagpur during the year *kharif* season of 2013-2014 on variety NRC-37 in randomized block design replicated thrice with nine treatments (75% phosphorus (T1), 75% phosphorus + Rhizobium+ PSB (T2), 75% phosphorus + Rhizobium + PSB + 2.5 t vermicompost (T3), 100% phosphorus (T4), 100% phosphorus, + Rhizobium + PSB (T5), 100% phosphorus + Rhizobium + PSB + 2.5t vermicompost (T6), 125% phosphorus (T7), 125% phosphorus + Rhizobium + PSB (T8), 125% phosphorus + Rhizobium + PSB + 2.5t vermicompost (T9). The gross and net plot size were 3.6 m × 4.5 m and 2.7 m × 4.2 m respectively and spacing of 45 x 5 cm. The data were recorded and statistically analysed.

Table 1. Mean performance of different traits as influenced by various treatments in soybean

Treatment	Seed yield/ha (t)	Straw yield/ha (t)	Harvest index (%)	P content (%)		P uptake (Kg/ha)			B:C ratio
				Grain	Straw	Grain	Straw	Total	
T1	1.97	2.63	42.79	0.46	0.16	9.03	4.09	13.12	3.20
T2	2.03	2.74	42.38	0.47	0.17	9.50	4.75	14.25	3.20
T3	2.09	2.83	42.51	0.48	0.19	10.10	5.45	15.55	2.15
T4	2.14	2.85	42.95	0.50	0.20	10.77	5.79	16.56	3.34
T5	2.16	2.87	42.98	0.52	0.21	11.24	6.13	17.37	3.27
T6	2.22	2.91	43.31	0.53	0.22	11.79	6.39	18.18	2.23
T7	2.29	3.13	42.28	0.55	0.24	12.65	7.48	20.13	3.43
T8	2.36	3.21	42.36	0.57	0.26	13.35	8.23	21.59	3.42
T9	2.58	3.32	43.82	0.58	0.27	15.08	8.92	24.00	2.52
SEm±	0.11396	0.1352	1.07	0.02	0.01	0.74	0.50	0.78	-
CD(P=0.05)	0.34166	0.4054	NS	0.06	0.04	2.24	1.50	2.35	-
G.M.	2.21	2.94	42.82	0.52	0.21	11.50	6.36	17.86	-

RESULTS

The soil of the experimental field characterized as clayey in texture, moderate organic carbon status, low in available nitrogen and phosphorus content and fairly rich in potassium status having pH 7.8. Height of plant, number of branches/ plant, number of leaves/plant, leaf area/plant and dry matter accumulation/plant were significantly increased and were highest in treatment receiving 125% phosphorus + Rhizobium + PSB + 2.5 t vermicompost (T9) but remained at par with treatments receiving 125% phosphorus (T7) and treatment 125% phosphorus + Rhizobium + PSB (T8), respectively. The yield contributing characters *viz.,* number of pods/plant and grain weight/plant were maximum with 125% phosphorus + Rhizobium + PSB + 2.5 t vermicompost (T9) and they were statistically at par with treatments receiving 125 phosphorus (T7) and 125% phosphorus + Rhizobium +PSB treatment (T8) however, test weight remained uninfluenced. Grain and straw yield/ha was highest in treatment T9 but remained at par with treatment T7 and T8. Total P uptake was maximum in treatment T9 receiving 125% phosphorus + Rhizobium +PSB + 2.5 t vermicompost (T9) which was significantly superior over all the treatments. Application of 125% phosphorus + Rhizobium + PSB + 2.5 t vermicompost (T9) resulted in significantly highest gross monetary return (Rs.86657) however, it was at par with application of 125% phosphorus (T7) and 125% phosphorus + Rhizobium + PSB (T8). Application of 125% phosphorus + Rhizobium + PSB resulted in significantly highest net monetary return (56099) and proved significantly superior over rest of the treatments. Maximum benefit: cost ratio of 3.43 was recorded with the application 125% phosphorus (T7).

CONCLUSION

It is concluded from this study that application of 125% phosphorus + Rhizobium + PSB + 2.5 t vermicompost recorded the highest yield of soybean with highest gross monetary return.

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Phosphorus management in *rabi* niger (*Guizotia abyssinica*)–fodder sorghum (*Sorghum bicolor*) cropping sequence

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A field experiment was conducted during 2010-2011 and 2011-2012 on deep black soil of Navsari, Gujarat to study the Phosphorus management in *rabi* Niger (*Guizotia abyssinica* L. Cass) – Fodder Sorghum (*Sorghum bicolor* L. Moench) cropping system. Application of 20 kg P_2O_5/ ha from SSP with PSM recorded significantly higher grain yield (628, 766 and 697 kg/ha), total P uptake (4.51, 5.65 and 5.08 kg/ha) by Niger and available P status of soil (50.11 and 49.44 kg/ha) after harvest of niger than control (no phosphorus) during both the years and remained at par with application of 10 kg P_2O_5/ha from SSP + PSM. Similarly application of 10 kg P_2O_5/ha from SSP + 100 kg RP/ha + PSM preceding fodder sorghum recorded significantly higher green fodder yield of sorghum (368, 415 & 391 q/ha), available P status of soil (43.37 and 44.19 kg/ha) after harvest of fodder sorghum and net realization from niger-fodder sorghum cropping system (Rs. 5915 and 39,109/ha) over other treatments during both the years. Thus, it is evident that with respect to the economy in fertilizer use, a saving of 25 per cent RDF (20 kg N + 10 kg P_2O_5/ha) in fodder sorghum can be achieved under adequately fertilized niger-fodder sorghum cropping system.

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On farm response of soybean - chickpea cropping system to NPK and sulphur application in western Vidarbha

VARSHA TAPRE

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Wheat, Chickpea and safflower are most important Rabi crops in the zone. Average fertilizer consumption is 37.85 kg N, 36.50 kg P_2O_5, 6.5 kg K_2O per hectare and sulphur consumption is very meager to minimal which is quite in adequate considering requirement of mono or double crop in a year. Farmer's hesitate to supply recommended dose to the crops because of varied problems and therefore imbalance application of NPK is also commonly observed, keeping this in view the present investigation entitled "On farm response of soybean - chickpea cropping system to N P K and Sulphur" was conducted in two blocks of WasternVidarbha Zone.

METHODOLOGY

Field experiments were conducted at six locations (four experiments per villages) each year during 2013-14, 2014 –15 and 2015 – 16 respectively with seven treatments, treating location as a replication. Villages were selected in Nandgaon khandeshwar and Morshi block of Amravati district. Treatments consist of no NPK (control), recommended dose of N alone, NP alone, NK alone and NPK (30:75:30 and 20:40:20) kg NPK /ha and NPK plus 25 kg sulphur /ha for soybean and chickpea respectively, applied to both the crops on plot size of 20mX10 m. The soils of experimental site is mostly medium to deep black cotton and slightly alkaline in reaction ,

Table 1. Mean pooled grain yield (kg/ha), Economics (Rs/ha) & nutrient response (kg/kg) of crops as influenced by various treatments on soybean- chickpea cropping system

Treatment	Soybean Equivalent yield (Kg/ha)	System cost of Cultivation (Rs./ha)	System Net Monetary Returns	System Net Monetary Returns over control (Rs/ha)	Nutrient response (Kg/kg) (Rs/ha)
Control	1691	31307	33166	1859	-
Rec. N	2108	33442	41300	8134	9.04
Rec. NP	2556	39633	51842	18676	9.00
Rec. NK	2306	35415	45088	11922	6.04
Rec.NPK	2992	41618	64608	31442	6.19
Rec.NPK+ Sulphur	3362	45191	74470	41304	6.93
Farmers practice	2085	38062	41369	8203	3.60

The data onresponse to N P & K in terms of Soybean equivalent yield (Table1) indicated that the response to N was 9.04 Kg/kg for P_2O_5 it was 9.00 Kg/kg while that for K_2O, the same was 6.04 Kg/kg.

well distributed rainfall ranged between 721to 1096 mm was received during the crop growth period. Soybean 'JS 9305' was sown from 15th June to 23th July, Chickpea 'JAKI 9218' was from 28th October to 24th of November both the crops were raised with recommended package of practices except fertilization. NPK was supplied through straight fertilizers and supply of sulphur through bensulf to both the crops as per recommended timing. Life irrigations were given to soybean and chickpea crop as per the recommendation.

RESULTS

Pooled data indicated that the yield of soybean was highest with recommended dose of NPK + Sulphur but treatment NP & NK both alone being at par has increased the yield significantly over control & recommended dose of N alone. But in case of chickpea application of recommended dose of Sulphur NPK +S was found significantly superior over all the treatments. Data on economics of soybean–chickpea sequence as affected by fertilizer application (Table 1) indicated that total per hectare monetary benefit was augmented by Rs.41304 per hectare due to fertilization with NPK +Sulphur, and Rs. 31442 per hectare by application of recommended dose of NPK to both crop over control. Least monetary returns were achieved by only application of recommended Nitrogen application to both the crop over control. Recommended dose of Nitrogen and Phosphorus to soybean as well as chickpea showed more monetary returns (18676 Rs./ha) than that of application of Recommended dose of Nitrogen and Potash application (Rs11922/ha)over control.

CONCLUSION

Soybean and Chickpea in sequence cropping should be fertilized with 30:75:30:25 and 20:40:20:25 Kg NPKS/ha respectively for getting maximum production in terms of yield and net monetary returns from the cropping system. And it is widely adapted cropping system in rainfed situation at Amravati district of westernVidarbha of Maharashtra state.

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Integrated nutrients management based on soil test crop response (STCR) in soybean (*Glycine max* L.)-sunflower (*Helianthus annuus* L.) cropping system in vertisols

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Soybean is major *kharif* crop of Marathwada region of Maharashtra in vertisols. However, in soybean based cropping system hardly 10-15 days time is available between harvesting of soybean and timely sowing of winter crop. Sunflower has been proved to be highly promising for round the year cultivation under different agro-climatic regions owing to its thermo-photo-insensitivity and can fit in crop rotation any time. Soybean is sown from first fortnight of June to first fortnight of July depending upon onset of monsoon. Being a legume crop, soybean fixes atmospheric nitrogen in the soil to an extend of 65 to 100 kg/ha through symbiotic association with *Rhizobium* bacteria (Rao, 2007). Under such situation soybean – sunflower cropping system is the best cropping system. The effective fertilizer recommendation should consider crop needs and nutrients already available in the soil. Among various methods of fertilizer recommendations such as Recommended dose of fertilizer (RDF), soil test based recommendations, critical value approach *etc.,* the soil test crop response (STCR) approach for targeted yield is unique in indicating both soil test based fertilizer dose and the level of yield that can be achieved with good agronomic practices. In the view of above facts, a study on refining the integrated nutrient management on STCR basis was conducted to access the site specific nutrient management practices through STCR equation to achieve higher production of soybean-sunflower cropping system

METHODOLOGY

A field experiment was conducted continuously on fixed site from 2011-12 to 2014-15 with soybean-sunflower cropping system with various combinations of organic and inorganic nutrient management at AICRP on sunflower, Oilseeds Research Station, Latur. Geographically Latur is situated between $18^0 05'$ to $18^0 75'$ North latitude and between $76^0 25'$ to $77^0 25'$ East longitude. It’s height from Mean Sea Level is about 540.63 m and has sub-tropical climate. The experimental soil was medium black with initial soil fertility of slightly alkaline in nature (*p*H 7.75) containing low in organic carbon (0.42%), available nitrogen (123.75 kg/ha), available phosphorus (9.45 kg/ha) and high in available potassium (426 kg/ha). In soybean-sunflower cropping system soybean was grown in *kharif* season with recommended dose of fertilizer followed by *rabi* sunflower with six treatments, replicated four times in RBD . Following validated targeted yield soil test crop response (STCR) equation (Anonumous,1998) was used FN = 13.94T-0.61SN, FP_2O_5=7.18T-6.82SP, FK_2O=4.82T-0.12SK;Where FN= Fertilizer N (kg/ha), FP_2O_5= Fertilizer P_2O_5 (kg/ha), FK_2O= Fertilizer K_2O (kg/ha), Target yield (18 q/ha), SN= Soil test value of N (kg/ha), SP= Soil test value of P (kg/ha) and SK= Soil test value of K (kg/ha). Data on various variables were analyzed by analysis of variance (Panse and Sukhatme, 1967) and pooled analysis for four years were carried out as per procedure outlined by Cochran and Cox (1957).

RESULTS

The data pertaining to pooled seed yield of soybean and sunflower have been presented in Table 1. The seed yield of soybean and sunflower varied significantly due to various combinations of organic and inorganic nutrient treatments. In soybean-sunflower cropping system application of STCR fertilizer + S @ 20 kg/ha + $ZnSO_4$ @ 20 kg/ha + FYM @ 5 t/ha + Crop residue of soybean to *rabi* sunflower crop recorded significantly higher seed yield of soybean (3.34 t/ha) and sunflower (1.46 t/ha) and was at par with application of STCR fertilizer + S @ 20 kg/ha + $ZnSO_4$ @ 20 kg/ha to *rabi* sunflower. The pooled system productivity and in terms of sunflower equivalent yield (SEY), GMR and NMR were computed (Table 1). The significantly higher system productivity (4.28 t/ha), GMR (‘ 146.22 x10^3 /ha) and NMR (‘ 102.47 x10^3 /ha) were recorded with the application of STCR fertilizer + S @ 20 kg/ha + $ZnSO_4$ @ 20 kg/ha + FYM @ 5 t/ha

Table 1. Yield and economics of soybean - sunflower cropping system as influenced by different treatments (Pooled 2011-2014)

Treatment for Sunflower	Yield t/ha			Economics (Rs./ha)		
	Soybean	Sunflower	SEY	GMR ($\times10^3$/ha)	NMR ($\times10^3$/ha)	B:C Ratio
Control	2.92	0.84	3.39	113.36	79.55	3.43
RDF	3.03	1.16	3.80	126.68	89.04	3.42
150% RDF	3.07	1.20	3.88	129.33	89.53	3.28
RDF+FYM@ 5t/ha+CR	3.08	1.24	3.92	130.78	88.27	3.12
STCR fertilizer+S@20 kg/ha+$ZnSO_4$ @ 20 kg/ha	3.21	1.38	4.19	139.78	100.89	3.64
STCR fertilizer+S@20 kg/ha+$ZnSO_4$ @ 20 kg/ha+ FYM@ 5t/ha+CR	3.34	1.46	4.28	146.22	102.47	3.37
SE±	0.07	0.04	0.08	2.55	2.55	0.07
CD (P=0.05)	0.20	0.11	0.21	7.07	7.08	0.19

+ Crop residue of soybean to *rabi* Sunflower, followed by application of STCR fertilizer + S @ 20 kg/ha + $ZnSO_4$ @ 20 kg/ha to *rabi* sunflower. The pooled data on system economics (Table 1) showed significantly higher Benefit : Cost ratio (3.64) with the application of STCR fertilizer + S @ 20 kg/ha + $ZnSO_4$ @ 20 kg/ha to *rabi* sunflower.

CONCLUSION

From the results it may be inferred that integrated approach for nutrient management based on STCR proved most efficient to sustainable productivity of soybean-sunflower cropping.

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Precision nutrient management in wheat under different tillage options

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Application of nutrient at right time with right rate and at right place is the key in efficient utilization of scare and costly available fertilizers. General recommended doses of fertilizers now a day are not found to better because of the heterogeneity in soil nutrient status and other physico- chemical and biological characteristics from place to place even in small area.

METHODOLOGY

To optimize nutrient usage and wheat yield, an experiment was conducted in Norman E. Borlaug Crop Research Centre, GB Pant University of Agriculture and Technology, Pantnagar during the year 2013-14 in strip plot design and three replications with two tillage options as vertical strips [*viz.* conventional tillage (CT) and zero tillage (ZT)] and four nutrient management treatments as horizontal strips (*viz.* NPK @ 150:60:40 kg/ha, where full P and K applied through NPK mixture as basal and remaining N top dressed in two equal splits after first and second irrigation, the same NPK dose but N application just before first and second irrigation, Site Spe-

Table 1. Effect of different tillage and nutrient management practices on yield and yield parameters of wheat

Treatment	Grain Yield (kg/ha)	Earhead/m^2	Grains/ earhead	1000 grain weight (g)
Tillage				
ZT	4388	315	37.44	37.53
CT	4785	308	43.07	36.63
CD (P=0.05)	163	NS	1.49	NS
Nutrient management				
150:60:40 NPK kg/ha (After irrigation)	4660	320	38.01	38.63
150:60:40 NPK kg/ha (before irrigation)	4858	345	38.01	37.28
SSNM: nutrient expert	4538	303	40.16	37.43
SSNM: Green seeker	4288	278	44.82	34.97
CD (P=0.05)	305	30.01	4.64	1.00

(ZT: Zero tillage, CT: conventional tillage, SSNM: Site Specific Nutrient Management)

cific Nutrient Management (SSNM) based on wheat nutrient expert (Full PK + micronutrients, if any and 70% N), and Green seeker based N application along with recommended P and K. Seed bed was prepared by two times operation of disc harrow was followed in conventional tillage; whereas the seed was directly sown with zero till seed drill in zero tillage plots. All other required agronomic practices were followed as per the requirement with 100 kg/ha seed sowing rate.

RESULTS

The different yield attributing characters and grain yield of wheat were found to be significantly affected by tillage treatments where conventional tillage (CT) produced 109% and 115% higher grain yield and grains/earhead, respectively over zero tillage (ZT). Singh *et al.* (1998) reported the optimum soil environment, seed sowing at optimum depth and covering with soil which promotes proper seed germination, plant stand and increased number of tillers per m^2 might be responsible for higher grain yield in conventional tillage over zero tillage.Wheat grain yield and earhead/m^2 were found at higher side with application of 150:60:40 kg NPK/ha with N application just before the irrigation; whereas production of number of grains/earhead was found to be higher in green seeker based SSNM (Table 1). The availability and uptake of N in appropriate amount which ultimately responsible for the uptake all the other nutrients might be resulted into such superiority of SSNM which was achieved through green seeker based N application and when N applied just before the irrigation. Mohanty*et al.* (2015) reported the similar results with time and amount based nutrient application for wheat crop.

CONCLUSION

Application of 150:60:40 NPK kg/ha with nitrogen in three split doses as- first at the time of sowing and remaining two doses just before the first and second irrigations along with conventional system of tillage may produce higher wheat grain yield in Tarai region of Uttarakhand.

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Relative performance of zinc, boron and sulphur coatings onto prilled urea on productivity and N and Znconcentration in aromatic rice

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Zinc (Zn), boron (B) and sulphur (S) nutrients deficiency is well–identified, leading to reduced nutritional quality and yields of rice. Following cereal based intensive–rotations over the years leads to depletion of micronutrients of soils (Borlaug, 2003). Studies suggest that micro–(Zn, B) and secondary (S) nutrients deficiency in field crops occurs in different parts of India. Application of high–analysis fertilizers has reduced these nutrients application to soil. Globally, Zn and S deficiency has been reported by several workers and B inadequacy is also wide spread in highly calcareous soils of India. The Zn, B and S deficiency leads to low productivity and nutrient–use–efficiency which ultimately accord less profit to farmers. However, coated urea with graded doses of Zn, S and B has so far not been tried in basmati rices and our efforts were, therefore, directed towards evaluating the effect of B–coated (BCU), S–coated (SCU) and Zn–coated (ZnCU) ureain terms of grain yield, concentrations of Zn/N in rice grain, straw and husk and input–economics in the basmati rice.

METHODOLOGY

Three different coated urea materials, ZnCU, SCU and BCU were tested in three different field experiments during *kharif* season of 2013 at the research farm of the IARI, New Delhi. The experiments were laid–out in a randomized block design with three replications. Experiment I consisted of seven fertilizer treatments: control, prilled urea (PU), 0.1%, 0.2%, 0.3%, 0.4% and 0.5% BCU (the amount of B applied was 0.28, 0.56, 0.84, 1.12 and 1.40 kg ha^{-1}, respectively). Experiment II also had seven fertilizer treatments: control, PU, 1, 2, 3, 4 and 5.0% S–coated urea and the amount of S applied was 3.14, 6.28, 9.42, 12.56 and 15.7 kg ha^{-1}, respectively with SCU. Experiment III consisted of ten combinations of two coating materials, zinc sulphate hepta hydrate (ZnSHH) and zinc oxide (ZnO), with five levels of Zn coating (0.5, 1.0, 1.5, 2.0 and 2.5% w/w of prilled urea) and an absolute control (no Zn/N). Nitrogen was applied at 130 kg/ha as PU or ZnCU/SCU/BCU in all the treatments except the control, into two equal splits; half at 7 days after transplant-

Table 1. ZnCU on profitability and Zn concentrationsin transplanted puddle rice

ZnCU	% increase in grain yield over PU	Net return (US $/ha)	Zn concentration(mg/kg)			
			Grain	Bran	Husk	Straw
Absolute control	-	490.4	19.2	63.5	27.3	33.8
Prilled urea (PU)	-	989.9	21.5	65.6	31.3	36.4
0.5% ZnCU ($ZnSO_4.7H_2O$)	4.41	1069.3	22.7	67.3	32.4	38.3
0.5% ZnCU (ZnO)	9.87	1061.7	22.4	67.1	32.2	38.1
1.0% ZnCU ($ZnSO_4.7H_2O$)	13.66	1168.2	23.6	69.5	34.7	40.7
1.0% ZnCU (ZnO)	16.81	1161.4	23.5	69.2	34.3	40.2
1.5% ZnCU ($ZnSO_4.7H_2O$)	17.86	1238.1	24.8	71.7	36.2	42.9
1.5% ZnCU (ZnO)	3.99	1228.5	24.6	71.2	35.8	42.1
2.0% ZnCU ($ZnSO_4.7H_2O$)	9.45	1294.8	25.9	73.6	37.8	44.7
2.0% ZnCU (ZnO)	13.03	1281.9	25.5	72.9	36.7	44.2
2.5% ZnCU ($ZnSO_4.7H_2O$)	15.97	1312.5	26.8	75.9	38.3	46.9
2.5% ZnCU (ZnO)	17.23	1303.9	26.4	74.7	37.5	45.7
SEm±	-	38.1	0.60	0.74	0.85	0.60
CD (P=0.05)	-	111.8	1.77	2.16	2.48	1.77

Value of one US$ = 68 INR

ing and the remaining half at 45 days after transplanting.Two to three 25-days-old seedlings of *Basmati* rice varieties ‘PusaSugandh 5’ in ZnCU/SCU and’Pusa Basmati 6' in BCU experimentswere transplanted on hills at 20 cm x 10 cm in the first fortnight of July.

RESULTS

The highest grain yield was achieved with 0.5% BCU (3.48t/ha), 5% SCU (3.85t/ha) and 2.5% ZnCU–zinc sulphate hepta hydrate (ZnSHH) (5.61t/ha); these treatments increased yields by ~13, 25, and 17% over prilled urea (PU). Combined use of N with Zn/B/S through ZnCU, BCU and SCU in intensive cereal–cereal rotations assured the regular/controlled supply of micro and secondary nutrients in deficient soils that reflected in yield. Zn–coated fertilizers significantly improved grain yield of rice over control and PU. A similar positive response of rice to applied Zn in Zn deficient soils of India has been reported by several workers (Pooniya*et al*., 2012; Shivay*et al*., 2010). Similarly, the highest Zn concentration in rice grain (26.8 mg/kg) registered with 2.5% ZnCU–ZnSHHwhich was ~24% higher than PU. However, Zn concentration in different parts of rice was in the order of bran>straw>husk>grain while N concentration in the order of bran>grain>straw>husk.Applicationof5% SCU resulted in highest N and S concentration in grain which was 9% and 22% higher than PU. SCU might have increased N as well as sulphur concentrations due to positive interactions which ultimately enhanced their uptake in grain.Coated–urea materials also enhanced N/Zn use–efficiencies such as partial factor productivity (PFP_N), agronomic efficiency (AE_N), recovery efficiency (RE_N), and harvest index (HI_N) over those of PU.The positive improvement in efficiencies was due to the positive effect of applied coated fertilizers on yields and N uptake. From the economics viewpoint this study suggests that coating of urea with 0.5% boron, 5% sulphur or 2.5% ZnSHH/2.5%ZnO gives maximum net returns. Therefore, coating of B, Zn and S onto urea is recommended for increased rice yields and profitability.

CONCLUSION

Present study showed that 1% ZnCU either with $ZnSO_4$ or ZnO can be applied for higher productivity and net return to the farmers under deficient soils. However, to get the highest productivity, an application of 2.5% ZnCU–ZnSHHis recommended. Based on the economic analysis, 0.5% BCU and 5% SCU is possible option to get higher productivity and net returns from the transplanted puddled rice.

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Influence of Integrated Nutrient Management on sustainable maize-wheat productivity and water use efficiency in sub-humid rainfed areas of Jammu

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Maize-wheat is predominant cropping sequence in the rainfed areas of Jammu region and maize is mainly consumed as staple dietary supplement and fodder in the region (Jamwal, 2005). The productivity of maize is affected by the distribution of crop seasonal rainfall received from sowing to harvest, soil fertility and applied fertilizer nutrients (Maruthi Sankar *et al.,* 2008; Abrol *et al.,* 2015) and yield could drastically reduce due to deficiency of moisture in soil during reproductive stage of maize and early withdrawal of monsoons. The modest quantities of organic residues are rapidly oxidized due to high temperatures prevailing in the region, allowing very little humification which makes integrated nutrient management a pivotal factor for attaining sustainable crop productivity and efficient utilization of rain water. Thus present study was undertaken with following oobjectives: (i) To identify the suitable nutrient management practice for attaining sustainable crop productivity and utilization of rain water during crop growth period; (ii) To establish relationships between sustainability yield index (SYI) and rainwater use efficiency (RWUE)

METHODOLOGY

The field investigation was conducted under AICRPDA at the Advance Centre for Rainfed Agriculture of SKUAST-Jammu during 2001 to 2012 at experimental at a latitude of 32° 39" North and longitude of 74° 53" East at an altitude of 332 meters above mean sea level

The region is characterized as sub-humid climate with 1152 mm precipitation, about 75% of which occurs in the summer from July through September.

The analysis of initial soil samples taken from the experimental site at the start of the study in 2001 in surface depth was determined following standard procedures. The experimental site had a pH of 6.5, soil organic carbon (SOC) content of 2.9 g kg^{-1}, soil N of 150 kg ha^{-1}, P of 15 kg ha^{-1} and K of 115 kg ha^{-1}.

The treatments T1: Control; T2: FYM @ 10 t ha^{-1} + 20 kg N ha^{-1}; T3: FYM @ 10 t ha^{-1} + 30 kg N ha^{-1}; T4: FYM @ 10 t ha^{-1} + 40 kg N ha^{-1}; T5: Green manuring with sunhemp + 20 kg N ha^{-1}; T6: Green manuring with sunhemp + 30 kg N ha^{-1}; T7: Green manuring with sunhemp + 40 kg N ha^{-1}; T8: Leucaena leaves @ 5 t ha^{-1} + 20 kg N ha^{-1}; T9: *Leucaena* leaves @ 5 t ha^{-1} + 30 kg N ha^{-1}; T10: Leucaena leaves @ 5 t ha^{-1} + 40 kg N ha^{-1} were applied to the same plots every year in maize crop only in a Randomized Block Design with replications and their residual effect was monitored in wheat crop.

Sustainability yield index (SYI) of treatment 'k' was calculated as $SYI_k = [(T_k - PE_k) / Y_{max}] * 100$ following Maruthi Sankar *et al.,* (2013) and Rani water Use Efficiency (RWUE) = Yield (kg ha^{-1})/Crop seasonal rainfall (mm)

RESULTS

Grain yield of maize and wheat differed among treatments. The pooled data revealed a higher grain yield of maize (23.4 q ha^{-1}) and wheat (18.33 q ha^{-1}), with 107 and 62 percent increase over control, respectively through the application of FYM @ 10 t ha^{-1} with 40 kg N ha^{-1} and the least yield was measured in control (Table 1).

Among different treatments, integration of FYM @ 10 t ha^{-1} with 40 kg N ha^{-1} obtained maximum sustainable yield index (SYI) value 49.3 and 64.1 in maize and wheat with 136 and 64 % increase over control respectively (Table 1). Application of with FYM @ 10 t ha^{-1} + 40 kg N ha^{-1} recorded maximum RWUE of 2.74 and 8.45 in maize and wheat respectively with 95 and 62 % increase over control (Table 1).

Results revealed a positive and significant relationship between SYI and RWUE in maize (R^2 = 0.93) (Fig 1) and wheat (R^2 = 0.98) (Fig 2).

In comparison with the control, application of FYM @ 10 t ha^{-1} + 40 kg N ha^{-1} contributed to build up of SOC and ob-

Table 1. Mean grain yield, sustainability yield index and rain water use efficiency of maize and wheat crops under different fertilizer and manure treatments

Treatment	Mean Grain Yield (q/ha)		SYI		RWUE(kg/ha/mm)	
	Maize	Wheat	Maize	Wheat	Maize	Wheat
T1	11.3	11.35	20.9	39.9	1.41	5.23
T2	19.2	15.54	39.9	54.0	2.27	7.17
T3	21.7	17.29	48.5	60.6	2.55	7.97
T4	23.4	18.33	49.3	64.1	2.74	8.45
T5	16.2	13.31	29.5	43.3	1.94	6.14
T6	17.5	15.12	37.6	52.8	2.08	6.97
T7	19.0	16.16	42.8	55.8	2.25	7.45
T8	17.8	14.51	38.0	50.2	2.09	6.69
T9	19.7	15.56	45.8	52.9	2.32	7.18
T10	21.1	16.67	48.3	58.4	2.47	7.69
Minimum	1132	11.35	29.50	39.93	1.94	5.23
Maximum	2343	18.33	49.30	64.10	2.74	8.45
Mean	1868	15.38	42.19	53.20	2.30	7.09
CD	1.01	0.97	-	-	-	-

T1: Control; T2: FYM @ 10 t ha^{-1} + 20 kg N ha^{-1}; T3: FYM @ 10 t ha^{-1} + 30 kg N ha^{-1}; T4: FYM @ 10 t ha^{-1} + 40 kg N ha^{-1}; T5: Green manuring with sunhemp + 20 kg N ha^{-1}; T6: Green manuring with sunhemp + 30 kg N ha^{-1}; T7: Green manuring with sunhemp + 40 kg N ha^{-1}; T8: Leucaena leaves @ 5 t ha^{-1} + 20 kg N ha^{-1}; T9: Leucaena leaves @ 5 t ha^{-1} + 30 kg N ha^{-1}; T10: Leucaena leaves @ 5 t ha^{-1} + 40 kg N ha^{-1}

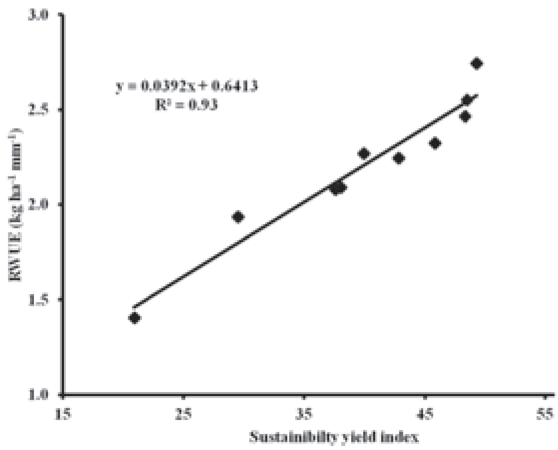

Fig. 1. Relationships of rain water use efficiency with sustainable yield index (SYI) of maize in long-term experiment

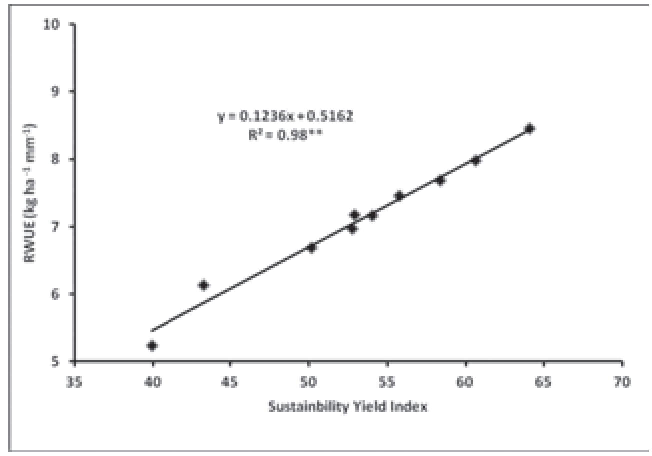

Fig. 2. Relationships of rain water use efficiency with sustainable yield index (SYI) of wheat in long-term experiment.

tained significantly higher SOC (39 g kg^{-1}) with 44 percent increase over control.

CONLCUSION

Application of FYM in conjunction with mineral fertilizers was the most efficient for attaining sustainable higher grain yield and improving rain water use efficiency with concomitant build up of SOC in the maize based cropping systems in drylands.

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Response of rice (*Oryza sativa* L.) to planting geometry and nitrogen levels

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Rice (*Oryza sativa* L.) is one of the principal and widely grown food grain crops and is a staple food for more than half of the human population. India has the largest area under rice and is the second largest producer of rice after China. It is the main food crop in India contributing around 45% to the total food grains production and thus holds the key to the food security in the country. Rice in India is grown over an area of about 44 million hectares with a production of 106.3 million tons. It is the major *kharif* season crop in Haryana which occupied an area of 1.23 million hectares with a production of 39.98 million tons (Anonymous, 2013). Although productivity of the crop in Haryana (3256 kg/ha) is greater than the national average (2416 kg/ha), yet it can further be increased significantly with proper management practices. Rice in Haryana is grown mainly by transplanting method of crop establishment. But the conventional manual transplanting, done usually by hired labour, is one of the major constraints to rice productivity because the actual plant population obtained with the manual transplanting is inadequate (15-20 hills/m^2) and much below the recommended density (33 to 44 hills/m^2). Moreover, the transplanting at most of the farmers fields is done with a random geometry without any specified inter and intra row spacing. Nitrogen is the most important plant nutrient that determines the yield of crop, especially under intensive cultivation and is a key input for rice production in the state as the soils are often low in native N. Adoption of exhaustive cropping systems such as rice-wheat in the state have further underlined the importance of N fertilization. Excess amount of N application can result in lodging of the plants and reduction of yield. Similarly deficiency of N causes reduction in the yield. Therefore, application of N in optimum amount is important for obtaining higher crop yield. There may be interactions between planting geometry and nitrogen requirement of the crop and hence the quantity of N required by the crop may vary with the planting geometry. Moreover, many farmers tend to apply higher doses of fertilizers, particularly of nitrogenous fertilizers, in order to compensate for the inadequate plant density obtained with the conventional manual transplanting in order to get higher crop yield. Therefore, there is also a need to find out the proper dose of nitrogen under various planting geometry and the extent to which the higher dose of N compensates for the lower plant density at the farmers field. Therefore, there is need to find out the proper dose of applied N for various planting patterns.

METHODOLOGY

The experiment was laid out in a split plot design with 4 main plot treatments and 4 sub plot treatments with replicated thrice. The main plot having planting geometry which were transplanting at 15 cm x 15 cm spacing (44 hills/m^2), transplanting at 20 cm x 15 cm spacing (33 hills/m^2), transplanting at 30 cm x 20 cm spacing (17 hills/m^2) and random transplanting (15-20 hills/m^2). In sub plot treatments consisted of Nitrogen levels which were 120, 150, 180 and 210 kg/ha. The crop was raised according to package of practices of CCSHAU, Hisar. The nursery seedbed was well prepared. Rice grains at a rate of 168 kg/ha was soaked in water for 48 hrs and incubated for 24 hrs, thereafter were hand broadcasted in the nursery area on 15th May. Seedlings were kept free from weeds, insects and diseases, fertilized and irrigated as normally done by farmers in their fields. Thirty days old seedlings were transplanted to the permanent field area transplant in rows as previously mentioned hill spaces. Nitrogen in the form of urea (46% N) with previously mentioned rates were applied in two splits; 2/3 basal application and 1/3 at five days before panicle initiation. Following parameters were studied; Yield and its attributes like plant height (cm), number of tillers/m^2, number of filled grains/panicle, 1000-grain weight and grain yield (t/ha). Data were subjected to analysis of variance as the technique of analysis of variance of the split plot design Computations was done using the personal computers (PC) with the famous statistical software OPSTAT.

RESULTS

Plant height, number of tillers/m^2, 1000-grain weight, No. of grains/panicle and grain yield/ha were significantly influenced by different levels of nitrogen. Thousand grain weights remained unaltered due to N fertilizer application. Plant height increased with the increasing rates of nitrogen upto 180 kg/ha and it was found significantly higher than other levels of nitrogen. The shortest plant (95 cm) was found in the 120 kg/ha nitrogen. Nitrogen induced vegetative growth with higher rates. Similar results were also reported by Navin *et al.* (1996). Number of panicle/hill followed a pattern similar to

Table 1. Effect of planting geometry and nitrogen levels on yield attributes and yield of rice

Treatment	Plant height (cm)	Number of tillers/m^2	No. of filled grains/ panicle	1000-grain weight (g)	Grain yield (t/ha)
Planting geometry					
Transplanting at 15 cm x 15 cm spacing (44 hills/m^2)	100.083	440.083	99.5	25.117	3.72
Transplanting at 20 cm x 15 cm spacing (33 hills/m^2)	98.333	430.583	98	24.958	3.58
Transplanting at 30 cm x 20 cm spacing (17 hills/m^2)	97.167	419.917	95.5	24.817	3.45
Random transplanting (15-20 hills/m^2)	95.333	410.833	93.083	24.758	3.35
SEm±	0.125	1.624	0.702	0.12	0.017
CD (P=0.05)	0.441	5.729	2.477	NS	0.061
Nitrogen level (kg/ha)					
120	95	369.833	93	24.317	3.07
150	96.833	397	94.667	24.633	3.2
180	99.667	469.583	100	25.425	3.89
210	99.417	465	98.417	25.275	3.81
SEm±	0.584	0.808	0.786	0.102	0.017
CD (P=0.05)	1.714	2.372	2.308	NS	0.05

that obtained for plant height. The highest number of filled grains/panicle (100) was obtained at 180 kg/ha, which was significantly superior than other N levels. Nitrogen helped in proper filling of seeds which resulted higher produced plump seeds and thus the number of filled grains/panicle. The lowest number of grains/panicle (93) was obtained from 120 kg N/ha. Grain yield of rice increased gradually with the increasing levels of nitrogen upto 180 kg N/ha, but at higher rates (210 kg/ha), grain yield tended to decrease. The highest grain yield was obtained at 180 kg N/ha and the lowest from 120 kg N/ha. Similar trend was also observed by Haider *et al.* (1988). The yield advantage of N application upto 180 kg/ha was mainly due to improvement of yield components *viz.*, panicle length and number of grains/panicle. Plant spacing significantly influenced the plant height, number of tillers/m^2, filled grains/ panicle, test weight and grain yield/ha. Plant spacing did not show any significant variation in respect of 1000-grain weight. Sparsely populated plants (30 cm x 20 cm) were the tallest and the shortest from densely populated plants. Number of tillers/m^2 was significantly highest (440.083) at the spacing of 15 cm x 15 cm (Table 1). Number of filled grains/ panicle decreased with closer and wider spacing did not vary and were at par. However, the highest filled grains/panicle (99.5) was observed from the spacing 15cm x 15cm. Plant spacing had significant effect on grain yield/ha. Grain yield increased from 3.35 t/ha to 3.72 t/ha with the decrease in plant spacing. Higher grain yield (3.72 t/ha) was obtained at closer spacing (15cm x 15cm) followed by 20cm x 15cm (3.57 t/ha) and the lowest (3.45 t/ha) from 30 cm x 20 cm. The contribution of closer spacing for higher yield was strongly supported by Azad *et al.* (1995).

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Yield and quality of wheat as influenced by split application of nitrogen

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Wheat is one of the most important staple food crops of India grown in diverse agro-climatic conditions from 11 °N-35°N latitude and 72°E- 92°E longitudes. Wheat (*Triticum* spp.) a feeding bowl to mankind occupies a premier position of all the grain crops and an intellectual challenge that possess in a range of biological disciplines, archaeology, social and economic history. The major three main species of wheat viz., *Triticum aestivum*, *Triticum durum* and *Triticum dicocum* L. are cultivated in India; however, *Triticum aestivum* and *Triticum durum* are popularly grown in Gujarat. Researchers have been looking for ways and means to increase the efficiency of fertilizer nitrogen use, but there are several constrain to come on conclusion because response of nitrogen varies with soil type, variety and management practices. The research changing in climate towards global warming has created more confusion among the researcher to finalize the line of research for yield potential as well as quality. Quality is such factor which is governs by several biochemical processes and microclimate of the crop, but so far consumer preference is concern grain appearance, hardness and hectoliter weight is on top. In recent years, intensive management studies have shown that split top dressing of fertilizer nitrogen recommendation may improve N efficiency vis-a-vis enhance yield levels and quality. Quality production with maximum nitrogen use efficiency was objective of the study.

METHODOLOGY

The field experiment was laid out in Plot C-9 at the Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during the *rabi* seasons of the years 2013-14 and 2014-15. The experimental field has an even topography with a gentle slope having good drainage. The soil samples were taken randomly from experimental plot to a depth of 0-15 and 15-30 cm. The soil was loamy sand in texture, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potash. The experiment was conducted in Randomized Block Design with factorial concept with 3 replications. Wheat variety GW 322 was sown in the experiment. The treatments consisted of 2 levels of nitrogen (120 kg/ha and 160 kg/ha) and 7 split application of nitrogen, viz., S_1: 50% at sowing and 50% at CRI stage, S_2: 50% at sowing, 25% at CRI stage and 25% at 1st node stage, S_3: 25% at sowing, 25% at 1st node stage, 25% at tillering stage and 25% at heading stage, S_4 : 25% at CRI, 25% at 1st node stage, 25% at flag leaf stage and 25% at milking stage, S_5 : 20% at sowing, 20% at CRI, 20% at 1st node stage, 20% at flag leaf stage and 20% at flowering stage, S_6 : 20% at sowing, 20% at 1st node stage, 20% at flag leaf stage, 20% milking stage and 20% at dough stage and S_7 : 10% each at sowing, CRI, 1st node stage, tillering stage, flag leaf stage, heading stage, flowering stage, milking stage, dough stage and hard dough stage. Nitrogen application from Urea as per the treatments and Common application of Phosphorus and Potash at 60 kg P_2O_5/ha and 30 kg/ha K_2O as a basal dose for all the treatments respectively. The sowing of wheat was done on 22th November during the first year and 25th November during second year with hand sowing in dry moist soil. Wheat was harvested during 3rd April during first year and 20th March during second year.

RESULTS

Split application as 50% at sowing, 25% at CRI stage and 25% at 1st node stage recorded 4964 and 5793 kg/ha grain and straw yields, respectively on pooled basis. Based on pooled data under S_2, the percentage increase wasto the tune of 27.77, 27.09, 16.8, 10.46, 8.60 and 2.48 percent over S_7, S_4, S_6, S_3, S_1 and S_5, respectively. Similar trends were observed in case of straw yield. Harvest index found to be non-significant. It might be attributed to favorable effect on yield attributes viz., plant height, dry matter accumulation, number of leaves per plant, total tillers and effective tillers per meter row length, ear length and no. of grains per ear. The average increase in yield might be owing to continuous and sufficient availability of nitrogen during the formation of spikelet's in miniature plant around the first node stage. Effect of split application of nitrogen on quality of wheat grain indicated that protein content (12.21) being at par with splitting treatment S_5 (12.14) and S_6 (12.11) was recorded under splitting treatment S_7 (10% each at sowing, CRI, 1st node stage, tillering stage, flag leaf stage, heading stage, flowering stage, milking stage, dough stage and hard dough stage). Same way wet gluten content (29.87 %) being at par with S_5 (29.83) and S_4 (29.68), hectoliter weight

Table 1. Yield and quality of wheat as influenced by split application of nitrogen

Treatment	Yield (kg/ha) Grain yield	Straw yield	Protein content (%)	Wet gluten content %	Hectoliter weight (kg/ml)	Sedimentation value (ml)	Grain diameter (mm)
S_1 :50% at sowing and 50% at CRI stage	4570	5739	11.66	28.67	79.07	39.72	2.71
S_2 : 50% at sowing, 25% at CRI stage and 25% at 1st node stage	4964	5792	11.99	28.84	79.69	40.07	2.71
S_3 : 25% at sowing, 25% at 1st node stage, 25% at tillering stage and 25% at heading stage	4494	5649	11.92	28.95	80.19	40.28	2.73
S_4 : 25% at CRI, 25% at 1st node stage, 25% at flag leaf stage and 25% at milking stage	3905	4461	11.99	29.68	80.72	40.49	2.76
S_5 : 20% at sowing, 20% at CRI, 20% at 1st node stage, 20% at flag leaf stage and 20% at flowering stage	4844	5771	12.14	29.83	81.53	41.13	2.80
S_6 : 20% at sowing, 20% at 1st node stage, 20% at flag leaf stage, 20% milking stage and 20% at dough stage	4249	4747	12.11	29.35	81.09	40.08	2.77
S_7 : 10% each at sowing, CRI, 1st node stage, tillering stage, flag leaf stage, heading stage, flowering stage, milking stage, dough stage and hard dough stage	3884	4274	12.21	29.87	81.57	41.23	2.82
SEm±	109	202	0.06	0.14	0.190	0.249	0.01
CD (P=0.05)	309	574	0.16	0.39	0.54	0.71	0.04

(81.57) being at par with S_5 (81.53) and S_6 (81.09), sedimentation value (41.23) being at par with treatment S_5 (41.13) and grain diameter (2.82) being at par with S_5 (2.80) was recorded under the split application of nitrogen as 10% each at sowing, CRI, 1st node stage, tillering stage, flag leaf stage, heading stage, flowering stage, milking stage, dough stage and hard dough stage (S_7).

CONCLUSION

It can be concluded that best quality wheat grain was produced with 160 kg N/ha applied as full split *i.e.* 10% each at sowing, CRI, 1st node stage, tillering stage, flag leaf stage, heading stage, flowering stage, milking stage, dough stage and hard dough stage.

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Productivity and nitrogen use efficiency in baby corn (*Zea mays* L.) influenced by nutrient schedules

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The land and climate of Kerala is suitable for a number of crops. About 45 per cent of the net area sown is under perennial crops like coconut. Studies conducted in Tamil Nadu and isolated pockets in Kerala, have shown that baby corn production could be an important on-farm income generation activity when intercropped with annual crops (Thavaprakash and Velayudham, 2008) and perennial crops like coconut (CPCRI, 2012). Baby corn is comparatively a new crop for Kerala and small farmers are often hesitant in trying new crops under sole cropping situations, since it involves certain degree of risk. Coconut gardens provide ample scope for inter crop Baby corn production being a very recent development, cultivation practices, especially nutrient management needs to be standardized before it finds a prominent place in the existing cropping systems with the following objectives to standardize the nutrient schedule for baby corn intercropped in coconut garden and to work out the economics.

METHODOLOGY

The soil of experimental field was sandy loam in texture, acidic in reaction (pH 4.60), low in available nitrogen (200.70 kg N/ha), medium in available phosphorus (18.56 kg P/ha) and available potassium (108.70 kg K/ha). The experiment was laid out in randomized block design with 10 treatments replicated thrice, using the baby corn hybrid, G 5414 as the test variety. The treatments comprised combinations of 3 nutrient doses, 3 split application schedules and a control. The treatments were T_1 : 100:40:60 kg NPK /ha (½ N + ½ K basal; ½ N + ½ K at 25 DAS); T_2 : 100:40:60 kg NPK /ha (½ N + ½ K basal; ½ N + ½ K at 45 DAS); T_3 : 100:40:60 kg NPK /ha (½ N + ½ K basal; ¼ N + ¼ K at 25 DAS; ¼ N + ¼ K at 45 DAS); T_4 : 150:60:40 kg NPK /ha (½ N + ½ K basal; ½ N + ½ K at 25 DAS); T_5 : 150:60:40 kg NPK /ha (½ N + ½ K basal; ½ N + ½ K at 45 DAS); T_6 : 150:60:40 kg NPK /ha (½ N + ½ K basal; ¼ N + ¼ K at 25 DAS; ¼ N + ¼ K at 45 DAS); T_7 : 135:65:45 kg NPK /ha (½ N + ½ K basal; ½ N + ½ K at 25 DAS); T_8 : 135:65:45 kg NPK /ha (½ N + ½ K basal; ½ N + ½ K at 45 DAS); T_9 : 135:65:45 kg NPK /ha (½ N + ½ K basal; ¼ N + ¼ K at 25 DAS; ¼ N + ¼ K at 45 DAS) and T_{10} : control. Farm yard manure @ 12.5 t /ha was applied uniformly to all the treatments, including control. The entire dose of phosphorus was applied basally to the treatments T_1 to T_9.

Table 1. Effect of nutrient schedules on yield attributes and yields of baby corn

Treatments	Cob yield with husk (kg /ha)	Marketable cob yield (kg /ha)	Green stover yield (kg/ha)
T_1 : 100 : 40 : 60 kg NPK /ha ½ N + ½ K basal ; ½ N + ½ K at 25 DAS	12768.52	4589.50	22083.30
T_2 : 100 : 40 : 60 kg NPK /ha½ N + ½ K basal ; ½ N + ½ K at 45 DAS	10648.14	3882.71	21620.33
T_3 : 100 : 40 : 60 kg NPK /ha ½ N + ½ K basal ; ¼ N + ¼ K at 25 DAS; ¼ N + ¼ K at 45 DAS	11495.37	4165.12	20324.10
T_4 : 150 : 60 : 40 kg NPK /ha ½ N + ½ K basal ; ½ N + ½ K at 25 DAS	15532.66	6177.55	23013.90
T_5 : 150 : 60 : 40 kg NPK /ha ½ N + ½ K basal ; ½ N + ½ K at 45 DAS	14129.62	5043.20	22495.37
T_6 : 150 : 60 : 40 kg NPK /ha ½ N + ½ K basal ; ¼ N + ¼ K at 25 DAS; ¼ N + ¼ K at 45 DAS	14574.07	5191.35	21643.50
T_7 : 135 : 65 : 45 kg NPK /ha ½ N + ½ K basal ; ½ N + ½ K at 25 DAS	17162.03	6720.67	26203.70
T_8 : 135 : 65 : 45 kg NPK /ha ½ N + ½ K basal ; ½ N + ½ K at 45 DAS	13611.11	4870.37	23194.48
T_9 : 135 : 65 : 45 kg NPK /ha ½ N + ½ K basal ; ¼ N + ¼ K at 25 DAS; ¼ N + ¼ K at 45 DAS	11884.25	4294.75	20925.93
T_{10} : Control	8715.27	1496.96	15138.87
CD (P=0.05)	1784.584	563.328	1804.166

Table 2. Effect of nutrient schedules on nitrogen use efficiency

Treatments	AE (kg/kg)	PE (kg/kg)	ARE (%)	PFP (kg/kg)
T_1 : 100 : 40 : 60 kg NPK /ha (½ N + ½ K basal ; ½ N + ½ K at 25 DAS)	40.53	64.17	0.62	38.87
T_2 : 100 : 40 : 60 kg NPK /ha (½ N + ½ K basal ; ½ N + ½ K at 45 DAS)	19.32	70.86	0.27	32.88
T_3 : 100 : 40 : 60 kg NPK /ha (½ N + ½ K basal ; ¼ N + ¼ K at 25 DAS; ¼ N + ¼ K at 45 DAS)	27.80	93.93	0.33	35.27
T_4 : 150 : 60 : 40 kg NPK /ha (½ N + ½ K basal ; ½ N + ½ K at 25 DAS)	58.78	90.28	0.65	45.82
T_5 : 150 : 60 : 40 kg NPK /ha (½ N + ½ K basal ; ½ N + ½ K at 45 DAS)	36.09	122.72	0.29	37.41
T_6 : 150 : 60 : 40 kg NPK /ha (½ N + ½ K basal ; ¼ N + ¼ K at 25 DAS; ¼ N + ¼ K at 45 DAS)	39.05	117.12	0.36	38.50
T_7 : 135 : 65 : 45 kg NPK /ha (½ N + ½ K basal ; ½ N + ½ K at 25 DAS)	77.38	112.32	0.71	51.77
T_8 : 135 : 65 : 45 kg NPK /ha (½ N + ½ K basal ; ½ N + ½ K at 45 DAS)	36.26	132.34	0.28	37.51
T_9 : 135 : 65 : 45 kg NPK /ha (½ N + ½ K basal ; ¼ N + ¼ K at 25 DAS; ¼ N + ¼ K at 45 DAS)	23.47	47.32	0.50	33.09
T10 Control	-	-	-	38.21
CD (P=0.05)	17.27	52.09	0.137	5.109

RESULTS

The yield attributes *viz.*, cob length (11.60 cm), cob girth (5.30 cm) were significantly higher with treatment T_7 (135:65:45 kg NPK /ha ½ N + ½ K basal; ½ N + ½ K at 25 DAS) which was on par (11.33 cm and 5.13 cm cob length and cob girth respectively) with T_4 (150: 60: 40 kg NPK /ha; ½ N + ½ K basal; ½ N + ½ K at 25 DAS). Significantly higher cob weight with husk (84.22 g /plant) was recorded by the treatment T_7 and it was followed by T_4 with a cob weight of 79.58 g/ plant.The treatment T_7 (135: 65: 45 kg NPK /ha; ½ N + ½ K as basal; ½ N + ½ K at 25 DAS) produced significantly larger cobs (in terms of both length and girth), higher cob yield with husk (17162.03 kg /ha) and marketable cob yield (6720.67 kg /ha) and remained at par (15532.66 kg / haand 6177.55 kg /ha cob yield with husk marketable cob yield respectively) with T_4 (150: 60: 40 kg NPK /ha; ½ N + ½ K as basal; ½ N + ½ K at 25 DAS). Significantly higher green stover yield (26203.70 kg /ha) was obtained in T_7 (Table 1).The nutrient schedules tested had significant effect on the nitrogen use efficiency *viz.*, agronomic efficiency (AE), physiological efficiency (PE), apparent recovery efficiency (ARE) and partial factor productivity (PFP) (Table 2). The treatment T_7 (135: 65: 45 kg NPK /ha; ½ N + ½ k as basal; ½ N + ½ K at 25 DAS) recorded significantly high AE for nitrogen (30.95 kg /kg). The significantly higher cob yield recorded in T_7 might have contributed to higher AE. The physiological efficiency (22.90 kg /kg), apparent recovery efficiency (1.36 kg /kg) and partial factor productivity (PFP) of N were also recorded significantly higher in the treatment T7.

CONCLUSION

The study revealed that application of FYM @ 12.5 t /ha along with 135:65:45 kg NPK /ha (½ N + full P + ½ K as basal ; ½ N + ½ K at 25 DAS) was the best nutrient schedule for baby corn hybrid G 5414 intercropped in coconut garden, as it resulted in significantly higher marketable cob yield, nutrient use efficiency and profitability.

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Productivity and economics of Bt cotton as affected by variable rate of N application

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Cotton (*Gossypium* sp.) is a most important fiber and cash crop grown commercially for agricultural and industrial purposes (Smith, 1999). Although cotton is mainly grown for fiber purpose but it has many valuable uses as its seed contain 30% starch, 16.2% protein and 25% oil. In India cotton is one of the major cash crop occupying an area of 12.5 with the production of 0.34 m cotton bale. After the approval of Genetic Engineering Approval Committee (GEAC) in 2003, the area of Bt cotton spread rapidly. At present Bt cotton (11.76 m ha) accounts for more than 90% of total cotton area in India. Nitrogen is essential for photosynthetic activity and it also prevents abscission of squares and bolls thus increase the no of bolls. Nitrogen also stimulates the mobilization and accumulation of photosynthates in newly form bolls, thus it increase the number of bolls and their weight. Additionally, with a crop like cotton, which has indeterminate growth behaviour excess N causes delayed maturity, promote excessive vegetative growth, and usually results in lower seed cotton yields (Rinehardt*et al.,* 2004). Beneficial effect of N was realized only with optimum N dose and it differed with growing conditions based on soil and prevailing environment conditions. Cotton must receive optimum rates of N fertilizer in order to

Table 1. Productivity and profitability of *Bt* cotton as affected by nitrogen levels and timing of its application.

Treatment	Seed cotton yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Net return (Rs/ha)	B C Ratio
Nitrogen levels (kg/ha)					
100	2.11	6.71	31.5	44,892	1.04
125	2.31	7.27	31.8	52,710	1.22
150	2.56	7.80	32.8	62,705	1.44
175	2.65	8.07	32.9	66,275	1.51
CD (P=0.05)	0.040	0.096	0.39	1,644.6	0.038
Time of application					
No basal only 2 splits	2.35	7.33	32.0	54,273	1.25
Basal + 2 splits	2.47	7.59	32.4	59,018	1.36
CD (P=0.05)	0.028	0.068	0.27	1,162.9	0.027
Control vs Rest					
Control	1.39	5.01	27.8	16,304	0.39
Rest	2.41	7.46	32.2	56,645	1.30
CD (P=0.05)	0.043	0.101	0.409	1,744.6	0.040

maximize yields; both under- fertilization and over-fertilization with N can adversely affect the required growth pattern of cotton plants, and thus decrease fibre quality and reduce yield.

METHODOLOGY

The field experiments were conducted during *kharif* seasons of the 2014-15 at the research farm of ICAR- IARI, New Delhi located at 28.35°N latitude and 77.12°E longitude and 228.6 m above mean sea level (MSL). The soil of the experimental site was having sandy loam texture, bulk density of 1.47 g/cm^3, organic carbon of 0.42%, KMnO4 oxidizable N of 178.75 kg/ha, 0.5 N NaHCO3 extractable P of 11.4 kg/ha, 1.0 N NH4OAC exchangeable K of 216.6 kg/ha, pH of 7.6 and EC of 0.33dS/m at the beginning of experiment. The experiment was laid out in factorial randomised block design with four nitrogen rates (100, 125, 150 and 175 kg/ha) and two time of N application (30 kg N/ha as basal and without basal) with four replications. Total 9 treatments are formed by combination of above two factors with an absolute control. Sowing was done manually by dibbling method at a row spacing of 75 cm and plant to plant spacing of 60 cm. Recommended dose of phosphorus (60kg/ha) through single super phosphate and potassium (60 kg/ha) through potassium chloride was applied as basal dose at the time of last preparatory tillage.

RESULTS

The data pertaining to productivity and profitability of Bt cotton are presented in Table 1. A significant increase in the seed cotton yield and biological yield up to 175 kg N/ha was obtained with each increase of 25 kg N/ha. Amongst different levels of N application, 175 kg of N/ha recorded significantly higher seed cotton yield than rest of the treatments. The highest seed cotton yield was recorded with 175 kg N/ha (2.65 t/ha) which is 25.6%, 14.7% and 3.5% more than 100, 125 and 150 kg N/ha respectively. An increase of 5.1% in seed cotton yield was observed in the treatment where 30 kg N/ha was applied as basal dose over the treatment where basal amount of nitrogen was not applied. The highest harvest index (32.9%) was recorded with 175 kg N/ha, which was statistically at par with 150 kg N/ha. The data showed that different levels of N tested differ significantly for net returns of *Bt* cotton. The dose 175 kg/ha N recorded maximum net returns/ha (₹66,275), while the lowest net returns was recorded with 100 kg N/ha (₹44,892). The gross returns and B: C ratio of *Bt* cotton followed the same pattern as net returns and the maximum gross returns and B: C ratio were found with application of 175 kg/ha N. Gross returns, net returns and B: C ratio were highest with application of 175 kg N/ha. The higher yields (seed cotton and stalk) have led to more gross revenue while the additional cost for imposing 175 kg N/ha application was meagre, thus gave highest net returns. Higher net income coupled with small change in cost of cultivation led to higher B: C ratio with 175kg N/ha.

CONCLUSION

Based on present investigation it can be concluded that a significant increase in seed cotton, stalk, biological yields, and net returns of the *Bt* cotton were recorded with increasing rate of N upto 175 kg/ha. These parameters are also significantly better with application of 30 kg N/ha as basal. Thus, the use of 175 kg N/ha with 30kg N/ha as basal dose helps in maximizing the yields and net returns.

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Site-specific nutrient management (SSNM) for maize in plateau of Odisha to improve farmers' productivity and profitability

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Maize is one of the principal cereal crops of global importance which provides approximately 30% of the food calories to more than 4.5 billion people worldwide. In India, it is considered as the third most important food crop among the cereals and contributing nearly 9% in the nationalfood basket (Jat*et al*.,2014).Average maize yield in India is 2.5 t/ha, which is very low mainly because of sub-optimal crop management practices in kharif season.In addition, yields of maize need to be increased to sustain high growth rate to meet India's growing food, feed and industrial needs.In plateau of Odisha in Mayrbhanj district, soils are highly drained, red and lateritic acidic and are highly depleted and therefore, large area remain fallow. Recently, there are increased efforts by Government to promote maize in *kharif* season in the region. The productivity of maize in these areas is very low because of multiple factors including sub-optimal plant population and poor knowledge of nutrient and weed management. In these depleted soil, optimum nutrient management is crucial for achieving maximum economic yield and for long term sustainability.Site-specific nutrient management (SSNM) has potential to increase crop yields and efficiencies of nutrients. Currently in India, the fertilizer recommendations are fixed rate and fixed time for large area. This approach has not taken into account the site specificity e.g. tillage, residue management, indigenous nutrient supplying capacity, crop management, potential yield of the area etc. leading to poor nutrient use efficiencies.Soil test based fertilizer recommendation is one approach of SSNM. Lack of infrastructural facilities has been identified as the primary bottleneck for soil test based fertilization in India. In South Asia, 90 percent of smallholder farmers using fertilizer, lack access to soil testing services, therefore, there is a need of alternative approach of fertilizer recommendation which is simple, science based and easy to out scale. In addition to amount of fertilizers, it is equally important to apply at the right time and in the right locations to enhance productivity and increase crop yields. Under the umbrella of regional initiative "Cereal System Initiative for South Asia (CSISA)" studies were conducted to develop and evaluate ICT-based decision tools such as 'Maize Crop Manager' based on the principles of SSNM to provide location-specific fertilizer recommendations to improve the yield and income of maize growing farmers in Odisha.

METHODOLOGY

To develop decision support tool for site-specific nutrient management in maize, nutrient omission plot technique (NOPT) trials were conducted in red and lateritic acidic soils of North Central Plateau in Mayurbhanj district of Odishaduring *kharif*2013 and 2014. Atotal of 18on-farm trials wereconducted across a diversity of field locations with each location serving as a replication. Treatments included N omission (NPK; 0:70:120), P omission (NPK; 150: 0:120), K omission (NPK; 150:70:0) to estimate nutrient limited yield, and a fully fertilized treatments with no limitation of NPK fertilizer (NPK; 150:70:120) to estimate attainable yield. In addition, a farmers fertilizer practice treatment (NPK; 80:40:40), state recommendation (NPK; 120:60:60), and fertilizer based on two decision support tools (Nutrient Expert and Maize Crop Manager) for SSNM in maize were also included for comparison. In these omission plots, recommended micronutrients, S and lime were also added. DKC 9133 hybrid has been used with a spacing of 60 x 20 cm, seed rate of 20 kg/ha and plot size was 100 m^2. Recommended improved agronomic practices were followed and yield data were taken at harvest at 15% moisture level.

RESULTS

The average of 18 NOPT trials revealed 4660, 4980, and 1140 kg/ha response of N, P and K, respectively over yields achieved with indigenous sources of each nutrient only, which suggest that these red and lateritic soils are highly degraded (Fig. 1). Yield responses to fertilizer application across the region followed the order P>N>K.Decision support tools on nutrient management increased maize yield from 3665 kg/ha to 5385-6060 kg/ha with additional investment in nutrients for harnessing full potential of hybrids. This indicate yield advan-

Table 1. Evaluation of decision support tools (Nutrient Expert® and Maize Crop Manager) for SSNM over farmers' practice and state fertilizer recommendation (2 yrs. average; N=18).

Treatments*	Yield	Ä in yield over FP	N	P_2O_5	K_20
	kg/ha				
Farmers' Practice	3665	0	80	40	40
State Recommendation	4720	1055	120	60	60
Nutrient Expert®	5385	1720	140	51	76
Maize Crop Manager	6060	2395	160	100	80

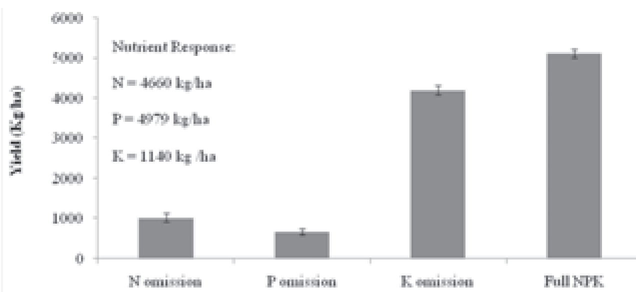

Fig. 1. Maize yield under N, P, K omission and full NPK (2 yrs. Average of 18 on farm trials)

tage of 1720-2395 kg/ha over current farmers' practice and 665-1340 kg/ha over state recommendation (Table 1). These results showed that site specific nutrient recommendation and proper time of nutrient application are the two key factors for achieving higher yield and profit through better nutrient use efficiency. It also indicated that specific nutrient management technology through decision support tools may appear as an effective alternate option to soil test based recommendation. These results demonstrate the depleted conditions of the soils in the plateau of Odisha, but also dispel the myth that these soils do not respond to fertilizer inputs. Phosphorous nutrition is commensurately important to nitrogen in these ecologies.

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Drymatter production and seed yield of dhaincha as influenced by time of sowing and phosphorus fertilization

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India has changed from a region of food scarcity to food surplus due to increased fertilizer consumption in the recent past. But, late escalating prices and non availability of sufficient quantity of chemical fertilizers had forced the farming community to identify alternate sources to meet crop nutrient requirements. Further, the interest towards green manure crops has been renewed with the growing emphasis on sustained soil productivity though organics. Dhaincha [*Sesbania aculeata* (wills.) poir] is the most important crop for green manuring *in-situ* in India due to its ease of establishment, fast growth and accumulation of huge biomass within a short period. But availability of adequate quantity of quality seed in the market is the most significant agronomic constraint limiting the dhaincha green manuring. The availability of seed in the market depends on its multiplication but the farmers are perplexed regarding the optimum time of sowing and nutrient management particularly the phosphorus. Keeping the above deficiencies in the current state of information, the present study was conducted to identify the optimum time of sowing and dose of phosphorus for higher seed yield of Dhaincha in Southern Agro-Climatic Zone of Andhra Pradesh, which falls under Semi-Arid Tropics according to Troll's classification.

METHODOLOGY

The field experiment was conducted during *rabi*, 2013 at S.V Agricultural College, Tirupati, campus of Acharya N.G. Ranga Agricultural University Andhra Pradesh, to identify the optimum sowing time and dose of phosphorus for seed production in Dhaincha. The experiment was laid out in Randomized Block Design with factorial concept and replicated thrice. The soil of the experimental field was sandy loam, neutral in reaction, low in organic carbon, available nitrogen and phosphorus and medium in available potassium. The treatments comprised of four times of sowing *viz*., S_1 - Second fortnight of October, S_2 - First fortnight of November, S_3 - Second fortnight of November and S_4 - First fortnight of December and four levels of phosphorus application *viz.,* P_1 - control, P_2 -15 kg P_2O_5/ha, P_3-30 kg P_2O_5/ha and P_4- 45 kg P_2O_5/ha. Uniform dose of 20 kg N and 30 kg K_2O ha through urea and muriate of potash were applied respectively as basal for all the treatments. Phosphorus was applied as per the treatments in the form of single super phosphate at the time of sowing. For dry matter production the plant samples were dried till to a constant weight. Seed yield obtained from each net plot area was sun dried, cleaned thoroughly, weighed and expressed as kg/ha.

RESULTS

The dry matter production of Dhaincha at harvest was significantly influenced by time of sowing and phosphorus fertilization and their interaction (Table 1). Among the different dates of sowing, the highest dry matter production in dhaincha was obtained in the crop sown during first fortnight of November, which was significantly superior to the rest of the sowing dates. Increase in the drymatter production with first fortnight of November compared to rest of the sowing dates is mainly attributed to the exposure of important phenophases of the crop to favorable weather conditions thereby higher drymatter accumulation. The lower dry matter production recorded with October second fortnight might be due to excess rainfall i.e. 163 mm of rain received in 9 rainy days immediately after sowing of the crop growth leading to leaching of nutrients in the light soils. Drymatter production in dhaincha increased with each successive increase of 15 kg P/ha from 0 to 45 kg/ha. The increase in drymatter production was probably due to result of better availability phosphorus to the plants, which plays a significant role in the formation of energy rich phosphate bonds like and Adenosine di phosphate (ADP) and adenosine tri phosphate (ATP). Regarding interaction sowing of dhaincha during first fortnight of November with application of 45 kg P_2O_5/ha has recorded significantly higher drymatter production, while it was the lowest with first fortnight of December with non application of phosphorus. The seed yield of *dhaincha* was significantly influenced by time of sowing, phosphorus application and their interaction (Table 2). The highest seed yield (583 kg/ha) was recorded with sowing of dhaincha during first fortnight of November, which was significantly superior to either early or later two sowings. Dhaincha sown during first fortnight of November recorded 39.1, 46.1 and 91 per cent higher seed yield over October second fortnight or November and first fortnight of December respectively. Significantly higher seed yield with first fortnight of November over early or delayed sowing dates might be due to partitioning of higher proportion of its total drymatter into the reproductive parts (seed) of the plant. Significantly the lowest seed yield (305 kg/ha) of dhaincha was recorded with first fortnight of December. The reduction in seed yield with delayed sowing could also be attributed to the shorter growing period and time available at the disposal of late sown crop is also limited. The highest seed yield (560 kg/ha) of dhaincha was recorded with application of 45 kg P_2O_5/ha, with a significant disparity between any two of the four levels of phosphorus tried. The seed yield of dhaincha was increased by 14.1, 19.8 and 25.3% with application of 15, 30 and 45 kg P_2O_5/ha over control, 15 kg P_2O_5 and 30 kg P_2O_5/ha. With respect to interaction, sowing of Dhaincha

Table 1. Dry matter production (kg/ha) of dhaincha as influenced by time of sowing and phosphorus fertilization at harvest

Time of sowing	Phosphorus levels (P_2O_2 kg/ha)				
	P_1: 0	P_2:15	P_3:30	P_4:45	Mean
S_1: Second fortnight of October	4711	4804	5138	5418	5018
S_2 : First fortnight of November	4691	5574	6354	7384	6001
S_3 : Second fortnight of November	4212	4326	4711	4898	4537
S_4: First fortnight of December	2434	2683	3689	4594	3650
Mean	4012	4347	4973	5574	
	SEm ±	CD (P=0.05)			
Time of sowing	26.54	76			
Phosphorus levels	26.54	76			
Interaction	53.07	15			

Table 2. Interaction effect of time sowing and phosphorus levels on seed yield (kg/ha) of Dhaincha

Time of sowing	Phosphorus levels (P_2O_2 kg/ha)				
	P_1: 0	P_2:15	P_3:30	P_4:45	Mean
S_1: Second fortnight of October	329	349	464	535	419
S_2 : First fortnight of November	456	507	617	751	583
S_3 : Second fortnight of November	319	370	407	498	399
S_4: First fortnight of December	204	264	297	454	305
Mean	327	373	447	560	
	SEm ±	CD (P=0.05)			
Time of sowing	4.9	14			
Phosphorus levels	4.9	14			
Interaction	9.8	28			

during first fortnight of November with application of 45 kg P_2O_5/ha has recorded the highest seed yield of Dhaincha, which was significantly superior over the rest of the treatment combinations.

CONCLUSION

From the study it can be concluded that sowing of Dhaincha during first fortnight of November with application of 45 kg P_2O_5/ha has resulted in higher seed during *rabi* in the Southern Agro Climatic Zone of Andhra Pradesh.

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Evaluation of sulphur coated urea in transplanted puddled rice (*Oryza sativa*)

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Sulphur coated urea (SCU) was first developed by Tennessee Valley Authority (TVA) researchers for controlled release of nitrogen and is a popular turf fertilizer in USA. It is currently manufactured by a number of companies in USA, Canada, Japan and China using different techniques and sulphur (S) content may vary from 4 to 15% or more. SCU has also been widely tested for rice, where nitrogen use efficiency is fairly low (Prasad 2013). In an international study conducted by the International Rice Research Institute, Philippines in Asia under International Soil Fertility and Fertilizer Evaluation for Rice (INSFER), 22-25% less SCU was required to produce same rice yield as urea (Flinn *et al*., 1984). In the rice-wheat cropping system at New Delhi, SCU recorded 15.6% increase in grain yield over urea (Prasad *et al*. 2013). No reports are available on SCU as a source of S. In India, continued use of high analysis fertilizers such as diammoniumphosphate in place of ordinary superphosphate and urea in place of ammonium sulfate over years, has considerably decreased sulphur application to crop fields, which has led to widespread sulfur deficiency in Indian soils. SCU therefore holds promise as a slow release N fertilizer as well as a source of S.

METHODOLOGY

A field experiment was conducted at the research farm of the Indian Agricultural Research Institute, New Delhi, India ($28^0$38'N, $77^0$10'E, 228.6m above mean sea level) during the rainy (June–October) season of 2013 on a sandy clay-loam soil (Typic Ustochrept). The mean annual rainfall of New Delhi is 650mm and more than 80% generally occurs during the south-west monsoon season (July-September). The mean annual evaporation is 850 mm. The soil of the experimental field had 147.3 kg/ha alkaline permanganate oxidizable nitrogen N, 13.7 kg/ha available phosphorus, 283.1 kg/ha 1 N ammonium acetate exchangeable potassium and 0.53% organic carbon. The pH of soil was 8.2 (1:2.5 soil and water ratio) and sulphate sulfur extracted with 0.15% $CaCl_2.2H_2O$ and the soluble sulphate estimated turbidimetrically was 10 mg/kg of soil (Chesnin and Yien, 1950). Seven fertilizers treatments viz. absolute control, prilled urea, 1.0%, 2.0%, 3.0%, 4.0% and 5.0% sulfur-coated urea, made in our laboratory, were laid out in a randomized block design with three replications. The experimental field was disk-ploughed twice and levelled. Phosphorus and potassium @ 26.2 kg P/ha as single super phosphate and 33.3 kg K/ha as muriate of potash was broadcast at final puddling and incorporated in soil. Nitrogen at the rate of 130 kg N/ha as urea or sulfur-coated urea was applied in two equal splits; half 7 days after transplanting (DAT) and the other half at maximum tillering (45 DAS). The amount of sulfur applied was 3.14, 6.28, 9.42, 12.56 and 15.70 kg/ha with 1, 2, 3, 4 and 5% SCU, respectively. Rice variety grown was 'Pusa Sugandh 5', which is a high yielding Basmati variety.At harvest, samples of rice grain and straw were collected from each plot and analyzed for nitrogen & sulphur concentration. Data were analyzed using the F-test. Least significant difference (LSD) values at $P = 0.05$ were used to determine the significance of differences between treatment means.

RESULTS

This paper focuses on response to sulphur coated urea as a source of S. Leaf area index recorded after 40 and 60 days after transplanting was significantly influenced with sulphur coated urea. The highest LAI at both the stages was recorded with 5% sulphur coated urea which was significantly superior to prilled urea at both the stages. Sulphur coated urea significantly increased plant height, panicle length, effective tillers/ hill, filled grains/panicle and grain weight/panicle. However, 1,000-grain weight was not influenced significantly due to sulphur coated urea application. The highest values of all the yield attributes were recorded with 5% sulphur coated urea which were significantly superior to prilled urea. An application of 2% SCU was at par with 3% SCU produced significantly higher grain and straw compared to prilled urea, however, the highest grain and straw yield of rice was recorded with 5% sulphur coated urea which was 25% more compared to prilled urea. Similarly straw and biological yields were also significantly influenced due to sulphur coated urea. Nitrogen and sulphur content in grain and straw of rice: Sulphur coated urea application significantly increased nitrogen and sulphur concentration in rice grain and straw. The highest nitrogen concentration in grain i.e., 1.39% was recorded with 5% SCU, which was 9.4% higher than prilled urea. Sulphur content in rice grain and straw was higher with SCU over prilled urea and varied from 0.47% to 0.55% in grain and that in straw from 0.30% to 0.34% with different levels of S coating. The highest values of S concentration in grain and straw were recorded with 5% sulphur coated urea and the lowest with absolute control and prilled urea.The cost of cultivation of different treatments under study varied from 64,354 to 64,758 INR/ha as influenced by sulphur coated urea. The highest gross return was recorded with 5% sulphur coated urea and was 25% higher than that with prilled urea. Similarly, the highest net return was recorded INR 91,137/ha with 5% sulphur coated urea, which was 50.5% higher than that with prilled urea. The maximum benefit: cost ratio of 1.41 was also realized with 5% sulphur coated urea and was significantly superior to that obtained with prilled urea and 1% SCU.

CONCLUSION

For higher productivity and net returns from the transplanted puddled rice, application of 5% SCU is a good source of N and S.

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Performance of soybean varieties on different nutrient management practices

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Soybean (*Glycine max* L. Merrill) is known as "Golden Bean" of the 21^{st} century. Balanced and timely nutrient management practices applied for soybean contributes to sustainable growth of yield and quality, influences plant health and reduces environmental risk (Shinde *et al.,* 2015). In the present study efforts were made to assess the performance of different promising newly released soybean varieties and different nutrient management combinations to increase yield potential of *kharif* soybean, for this purpose experiment was conducted on "Performance of soybean varieties on different nutrient management practices" during 2015, with following objectives (1) To study the effect of different nutrient management practices in growth and yield of soybean. (2) To study the economics of soybean.

METHODOLOGY

The field experiment was conducted at Instructional Farm of Post Graduate Institute, MPKV, Rahuri, (19° 48' N latitude and 74° 32' E longitude and 495 meter above mean sea level), in factorial randomized block design with three replications during *Kharif* season of 2015. The available nitrogen, phosphorus and potassium were 144.57, 17.24, 388.20 kg/ha and Moderate in organic carbon, pH and EC were 0.47%, 7.72 and 0.25 dS/ m of soil, respectively. The main plot treatment consists of three varieties *viz.*,V_1: KDS-344,V_2: JS-9305 and V_3: KS-103 and five nutrient management practices *viz.,* N_1: GRDF (50:75:00 N, P_2O_5, K_2O kg/ha+ 5tons FYM/ ha), N_2: 75% GRDF (37.5:56.25:00 N, P_2O_5, K_2O kg/ha + 3.75 tons FYM/ha) + 0.5% foliar spray of grade IInd at 30 and 45 DAS,N_3: 100% GRDF (50:75:00 N, P_2O_5, K_2O kg/ha + 5tons FYM/ ha) + 0.5% foliar spray of grade IInd at 30 and 45 DAS, N_4: 125% GRDF (62.5:93.75:00 + 6.25 kg/ha+ 6.25 tons FYM/ ha) + 0.5% foliar spray of grade IInd at 30 and 45 DAS and N_5: 50:75:30 N, P_2O_5, K_2O+ 5tons FYM/ha. The crop soybean was dibbled at 30 cm x 10 cm in Ist week of July and harvested at Ist to IIIrd week of october. Common treatments of *Rhizobium* and *PSB* were given at time of sowing and 0.5% foliar spray of grade IInd micronutrient (Fe - 2.5%, Zn- 3.0%, Mn-1.0%, Cu-1.0%, Mo-0.1% and Bo-0.5%) at 30 DAS and 45 DAS of soybean.

RESULTS

The grain yield of soybean variety KDS-344 was recorded

Table 1. Growth and yield of soybean as influenced by different treatments at harvest

Treatment	Number of nodules at 50% flowering	Weight of seeds/plant (g)	Grain yield (t/ha)	Net returns (Rs/ha)	B:C Ratio
Varieties					
V_1	23.11	11.92	3.66	87355	3.17
V_2	21.06	10.23	3.20	71679	2.82
V_3	22.39	10.98	3.41	78102	2.94
SEm ±	0.45	0.12	0.05	1730	—
CD (P=0.05)	1.29	0.35	0.14	5013	—
Nutrient management					
N_1	21.88	10.86	3.35	77079	2.45
N_2	21.63	10.85	3.45	82786	2.49
N_3	22.59	11.12	3.48	80380	2.51
N_4	23.62	11.31	3.58	80597	2.58
N_5	21.20	11.06	3.25	74386	2.30
SEm ±	0.58	0.04	0.06	2234	—
CD (P=0.05)	1.67	0.15	0.18	N.S.	—

significantly higher than variety KS-103 and JS-9305 (Table 1). Similarly, growth and yield attributes *viz.,* plant height (cm), number of branches, number of root nodules/plant, number of pod/plant and weight of seeds/plant were recorded maximum as compared to rest of all the treatments. The grain yield of soybean was significantly higher by application of fertilizer dose of 125% GRDF + 0.5% Grade IInd foliar spray at 30 and 45 DAS recorded significantly higher than GRDF and 50:75:30 N:P_2O_5: K_2O kg/ha + 5 tons FYM/ha, however, it is at par with 75% GRDF + 0.5 Grade IInd foliar spray at 30 and 45 DAS and 100% GRDF + 0.5% Grade IInd foliar spray at 30 and 45 DAS. The fertilizer dose of 75% GRDF + 0.5 Grade IInd foliar spray at 30 and 45 DAS was also beneficial treatment for increase of fertilizer use efficiency. Similarly, growth and yield attributes *viz.,* plant height (cm), number of branches, number of root nodules plant, number of pod/plant, weight of seeds/plant were maximum as compared to rest of all the treatments. The variety KDS-344 with application of 125% GRDF (62.5:93.75:00 N: P_2O_5: K_2O kg/ha + 6.25 tons FYM/ha) + 0.5% Grade IInd foliar spray at 30 and 45 DAS recorded significantly maximum yield of soybean but at par with 75% GRDF (37.5:56.25:00 N, P_2O_5, K_2O kg/ha +3.75 tons FYM/ha) +0.5 Grade IInd foliar spray of micronutrient at 30 and 45 DAS.

CONCLUSION

It can be concluded that the optimum yield of soybean was achieved by the variety KDS-344 with application of 75% GRDF (37.5:56.25:00 N, P_2O_5, K_2O kg/ha + 3.75 tons FYM/ ha) + 0.5% Grade IInd foliar spray of micronutrient at 30 and 45 DAS.

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SSNM for yield maximization in sugarcane

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Sugar is the main house hold essential commodity of India. At National level Uttar Pradesh contributing 28 percent in sugar production from 47 per cent cropped area. Karnataka's sugarcane production during 2012 is likely to decline by 10 per cent to 30 million tonnes. The state's production of sugarcane touched 33.4 million tonnes. Sugarcane is largely grown in the districts of Belgaum, Bagalkot, Bidar, Mandya, Gulbarga and Bijapur. For the current year, the cane planting has been done in about 500,000 hectares across the state. The Productivity of sugarcane is low mainly due to use of imbalance fertilizers. Despite having higher fertilizer inputs than most of the surrounding states (excluding Andhra Pradesh), nutrient application rates can be considered low and imbalanced with total nitrogen (N), phosphorus (P), and potassium (K). Besides NPK deficiencies, emerging secondary and micronutrient deficiencies also provide significant constraints to high yields in Karnataka. Little to no consideration is given to anything beyond the basic NPK needs of sugarcane and it is apparent that the potential of its production systems is largely being overlooked. Keeping the above aspects in the mind, the present research is put forth with the site specific nutrient management (SSNM) techniques on the basis of target yield and is only the way to increase production potential yield of sugarcane.

METHODOLOGY

An experiment was conducted during *Rabi* 2013 and 2014 on SSNM for yield maximization in sugarcane under Tunga Bhadra Project area at Agricultural Research Station, Dhadesugur, University of Agricultural Sciences, Raichur, Karnataka, India. The soil of the experimental site was deep black and neutral in pH (8.04), EC (0.47 ds/m), medium in organic carbon content (0.41 %), low in nitrogen (189 kg/ha), medium in phosphorus (58.5 kg/ha) and potassium (287.5 kg/ha). The total actual rainfall received during *Rabi 2013* and 2014 was 472.0 and 339.0 mm, respectively. It was not good as compared to the average normal rainfall received over the last thirty years. The experiment was laid out in a split plot design with combinations which forms eight treatments (two factors *viz*., varieties (2003-V-46 and Co-86032) and SSNM practices (T_1: RDF (250:75:190 kg NPK/ha, T_2: SSNM with the Target yield of 150 t/ha, T_3: SSNM with the Target yield of 200 t/ha and T_4: SSNM with the Target yield of 250 t/ha) and replicated thrice. The crop was planted in fortnight of November month during both the years. Fetilizers (Urea, DAP and MOP) were applied as per the SSNM practices and principles. The overall pest and disease incidence was least during cropping seasons. Five plants were randomly selected in each plot of each replication and were tagged for the purpose of recording the observations *viz*., Length of millable cane (cm), Millable cane yield (t/ha) and Green top yield (t/ha). Similarly, Sugarcane from each net plot in each replication was harvested and weighed and recorded as millable cane yield per net plot. Further, this net plot millable cane yield was converted to millable cane yield per hectare.

Table 1. Yield parameters of sugarcane varieties as influenced by SSNM (Pooled data)

Treatment	Length of millable cane (cm)	Millable cane yield (t/ha)	Green top yield (t/ha)
Variety			
V_1	259	161	16.5
V_2	241	158	15.6
CD (P=0.05)	16.9	NS	NS
SSNM			
T_1	248	157	15.7
T_2	229	124	12.6
T_3	259	172	17.2
T_4	266	186	18.8
CD (P=0.05)	23.9	17.1	1.99
Interaction			
V_1T_1	244	160	16.2
V_1T_2	232	123	12.8
V_1T_3	270	174	17.7
V_1T_4	292	188	19.5
V_2T_1	252	154	15.2
V_2T_2	225	124	12.4
V_2T_3	247	169	16.7
V_2T_4	240	185	18.2
CD (P=0.05)	33.8	24.2	2.81

V_1, Co-86032; V_2, 2003-V-46; T_1, RDF (250:75:190 kg NPK/ha); T_2, SSNM with the Target yield of 150 t/ha; T_3, SSNM with the Target yield of 200 t/ha; T_4, SSNM with the Target yield of 250 t/ha.

RESULTS

The pooled data on yield parameters of sugarcane varieties as influenced by the site specific nutrient management practices are presented in Table 1. Results are revealed that, between two varieties, there was no significant difference with respect to millable cane and green top yield. Among Site Specific Nurient Management (SSNM) practices, application of fertilizer as per the SSNM with the target yield of 250 t/ha recorded significantly higher millable cane yield (186 t/ha) and green top yield (18.8 t/ha) and which was onpar with the application of fertilizer as per the SSNM with the target yield of 200 t/ha (172 and 17.2 t/ha, respectively) compared to other SSNM treatments. Whereas, variety Co-86032 + application of fertilizer as per the SSNM with the target yield of 250 t/ha recorded significantly higher millable cane yield (188 t/ha) and green top yield (19.5 t/ha) and which was on par with the variety 2003-V-46 + application of fertilizer as per the SSNM with the target yield of 250 t/ha (185 and 18.2 t/ha, respectively).

CONCLUSION

Results indicated that, between two varieties, there was no significant difference in the millable cane yield. Either, 2003-V-46 or Co-86032 were best for higher yield under SSNM practices. Further, Application of fertilizer as per the site specific nutrient management with the target yield of 200 or 250 t/ha were increased maximum millable cane yield in sugarcane.

Symposium 8

Conservation Agriculture and Smart Mechanization

Extended Summaries Vol. 2 : 4th International Agronomy Congress, Nov. 22–26, 2016, New Delhi, India

Conservation agriculture and cropping system diversification for improving yield, profit and input use efficiency of intensive cereal based rotations in NW India

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In North-West (NW) India, rising concerns related to overexploitation of groundwater resources, soil quality deterioration, increasing cultivation cost, scarcity of labour and energy, poor management of crop residues coupled with climate change induced weather risks are major factors for non-sustainability of intensive cereal systems. Conservation agriculture (CA) based management practices and resource use efficient diversified cropping systems are developed and promoted as solutions to these challenges. Maize being a water use efficient crop (require 10% of the irrigation water than that of rice) is one of the potential candidate crop for diversification to happen in NW India. Reduced pumping of fresh groundwater has direct bearing on the salinity in the upper soil profile as it doesn't allow to build-up salt in upper soil profile and salinity increases with water table depth. The experiment was therefore initiated to explore the scope in terms of system productivity, profitability and resource use and implications (in terms of dynamics of salinity) of diversifying rice with maize on reclaimed sodic soils of NW India.

METHODOLOGY

A field experiment was carried out during 2014-15 to 2015-16 at ICAR-CSSRI, Karnal under CSISA (Cereal Systems Initiative for South Asia). The trial consisted of seven combinations of tillage, residue and cropping systems comprised of i) puddled transplanted rice followed by (fb) conventional till wheat (PTR-CTW); ii) Conventional till dry drill seeded rice fb Zero till wheat (CTDSR-ZTW); iii) Zero till dry drill seeded rice fb ZT-wheat (ZTDSR-ZTW) with full residue of rice and anchored residue of wheat; iv) Maize on fresh bed fb CT-wheat (FBM-CTW); v) Maize-wheat on permanent beds with 65 % maize and anchored wheat residue retention (PBM-PBW); vi) Maize-wheat on ZT flat with 65 % maize and anchored wheat residue retention (ZTM-ZTW); vii) Maize-wheat-mungbean on ZT flat with 65 % maize and anchored wheat residue retention (ZTM-ZTW-ZTMb). Experiment was conducted in randomized complete block design with three replications in large size plots of 550 m^2. Best

Table 1. Effect of tillage, crop establishment, cropping system and residue management on yield, water use and system net return (two year pooled mean)

Treatments	Grain yield (t/ha)			Irrigation water use (cm/ha)			System net return (1×10^3 Rs/ha/yr)
	Rice/maize	Wheat	System	Rice/maize	Wheat	System	
PTR-CTW	6.19^{ab}	5.26^{a}	11.46^{ab}	187.18^{a}	46.21^{a}	233.39^{a}	92.1^{b}
CTDSR-ZTW	6.98^{a}	5.64^{a}	12.62^{a}	146.61^{b}	44.09^{ab}	190.70^{b}	120.9^{a}
ZTDSR-ZTW	6.86^{ab}	5.35^{a}	12.22^{ab}	144.61^{b}	43.79^{ab}	188.39^{b}	117.0^{a}
FBM-CTW	5.91^{b}	5.04^{a}	10.95^{b}	30.45^{c}	43.18^{ab}	73.64^{c}	100.1^{b}
PBM-PBW	6.05^{ab}	5.44^{a}	11.49^{ab}	29.24^{c}	39.24^{b}	68.48^{c}	119.1^{a}
ZTM-ZTW	6.12^{ab}	5.32^{a}	11.45^{ab}	37.27^{c}	43.48^{ab}	80.76^{c}	115.3^{a}
ZTM-ZTW-ZTMb	6.42^{ab}	5.46^{a}	11.88^{ab}	35.76^{c}	44.70^{a}	80.45^{c}	123.1^{a}

[†]Means followed by a similar lowercase letters within a column are not significantly different (P=0.05).

agronomic management practices were followed and standard methods were practiced in collection of data on crop parameters.

RESULTS

In rice based systems, highest rice yield (6.98 t/ha) was recorded with CTDSR-ZTW as compared to other treatments. However, in maize based systems, highest maize yield (6.42 t/ha) was recorded with ZTM-ZTW-ZTMb. The highest wheat yield (5.64 t/ha) was recorded in the plots of CTDSR-ZTW followed by ZTM-ZTW-ZTMb (5.46 t/ha). Highest system yield (wheat equivalent) was recorded with CTDSR-ZTW which was comparable with ZTDSR-ZTW, ZTM-ZTW-ZTMb, PBM-PBW, PTR-CTW and ZTM-ZTW and significantly higher than FBM-CTW. Yadav *et al.* (2011) and Gathala *et al.*(2011) also reported similar findings in rice (DSR) based system. Water saving were recorded to the tune of 22-23% and over 80%, respectively in DSR and maize compared to PTR. While, wheat on permanent bed (PB) saved 15% of irrigation water. DSR and maize based systems saved 18-19 % and 65-71% irrigation water on system basis compared to farmers practice (TPR-CTW). CA based management of rice/maize systems recorded higher net returns compared to conventional management of respective crops. In treatment CTDSR-ZTW and ZTDSR-ZTW, 31 and 27 % higher net return was obtained than PTR-CTW. Net returns were in order of FBM-CTW (9%), PBM-PBW (29%), ZTM-ZTW (25%) and ZTM-ZTW-ZTMb (34 %) over PTR-CTW. ZT reduces the cost of production and also improved wheat yield which resulted in higher net returns. Similar finding were also reported by Jat*et al.* (2013). Data recorded on salinity under different treatments revealed that there were no movement of salts from lower layer to upper layers. Secondary salinization in maize based system didn't appear in the first two year of experimentation as EC and pH were almost same in all the treatments. Therefore, replacement of rice with maize is feasible in the reclaimed salt affected soils of NW India.

CONCLUSION

Conservation agriculture based maize-wheat system was found more remunerative and as potential alternative to input intensive rice-wheat system in NW India. CA based management practices provides opportunity of increasing crop productivity while saving precious water and improve farmers' profits. DSR followed by ZT wheat produced highest system yield (12.62 Mg/ha) and net returns (Rs. 1,20,900/ha) in case of rice based system while ZTM-ZTW-ZTMb produced highest system yield (11.88 Mg/ha) and net returns (Rs. 1,23,100/ha) in case of maize based systems.

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Simulation of evapotranspiration, grain and biomass yield and water use efficiency in wheat under different tillage, residue and nitrogen regimes

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Acquisition and analysis of experiment generated data pertaining to optimization of crop production without degrading soil quality and minimization of environmental pollution is a challenging task for the researchers (Pang *et al.*, 1997). This challenge can be addressed by studying the complex interactions between soil, plant and its atmosphere at variable management practices. As experimental methods are time-consuming, costly, labour intensive and require numerous trials, the crop simulation models serve as a better alternative to generate efficient scenarios for use of inputs viz. tillage, irrigation and nutrients. Crop simulation models need a minimum data set of soil, weather, genetic information of cultivars and crop management for their operation. The Decision Support System for Agro-technology Transfer (DSSAT) is an assemblage of various models which links the decision support system with crop simulation models (Ngwira *et al.*, 2014). DSSAT 4.6 ver. has unique algorithm to simulate the influence of tillage practices along with water and nutrient management on 16 different crops (Hoogenboom *et al.*, 2014). Wheat is the second most important crop after rice in India and sustainable intensification of wheat production can be achieved through optimization of input use. Keeping this in view, the present study was undertaken to calibrate and validate DSSAT crop model for simulation of evapotranspiration, grain and biomass yield besides water use efficiency of wheat under conventional and no-tillage system in the presence and absence of residueswith three different levels of Nitrogen.

METHODOLOGY

A field experiment was conducted on wheat cultivar HD2967 in a sandy loam soil during *rabi*season of 2014-15 and 2015-16 at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi. Different treatments comprising of two levels of tillage as main plot factor (Conventional tillage (CT) and No Tillage (NT)), two levels of residue as sub-plot factors (Maize residue @ 5t/ha (R_+) and without residue (R_0), and three levels of Nitrogen as sub-sub plot factors (60, 120 and 180 kg N/ha, representing 50%, 100% and 150% of recommended dose of Nitrogen, respectively) were evaluated in a split-split plot design with three replications. Water balance method was used for the determination of evapotranspiration by the wheat crop. Weather, crop, soil and management data was provided as the input to DSSAT 4.6 model. Modified Penman-Monteith method was used by model for computation of potential evapotranspiration. The model was calibrated with the field experiment data on wheat for the year 2014-15. The genetic coefficients were estimated using Generalized Likelihood Unbiased Estimator (GLUE) until the mean growth and grain yield were simulated within 10% of the measured values. The model was validated for prediction of grain and biomass yield, evapotranspiration and water use efficiency of wheat under different tillage, residue and nitrogen management for the year 2015-16. The simulated data were compared with the independent data sets from the field experiment data for the year 2015-16 using different statistical approaches viz. prediction error (PE), coefficient of determination (R^2), root mean square error (RMSE), normalized root mean square error (nRMSE) coefficient of residual mass (CRM) and index of agreement (d index).

RESULTS

The results indicated that the grain and biomass yield were not significantly influenced by the tillage and residue management but both grain and biomass yield increased significantly with the increase in Nitrogen application. Tillage treatments did not affect the evapotranspiration and water use efficiency significantly, but there was low evapotranspiration and thus, significantly higher water use efficiency under crop residue mulch treatment(17.99 kg/ha-mm) as compared to non-mulched treatment (11.91 kg/ha-mm). Evapotranspiration increased significantly with increase in Nitrogen levels, but water use efficiency increased significantly upto 120 kg N/ha. This could be attributable to the fact that yield increase was not in proportion to the crop evapotranspiration, which in turn decreased the water use efficiency at 180 kg N/ha. The DSSAT 4.6 model could satisfactorily simulate the grain yield, evapotranspiration and water use efficiency,but underestimates the above ground crop biomass yield. The statistical summary showed that the model could account for 75.6% variation in the grain yield of wheat and the negative value of CRMindicates that the model overestimated the grain yield of wheat (Table 1). However, the model underestimated the biomass yield of wheat and could account for 47.3% variation in the observed biomass yield. The model could account for 98.8 and 81.8% variation in the observed evapotranspiration and water use efficiency of wheat, respectively.

CONCLUSION

It can be concluded that the CERES-Wheat module of DSSAT was able to simulate the grain yield, biomass yield,evapotranspiration and water use efficiency of wheat under different tillage, residue and nitrogen management practices with acceptable accuracy. However, the predictability of the crop model can be further improved by recalibration of

Table 1. Statistical summary comparing observed data with simulated values for wheat crop grown under different tillage, residue and nitrogen regime during validation of DSSAT 4.6 wheat simulation model

Parameter	PE	R^2	RMSE	nRMSE	CRM	D index
Grain yield (kg/ha)	21.0	0.756	698.5	22.1	-0.210	0.96
Biomass yield (kg/ha)	-16.5	0.473	2111.3	19.6	0.165	0.96
ET (mm)	26.9	0.988	62.89	28.7	-0.269	0.97
WUE (kg/ha-mm)	-7.7	0.818	2.517	16.8	0.077	0.98

genetic coefficients. The DSSAT 4.6crop model validated for wheat in this study can be used to simulate the yield and water use efficiency of wheat under different input management scenario, which will help in taking critical decisions with respect to efficient use of inputs for sustainable intensification of wheat production.

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Tillage and nutrient management in wheat at different row spacing under rice-wheat cropping system

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Rice and wheat in sequence are cultivated in two contrasting soil environments- rice requires soft, puddled and water saturated soil conditions, while wheat requires well aggregated and well aerated soil with fine tilth. Puddling creates soil conditions ideal for rice cultivation, but unsuitable for succeeding upland crops *viz*. wheat. After rice harvest, puddled soils, upon drying shrink, become compact and hard, which increases penetration resistance against the root growth in soil, causing less nutrient and water availability, retarded growth and ultimate reduction in yield.

METHODOLOGY

To overcome this issue in rice-wheat cropping system with improving growth and yield of both the crops in lowland rice-wheat cropping system an experiment was conducted in Norman E. Borlaug Crop Research Centre, GB Pant University of Agriculture and Technology, Pantnagar for three consecutive years during 2012-13 to 14-15 in strip plot design with three replications. Vertical strips were contained six combinations of three tillage treatments [*viz.* no chiseling followed by conventional tillage (CT) which included two times disc harrow operation, chiseling followed by CT and chiseling followed by rotary tillage (RT)] and two row spacing of 20 and 15 cm. Three nutrient management treatments were applied in horizontal strips *viz*. recommended dose of fertilizer (RDF) i.e. 15:60:40 kg NPK/ha, RDF+ FYM @ 15t/ha and 125% RDF+ FYM. All the agronomic practices of sowing with 100 kg/ha seed rate, irrigation management, weed control, plant protection measures, etc, were followed in same way for all the treatments.

RESULTS

Three years pooled analysis data in Table 1 reveals that chiseling was responsible for significantly increase in various growth and yield characters of wheat. Chiseling followed by conventional tillage produced taller plants, higher dry matter, yield/ha with superiority of yield attributing characters; however all these characters were found to be at par in chiseling combination with conventional tillage and rotary tillage at different row spacing. Deeper tillage can break plow pan layer after puddle rice which results into the increase root depth, improve infiltration and water storage along with nutrient availability and it might ultimately increase crop yield. Khan *et al.* (2013) has been reported the same results.In respect of nutrient management 125% RDF along with 15t/ha FYM produced superior growth and yield characters as compared to

Table 1. Effect of different tillage and nutrient management practices with various row spacing on growth and yield of wheat (Pooled data of three years from 2012-13 to 2014-15)

Treatment	Plant height (cm)	Dry matter (g/m^2)	Grain Yield (kg/ha)	Earhead/m^2	Grains/ earhead	1000 grain weight (g)
Tillage and row spacing						
No chiseling+ CT+20cm	76.8	823.8	3890	321.8	25.3	36.8
No chiseling+ CT+15cm	79.3	895.6	4060	339.5	24.9	36.5
Chiselling+ CT+20cm	89.7	1085	4640	381.0	31.6	39.3
Chiselling+ CT+15cm	91.4	1136.7	4790	399.3	30.5	39.8
Chiselling+ RT+20cm	84.3	1043.2	4600	378.3	31.5	39.4
Chiselling+ RT+15cm	86.5	1096.8	490	420.0	28.4	39.7
CD (P= 0.05)	7.5	191.4	370	25.6	2.9	2.4
Nutrient management						
Recommended NPK	73.2	827.7	4190	344.9	25.6	37.6
Recommended NPK+ FYM	87.8	1016	4450	375.7	28.7	38.7
125% of rec. NPK+ FYM	93.1	1196.8	4710	399.3	31.8	39.5
CD (P= 0.05)	4.2	141.5	190	22.4	2.1	1.3

other treatments. The yield increase in this treatment was 112% and 106% higher over only RDF and RDF with FYM, respectively.Significant growth and yield increase in wheat crop with combined application of chemical fertilizers and FYM has also been reported earlier by Majundar *et al.* (2008).

CONCLUSION

Inclusion of chiseling operation before conventional or rotary tillage along with application of 125% recommended NPK combined with FYM @ 15t/ha may produce higher growth and yield of wheat crop in Tarai region under transplanted rice- wheat cropping system.

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Effect of different land configuration on yield attributes and yield of soybean (*Glycine max*) in Vertisols

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Soybean (*Glycine max*. L.) is a major crop grown during the *kharif,* or monsoon, season (July-October) in the rain-fed (dry land) areas of central and peninsular India. Madhya Pradesh is known as the "soybean state" of India, comprising 55% of the total national area 5.56 million hectare of soybean cultivation. Soybean plant is classified as oilseed rather than

Table 1. Effect of different land configuration treatments on various yield attributes and yield in soybean

Treatment	No. of pods/plant	No. of seeds/pod	Seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
Land configuration					
Flat sowing - 45 cm	47.30	2.34	9.80	1295	2718
Raised bed of 90 cm with 3 rows/bed(RB-90)	50.54	2.61	10.98	1500	3227
Raised bed of 60 cm with 2 rows/bed (RB-60)	53.23	2.71	11.71	1675	3672
CD (P = 0.05)	1.31	0.09	1.27	104.75	618.9
Seed rate					
60 kg/ha	50.41	2.72	12.21	1577	3462
40 kg/ha	50.30	2.38	9.45	1403	2949
CD (P=0.05)	NS	0.06	0.32	113.29	320.6
Variety					
RVS 2001-04	59.28	2.64	11.23	1637	3745.2
JS 335	41.43	2.47	10.43	1343	2666.0
CD (P=0.05)	1.21	0.06	0.32	113.29	320.6

pulse crop as approximately 85% of the world's soybean crop is processed into soybean meal and vegetable oil.It is the cheapest and richest source of high quality protein containing 38-44% protein and 18-22% oil. It supplies most of the nutritional constituents essential for human health. Hence, soybean is called as wonder crop or golden bean or miracle bean.India is the third largest importer of soya oil in the world and is one of the major exporters of soya meal to the other Asian countries (Anonymous, 2013).

METHODOLOGY

A field experiment was conducted during *kharif* season of 2014-15 in Agronomy Farm, college of Agriculture at Indore, Madhya Pradesh, India to study the effect of different land configuration on yield attribute and yield of soybean (*Glycine max*) in Vertisols. The experiment, consisted of twelve treatments which were laid out in split plot design with three replications The soil of experimental field was clayey in texture and slightly alkaline in reaction with pH 7.76 and low available N (180 kg/ha), medium P (11.20 kg/ha) and high in K (540 kg/ha). Electrical conductivity (0.33ds/m) of soil is normal.

RESULTS

The experimental results clearly indicated the need of different land configuration practices to reduce the influence of waterlogging and weed in *kharif* of Soybean cultivation. Raised bed system of 60 cm width with 2 rows/bed significantly enhanced the number of pods/plant, number of seeds/pod, seed weight/plant, seed yield and straw yield over flat sowing of 45 cm inter row spacing and raised bed of 90 cm width with 3 rows/bed (Table 1). However, raised bed of 90 cm width with 3 rows/bedof seed weight/plant and straw yieldwere statistically at par. Further, 29.34% increase in seed yield was recorded in raised bed system of 60 cm width (2 rows/bed) over flat sowing of 45 cm inter row spacing.He was suggested that the land configuration practices such as raised-sunken bed system for normal as well as problematic soils, broad bed and furrow and tied furrow for conserving rainwater, nutrient and soil resources are appropriate and cost effective. They found higher Seed and Straw yield under modified land configurations as compared to the traditional planting system by Tomar *et al.* (2007).

CONCLUSION

It can be concluded that recommends Raised bed of 60 cm with 2 rows/bed in soybean is the best land configuration practice to obtain greater yield with more efficient water use.

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Agronomic performance of rice-wheat system as influenced by nitrogen and weed management under conservation agriculture

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Rice-wheat systemis followed on an area of 1.06 M ha in Kymore Plateau and Satpura hills agro-climatic zone of Central India outside the Indian IGP (Mishra and Singh, 2012). In order to alleviate environmental and management constraints and enhance productivity in the R-W rotation, new approaches that are more productive and sustainable are needed.A conversion from conventional agriculture system to conservation agriculture system may the potential solution for these problems.In initial stage of conversion, weed infestation is a major concern under conservation agriculture. Nitrogen is the primary nutrient, and inefficient N use contributes to greater use of energy resources, increased production cost, and possible pollution of water by nitrates. Therefore, the present study was carried out to study the performance of R-W rotation with weed and nitrogen management under conservation agriculture.

METHODOLOGY

The field experiment consisted of 24 treatments, comprising of four tillage and residue management practices as main-plot treatments,*viz.*zero tillage with residue retention (ZT+RR), zero tillage with residue burnt (ZT+RB), conventional tillage with residue incorporation (CT+RI) and conventional tillage with residue burnt (CT+RB); and two N levels as sub-plot treatments,*viz.*100% recommended dose of N (RDN) (N_1) and125% RDN (N_2) and three weed management practices as sub-sub-plots treatments, *viz.*unweeded check (W_1), chemical approach (W_2)(pendimethalin 1000 g/ha as pre-emergence (PE) followed by bispyribac-Na 25 g/ha at 25 days after sowing (DAS) in rice and mesosulfuron + iodosulfuron (12+2.4 g/ha) at 25 DAS in wheat) and integrated weed management (W_3) (*Sesbania* co-culture + pendimethalin 1000 g/ha as PE followed by 2,4-D 500 g/ha at

Table 1. Yield performance of rice-wheat system as influenced by tillage and residue management, N-levels and weed management

Treatment	Plant height at maturity (cm)		Panicle or spikes/m^2		Grain yield (t/ha)	
	Rice	Wheat	Rice	Wheat	Rice	Wheat
Tillage and residue management						
ZT+RR	103.3	94.4	271.7	352.9	4.2	4.6
ZT+RB	101.2	89.5	248.7	316.1	3.4	4.0
CT+RI	102.7	92.9	266.8	335.2	4.2	4.3
CT+RB	102.5	88.6	255.4	310.4	3.7	4.0
LSD (P=0.05)	NS	2.9	8	30.3	0.3	0.3
N-level						
100% RDN	102.0	90.5	257.8	310.0	3.9	4.2
125% RDN	102.0	92.1	263.5	330.3	4	4.3
LSD (P=0.05)	NS	1.2	NS	NS	NS	NS
Weed management						
Unweeded Check	97.4	91.2	230.2	283.1	3.1	3.7
Chemical approach	102.3	90.2	268.7	337.6	4.2	4.5
Integrated weed management	107.7	92.5	283.0	339.8	4	4.6
LSD (P=0.05)	2.8	NS	7.6	22.1	0.2	0.3

25-30 DAS followed by hand weeding (HW) at 45 DAS in rice, and sulfosulfuron 25 g/ha at 25 DAS + HW at 45 DAS in wheat). A split-split plot design with three replications was followed.The recommended dose of 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha was applied in the both crops. Nitrogen was applied as per the treatments, with basal dose of 70% N along with 100% P and K at the time of sowing, and remaining 25% N after the first irrigation in the both crops. The sowing was done at 20 cm row spacing with the help of happy seeder.

RESULTS

In rice, plant height and panicle length were comparable under all tillage and residue management practices whereas panicle density and grain yield were significantly superior under ZT+RR and CT+RI than ZT+RB and CT+RB. There was no significant increase in yield components and grain yield in response to applied N above the RDN. All yield components and grain yield were the highest with integrated weed management, and the lowest with unweeded check. Chemical approach also recorded significantly higher yield components and grain yield than unweeded check. In wheat,plant height,spike density andgrain yield were significantly higher under ZT+RR, which were however, comparable with CT+ RI and the lowest value was under CT+RB followed by ZT+RB. Zero tillage ensured advance sowing and resulted in proper placement of seed, early emergence of seedlings and availability of higher nutrient and moisture content due to surface retention of previous crop residue.Crop fertilized with 125% RDN recorded plant height which was significantly superior to 100% RDN. The differences in spikes/m^2, spike length and grain yield were not significant. Integrated weed management recorded the highest spikes/m^2, spike length and grain yield, which was at par with chemical approach. However, both weed management practices were significantly superior to unweeded check.

CONCLUSION

Conservation agriculture practice involving zero till sowing with crop residue retention on soil surface with recommended dose of N and effective weed management by integrated or chemical approach appeared to be the best practice for improving productivity of rice-wheat system in vertisol of central India.

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Productivity and soil quality of rice-pea cropping system under different tillage and residue management practices in North Eastern Hill Region of India

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Rice (*Oryza sativa* L.) is the main staple food crop ofNorth Eastern Region (NER) of India. It iscultivated in an area of about 3.5 million hectare with a productivity of 2 t/ha only as against the National productivity of 2.46 t/ha. Retention of crop residues as mulch in combination with no-till (NT) improves resource-use efficiency and soil quality. The large area in hilly tracts of NER remains fallow after *kharif* rice dueto excess moisture owing to seepage from surrounding hillocks. It is difficult to grow a second crop of rice under such landscape due to early onset of winter that results in spikelet sterility. However, if excess water is drained out during physiological maturity of rice, a favourable soil condition can be created for cultivation of arable crops such as pulses and oilseeds especially under NT. Any tillage under such condition would destruct soil structure and cause puddling, hence NT is the only option. Pea (*Pisum sativum*) has got very good potential as second crop after rice for increasing farm income as well as cropping intensity. Thus, thepresent investigation on rice-pea system was conducted to develop suitable tillage and residue management practices for enhancing productivity and soil quality in hill agriculture.

METHODOLOGY

The present investigation was carried out under lowland rainfed conditions at ICAR Research Complex for NEH region, Umiam, Meghalaya, India during 2012-16. The experiment was laid out in a factorial randomized block design (FRBD) with three replications. The soils of the experimental site before initiation of the study (2012) hadbulk density (ñb) of 1.12 Mg/m^3 with soil organic carbon (SOC), available N, and P_2O_5 of 2.40%, 250, and 20.2 kg/ha, respectively. Treatments comprised of three tillage practice *i.e.*, no-till (NT), minimum tillage (MT) and conventional tillage (CT) and five residue management (RM) practices as sub-plot *i.e.,* 100% NPK (80:60:40 N:P_2O_5:K_2O kg/ha), 50% NPK (40:30:20 N:P_2O_5:K_2O kg/ha), 50% NPK + *in-situ* residue retention (ISRR) of rice straw @ 5 t/ ha, 50% NPK + weed biomass (WB) of *Ambrosiaartemisiifolia*@ 10t/haon fresh weight basis and 50% NPK + green leaf manure (GLM)of *Tephrosiapurpurea* @10 t/haon fresh weight basis. After harvest of rice (cv. Shahsarang-1), peavariety Prakash (field pea) was sown uniformly under NTwith 20 cm standing rice stubble and grown with recommended package of practices (20:40:30 NPK kg/ha). Residual effects of treatments applied to rice were evaluated on succeeding peacrop.

RESULTS

The four year meangrain yield of rice was significantly higher under NT than that of MT and CT. The mean grain yield obtained with NT was 6.0 % and 7.6 % higher than MT and CT, respectively (Table 1). Among the RM practices, application of 50% NPK+WB recorded significantly higher rice grain yield as compared to 50 % NPK or 100% NPK but was statistically at par with 50% NPK+ISRR and 50% NPK + GLM. The mean grain yield of rice under 50 % NPK +WB was 8.2% and 14 % higher than that of 100 % NPK and 50 % NPK, respectively. The residual effect of tillage and RM practices applied for rice had significant effect on green pod yield of succeeding pea. The mean green pod yield of pea was highest under MT in rice followed by CT and the lowest was under NT. Among different RM practices followed in rice, the productivity of green pea was significantly higher under 50 %NPK+WB than that of 50% NPK alone. Over the four year, the mean REY of rice-pea cropping system obtained WAS significantly higher under 50% NPK + WBas compared to 50% NPK/100% NPK but remained at par with 50% NPK+ GLM and 50% NPK+ISRR. However, application of 50% NPK recorded the lowest REY in all four years of experimentation. In comparison with the baseline, there was a marked improvement in physico-chemical properties of soil after four years of experimentation. Among the RM practices, application of 50% NPK recorded significantly higher ñb and the lowest was under 50% NPK+GLM. Soil under NT had significantly higher available nutrients (N, P_2O_5) and SOC concentration than those of soil sunder CT. The available N, P_2O_5 and SOC of soils were recorded significantly higher under 50% NPK+GLM as compared to 50% NPK alone at 0-15 cm soil depth. Increase in soil available nutrient status due to surface retention of crop residues have been reported by Mandal *et al*. (2004).

CONCLUSION

Four-year results indicated that grain yields of rice was statistically similar under NT and MT but was higher than that under CT. Growing pea in rice fallow under NT leaving 20 cm

Table 1. Effect of tillage and residue management practices on grain yield of rice, green pod yield of peaand soil fertility status after four years of experimentation

Treatment	*Grain yield of rice (t/ha)	*Green pod yield of pea (t/ha)	REY (t/ha)	Bulk density (Mg/m^3)	Available nutrients (kg/ha) N	Available nutrients (kg/ha) P_2O_5	SOC (g/kg)	SOC stock (t/ha)
Tillage practice								
NT	4.85	6.80	13.9	0.96	290	26.5	26.5	38.4
MT	4.56	8.16	15.4	0.99	284	25.1	25.1	37.2
CT	4.48	7.47	14.4	1.04	276	23.3	23.3	36.5
CD (P=0.05)	0.23	0.23	0.45	0.03	6.24	1.43	1.43	NS
Residue management practices								
100 % NPK	4.47	7.42	14.3	0.99	268	24.4	24.4	36.2
50 % NPK	4.19	6.64	13.0	1.05	251	22.3	22.3	35.0
50 % NPK + ISRR	4.78	7.63	14.9	0.99	292	24.6	24.6	36.4
50 % NPK + WB	4.87	7.88	15.4	1.02	300	25.6	25.6	39.0
50 % NPK + GLM	4.82	7.81	15.3	0.95	305	27.9	27.9	39.9
CD (P=0.05)	0.30	0.30	0.59	0.04	8.06	1.84	1.84	3.40

*Mean yield of four years, NT-No-till, MT- Minimum tillage, and CT- Conventional tillage, ISRR- *in-situ* residue retention; WB- weed biomass; GLM- green leaf manure, REY- Rice equivalent yield, SOC -Soil organic carbonC.D- Critical difference, NS-Non-significant standing rice stubble can be helpful in conserving soil moisture and enhanced green pod yield. Hence, NT/MT with residue management practices is a recommendable option for resource conservation, improving soil health and productivityof rice-pea cropping system in hill region of NER, India.

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Conservation agriculture: Benefits and prospects

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Conservation agriculture (CA) is a management system, based on minimal soil disturbance and permanent soil cover combined with rotations of crops. As per FAO definition, CA aims to achieve acceptable profits, conserve, improve and sustained production levels. The main principles of conservation agriculture include minimum soil disturbance by adopting minimum/ no tillage, proper crop rotation and minimum traffic for agricultural operations. An extreme tillage requirement with no return of crop residue and other organic materials is loss of soil organic matter and is not sustainable. Thus, it requires practices to enhance the sustainability of this system, which can be attained by reducing the intensity of tillage and inclusion of organic material in soil. So, zero tillage can be preferred over the conventional tillage as it results in minimum compaction and improves natural structural formation, improve soil physical properties.Various potential benefits of CA by adoption and spread of ZT wheat are improving the soil quality; enhancement in soil organic matter; reduction of the incidence of weeds,such as *Phalaris minor* in wheat; enhancement of production and productivity; enhancement of water and nutrient use efficiency.Also it allows timely sowing ofwheat, improves fertilizer use-efficiency, saves water and increases yield up to20%. Several prospects by the use of CA are reduced cost of production, reduced weed population, water saving, increasing nutrient useand ultimately increasing the yields by reducing green house gas emissions and burning of crop residues.

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Rice cultivation strategies for changing climate in EPZ of Uttar Pradesh

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Rice is the staple food crop in Eastern Plain Zone (EPZ) of Uttar Pradesh and primarily grown during monsoon season. Weather data observation of 1971-2012 from NDAUT Faizabad shows that monsoon season rain fall is decreasing @ about 10 mm/year which is quite alarming. Seasonal and decadal analysis of rainfall also shows that there is a consistently gradual decrease in seasonal rainfall. During 1971-80 monsoon season rainfall use to be about 1200 mm but has reduced to about 800 mm during 2000-2010. Other weather elements viz. day length, Maximum temperature, minimum temperature etc are directly linked to the occurrence of rainfall. Aberrations of temperature rise & fall as well as the extreme rainfall events and larger gap between two rainfall events are occasional in occurrence. General observations of the period 1971-2012 on area and productivity of rice as well as the rainfall during its growing season also reveal certain astonishing facts. In Faizabad district productivity increased from 15 q/ha to 25 q/ha contrary to the acreage and rainfall reduction during the observation period. This could be attributed to the technological contributions made by our scientists.

Keeping these points in view CERES Rice model was run to assess the sustainability of rice production. The average weather condition of 1971-2012 was used to run the model. In the model run best available technology was adopted and rice varieties presently recommended for the area were used for yield assessment. Simulation model run with three rice varieties viz. NDR 97, NDR 359 and Swarna Sub 1 and average weather condition that prevailed over the last forty two years as well the soil and crop management practices recommended by the University recorded yield as 4835 kg/ha, 5547 kg/ha and 4711 kg/ha when transplanted on June 30; 4739 kg/ha, 5549 kg/ha and 5014 kg/ha when transplanted on July 15 whereas 4778 kg/ha, 5025 kg/ha and 4614 kg/ha when transplanted on July 30.

DSSAT simulation model run modifying various weather related parameters viz. day length and temperature regimes indicated that increase in day length will increase productivity but increase in temperature will decrease the productivity of rice in the EPZ area. In order to obtain sustained and ever increasing rice productivity in the area, new rice varieties with immunity to water stress, day length and temperature regime need to be developed.

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Practicing conservation agriculture in blackgram and greengram under bael (*Aegle marmelos*) based agroforestry system in semi-arid tropics

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Agriculture is the diverse, complex, under-invested, risky and vulnerable occupation in rural Bundelkhand. Agroforestry is one of alternative approaches, which can reduce the high risk of crop failure, low biomass productivity, degradation of natural resources etc. Adoption of conservation agriculture (CA) practices could be the another viable solution for the constraints of agriculture in semi-arid region. However, competing uses for crop residues for livestock production, inadequate biomass production by crops and increased labour demands for manual weeding are the major constraints for adoption of CAin semi-arid region. Integration of trees with CA practices could overcome the constraints and can provide year round land cover (Garrity *et al*., 2010). Bael is drought tolerant, long storability of fruits with increasing market demand. In rainfed conditions, greengram and blackgram grows well under limited moisture availability. Considering all these alternatives and compulsions, a field experiment was designed with the objective of maximising the crop productivity of greengram and blackgram under bael based agroforestry system by using CA practices.

METHODOLOGY

Along term field experiment was initiated during 2014 at ICAR-CAFRI, Jhansi (U.P.), India. Thesoil was poor in soil organic carbon (0.34%), available N (118 kg/ha), available P (6.4 kg/ha) and available K (112 kg/ha) with 6.59 soil pH. Improved variety of bael (CISH-B2) was planted uniformly in July 2014 at a spacing of 9 m x 4 m. The experiment comprising of 04 main plot treatments *viz.*,Conventional Tillage (CT)-Blackgram-Mustard; CT-Greengram-Barley; Minimum Tillage (MT)-Blackgram-Mustard and MT-Greengram-Barley and 03 subplot treatments (with crop residue; without crop residue and with leucaena residue). The experiment was laid out in split plot design with three replications. During *kharif*

Table 1. Growth, yield attributes and yields of blackgram and greengraminfluenced by conservation agriculture practices (Pooled data of two years)

Treatment	Blackgram					Greengram				
	DM at harvest (g/m^2)	Pods/ plant	Seeds/ pod	Seed yield (kg/ha)	Stover yield (kg/ha)	DM at harvest g/m^2)	Pods/ plant	Seed/ pod	Seed/ yield (kg/ha)	Stover yield (kg/ha)
Main plot										
CT-Blackgram-Mustard	181.5	13.35	5.26	465.2	990.4	-	-	-	-	-
CT-Greengram- Barley	-	-	-	-	-	246.5	13.85	10.06	687.0	1358.0
MT- Blackgram-Mustard	177.0	13.35	5.14	452.5	971.1	-	-	-	-	-
MT- Greengram- Barley	-	-	-	-	-	240.0	13.75	9.84	645.8	1317.7
SEm±	2.0	0.05	0.04	4.9	7.6	2.50	0.10	0.095	6.50	10.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot										
Without crop residue	170.0	12.50	4.99	422.5	920.2	231.0	13.00	9.48	618.6	1239.8
With crop residue	182.0	13.70	5.29	471.2	1005.2	246.5	14.20	10.16	688.7	1379.1
With leucaena residue	186.5	13.90	5.33	482.8	1017.4	252.5	14.20	10.22	692.2	1394.3
SEm±	3.0	0.20	0.08	10.1	10.3	2.5	0.20	0.17	17.6	28.8
CD (P=0.05)	9.0	0.55	0.26	28.9	32.7	6.7	0.65	NS	35.3	66.5

CT-Conventional tillage; MT-Minimum tillage; DM-Dry matter accumulation season greengram (PDM-139) and blackgram (Azad-2) were sown as per the treatment details. *Leucaena leucocephala* (K-636) was planted on boundary of experimental field at 1.0m distance. Crop and leucaena residuehave been added @1.0 tonne/ha.

RESULTS

During second year of experimentation bael was attained the average height of 136.9cm and collar diameter of 30.5mm, however as these parameters were not affected significantly by tillage practices and residue management. Pooled data of 2014 and 2015 (*kharif season*) showed that dry matter accumulation, yield attributes and yields of blackgram and greengram with minimum tillage were statistically at par with conventional tillage system. This might be due to formation of compact layer in plough zone, low soil organic carbon (SOC), stratification of P and K fertilizers in top soil during initial years of experimentation (Shekhawat *et al.*, 2016). Perusal of the data on residue management revealed the fact that, dry matter accumulation, yield attributes and yields improved under *leucaena* residue incorporation followed by crop residue than without crop residue. Residue management practices through application of *leucaena* resulted in 14.27 and 11.89% higher seed yield of blackgram and greengram as compared to without crop residue, respectively during the both years. The corresponding increases in stover yields due to leucaena residue were 10.56 and 12.46%, respectively. Increase in seed yield of blackgram and greengram with incorporation of crop residue was 11.52 and 11.33%, respectively over without crop residue. The corresponding values for increase in stover yields due to crop residue were 9.23 and 11.23%, respectively (Table 1). The organic supplements from the *leucaena* and crop residue improves the SOC, plant growth, soil health, and widened the sink base through optimum biomass partitioning resulting in higher yield attributes and yields (Das *et al*., 2014).

CONCLUSION

Among the residue management practices, addition of *leucaena* residue performed better than the addition of crop residue. Based upon two year of study it can be concluded that residue management practices in conjunction with tillage practices offers the great potential to enhance the production in semi-aridregion with less cost and higher environmental security.

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Effect of tillage and residue management on productivity of winter maize in rice-winter maize cropping system

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Rice (*Oryza sativa* L.) and maize (*Zea mays* L.) are grown in sequence on the same land in the same year either in double or triple-crop systems. It is, therefore, essential that soil environment be manipulated suitably for ensuring a good crop stand and improving resource-use efficiency. Intensive soil cultivation has worldwide resulted in the degradation of agricultural soils with decrease in soil organic matter and loss of soil structure, adversely affecting soil functioning and causing a long-term threat to future yields (Pingali *et al*., 2004). Rice-maize is an emerging cropping system in many parts of India but its potential is yet to be assessed in north-western plain zone. Comparative evaluation of winter maize under conventional and zero tillage conditions and its sowing after direct-seeded and transplanted rice, require a thorough investigation. In addition, the issues of cold injury in maize is a major concern, and require suitable mitigation measures through timely sowing, residue management, relay cropping with mungbean etc. Information on all these aspects is not available, hence the present comprehensive study was carried out to study the effect of tillage and residue management on yield attributes and productivity of winter maize in rice- winter maize cropping system.

METHODOLOGY

A field experiment was conducted on a fixed site during rainy season (June to October) and winter season (November to April) of 2010-11 and 2011-12 at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi. The treatments comprised viz. direct-deeded rice – zero-till maize (DSR-ZTW), direct-deeded rice – zero-till maize + rice residue (DSR-ZTW+RR), direct–deeded rice + brown manuring–zero-till maize (DSR+BM-ZTM), direct-deeded rice + brown manuring–zero-till maize + rice residue (DSR+BM-ZTM+RR), mungbean residue + direct-deeded rice- zero-till maize + relay mungbean (MBR+DSR-ZTM+MB), mungbean residue + direct-deeded rice –zero-till maize + rice residue + relay mungbean (MBR+DSR-ZTM+RR+MB), transplanted rice – conventional till maize (TPR-CTM) and transplanted rice – zero-till maize (TPR-ZTM). The experiment was laid out in randomized block design and replicated thrice. 'HQPM 1' variety of maize was taken for experimentation. Zero-till and conventional till maize was sown in the first week of November and second week of November respectively and harvested in first week of May during both the years. For brown manuring practice seedsof *sesbania* @ 40kg/ha, was broadcasted together with the sowing of direct-seeded rice as per treatments and then *sesbania* crop was knocked down at 30 days after sowing with 2,4-D ester. Sowing of relay

Table 1. Yield attributes of maize as influenced by tillage, crop establishment, brown manuring and residue management

*Treatment	2010-11				2011-12			
	Cob length (cm)	Grains/ cob	Cob weight (g)	1000-grain weight (g)	Cob length (cm)	Grains/ cob	Cob weight (g)	1000-grain weight (g)
[1]DSR-ZTM	15.1	382.1	95.5	217.27	14.9	378.3	92.4	216.60
[2]DSR-ZTM+RR	15.6	384.2	96.2	218.07	15.4	380.4	93.6	217.40
DSR+BM-ZTM	15.7	388.3	96.7	218.93	15.5	384.5	94.1	218.27
DSR+BM-ZTM+RR	15.8	391.8	97.4	220.83	15.6	388.0	94.9	220.17
[1]MBR+DSR-ZTM+MB	15.5	382.5	95.8	217.50	15.8	393.6	95.2	221.15
[2]MBR+DSR-ZTM+RR+MB	15.4	384.3	96.0	218.87	15.9	396.9	95.8	222.52
TPR-CTM	16.3	406.8	100.5	223.80	16.2	401.4	98.7	223.67
TPR-ZTM	15.9	393.3	97.7	220.53	15.7	386.8	95.3	219.87
SEm±	0.20	4.14	0.94	1.54	0.23	4.24	1.11	1.69
CD (P=0.05)	0.59	12.56	2.84	NS	0.68	12.85	3.37	NS

*Treatments with superscript 1 and 2 were maintained similarly in 2010-11.

Table 2. Productivity of maize as influenced by tillage, crop establishment, brown manuring and residue management.

*Treatment	2010-11				2011-12			
	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
[1]DSR-ZTM	3.75	5.53	9.27	40.39	3.36	5.77	9.13	36.79
[2]DSR-ZTM+RR	3.81	5.60	9.41	40.51	3.43	5.81	9.23	37.11
DSR+BM-ZTM	3.87	5.64	9.51	40.71	3.48	5.89	9.37	37.15
DSR+BM-ZTM+RR	3.93	5.68	9.61	40.91	3.54	6.03	9.56	36.99
[1]MBR+DSR-ZTM+MB	3.77	5.55	9.32	40.45	3.58	6.14	9.73	36.84
[2]MBR+DSR-ZTM+RR+MB	3.80	5.60	9.40	40.46	3.62	6.21	9.83	36.90
TPR-CTM	4.21	6.03	10.23	41.11	3.83	6.42	10.22	37.34
TPR-ZTM	3.90	5.66	9.56	40.77	3.50	5.89	9.39	37.28
SEm±	0.07	0.09	0.15	0.69	0.08	0.12	0.18	0.84
CD (P=0.05)	0.22	0.27	0.46	NS	0.24	0.38	0.53	NS

*Treatments with superscript 1 and 2 were maintained similarly in 2010-11.

mungbean was done into the respective treatments in the second forth-night of march by broadcasting in the standing maize crop and after one picking of pods, it's residues was incorporated into soil in respective treatments through rotavator in June before sowing of direct-seeded rice. After harvesting of rice, its chopped residue was applied into respective treatments @ 5.0 t/ha before sowing of zero-till maize.

RESULTS

The yield attributes (cob length, grains/ cob, and cob weight) were influenced due to tillage and significantly higher yield attributes recorded under conventional till maize (TPR-CTM) during 2010-11. However during second year mungbean residue incorporation in previous rice crop and zero-till maize with rice residue (MBR+DSR-ZTM+RR-MB) produced significantly at par yield attributes than the conventional till maize (TPR-CTM) which was grown after puddled transplanted rice. During second year poorest performance of the yield attributes were recorded under zero-till maize (DSR-CTM) which was grown after DSR. Tillage and residue management practices could not affect1000-grain weight significantly. Tillage, residue management and brown manuring in previous crop could not affect grain, straw, and biological yields significantly during 2010-11. However, significantly higher yield was recorded under mungbean residue incorporated in previous direct-seeded rice and zero-till maize with rice residue treatment (MBR+DSR-ZTM+RR+MB) than the no-residue treatments and it performed at par with conventional till maize. During second year lowest yield performance was recorded under zero-till maize, which was grown after direct deeded rice. The performance of maize in 2010-11 was better than 2011-12 due to favourable weather conditions. Tillage and reside management practices could not bring any significant change in harvest index during both the year of study.

CONCLUSION

This study indicates that comparatively higher yield and yield attributes of maize was obtained with conventional till maize followed by sowing of zero-till maize with rice residue after incorporation of mungbean residue and direct seeded rice (MBR+DSR-ZTM+RR-MB) in both the years. However, rice-wheat system found superior to rice-maize system with this conservation agriculture practice.

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Crop productivity and profitability under conservation agriculture

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The field experiments were conducted at University of Agricultural Sciences, Dharwad, Karnataka during 2014-15 and 2015-16 to study the effect of conservation tillage systems and land configuration practices in cotton and pigeonpea based cropping systems under rainfed situations. The experiment was laid out in a strip block design consisting of six tillage practices (CT_1 - Conservation tillage with broad bed and furrow (BBF) and crop residues retained on the surface, CT_2 - Conservation tillage with BBF and incorporation of crop residues, CT_3 - Conservation tillage with flat bed with crop residues retained on the surface, CT_4 - Conservation tillage with flat bed with incorporation of crop residues, CT_5 - Conventional tillage with crop residues incorporation. and CT_6 - Conventional tillage without crop residues) and five cropping systems viz., cotton + groundnut (CS_1), cotton + soybean (CS_2), pigeonpea + soybean (CS_3), sole cotton (CS_4) and sole pigeonpea (CS_5) and replicated thrice.

RESULTS

The two years pooled data showed that, irrespective of cropping systems, conservation tillage with BBF and crop residues retained on the surface (CT_1) and crop residues incorporation (CT_2) recorded significantly higher cotton equivalent yield (3056 and 3047 kg /ha respectively) and net returns (₹88124 and ₹87717/ha respectively) as compared to conventional tillage with crop residue incorporation (CT_5- 2680 kg/ha and ₹68179/ha respectively) and conventional tillage without crop residue (CT_6- 2399kg /ha and 56353 /ha respectively). However, these tillage systems were on par with CT_4 (2872 kg/ha and 81541/ha) and CT_3 (2822 kg/ha and 79459/ha) with respect to yield and net returns respectively. Conventional tillage system with crop residue incorporation recorded significantly higher cotton equivalent yield (2680 kg/ha) and net returns (₹68179/ha) as compared to conventional tillage without crop residues (2399 kg/ha ₹56353 /ha, respectively). Whereas, all the conservation tillage systems recorded significantly higher B:C ratio (CT_1-3.33, CT_2-3.32, CT_3-3.18 and CT_4-3.23) over conventional tillage systems with and without crop residues (2.63 and 2.36 respectively). Similar findings were also reported by Jat *et al.* (2013) and Saad *et al*. (2015), who reported that undoubtedly, zero tillage with bed or flatbed and residue retention on the surface have potential to improve the crop productivity, profitability and efficiency of water-use. Among different cropping systems, pigeonpea + soybean intercropping system (CS_3) produced significantly higher cotton equivalent yield (4291 kg/ha) as compared to other cropping systems and sole crops. In a system both the crops complement each other and soybean produced optimum yield without affecting pigeonpea yield. The next best was found to be sole pigeonpea (CS_5) (3984 kg/ha) followed by cotton + groundnut (CS_1) (2521 kg/ha) which was significantly superior to cotton + soybean (CS_2) (1653 kg /ha) and sole cotton (CS_4) (1614 kg/ha). Three years field trials conducted at PDKV, Akola showed that, minimum tillage with pigeonpea + soybean (1:2) intercropping produced significantly higher pigeonpea equivalent yield (Rajesh Kumar *et al.* (2014). Sole pigeonpea recorded significantly higher net returns (₹136005 /ha) and B:C ratio (5.39) as compared to other cropping systems and it was on par with pigeonpea + soybean intercropping system (₹135530/ha) which was mainly due to higher yields and good market price for pigeonpea during 2016. The interactions of different tillage practices and cropping systems were significant with regard to system productivity and profitability. Pigeonpea + soybean system is a productive system for Northern Transition Zone of Karnataka, with the greater benefits from conservation tillage practices mainly crop residues, higher soil organic matter, optimization of nutrients, soil moisture and enhanced soil biological activity, resulted in higher productivity and income of the system. The combination of conservation tillage with BBF and residue retention on the surface in pigeonpea + soybean intercropping system produced significantly higher cotton equivalent yield (4654/ha) and net returns (₹151761/ha) as compared to other treatment combinations. However, it was on par with conservation tillage with BBF with residue incorporation in pigeonpea + soybean intercropping system (4645 kg/ha and ₹151387/ha), CT_2CS_5 (4275 kg/ha and ₹149239/ha), CT_4CS_3 (4435 kg/ha and 143741/ha) and CT_3CS_3 (4400 kg ha and ₹142280/ha), respectively. Whereas, CT_1CS_5 combination recorded significantly higher B:C ratio (5.95) over other combinations and it was on par with CT_2CS_5 (5.93), CT_4CS_5 (5.77) and CT_3CS_5 (5.75).Conservation tillage and BBF with both crop residue retention on the surface and incorporation treatments with intensive cropping systems, pigeonpea + soybean, cotton + groundnut and sole pigeonpea were found more productive and profitable. Conservation tillage with legume crop intensification eliminates unsustainable part of conventional agricultural system and is crucial for sustaining productivity and conservation of natural resources under rainfed farming.

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Effect of different rice establishment methods on growth, yield and uptake of NPK of different varieties during *kharif* season

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The present investigation "Effect of different rice establishment methods on growth, yield and uptake of NPK of different varieties during *kharif* season" was conducted at Agronomy farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during *kharif* season of 2014. The field experiment was laid out in spit plot design replicated three times. The gross plot size of each treatment was 4.40 m × 3.30 m and net plot size 4 m × 3 m. There were 24 treatment combinations which were replicated thrice. The treatments mainly comprised of different establishment methods and varieties. The sowing experimental plot was done on 11th June, 2014. In drilling methods of sowing rice seeds were sown by using manually with 15 cm row spacing as per seed rate (60 kg/ha and hybrid seed rate 15 kg/ha). In early transplanting (15 days age old seedling), transplanting as per as recommended (21 days old age seedling) and thomba methods transplanted seedling with 20x15 cm spacing with 3 to5 seedling/hills. The other common packages of practices were followed time to time and periodically are observations were recorded on growth, quality and yield for evaluate the treatment effects. Among the treatments the transplanting was recorded maximum plant height (cm), number of tillers/m^2, number of functional leaves/m^2, dry matter (g/m^2) number of panicles/m^2, length of panicle (cm), number of filled grains/panicle, weight of filled grains/panicle (g), test weight (g), grain yield (q/ha) and straw yield (q/ha) but thomba method recorded highest number of unfilled grains. The rice variety Sahyadri-2 recorded maximum plant height, number of tillers/m^2, number of panicles/m^2, length of panicle, number of filled grains/panicle, weight of filled grains/panicle, test weight (g), grain yield (q/ha) and straw yield (q/ha). The rice variety Karjat-2 recorded maximum number of functional leaves/m^2), dry matter (g/m^2) and number of unfilled grains. The treatment combination early transplanting variety Sahyadri-2 (M_2V_4) recorded maximum plant height (cm) and tillers/m^2). The treatment combination transplanting variety Sahyadri-2 (M_3V_4) recorded maximum dry matter (g/m^2), yield attributes viz., number of panicles/m^2, length of panicle (cm), number of filled grains/panicle, weight of filled grains/panicle and test weight. The maximum gross monetary returns (₹65268/ha), net monetary returns (₹36013/ha) and B:C (2.23) ratio was obtained when using recommended method of transplanted method of rice establishment along with Sahydri-2 variety. On the basis of present investigation it can be concluded that, rice should be transplanted by recommended method with variety Sahyadri-2 for obtaining higher grain yield as well as straw yield.

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Effect of crop residue management on yield and economics in soybean based cropping system

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In India, soybean is grown on 108.83 lakh ha area with a production of 104.36 lakh MT and productivity of 959 kg/ha. In vidarbha, area under soybean is 19.31 lakh ha with a production of 14.75 lakh MT and productivity of 776 kg/ha (Anonymous, 2014). Crop residues (stover) have many potential uses by society: food, feed, shelter, fuel, and soil amendment. Use of residues for purposes other than as a soil amendment may have serious negative consequences on crop productivity (Wilhelm *et al.*, 1986). This review reveals that crop residues of common cultivated crops are an important resource not only as a source of significant quantities of nutrients for crop production but also affecting soil health. Nitrogen benefits and nitrogen recoveries from residues show that a considerable potential exists from residues, especially leguminous residues, not only in meeting the N demands of the succeeding crops, but also in increasing the long term fertility of the soils, Hence the present investigation was taken.

METHODOLOGY

A field experiment was carried out during *kharif* and *rabi*2003-04 to 2013-14 at Agriculture Research Station, Buldana, (Maharashtra) to study the effect of recycling of soybean crop residue on the yield of succeeding *rabi* crops and on soil health. The main plot treatments comprised four crop residue management, viz. wheat with residue incorporation, wheat with no residue incorporation, chickpea with residue incorporation, chickpea with no residue incorporation and sub-plot treatment were fertilizers i.e.50,75 and 100% recommended dose of fertilizers for *rabi* crops were arranged in a split–plot design with three replications. Soybean 'JS-335' was sown in *kharif* season with all recommended package of practices for soybean residue only. After harvesting crop well dried soybean crop residue (SCR) was applied on each residue incorporation plot @ 3.90 kg/plot (2.0 t/ha). The harrowing was undertaken to incorporate the residue in the soil. The seed–bed was prepared; the plots were irrigated prior to cultivation of both *rabi* crops. Wheat 'AKW-1071' and Chickpea 'JAKI-9218' were sown in row space 22.5 cm and 30 cm respectively in the last week of November and harvested in end of March to middle of April during every year. As per treatments recommended dose of fertilizer for wheat 120:60:60 kg NPK/ha and chickpea 25:50:00 kg NPK/ha were applied to crop and data on yield and economics were recorded.

RESULTS

On the basis of ten years study reflected that, incorporation of SCR significantly recorded the highest yield viz. wheat (3154 kg/ha) and chickpea (3077 kg/ha) crops as compared to no residue incorporation treatments. Linear and significant grain yield increase was observed with increase in fertilizer dose in both the crops. The application of 100% dose of fertilizer to wheat and chickpea recorded significantly highest grain yield (3286 kg/ha) than the 75% recommended dose of fertilizer (3016 kg/ha) and 50% recommended dose of fertilizer (2448 kg/ha). The pooled data revealed that grain yield of wheat and chickpea was significantly increased due to combined effect of SCR incorporation and fertilizer doses applied to both the crops. Incorporation of SCR showed higher wheat and chickpea grain yield (3469 and 3559 kg/ha. respectively) with 100% RDF than with 50% RDF and at par with 75% RDF. Addition of SCR and its subsequent decomposition improved the organic matter status,soil health and released nutrients through the crop growth period that helped to increase the growth and yield of chickpea which ultimately resulted in higher chickpea grain yield as compared to no SCR treatment. The incorporation of SCR recorded higher GMR,NMR than no residue incorporation in both the *rabi* crops. However, B:C ratio was recorded higher under no incorporation treatments. Among *rabi* crop crops, chickpea recorded highest GMR, NMR and B:C ratio as compared to wheat. The application of 100% recommended dose of fertilizer to both crop recorded overall higher GMR,NMR and B:C ratio as compared to 75 and 50% recommended dose of fertilizer. Data presented in (Table 1) revealed that, the GMR and NMR of wheat and chickpea was significantly increased due to incorporation of SCR on decomposition released nutrients to soil slowly

Table 1. Pooled grain yields (Wheat equivalent) and economics as influenced by different treatments (2003-04 to 2013-14)

SN Treatment	Grain yield (kg/ha)	Gross monetary return (Rs/ha)	Netmonetary return (Rs/ha)	B:C ratio
ABC Main Plot [Crop residue]				
WI-Wheat with incorporation	3154	43336	22569	2.09
WN -Wheat with no incorporation	2816	38509	20747	2.23
CI-Chickpea with incorporation	3077	41348	23832	2.39
CN-Chickpea with no incorporation	2620	34914	20278	2.49
SEm±		21	261	261
CD (P=0.05)	71	886	901	
Subplot [Fertilizer dose]				
F_1 - 50% RDF	2448	32920	16132	2.04
F_2 - 75% RDF	3016	41153	23512	2.38
F_3 - 100% RDF	3286	44507	25928	2.48
SEm±		17	222	222
CD (P=0.05)	51	665	768	
Interactions				
SEm±		34	445	443
CD (P=0.05)	102	1331	1536	

throughout the growth period of chickpea and wheat plants resulted in increasing the value of yield, GMR,NMR and B:C ratio of chickpea and wheat. In both the crops, chickpea recorded significantly higher GMR (Rs.47812), NMR (Rs.29593) and B:C ratio with incorporation SCR along with 100% RDF as compared to rest of treatments.

CONCLUSION

It was concluded that, application of soybean crop residue (2.0 t/ha) along with 100% recommended dose of fertilizer to wheat and chickpea was recorded maximum grain yield, gross and net monetary return, improve organic carbon content in soil.

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Effect of conservation agriculture and cultivar for improving productivity and profitability of maize-wheat cropping system

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Among different maize based cropping systems, maize-wheat ranks 1st and is the 3rd most important cropping systems after rice-wheat and rice-rice having 1.8 M ha area that contributed about 3% in the national food basket (Dass *et al*., 2009). Traditionally, maize and wheat are grown in row geometry or by random broadcasting, mostly after thoroughly tilling the field till proper tilth is obtained for good seedling emergence. Tillage practices contribute greatly to the labour cost in any crop production system resulting to lower economic returns. In addition, intensive agriculture has led to dramatic losses of organic matter from cultivated soils. Reduced or conservation tillage systems are gaining more attention in recent years with the rising concern over natural resources degradation. Hence, conservation tillage practices, such as zero tillage and minimum tillage and permanent beds, may be introduced to offset the production cost and other constraints associated with land preparation. Conservation agriculture advanced the sowing date and resulted in proper placement of seed, early emergence of seedlings and availability of higher nutrient and moisture content which might have helped the crop to compete with the crop sown under conventional tillage.However, scientist will have to evolve new genotypes and management practices or technologies to deal with conservation agriculture as there existed wide scale variability among maize and wheat genotype in response to different tillage practices. Hence, there is need to evaluate maize and wheat cultivars for their suitability under different tillage technique.

METHODOLOGY

The field experiment was conducted during the *kharif* and *rabi* season of 2011-12 at Birsa Agriculture University, Ranchi, Jharkhand. The soil was sandy loam in texture with pH 6.2 having organic carbon 0.46%, available nitrogen 255.6 kg/ha, phosphorus 17.65 kg/ha and potassium 168.3 kg/ha. The experiment was laid out in split plot design with 3 replications. The treatment comprised of 3 tillage practices (Conventional, permanent narrow bed and zero tillage) in main plot and 5 cultivars of maize (HQPM-1, DHM-117, PHI-3540, Rashi-747 and Rashi-3022) and wheat (PBW-343, K-9107, WR-544, DBW-17 and BAZZ) in sub plot. The recommended dose of fertilizer i.e. 120:60:40 kg $N:P_2O_5:K_2O$/ha was applied to both maize and wheat crop.

RESULTS

The grain yield of maize and wheat were significantly influenced by different tillage practices. Permanent narrow bed produced significantly higher grain yield of maize (6.27 t/ha) and wheat (5.37 t/ha) as compared to zero tillage and conventional tillage. The zero tillage practices failed to increase the maize yield remarkably but, led to significantly higher wheat yield than conventional tillage as zero tillage facilitates early emergence of wheat seedlings and availability of higher nutrient and moisture content, which might helped the crop to compete with crop sown under conventional tillage (Kumar and Yadav, 2005). The system productivity of cropping system expressed in terms of maize equivalent yield (MEY) was also influenced significantly by tillage practices. The permanent narrow bed recorded significantly higher MEY (12.99 t/ha) than zero tillage (11.27 t/ha) and conventional tillage (10.72 t/ha), respectively. The zero tillage also resulted in significantly higher MEY than conventional tillage. The relative economics of different tillage treatments inferred that zero tillage had lowest cost of cultivation (Rs. 38163/ha) than permanent narrow bed (Rs. 42150/ha) and conventional tillage (Rs. 45714/ha) due to less machinery used as the primary tillage is completely avoided. However, net return and benefit : cost ratio under permanent narrow bed was significantly higher than zero tillage and conventional tillage. Similarly, zero tillage also resulted in significantly higher net return and benefit: cost ratio than conventional tillage.

Among the maize cultivars, maize cv. PHI-3540 recorded highest grain yield which was comparable with maize cultivar Rashi 747. However, both of cultivars recorded significantly

Table 1. Productivity and economics of maize-wheat system as influenced by tillage practices andcultivars.

Treatment		Maize yield (t/ha)	Wheat yield (t/ha)	System productivity (t/ha)	Cost of cultivation (Rs./ha)	Net return (Rs/ha)	B:C ratio
Tillage practice							
Conventional		5.21	4.40	10.72	45714	65794	1.44
Narrow bed		6.27	5.37	12.99	42150	92322	2.19
Zero tillage		5.33	4.75	11.27	38163	78842	2.07
SEm±		0.10	0.07	0.10	-	988	0.02
CD (P=0.05)		0.38	0.28	0.38	-	3880	0.09
Cultivar							
Maize	Wheat						
HQPM1	PBW 343	4.54	3.85	9.36	42009	55411	1.34
DHM 117	K 9107	5.20	4.89	11.31	42009	75405	1.81
PHI 3540	WR 544	6.66	5.66	13.74	42009	100282	2.42
RASHI 747	DBW 17	6.58	4.37	12.04	42009	83080	1.98
RASHI 3022	BAAZ	5.06	5.42	11.84	42009	80753	1.94
SEm±	0.17	0.15	0.15	-	2519	0.06	
CD (P=0.05)	0.51	0.44	0.44	-	7353	0.18	

higher grain yield than all of the other cultivars. The maize grain yield of DHM 117 and Rashi 3022 were at par but significantly higher than HQPM-1. Among the wheat cultivars, WR 544 and Baaz produced significantly higher wheat yield than all the other cultivars. The other cultivars followed the order K-9107 > DBW-17 > PBW-343 where the former shows its significant superiority over its preceding cultivar in respect of wheat yield. Among cultivars, the maximum system productivity, net return (Rs. 100282 /ha) and benefit: cost ratio(2.42) was recorded with maize cultivar PHI-3540 and wheat cultivar WR-544 which was significantly superior over other maize and wheat cultivars grown in system. The system productivity,net return and benefit: cost ratio of cultivars RASHI-747-DBW-17, RASHI-3022-Baaz and DHM-117-K-9107 were statistically at par between themselves but, all of them showed their significant superiority over HQPM-1-PBW-343 cropping system.

CONCLUSION

Maize cultivar PHI-3540 and wheat cultivar WR-544 were the most suitable cultivars grown under permanent narrow bed gave highest productivity and profitability in maize-wheat cropping system.

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Effect of crop residue management on soil fertility status in soybean based cropping system in Vidarbha region

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In India, soybean is grown on 108.83 lakh ha area with a production of 104.36 lakh MT and productivity of 959 Kg/ha. In vidarbha, area under soybean is 19.31 lakh ha with a production of 14.75 lakh MT and productivity of 776 kg/ha. (Anonymous, 2014). Crop residues (stover) have many potential uses by society: food, feed, shelter, fuel, and soil amendment. Use of residues for purposes other than as a soil amendment may have serious negative consequences on crop productivity. (Wilhelm *et al.*, 1986). This review reveals that crop residues of common cultivated crops are an important resource not only as a source of significant quantities of nutrients for crop production but also affecting soil health. When crop residues are returned to the soils, their decomposition can have both positive and negative effects on crop production as well as on the environment. Nitrogen benefits and nitrogen recoveries from residues show that a considerable potential exists from residues, especially leguminous residues, not only in meeting the N demands of the succeeding crops, but also in increasing the long term fertility of the soils. Hence the present investigation was taken.

METHODOLOGY

A field experiment was carried out during *kharif* and *rabi* 2003-04 to 2013-14 at Agriculture Research Station, Buldana, (Maharashtra) to study the effect of recycling of soybean crop residue on the yield of succeeding *rabi* crops and on soil health. The main plot treatments comprised four crop residue management, *viz.* wheat with residue incorporation, wheat with no residue incorporation, chickpea with residue incorporation, chickpea with no residue incorporation and sub-plot treatment were fertilizers i.e.50,75 and 100 % recommended dose of fertilizers for *rabi* crops were arranged in a split–plot design with three replications. Soybean 'JS-335' was sown in *kharif* season with all recommended package of practices for soybean residue only. After harvesting crop well dried soybean crop residue (SCR) was applied on each residue incorporation plot @ 3.90 kg/plot (2.0 t/ha). The harrowing was undertaken to incorporate the residue in the soil. The seed–

Table 1. Fertility status after harvest as influenced by different treatments.

Treatment	pH	Organic Carbon %	Available nutrients (kg/ha)		
			N	P	K
Main Plot (Crop Residue)					
WI-Wheat with incorporation	7.92	0.91	238	28.12	422
WN -Wheat with no incorpo^n	8.07	0.72	226	22.92	380
CI-Chickpea with incorporation	8.08	0.96	243	29.48	419
CN-Chickpea with no incorpo^n	7.93	0.86	233	25.84	405
SEm ±	0.09	0.03	2.8	0.96	5.9
CD (P=0.05)	NS	0.10	9.8	3.3	20.3
Subplot (Fertilizer dose)					
F_1 - 50 % RDF	8.00	0.83	233	25.95	403
F_2 -75 % RDF	8.06	0.86	234	26.60	408
F_3 - 100 % RDF	7.95	0.89	238	27.23	409
SEm ±	0.06	0.013	0.9	0.48	4.9
CD (P=0.05)	NS	0.041	2.7	NS	NS
Interactions					
SEm ±	0.11	0.028	1.8	0.96	9.8
CD (P=0.05)	NS	NS	NS	NS	NS
Initial Soil Status	7.98	0.29	186	15.74	281

bed was prepared; the plots were irrigated prior to cultivation of both *rabi* crops. Wheat 'AKW-1071' and Chickpea 'JAKI-9218' were sown in row space 22.5 cm and 30 cm respectively in the last week of November and harvested in end of March to middle of April during every year. As per treatments recommended dose of fertilizer for wheat 120:60:60 kg NPK/ha and chickpea 25:50:00 kg NPK/ha were applied to crop and data on yield and economics were recorded.

RESULTS

Data presented in Table 2 revealed that, the incorporation of SCR recorded significantly higher organic carbon, available N,P and K than no SCR incorporation in both the *rabi* crops. However, results were found statistically non significant in P^H. Among the two *rabi* crops, chickpea recorded higher fertility values as compared to wheat crop.At the onset of experiment, soil organic carbon content was 0.29% However, available N,P and K status of experimental site were 186, 15.74 and 281 kg/ha respectively. A gradual increase in soil organic as well as available N, P and K were noticed over the year. Continuous incorporation of SCR raised soil organic carbon content (0.96) and available N, P, K (243, 29.48, 419 kg/ha, respectively) after ten years. This attributed to improvement is soil fertility status due to residue incorporation resulting in higher levels of crop productivity. These results are closely resembled with those of Singh *et al.* (2009), Kumar and Goh (2000). Interaction effect due to SCR incorporation and fertilizer doses was found non-significant in respect of pH, organic carbon, available N, P and K.

CONCLUSION

It was concluded that, application of soybean crop residue (2.0 t/ha) along with 100% recommended dose of fertilizer to wheat and chickpea was recorded maximum grain yield, gross and net monetary return, improve organic carbon content in soil.

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Irrigation and residue management in wheat under rice- wheat cropping system

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The concept of irrigated wheat cultivation after green revolution started the tragedy of injudicious utilization and exploitation of this valuable resource particularly in Indo- Gangetic Plains. This considerably ignored the real concept of irrigation *i.e*. when, how much and how to irrigate. The psyche of 'more irrigation produces more yield needs to be changed to conserve water which will become insufficient during incoming future. On the other hand, the plenty available rice residue (approximately 120 million tons/annum) may also be utilized in various manner to conserve water, improve soil properties and ultimate increase in wheat yield under rice- wheat cropping system.

METHODOLOGY

To optimize irrigation use efficiency and rice residue management for increasing wheat yield, an experiment was conducted in Norman E. Borlaug Crop Research Centre, GB Pant University of Agriculture and Technology, Pantnagar during the year 2010-11 in split plot design with three replications. Application of five irrigation levels at different growth stages were plotted as main treatments and four different rates of previous rice crop residue retention *viz*. 0, 2, 4 and 6 t/ha were applied as sub plot treatments (Table 1). The weighed quantity as per the treatment requirement of previous rice crop residue was retained in plot after sowing of wheat.

RESULTS

Taller plants with higher yield attributing characters *viz*. earhead/m^2, number of grains/ earhead and 1000 grain weight and grain yield were observed in treatment five irrigations which were applied at CRI, tillering, jointing, boot leaf stage and milk stage over all the other treatments; however it was found to be at par with two, three and four irrigations at the crop growth stages as shown in Table 1in respect of all these characters. Thakur *et al.* (2000) reported similar response of wheat crop to the irrigation scheduling treatments, which might be due to the boosting up of all physio-chemical functions of plant with timely availability of moisture at the critical growth stage. In respect of residue management, retention of 2, 4 and 6 t/ha rice residue producedstatistically equivalent taller plants and higher wheat grain yield which was significantly superior over no residue retention. Similar results have been reported by Singh *et al*.(2007).

CONCLUSION

Application of two irrigations at crown root initiation and

Table 1. Effect of different irrigation levels and residue management practices on growth and yield of wheat

Treatment	Plant height (cm)	Grain yield (kg/ha)	Earhead/m^2	Grains/ earhead	1000 grain weight (g)
Irrigation Level					
One irrigation at CRI	89.4	4460	462	36.4	39.3
Two irrigations at CRI and boot leaf stage	94.4	4730	470	40.2	41.2
Three irrigations at CRI, tillering and boot leaf stage	95.5	4830	510	42.7	42.6
Four irrigations at CRI, tillering, boot leaf stage and milk stage	96.1	4860	515	42.8	42.8
Five irrigations at CRI, tillering, jointing, boot leaf stage and milk stage	97.6	4950	548	43.1	43.2
CD (P= 0.05)	4.5	300	52	4.3	2.5
Residue management					
No residue	90.8	4490	471	38.6	40.0
Residue @ 2t/ha	94.7	4730	497	40.0	41.2
Residue @ 4t/ha	95.9	4860	512	41.2	42.3
Residue @ 6t/ha	97.1	4970	525	44.3	43.8
CD (P= 0.05)	3.8	220	21	3.4	1.8

boot leaf stage with retention of 2t/ha previous rice crop residue may be efficient for increasing growth and grain yield of wheat crop in rice-wheat cropping system.

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Resource conservation technologies: adoption in Sri Muktsar Sahib district of Punjab

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At present, ground water level is depleting rapidly in the state and 110 out of 138 blocks have already been categorized as over-exploited or dark blocks and 4 other blocks are at critical stage (CGWB, 2016). To combat with these problems, many resource conservation technologies have been developed by the Punjab Agricultural University, Ludhiana but these are not being adopted to the desired level by the farmers of Punjab. So, this study was conducted with objective of, to know the extent of adoption of selected resource conservation technologies by the farmers of Sri Muktsar Sahib District of Punjab.

METHODOLOGY

Resource conservation technologies selected for study were direct seeded rice, zero tillage in wheat, laser leveler and tensiometer.Out of the four blocks of district Sri Muktsar Sahib, two blocks were selected purposively. From each selected block, further four villages were selected purposively. A total of 150 respondents were randomly selected from 8 villages based on the probability proportion to the number of farmers in each village.An interview schedule was prepared to measure the extent of adoption of selected resource conservation technologies by the farmers. Data were collected by per-

Table 1. Distribution of respondents according to their socio-personal characteristics (n=150)

S.No.	Charactestics	Category	Frequency	Percentage
1.	Age (years)	25-37	48	32
1.		38-50	62	41.33
1.		51-63	40	26.67
2.	Education	illiterate	9	6
1.		primary	29	19.33
1.		middle	23	15.33
1.		matric	48	32.00
1.		Senior Secondary	26	17.33
1.		Graduate	13	8.67
1.		Post-Graduate	2	1.33
3.	Operational land holding (acres)	Marginal	1	0.67
		Small	4	2.67
		Semi-Medium	26	17.33
		Medium	73	48.67
		Large	46	30.67

Table 2. Overall extent of adoption of selected recommended by respondents

Water saving technologies adoption (n=150) Total sampled area= 3270 acres		
Water Saving Technology	Area (acres)	Extent of Adoption (%)
Direct Seeded Rice	462	14.13
Zero-Tillage Wheat	619	18.93
Laser leveler	3081	94.22
Tensiometer	0	0
Laser leveler adoption (n=148)		
Extent of adoption (Scores)	Frequency	Percentage
Low (up to 59)	8	5.40
Medium (59-90)	13	8.78
High (90-100)	127	85.82

rect seeded rice had very low extent of adoption i.e. 18.93% and 14.13% respectively. Tensiometer had not been adopted by even single respondent and most of the farmers were not aware about tensiometer. A very high proportion (85.82%) of laser leveler adopters out of total adopter had high extent of adoption because of direct and observable benefits of laser leveling (Table 2). It was observed from the data given in (Table 3) about 38% of direct seeded rice adopters had medium extent of adoption whereas about 36% of adopter had low extent of adoption for direct seeded rice. More than one fourth proportion (26.19%) of DSR adopters had high extent of adoption.

In case of zero tillage in wheat, data pertained to (Table 3) revealed that majority of ZTW adopters i.e. about 48% had medium extent of adoption and also somewhat less proportion of adopters i.e. about 41% had high extent of adoption of ZTW. While only 10%farmers had low extent of adoption.

Table 3. Distribution of the respondents according to extent of adoption of direct seeded rice and zero tillage in wheat

Extent of adoption (Scores)	Direct Seeded Rice (n=42)		Zero tillage in wheat (n=29)	
	Frequency	Percentage	Frequency	Percentage
Low (up to 31)	15	35.71	3	10.34
Medium (31-64)	16	38.10	14	48.28
High (64-100)	11	26.19	12	41.38

sonally visiting the study area and interviewing the farmers.

RESULTS

Data in (Table 1) revealed that most of the respondents (41.33%) belonged to the age group 38-50 years and about one third of the respondents were matriculates. Majority of farmers (48.67%) had medium (10-25 acres) operational land holdings. Data given in (Table 2) showed that laser level had the maximum extent of adoption among all the selected resource conservation technologies. This may be due to high observability of benefits of laser leveling and laser leveler availability in villages whereas Zero tillage in wheat and di-

CONCLUSION

There is a lot of scope for increasing the extent of adoption of resource conservation technologies. Literature should be provided to aware farmers about these technologies. Training and demonstrations should be organized to influence the farmers for use of these technologies.

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Soil aggregate associated carbon as influenced by tillage and residue management in pigeon pea-wheat cropping system

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Soil structure is very pertinent in deciding the ability of soil to store organic matter. Inappropriate management (e.g., intense ploughing and not using cover crops) can cause rapid soil deterioration. Turnover rate of soil organic carbon and aggregates had a very good correlation with tillage intensity. Small changes in soil organic carbon can influence the stability of macro-aggregates. Understanding these relationships in a broader range of soils and management conditions may be of particular importance for developing management practices for sustainable crop production systems. The main objective of this study was to determine the changes in aggregate associated carbon for different tillage systems and crop residue under pigeonpea-wheat cropping system.

METHODOLOGY

The research work was undertaken in an ongoing field experiment initiated in *kharif* 2008 on a *Typic Haplustept* at the Research Farm of the Division of Agronomy, Indian Agricultural Research Institute (IARI), New Delhi. The pigeonpea (*Cajanus cajan* L.) variety 'Pusa 992' and Wheat (*Triticum aestivum* L.) variety 'HD 2932' were used for experiment. The experiment was laid out in split plot design. Four main plot treatments were conventional tillage-conventional tillage (CT-CT), conventional tillage-zero tillage (CT-ZT), zero tillage-conventional tillage (ZT-CT) and zero tillage-zero tillage (ZT-ZT) systems. In sub-plots, four residue treatments *viz.* no residue as control (R0), residue of pigeon pea alone (Rip), residue of wheat alone (Riw) and residue of both pigeonpea and wheat (R_2) were taken. Soil samples were collected after harvest of wheat during 2010 from 0-20 cm soil depths. The soil macro and micro aggregate were separated through wet sieving procedure. Macroaggregate and microaggregate associated carbon was determined by wet oxidation method (Snyder and Trofymow, 1984). The data generated were analyzed for the analysis of Variance (ANOVA) using SAS Software version 9.1.

RESULTS

The yield data in (Table 1) depicts that pigeonpea seed yield varied from 1.33 t/ha under ZT-ZT to 1.68 t/ha under CT-CT tillage combination and stover yield also varied from 6.43 to 7.15 t/ha in ZT-ZT to CT-ZT combination. The effect of residue addition showed that conjoint application of both the crop residues had better affect on performance of yield of both the crops. Macroaggregate associated carbon was highest in when residue of both the crops (R2) were added mainly under CT-ZT, ZT-CT and ZT-ZT tillage combinations (Table 2). The R2 residue treatment followed by Rip had better macroaggregate associated carbon than R0, though the effect was non-significant. The microaggregate associated carbon was significantly higher in R_2 especially, for ZT-CT and ZT-ZT combinations. There was an increment of 18.73% carbon aggradations under R2 residue treatment in ZT-CT combination and 44.98% in ZT-ZT tillage treatment over control. This

Table 1. Mean effect of tillage and residue management on yield performance of pigeon pea-wheat cropping system.

Crop	Yields	Tillage					Residue				
		CT-CT	CT-ZT	ZT-CT	ZT-ZT	CD (0.05)	R0	Rip	Riw	R2	CD (0.05)
Pigeon pea	Seed yield (t/ha)	1.68	1.65	1.36	1.33	0.142	1.31	1.5	1.48	1.73	0.09
(2009-10)	Stover yield (t/ha)	7.1	7.15	6.02	6.43	0.828	5.86	6.83	6.73	7.28	0.539
Wheat	Grain yield (t/ha)	4.48	4.72	4.13	3.9	0.367	3.92	4.08	4.38	4.83	0.224
(2009-10)	Straw yield (t/ha)	6.39	6.85	5.95	5.58	0.627	5.84	5.89	6.07	6.97	0.376

Residue levels as (R)-control, R2-residue of both crops, Rip-residue of pigeon pea only, Riw-residue of wheat only). Levels of tillage as CT-Conventional tillage and ZT-Zero tillage

Table 2. Effect of tillage and residue management on macro and microaggregate associated carbon (g/kg) in 0-20 cm soil depth.

	Levels of residues							
	Macroaggregate				Microaggregate			
Tillage	R0	R2	Rip	Riw	R0	R2	Rip	Riw
CT-CT	5.06	4.97	4.69	5.43	3.58	4.14	4.14	3.76
CT-ZT	5.61	6.07	5.82	4.42	4.69	4.78	4.05	4.14
ZT-CT	5.70	6.16	6.16	6.07	3.95	4.69	3.77	3.12
ZT-ZT	5.24	5.43	4.69	3.86	3.49	5.06	3.58	3.22
	TxR for similar level of tillage		TxR for similar level of residue		TxR for similar level of tillage		TxR for similar level of residue	
LSD (P=0.05)	0.62		0.64		0.53		0.51	

Residue levels as (R0-control, R2-residue of both crops, Rip-residue of pigeon pea only, Riw-residue of wheat only). Levels of tillage as CT-Conventional tillage and ZT-Zero tillage

might be due to the less disturbance of soil that leads to more carbon accumulation in microaggregates.

CONCLUSION

Conventional tillage along with zero tillage combination in both pigeon pea and wheat, along with retention of residues of both the crops provided better aggregate protected carbon as a management strategy for long-term carbon sequestration in semi-arid sub tropics of India.

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Zero tillage reduces soil and nutrient losses and improves soil quality compared to conventional tillage

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Most of the population (82%) in Himalayan region lives in rural areas. The rural population chiefly depends upon agriculture. The land holding is very small and fragmented and the slope is very high (Tuti *et al*., 2013). Tillage on sloping lands results in severe soil erosion and reduces soil organic C (SOC) content. In contrast to conventional tillage (CT), zero tillage (ZT) encourages soil stabilization and water conservation and the increase of soil organic matter in top soils (Beniston *et al*., 2015). Surface residues maintained under ZT systems moderate moisture fluctuations and thus reduce runoff. Many studies report increased macronutrient export with increasing rainfall intensity, with the amplitude of the response affected by tillage management (Beniston *et al*., 2015). Hence, adoption of ZT under rice-wheat systems may be a viable alternative for better soil and resource conservation (Bhattacharyya *et al*., 2008). Tillage systems also affect soil quality differently, because of their varied tillage intensities. Conversion from conventional tillage (CT) to ZT usually increases water holding capacity and decreases runoff (Bhattacharyya *et al*., 2008). Low yield in this region is mainly attributed to soil moisture deficits in the critical crop growth stages, as the region is mostly rainfed system. The importance of irrigation is clear, as both rice and wheat crops require water in drier periods (Singh *et al*., 2006). Aboveground and underground biomass crop yields vary with different irrigation levels, resulting in variations in crop residue on the soil surface. However, the specific effects of tillage and irrigation on soil and nutrient losses and soil quality are rarely investigated in the Himalayan region. Hence, we chose to estimate the impacts tillage and irrigation on soil and nutrient losses along with soil quality under rice-wheat system in the north-western Himalayas after twelve years of cropping. The objectives of the study were (i) to estimate soil and nutrient losses and (ii) to evaluate different soil quality parameters under different tillage system and irrigation levels under rice-wheat system.

METHODOLOGY

The field experiment was conducted during 2001 to 2013 at the experimental farm of ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora in the state of Uttarakhand, India. The experiment was laid out in a split-plot design with tillage operation (ZT in the form of no disturbance of the soil and CT in the form of two diggings with a spade to the 15-cm depth to prepare a seedbed for both rice and wheat) as main plots and application of four irrigation levels as subplots. Irrigations were applied at pre-sowing and critical growth stages of both crops.(Treatment I_1: pre-sowing; I_2: pre-sowing + active tillering or crown root initiation; I_3: pre-sowing + active tillering or crown root initiation + panicle initiation or flowering; and I_4: pre-sowing + active tillering or crown root initiation + panicle initiation or flowering + grain filling). These treatments were repeated in the same plots each year. Each treatment was replicated four times. Soil loss was estimated through height differences of experimental plot from reference point with help of dumpy level and bulk density after completing twelve years experiment. Nutrient losses are estimated by multiplying the nutrient concentration with amount of soil loss. Hydraulic conductivity was estimated following the standard method. Soil samples were collected from 0-15 cm depth at the end of the 12th cropping cycle and analyzed for soil organic C, available N, P and K, DTPA extractable Fe, Mn, Zn and Cu, dehydrogenase activity and water holding capacity using standard analytical methods. Bulk density was determined as the oven-dried core mass divided by the core volume using one sample set (three cores).

RESULTS

Pooled analysis of last three years experiment showed that rice and wheat yield under ZT plots (2.42 and 4.31 t/ha for rice and wheat, respectively) was higher than CT plots (2.40 and 4.31 t/ha for rice and wheat, respectively), but both are significantly at par with each other. The gain in yield under ZT might be due to lower soil and nutrient losses and higher soil quality parameters (Table 1). The better soil quality parameters under ZT than CT was not proportionately reflected due to very high density of weed (data is not presented). The soil and nutrient losses under ZT and CT applied with different number of irrigations were studied after 12 cycles of rice-wheat system. The estimation informed that the loss of soil under conventional tillage (167 t/ha/year) was 157 t/ha/year higher than zero tillage. The soil erosion might have been reduced due to residue retention, higher soil organic carbon and hydraulic conductivity under ZT plots. The soil loss was reduced as the irrigation number increased. Application of four irrigations at CRI, tillering, flowering and grain filling re-

Table 1. Effects of tillage and irrigation on soil quality parameters under rice-wheat system

Treatment	SOC content (g/kg)	Available nutrient (mg/kg)			DTPA extractable micro-nutrient (mg/kg)				Bulk density (Mg/m^3)	Dehydrogenase activity (µg TPF produced g/ 24 hr)
		N	P	K	Fe	Mn	Zn	Cu		
Tillage										
ZT	8.37	186	8.21	73.3	42.1	38.6	0.971	1.25	1.34	66.8
CT	7.33	172	7.44	67.8	40.6	36.6	0.894	1.17	1.39	61.4
CD (P= 0.05)	0.85	13	0.75	5.2	1.3	1.7	0.071	0.08	0.02	3.3
Irrigation										
I_1	6.84	168	7.15	66.0	39.7	35.9	0.883	1.15	1.40	56.9
I_2	7.36	173	7.69	69.1	41.1	36.9	0.903	1.18	1.38	61.3
I_3	8.33	182	8.08	72.1	42.0	38.3	0.964	1.24	1.35	66.7
I_4	8.86	193	8.39	74.9	42.7	39.2	0.980	1.26	1.33	71.5
CD (P= 0.05)	0.58	8	0.40	1.6	2.1	1.9	0.047	0.04	0.02	6.1

duced 40 t soil/ha/year soil erosion than under one pre-sowing irrigation. The increase in irrigation provided higher residue retention and reduced erosion. The total reduction of erosion of available N, P and K under zero tillage were 26.9, 1.2 and 10.6 kg/ha/yr than conventional tillage, respectively. The soil organic carbon concentration under ZT was 14% higher than CT (7.33 g/kg) (Table 1). The higher SOC under ZT might have been due to the reduction of soil erosion and addition of more root biomass and stubble. Similarly available N, P and K, DTPA extractable Fe, Mn, Zn, Cu, water holding capacity, hydraulic conductivity and dehydrogenase activity were higher in ZT than CT. The bulk density under ZT plot was 3.7% lower than the CT (1.39 Mg/m^3). All of the soil quality parameters improved under ZT might have been due to the higher SOC under it (Table 1).

CONCLUSION

The grain yield and soil quality parameters improved under ZT than CT. Hence, zero tillage could be recommended under rice-wheat system in the north-western Himalayas to reduce soil and nutrient erosions and for higher soil quality and yield.

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Effect of tillage, crop residue and weed management in rice – wheat cropping system

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Conservation agriculture is an agricultural management practice in which there is minimum soil disturbance, retention of residue for soil cover and rotation of major crops. (Chhokar *et al*., 2007). In conventional tillage farming weeds can be effectively controlled by tillage operations, which uproot and bury weeds deep into the soil. Due to lack of tillage, weeds grow and flourish in conservation agriculture. Weed control in conservation agriculture is a greater challenge than in conventional agriculture, if effective weed control measures are not taken growth and yield of crop is reduced. Effective weed management is a serious challenge for the adoption of DSR technology by farmers. The weed flora in direct seeded rice is diverse and consists of both aerobic and anaerobic grasses, broad-leaf weeds and sedges. Furthermore, weeds in DSR emerge in several flushes during the crop growth period. Weeds cause enormous losses in production and productivity of all major crops. Kurchania *et al.* (2000) reported that the uncontrolled presence of broad-leaf weeds in wheat crop led to the reduction of grain yield to the tune of 7-50% depending on their density. Considering these facts, a field experiment was carried out to evaluate the effect on crop productivity, weed dynamics, C-Sequestration and changes in physic-chemical in long term tillage and residue management in rice –wheat system**.**

METHODOLOGY

The study was conducted at the Indira Gandhi Krishi Vishwadidayala, Raj Mohini Devi College of Agriculture and

Table 1. Effect of tillage, crop residue and weed management on weed density and yield of wheat in rice based cropping system

Treatment	Grassy weed dry weight	Broad leaves weed dry weight	Total weed dry weight	Tillers/ plant	Grains/ panicle	Grain yield
	g /m^2 at 60 DAS			No.	No.	t/ha
Tillage practice						
Zero-tillage	30.11	12.81	42.92	59.11	33.22	2.78
Conventional tillage	36.22	17.44	53.66	51.66	28.11	2.54
Zero tillage + Residue	27.44	12.70	40.14	58.66	33.33	2.97
Conventional tillage + Residue	34.22	17.48	51.70	56.11	30.44	2.53
SEm±	2.02	1.17	3.10	1.12	0.38	0.06
CD (P=0.05)	6.97	4.07	9.30	4.21	1.33	0.19
Weed management practice						
Recommended herbicide (Clodinofop +Metsulfuron)	19.75	14.25	34.00	59.33	33.66	2.96
Integrated weed management (hand weeding fb Metsulfuron)	30.52	11.08	41.60	60.25	33.00	2.94
Unweeded check	45.72	19.99	65.70	49.58	27.08	2.04
SEm±	1.98	1.24	3.22	1.12	0.56	0.05
CD (P=0.05)	5.93	3.71	9.60	3.38	1.69	0.16

Research Station, Ambikapur, Chhattisgarh during *Kharif* and *Rabi* season of 2015 and 2016. The soil of experimental field was well-drained sandy loam soils (*Inceptisols*), which was low in nitrogen, medium in available phosphorus, high in potassium and slightly acidic in reaction (pH 6.5) . The main plot consisted four treatments of tillage practices *viz.,* Zero-tillage, Conventional tillage Zero tillage + Residue and Conventional tillage + Residue. While the sub- plot consisted of three treatments of weed management *viz.,* post-emergence application of recommended herbicide (Clodinofop + Metsulfuron) at 25 DAS, Integrated weed management (hand weeding fb Metsulfuron) at HW at 20 DAS followed by post-em herbicide at 35 DAS and Unweeded check were tested in split plot design with three replication. In *Kharif* season all the treatments are common in rice crop. 100:60:40 NPK kg/ha. full dose of P and K along with 40 kg N was applied as basal. Rest of the N was applied in two splits at tillering and panicle initiation. In rice bispyribac sodium @ 25 g/ha at 20 DAS has been very effective to reduce the mixed weeds density and their growth. The rice cultivar "Bamleshwari" was sown and harvested on 16th July, 2015 and 27th November, 2015, respectively. Wheat crop sowing was performed by seed drill (line sowing) after basal application of fertilizer using seed rate of 100 kg/ha, crop was fertilized with 120:60:40 kg NPK/ha. The wheat "GW-273" was sown and harvested on the 4th December 2015 and 4th April, 2016, respectively.

RESULTS

The dominant weeds at trial sites were *Phalaris minor, Avena sativa, Vicia sativa, Melilotus indica, Fumaria parviflora, Chenopodium album, Anagalis arvensis* etc. weed density was substantially quite low in zero tillage+ Residue than fb zero tillage system at each and every site of trails (Table 1). Foliar application of company mixed herbicides (Clodinofop +Metsulfuron) at 30 DAS effectively controlled both broad and grassy weeds as compared to unweeded cheek. The weed control efficiency (WCE) of Clodirofop + Metsulfuron was higher in grassy weeds and equally effective in comparison to IWM (HW at 20 DAS fb metsulfuron at 35 DAS). Result also revealed that zero tillage system of wheat sowing registered maximum effective tillers and grain yield over conventional tillage. The yield and yield attributes parameters were higher in application of broad spectrum herbicide Clodirofop + metfulfuron at 25g/ha at 30 DAS but which was at par with IWM (one HW at 20 DAS+ metsulfuron at 35DAS). Both herbicidal treatments were significantly higher yield and yield attributes than weeds cheek.

CONCLUSION

Zero-tillage+ residue or zero-tillage was found much effective in suppression of weed density and population of weeds in comparison to conventional tillage. A drastic reduction in weed density was obtained with the application of Clodinofop + metsulfuron at 25 g/ha ready-mix under both zero-tillage and conventional tillage method of wheat sowing. The higher average grain yield also achieved under zero tillage sown wheat combined with Clodinofop + metsulfuron as 30 DAS. However, yield attributes and yield obtained under zero tillage was almost comparable to HW at 20 DAS fb metsulfuron at 35 DAS.

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Promoting conservation agriculture in rice-wheat cropping system in Eastern region of Nepal

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Farmers of Sunsari district, Nepal shows their keen interest on conservation agricultural practices on rice-wheat farming system. Rice-Wheat farming system is the dominant cropping system in the terai areas which is synonymously called as food basket of the country. The productivity of rice-wheat system was rapidly increased by the adoption of the technological package of Green Revolution of 1960s. Howsoever, several yield reducing and limiting factors along with the delayed sowing of wheat and rice, infestation of weeds, insects and diseases, changing climate had reduced the yield and productivity of rice-wheat in Nepal. Ministry of Agricultural Development estimated the rice yield decline by 10% this year and also approximates the yield decline of wheat crop by 6-9%. "In terai areas of Nepal the soil organic matter content was low and the input use efficiency was also found low due to which the productivity was stagnated". So, we have to set new agricultural technologies to be tested and out-scaled to cope up the constraints in the rice-wheat farming system. Conservation Agriculture production systems have been demonstrated to be beneficial for sustainable ecosystem management and agriculture intensification. In order to test the new technology, SRFSI project is in work with collaboration with NARC and DOA and the grassroot organizations are RARS, Tarahara, DADO, Sunsari for Sunsari district and NRRP, Hardinath and DADO, Dhanusha to work for Dhanusha district. Farmers were reaping negative net returns for wheat because of the poor yield and the high input cost. This project is testing the farmer's conventional technologies with the Zero Tillage technologies at different five nodes of Sunsari district. At the first year many farmers were not easy to accept the concept of conservation agriculture in wheat crop and it was problem in the first year to inculcate the ideas of conservation agriculture in rice wheat farming system. After seeing the harvest of the leader farmer's at each node in the respective year now days demanding these technologies to be adopted in their own farm. The major costs for rice production were: land preparation (36%), raising and transplanting seedlings (21%), and harvesting and threshing (23%), and for wheat crop: land preparation (33%), inputs application and weed management (35%), harvesting and threshing (32%). In the preliminary results of the project the average B: C ratio was higher in the CA technologies as compared with the conventional technologies in rice, wheat and maize". Most of the farmers in the nearby nodes of Sunsari district are highly interested in the CA technologies are demanding several agricultural implements (zero till drill, rice transplanter, power tiller, reaper, combine harvestor) at DADO Sunsari with some subsidy from the government of Nepal and will adopt in the coming year.

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Resource conservation vis-a-vis carbon sequestration to combat green house gas from atmosphere into the soil

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Soils are the largest carbon reservoirs of the terrestrial carbon cycle which contains about three times more carbon than in the world's vegetation; hold double the amount of carbon that is present in the atmosphere and considered to be important sinks for carbon sequestration. Carbon sequestration in soil occurs by two ways: direct and indirect. Direct carbon sequestration occurs by inorganic chemical reactions that convert CO_2 into soil inorganic compounds such as calcium and magnesium carbonates. Indirect carbon sequestration occurs as plant photosynthesizes atmospheric CO_2 into plant biomass. Soils play a key role in the global carbon budget and greenhouse effect (Kumar *et al.* 2006). Other sustainable farming systems such as conservation tillage, further increases climate change mitigation potential. In cultivated land manures alone or in combination with fertilizers not only improve soil fertility, physical environment of soil, enhance biomass production but also help build up SOC content (Grace *et al*., 2012).

METHODOLOGY

A field investigation was conducted in during *Kharif* season of 2015 at Agricultural Farm of Banaras Hindu University, Varanasi, Uttar Pradesh to determine the effect of carbon sequestration into the babycorn crop followed by moong in soil. Plants are the main sources of the soil organic carbon, either from decomposition of aerial plants or underground plant parts such as root in the form of root decay, root exudates and root respiration. More than 200 carbon compounds are released from plant roots in the form of root exudates which is termed as rhizodeposition (Table 1). About 40% of the photosynthates synthesized in plant parts are lost through the root system into the rhizosphere. Agroforestry systems are believed to have a higher potential to sequester carbon than pasture and field crops (Kirby and Portvin, 2007).

RESULTS

The C pools and SOC stock changes are strongly associated with C input rate in no tillage soils where the C losses associated with conventional treatments agree with previous findings.In the tropical sites C increased in the upper and deeper layers, indicating the importance of the root system of the grass plants when developed in deeper layers during the dry season. These findings demonstrate the importance of introducing species of plants with high biomass input and with high adaptation capacity in adverse environments. Thus it is crucial in tropical areas to develop cropping systems with high biomass input for environmental and economic sustainability. Farmers can benefit from carbon sequestration through the use of conservation tillage, crop rotation, use of buffer strips, and permanent vegetation for highly eroded soils. These benefits include improved soil productivity, improved environment due to less erosion, and improved physical and biological properties of soil. There is a strong and emergent need to divert the CO_2produced in the atmosphere directly to soil for its rejuvenescence. The panacea is to remove carbon from the atmosphere by various means and store it in the soil through resource conservation. Adequate supply of nutrients in soil can enhance biomass production and soil organic carbon (SOC) content. Use of organic manure and compost enhances the SOC pool more than application of the same amount of nutrients as mineral fertilizers. Experiment shows changing from conventional tillage (CT) to no tillage (NT) does not cause an increase in CO_2 emissions, but in most cases contributes to a decrease.

Table 1. Effect of crop yields per ton of carbon in the root zone

Crop	Potential yield increase (kg/ha)
Maize	200-400
Wheat	20-70
Soybean	20-30
Cowpea	5-10
Rice	10-50
Millet	50-60

CONCLUSION

Adding organic matter to farmland is good for soil quality and crop yields, both short-term and long-term. Continuous no-till is an efficient way of doing this. Cover crops and manure also help raise carbon levels. Soil carbon sequestration is a natural, cost-effective, and eco-friendly process. Once sequestered, carbon remains in the soil as long as restorative land use, continuous no till, and other best management practices are followed. However, there is a need to develop, evaluate and adopt agro-techniques efficient in increasing soil organic carbon pool. Soil carbon sequestration is a win-win solution for agriculture and the environment.

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Impact of resource conservation technologies on productivity, nutrient use efficiency and GHGs emissions in rainfed maize- castor cropping system

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Maize (*Zea mays* L.) and castor are the most important crops having wider adoptability to survive under diverse agro-climatic conditions and are suitable for rainfed regions. But the productivity of these crops is low under rainfed regions. Alfisols are predominant in rainfed semi-arid tropic regions (SAT regions) and these soils are light textured, shallow depth with low water-retention capacity and poor soil fertility status. Furthermore these rainfed crops receive least attention of farmers towards balanced application of fertilizers and manures. Thenitrogen use efficiency is only 20-30 per cent due to poor moisture and nutrient status of the soils. In order to reduce nitrogen losses and increase its efficiency, one of the mechanisms is to apply nitrification inhibitors.However, the use of these inhibitors for inhibiting nitrification, reducing N losses and increasing NUE in agriculture ecosystem particularly in rainfed agriculture is still not common. As compared to synthetic nitrification inhibitors, the natural nitrification inhibitors are eco-friendly, easily available, implying lower cost of production and can be included in the farming systems. Hence the productivity of rainfed crops can be improved through efficient rain water management and improving the water holding capacity of these soils since soil moisture is a major constraint for sustainable agriculture and improving the nitrogen use efficiency in the SAT.The efficient rain water management can be achieved through site specific insitu moisture conservation technologies like conservation furrow and tank silt application in alfisols.

METHODOLOGY

Field experiments were conducted for four years from 2012 to 2015 at Gungal Research Farm of the ICAR- Central Research Institute for Dryland Agriculture, Hyderabad, India in the semi-arid region of Southern part of India. Average rainfall during the experimental period was 700 mm. The experiment was laid out in split-plot design with three replications. The treatments comprises three soil moisture conservation practices viz., conservation furrow, tank silt and control as main plot treatments and five nitrogen fertilizer sources viz., 50% RDN by farmyard manure (FYM) +50 % RDN byurea, 100% RDN by karanjan cake (*Pongamia glabra Vent.*) coated urea, 100% RDN by neem (*Azadirachta indica*) coated urea, 100% RDN by vavilia (*Vitex negundo)* leaf powder coated urea, 100% RDN by urea and control as sub plot treatments. Grain and straw yield and other soil and plant analysis was done by using the standard procedure (Jackson,.1958). Greenhouse gas measurements (CO_2, N_2O and CH_4) were determined using the insulated static vented rectangular aluminium chambers (80 cm x 40 cm x 10 cm) of cross-sectional area of 0.32 m^2 with a height of 10 cm. as described by (Livingston and Hutchinson, 1995). Gas samples were collected after 24 h of anchor installation to stabilize the anchor in the soil.

RESULTS

The grain yields of castor and maize were significantly influenced by moisture conservation practices during all the four years. Conservation furrow and tank silt application recorded 14.5 and 20% higher yield respectively as compared to controlin 2012-13 and 2013-14. Whereas in 2014-15 and 2015-16 conservation furrow recorded higher yield as compared to tank silt and control. This could be ascribed due to higher soil moisture conservation in conservation furrow treatment and tank silt application. Whereas, in drought years 2014 and 2015 the crop yields in tank silt was lower as compared to conservation furrow at the time of sowing (Fig 1). All the natural nitrification inhibitors recorded higher yield over the uncoated urea. Among natural nitrification inhibitors coating of urea with plant based products like vitex leaf powder and neem cake recorded 23.9 and 19.8% higher grain yield over uncoated urea. The Moisture conservation practices

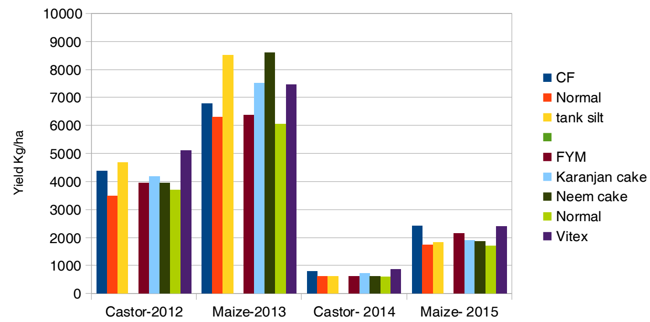

Fig. 1.

and nitrification inhibitors improved the nutrient use efficiency and decreased the GHG emissions in general and N_2O emissions in particular.

CONCLUSION

The four years study has revealed that plant based products coated urea has the potential to increase N use efficiency and lead to lower emissions of N_2O compared with uncoated urea. A significant interaction between coated urea and soil moisture conservation furrows increased the yield along with mitigation of GHG emissions by improving N use efficiency and soil moisture conservation.

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Conservation agriculture for sustainable crop production and soil fertility management under rainfed conditions

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Degradation of land under rainfed farming situation (>65% of cultivable area) due to continuous erosion has impoverished the soil resulted in declined crop productivity, soil health, reduced stress bearing capacity, frequent droughts hence, livelihood of farm families is under stake. In these areas, the green revolution technologies have made limited or no impact. The vast majority of poor lives and their livelihoods are intimately linked to our ability to improve farming situation in these areas. Rainfall regimes and soil characteristics are the key determinants for potential crop production as rainfed agriculture is being practiced under wide range of soil and climatic conditions. The problems of rainfed areas of Southern Plateau and Hills region (Region X) of the country are more diverse and intricate. The sustainable agriculture in this region can be achieved through stabilizing the environment, enhancing the productivity and establishing dynamic equilibrium between natural resources and population. Thus top priority should be given for conservation of natural resources mainly soil and water conservation. Conservation agriculture is a concept of resource saving agricultural crop production that strives to achieve acceptable profits together with high and sustainable production levels while concurrently conserving the environment. In the world it is being practiced over an area of 155 M ha (FAO, 2014) and found more sustainable under rainfed conditions. Sustainable application of conservation technologies has been built on ecological principles and making land use more sustainable. Adoption of CA technologies for increasing resource use efficiency and to foster sustainable improvement in agro-ecosystems productivity under rainfed agriculture is need of the hour. Hence, the field studies were conducted during 2013-14 and 2014-15 to evaluate the reduced tillage systems and water conservation practices in cotton and pigeonpea based cropping systems on efficient utilization of natural resources mainly soil, water and bio-diversity to enhance and sustain the productivity of soil and crops in rainfed ecosystem.

METHODOLOGY

Field trials were conducted on a fixed site of Conservation Agriculture Project, at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka during 2013-14 and 2014-15. The study aimed to know the reduced tillage practices and land configuration practice (BBF) in cotton and pigeonpea based cropping systems for enhanced crop productivity and profitability under rainfed situations. The experiment was laid out in a strip block design comprising six tillage practices (CT_1 - Conservation tillage with BBF and crop residue retained on the surface, CT_2 - Conservation tillage with BBF and incorporation of crop residue, CT_3 - Conservation tillage with flat bed with crop residue retained on the surface, CT_4 - Conservation tillage with flat bed with incorporation of crop residue, CT_5 - Conventional tillage with crop residue incorporation and CT_6 - Conventional tillage without crop residue) and five cropping systems mainly cotton + groundnut (CS_1), cotton + soybean (CS_2), pigeonpea + soybean (CS_3), sole cotton (CS_4) and sole pigeonpea (CS_1) with three replications. The experiment was initiated during 2013-14 and conservation tillage plots were maintained permanently with plot size of 15 m width and 9 m length. In convention plots, the land was ploughed once, cultivated and harrowed and soil was brought to fine tilth. In conservation plots, rotoslasher was used for crop residues to shred and retain on the surface and rotovater was used for partial shredding and incorporation of crop residues during 1st week of May, till than residue mulch was maintained on the surface. Intercrops were sown with the help of seed drill and hand dibbling was done for cotton and pigeonpea. BBF with 180 cm bed and 30 cm furrow width were formed immediately after sowing of the crops. During crop growth period there was uniform distribution of rainfall which helped to get good crop stand and optimum yield of crops.

RESULTS

Two years pooled data showed that, irrespective of cropping systems, conservation tillage with BBF and crop residue retained on the surface (CT_1) recorded significantly higher cotton equivalent yield (3288) as compared to conventional tillage with crop residue incorporation (CT_5- 2955 kg/ha) and conventional tillage without crop residue (CT_6- 2693 kg/ha). However, CT_1 was found on par with CT_2 (3243 kg/ha) CT_4 (3243 kg/ha) and CT_3 (3172 kg/ha). Conventional tillage system with crop residue incorporation recorded significantly higher cotton equivalent yield (2955 kg /ha) as compared to conventional tillage without crop residues (2693 kg/ha). All the conservation tillage systems recorded significantly higher net returns (CT_1- ₹ 97317 /ha CT_2- 95394 /ha, CT_3- 93617/ ha and CT_4- 92403/ha) and BC ratio (CT_1-3.54, CT_2-3.49, CT_3-3.52 and CT_4-3.48) over conventional tillage systems with crop residue (CT_5- 79100 /ha and 2.86) and without crop residue (CT_6- 68080 /ha and 2.61 respectively). Jat *et al.* (2013) reported that undoubtedly, zero tillage with bed or flatbed and residue retention has potential to improve the crop productivity and system profitability. In maize – wheat cropping systems suitable conservation agriculture practice (zero/ minimum tillage with crop residue management) enhances system productivity, reduces runoff, soil loss and conserve soil moisture. Among different cropping systems, pigeonpea + soybean intercropping system (CS_3) and sole pigeonpea (CS_1) produced significantly higher cotton equivalent yield (4339 and 4181 kg/ha respectively) as compared to other cropping systems. In a system both the crops complement each other and soybean produced optimum yield without affecting pigeonpea yield. The next best was found to be cotton + groundnut (CS_1) (3307 kg/ha) which was significantly superior to cotton + soybean (CS_2) (1833 kg /ha) and sole cotton (CS_4) (1835 kg/ha). Three years field trials conducted at PDKV, Akola showed that, minimum tillage with pigeonpea + soybean (1:2) intercropping produced significantly higher pigeonpea equivalent yield (Kumar *et al.*, 2014). Sole pigeonpea recorded significantly higher net returns (144313/ ha) and BC ratio (5.65) as compared to other cropping systems and it was on par with pigeonpea + soybean intercropping system (137541/ha) which was mainly due to higher yield and good market price for pigeonpea. The interactions of different tillage practices and cropping systems were significant with regard to system productivity and profitability. Pigeonpea + soybean system is a productive system for Northern Transition Zone of Karnataka. Conservation tillage practices have advantages of mainly crop residues, higher soil organic matter and optimization of nutrients and soil moisture and enhanced soil biological activity resulted in higher productivity and income. The combination of CT_1CS_3 recorded significantly higher cotton equivalent yield (4571 kg/ha) as compared to other treatment combinations however, this combination was on par with CT_2CS_3 (4518 kg/ha), CT_2CS_5 (4518 kg/ha), CT_3CS_3 (4509 kg/ha) and CT_4CS_3 (4496kg/ha) respectively. Whereas, CT_1CS_5 and CT_2CS_5 combinations recorded significantly higher net returns (157287/ha and 155631/ha, respectively) as compared to other combinations, and were on par with CT_1CS_3, CT_2CS_3, CT_3CS_3, CT_3CS_5, CT_4CS_3 and CT_4CS_5. With respect to BC ratio, the combinations such as CT_1CS_5, CT_2CS_5, CT_3CS_5 and CT_4CS_5 (6.19, 6.14, 6.10 and 5.99, respectively) recorded significantly higher BC ratio over other combinations. Soil organic carbon (SOC) is a primary indicator of soil quality (Conteh *et al*., 1997) especially the SOC concentration of surface soil. Among different tillage systems, conservation tillage systems recorded significantly higher SOC as compared to conventional tillage without crop residue (Fig. 1). Among different cropping systems, pigeonpea + soybean intercropping system and sole pigeonpea recorded significantly higher SOC over cotton + groundnut, cotton + soybean and sole cotton (Fig 2). Which might be due to crop residues are precursors of the SOC pool, and returning of more leaf litter and pigeonpea stalks to the soil is associated with an increase in SOC concentration under conservation tillage systems and also intensification of legume crops resulted in higher SOC contents by increasing the input of plant residues and providing a vegetal cover during critical periods (Dolan *et al*., 2006). Tillage, residue management and crop rotation have a significant impact on nutrient distribution and transformation in soils. Distribution of nutrients in a soil under zero tillage is different to that in tilled soil. Irrespective of cropping systems, all the conservation tillage systems (CT_1 to CT_4) and conventional tillage with crop residue incorporation (CT_5) recorded significantly higher availability of available nitrogen (269.39 to 271.66 and 258.25 kg /ha) and available phosphorus (31.44 to 31.83 and 30.1 kg /ha) whereas, available potassium did not differ significantly. There were no significant differences with respect to available nutrients as influenced by different cropping systems and their interactions. This might be due to higher residue input in conservation tillage systems, intensification of legumes enhances the N pool by symbiotically fixed N and also reduces the opportunity for leaching and denitrification losses of nitrogen. Jarecki and Lal (2003) observed conservation tillage and residue recycling increased stratification of nutrients and their availability near the soil surface under zero tillage as compared to conventional tillage.

CONCLUSION

Wide spread degradation of natural resources in rainfed areas and climatic change effects are threatening national food security and the food production capacity of irrigated intensive production systems has been showing a plateau. This has brought about the focus on rainfed ecology, now expected to play an increasingly important role. Conservation agricultural practices mainly reduced tillage and change in land configuration and legume cover crops soybean and groundnut as intercrops in cotton and pigeonpea intercropping were evaluated for higher productivity and sustainable resource management. These CA technologies with biological intensification through legume intercrops in rainfed cotton and pigeonpea systems have enhanced the productivity (25 -30%), increased soil organic carbon (20%) and available nitrogen and phosphorus and help to build greater stability under rainfed situation.

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Conservation agriculture based sustainable intensification of scented rice-wheat rotation in NW India

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The productivity and sustainability of conventional tillage based scented RW systems are threatened because of inefficient use of natural resources and production inputs, increasing energy cost, labour shortages, growing changing climate induced variability (Jat *et al.*, 2016) and volatile *Basmati* market leading to diminishing farm profits. Therefore, it is imperative to develop, adapt and out-scale management practices which can address these challenges. Conservation agriculture (CA) based sustainable intensification through minimizing mechanical soil disturbance and permanent soil cover combined with appropriate crop diversification/intensification has shown potential to sustain productivity, improve profits while arresting natural resource degradation in intensive RW system of NW India (Gathala *et al.,* 2013). We therefore undertaken a study with innovative approaches to intensify the scented rice-wheat rotation through inclusion of legume and CA based management optimization to improve crop and protein yields, farm profits, save water, while improving soil health.

METHODOLOGY

A farmer's participatory strategic research trial was conducted for 4-continuous years (2011-15) at Taraori village; the heartland of scented rice in Karnal, India. The experiment consisted of 6 combinations of tillage, crop establishment, residue management and legume integration in scented RW system. The treatments comprised of conventional till (CT) puddled transplanted rice (PTR) followed by CT wheat (CT PTR-CT W; farmers practice); CT PTR-CT W followed by CT mungbean (CT PTR-CT W-CT M); zero-till (ZT) direct seeded rice (DSR) followed by ZT wheat (ZT DSR-ZT W); ZT DSR-ZT W followed by relay mungbean (ZT DSR-ZT W-R M); ZT DSR-ZT W with full (100%) residue retention (ZT DSR-ZT W + R) and ZT DSR-ZT W- R M with full residue retention (ZT DSR-ZT W-RM + R). ZT. Data on yields (grain, protein), water use, and on carbon sustainability index were collected using the standard procedures. System productivity was calculated by considering the MSP of the concerned years. Net returns were calculated by deducting the total variable cost from the gross returns. The carbon sustainability index (CSI) was computed using the methodology given by Lal (2004).

RESULTS

Data (04 years) related to system productivity, economic returns, protein yield, water use and CSI were subjected to pooled analysis. The results revealed that all the parameters had significant influence of tillage, crop establishment, residue management and mungbean inclusion in scented rice-wheat system. On pooled average basis, 36 and 33% higher wheat equivalent system yield was recorded with ZT DSR-ZT W-R M + R and ZT DSR-ZT W-R M, respectively over CT PTR-CT W system (14.91 t/ha). Irrigation water saving of 35% (pooled average basis) was recorded with ZT DSR-ZT W + R, followed by ZT DSR-ZT W (26%) and ZT DSR-ZT W- RM (19%). In conventional tillage based system intensification (CT PTR-CT W- CT M) consumed 10% more irrigation water compared to conventional practice (CT PTR-CT W). ZT DSR-ZT W-R M and ZT DSR-ZT W-R M + R recorded 44 and 42% higher net returns (pooled average basis) respectively compared to conventional system. The increase in net returns with CA based sustainable intensification over 04 years ranges from 35-51% with ZT DSR-ZT W-R M and 32-49% with ZT DSR-ZT W-R M + R compared to farmers practice. Whereas, integration of mungbean in to RW system increased the net returns by 29% irrespective of treatments. The positive impacts of CA based sustainable intensification in RW system under similar production ecologies were also reported by Gathala *et al*. (2013). On pooled average basis, highest protein yield was recorded with ZT DSR-ZT W -R M + R (1043 kg/ha/yr), closely followed by ZT DSR-ZT W-R M and CT PTR-CT W- CT M. Mungbean integration in to RW

Table 1. Effect of sustainable intensification on yields, water use, net returns and carbon sustainability index in scented rice-wheat system (pooled data of 4 years)

Treatment†	System grain yield (t/ha/yr)	System irrigation water use (cm/ha/yr)	System net returns (USD/ha/yr)	System protein yield (kg/ha/yr)	Carbon sustainability index (CSI)
CT PTR-CT W	14.91d	2168b	2570d	795f	11.03e
T PTR-CT W- CT M	18.48b	2378a	3255b	964c	11.31d
ZT DSR-ZT W	15.09cd	1578d	2822c	820e	15.13b
ZT DSR-ZT W-R M	18.85ab	1713c	3687a	1019b	15.38a
ZT DSR-ZT W + R	15.31c	1365f	2820c	852d	14.65c
ZT DSR-ZT W -R M + R	19.36a	1445e	3652a	1043a	14.87c

Means followed by a similar lowercase letters within a column are not significantly different (p=0.05)

system increased the protein yield by 38-150 kg/ha/yr across the years. Significantly higher (34-38%) carbon sustainability index was recorded with CA based management compared to conventional practice (CT PTR-CT W) of RW system.

CONCLUSION

CA based management optimization of scented rice-wheat system provides opportunities for sustainable intensification while increasing system productivity by 4.45 t/ha/yr as well as higher protein yield (248 kg/ha/yr), save 72 cm irrigation water ha/yr, increase profit by US$ 1082 ha/yr in addition to significantly better CSI over farmer practice. This is a win-win for farmers and planners to achieve the target of (i) more crops per drop, (ii) doubling farmers' income, (iii) improving soil health, (iv) and improved nutrition security while attaining Sustainable Development Goals (SDGs).

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Effect of tillage and crop establishment methods on system productivity and economics of rice-wheat cropping system

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Rice-wheat cropping system has substantial role in world food security and provides about 8% staple grain to the world's population (Timsina and Connor, 2001). In South Asia, the area under rice-wheat cropping system is about 13.5 million hectares, which has meaningful role in food self-sufficiency (Saharawat *et al.*, 2010). Rice and wheat are staple food crops of the world cultivated on an area around 370.4 m ha. A large proportion of world population relies on rice and wheat for daily caloric intake, income and employment. In India, rice and wheat covering 43.3 and 30.2 m ha and recorded food grain production of 105.48 and 86.53 m t, respectively during 2014-15, (DAC, 2016) In India, it is the most important cropping system and stands ûrst in coverage. The system covers 23% of rice and 40% of wheat, and both crops together contribute 85% of the total cereal production contributing substantially to national food basket (Katyal *et al.*, 1998). Proper management of all important natural resources, particularly the soil by different manipulations techniques in rice-wheat system can lead to higher productivity of both rice and wheat. Improved soil physical properties and root growth under ZT, the significant increase in mass of grains and consequently increased the wheat yield (Singh *et al.*, 2014).

METHODOLOGY

The experiment was conducted on sandy clay loam soil having pH of 7.5 during *kharif* and *rabi* seasons at the Agriculture Research Farm, institute of Agriculture Sciences, Banaras Hindu University, Varanasi (U.P.). The experiment was conducted in strip-plot design with four tillage and crop establishment methods in rice (Direct seedling by zero till drill, direct seedling of sprouted seeds by drum seeder, manual transplanting and mechanical transplanting by self-propelled transplanter) as horizontal strip and tillage and crop establishment methods in wheat (Rotavator till drilling, conventional sowing, strip till drilling and zero till drilling) as vertical strips. . The rice hybrid variety 'PHB 71' was sown and transplanted at a distance of 20x15 cm, 15x15 cm and 23x15 cm between rows and plants by zero till drill, drum seeder and with a seed rate of 18 and 15 kg/ha to establish 1-2 seedlings / till, respectively. The nutrients were applied @ 150 kg N, 75 kg P_2O_5 and 75 kg K_2O/ha. The wheat variety HD 2824 (Poorva) was sown at a distance of 20.4 cm under all the sowing method with a seed rate of 100 kg/ha. The nutrients were applied @ 120 kg N + 60 kg $P_{-2-}O_5$ + 60 kg K_2O per hectares. Both crophalf of the dose of nitrogen and full doses of phosphorus and potassium were applied as basal at the time of sowing. Remaining nitrogen was applied in two equal split through urea at critical tillering and panicle initiation /spike emergence stages. Data on yields, REY, system productivityand economic return were calculated as per the standard procedures.

RESULTS

The findings of the present investigation indicated profound effect of different crop establishment methods of rice on yield. The higher grain yield under hand and mechanical transplanting may be owing to better performance of yield attributing characters through optimum utilization of resources which had direct bearing on the production of higher grain yield. The crop establishment methods applied in wheat could not influenced yield of rice.The crop establishment methods applied in wheat significantly influenced the grain yield. The better performancewas found in zero till drill sown wheat and being at par with rotavator till drill and conventional sowing produced significantly higher grain yield then strip till drill. The crop establishment methods applied in rice could not influenced yield of wheat.Among different methods of rice establishment, hand transplanting produced maximum of REY of the system and being at par with mechanical transplanting. The REY in hand and mechanical transplanting was significantly higher than drum seeder and zero till drill. Rice sowing by drum seeder also proved significantly superior to zero till drill with respect to REY. The results obtained with respect to REY do differ for system productivity. Among the different wheat establishment methods, zero till drill sowing

Table 1. Effect of crop establishment methods in rice–wheat cropping system on yield, REY system productivity and economics

Crop establishment method	Rice-Wheat				
	Rice grain yield (t/ha)	Wheat grain yield (t/ha)	REY (t/ha)	System productivity (kg/ha/day)	Benefit cost ratio
Rice					
Direct dry seeding by zero till drill	3.17	3.19	9.31	25.51	1.28
Direct seeding of sprouted seeds by drum seeder	4.28	3.09	11.17	30.61	1.56
Hand Transplanting	5.71	2.97	13.23	36.24	1.72
Mechanical Transplanting	5.42	3.04	13.01	35.65	1.86
LSD (P=0.05)	0.55	NS	0.85	2.32	0.10
Wheat					
Rotavator till drilling	4.65	3.12	11.59	31.74	1.70
Conventional sowing	4.72	3.04	11.79	32.30	1.49
Strip till drilling	4.49	2.73	11.34	31.06	1.52
Zero till drilling	4.73	3.41	12.01	32.91	1.72
LSD (P=0.05)	NS	0.41	0.64	1.75	0.18

produced maximum REY and being comparable to conventional sowing and rotovator till drill proved significantly superior to strip till drilling. The similar results were obtained for system productivity that followed the similar trend ZT > CT > RT > ST. The maximum BC ratio of 1.86 were found with mechanical transplantingfollowed by hand transplanting > drum seeding>zero till drill sowing but all the methods of rice establishment differed significantly. The zero till drill sowing of wheat though remained comparable to rotavator drill, resulted in significantly higher benefit cost ratio than conventional sowing. The benefit cost ration also did not differ significantly between zero till drill and rotavator drill sown wheat but differed significantly with other method of wheat establishment like strip tilling and conventional tilling.

CONCLUSION

On the basis of our investigation it could be concluded that hand transplanting and zero tillage recorded significantly higher yield, REY and system productivity of rice and wheat over other crop establishment methods. Mechanical transplanting and zero tillage gave highest B:C ratio.

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Response of paddy to selective mechanization in coastal Karnataka

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Paddy is the principal food crop cultivated in the Dakshina Kannada district of coastal Karnataka. In the recent year it is observed that increasing cost of cultivation and scarcity of labor is affecting timely operations in paddy resulting in decrease in yield making paddy cultivation un remunerative. Paddy cultivation needs appropriate mechanization to cope with increased cost of cultivation due to high wages and labor scarcity. Predominance of small and marginal farms and fragmentation of land holdings, with undulated topography limit large scale mechanization in the district. Therefore mechanization in paddy has to be selective to ensure a balance between available labor and the need of machines for timely operations. Transplanting, weeding and harvesting operations consume most of the labor requirement in rice cultivation and hence thrust should be given for this mechanizing these operations in order to reduce the labor requirement in rice cultivation. Carrying out timely operation and reducing cost of cultivation is the prerequisite for enhancing the production and productivity of rice and as well as to make rice cultivation commercially viable and profitable enterprise for the farmers. Selective mechanization can help to achieve this goal (Vidhan *et al.,* 2012). There is a need to adopt selective mechanization to benefit all kinds of farmers. ICAR-Krishi Vigyan Kendra (KVK) of Dakshina Kannada district has been creating awareness on selective mechanization in paddy for the past four years (2011-12 to 2014-15).

METHODOLOGY

ICAR- Krishi Vigyan Kendra, Dakshina Kannada organized Front Line Demonstrations (FLDs) under farmer par-

Table 2. Economics of selective mechanization in paddy

Year	Demo plot				Check plot			
	Gross cost Rs/ha	Gross returns Rs./ha	Net Returns Rs./ha	B:C ratio	Gross cost Rs./ha	Gross returns Rs/ha	Net Returns Rs./ha	B:C ratio
2011-12	22626	44500	21874	1.96	28424	38000	9576	1.33
2012-13	30000	68000	38000	2.26	37500	56000	18500	1.50
2013-14	39875	72500	32625	1.81	45750	58250	12500	1.27
2014-15	34350	54775	20425	1.59	40625	47125	6500	1.16
Average	31712.5	59943.75	28231	1.905	38074.75	49843.75	11769	1.315

Table 1. The impact on selected quantitative indicators is furnished below

Parameters	Demonstration	Local check
Yield (t/ha)	4.07	34.0
Seeds requirement (kg/ha)	18.0	25.0
Labors required/ha	5	45
Cost of operation/ha	12500	7500
Labor savings (Rs/ha)	6362	-
Cost of cultivation (Rs/ha)	31712	38074

ticipatory mode in cluster villages in the district. The technological interventions were through FLDs on selective mechanization in paddy. The technology transfer was mechanization of transplanting and weeding operations by use of transplanter and konoweeder. Over the period of four years spanning from 2011-12 to 2014-15, 24 villages were covered with 44 demonstrations covering an area of 21 ha. During this period technology transfer was made through 06 off campus trainings programmes, 12 method demonstrations of mat nursery preparation and 13 method demonstrations of mechanical paddy transplanting using 8 row mechanical transplanter. These capacity building programmes was attended by 1091 of 24 villages over a period of 4 years. Technology backstopping by regular field visits by scientists and crop advisory advices boosted the morale and confidence of the farmer. The FLDs was successfully concluded with celebration of 06 Field days with participation of 185 farmers.

RESULTS

The results indicated that the challenges of labor scarcity could be effectively met by selective mechanization in paddy. The results (Table 1) indicated that over a period of 4 years paddy under mechanization recorded an average yield of 4.07 t/ha compared to yield of 3.4 t/ha in local check. The increase in yield was 19.6 % .could be attributed to timely sowing, row spacing, early age of seedlings with vigor, and timely control of weeds by konoweeder. The data on economics (Table 2) indicated that an additional net returns of Rs.16694 was realized by mechanization compared to local check. The Labor cost saving was Rs.6362/ per ha in mechanization compared to manual transplanting. Besides saving in time and labor drudgery was also reduced. The availability of skilled service ensured timely operations in paddy and boosted the morale of the farmers confidence of farmers.

CONCLUSION

There was cost reduction in paddy cultivation by 20-22% and reduction in labor requirement by 30% through mechanization. The paddy area under mechanization increased from 65.32 ha in 2011-12 to 123 ha in 2013-14. Mechanization facilitated timely operations in paddy reduced drudgery and saved time. Line transplanting resulted in easy operations in weed removal. Hence majority of farmers desired to adopt the technology.

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Productivity enhancement of baby corn (*Zea mays*) through conservation agriculture and cover crops

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Maize (*Zea mays* L.) is one of the important staple food crops and ranks next only to wheat and rice as a third most important crop in the world. Maize being a C_4 crop, has high yield potential and can prove to be the best substitute for overcoming the hazards associated with paddy cultivation. Development of improved maize hybrids and minimum tillage technology resulting in reduction in cost of cultivation can push more area under maize. The non-leguminous cover crops are the plants that are grown to provide soil cover and to improve the physical, chemical and biological characteristics of the soil. The application of green manures to soil increases its organic matter, fertility levels and escalating nutrient retention (Dinnes *et al.,* 2002). No-tillage as conservation agriculture practice gave the highest maize grain yield and also resulted in better conservation of soil nutrients than the conventional tillage practice (Kutu 2012). Cover crops have the ability to "Jump start" no-till perhaps eliminating any yield decrease especially in initial years. Thus, the present investigation was under taken with an objective to study the effect of cover crops and their time of chopping on growth and yield of baby corn

METHODOLOGY

Field experiment was conducted at the Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana, during *kharif* 2014 and 2015. The experiment was laid in split plot design with four replications and nine treatments having three cover crops i.e. Bajra (*Pennisetum glaucum*), Maize (*Zea mays* L.) andsorghum (*Sorghum bicolor*) in main plots and three different time of chopping of cover crops i.e. 25, 35, 45 days after sowing in sub plots. The 25, 35 and 45 days old cover crops were chopped with chopper cum spreader *in-situ* and left uniformly on the surface followed by sowing of baby corn under no-till conditions on same day G-5414 variety of baby corn was sown by dibbling method at 30 x 20 cm spacing and immature cobs were harvested in second fortnight of August during 2014 and 2015. The crop was detasseled before pollen shed to prevent fertilization and also to divert nutrient flow to developing cob.Half of nitrogen (60 kg/ha) was applied at the time of sowing baby corn to all the plots. Remaining half dose of nitrogen was applied at 30 DAS. Nitrogen was given in the form of urea. Statistical analysis of the data was done as suggested by Cochran and Cox (1967)

RESULTS

The data shown in Table 1 represents that plant height at 45 days after sowing (DAS) was significantly influenced by

Table 1. Effect of cover crops and their time of chopping on growth, marketable and fodder yield of baby corn

Treatment	Plant Height (cm) 45 DAS	Dry Matter (t/ha) 45 DAS	Baby corn yield (t/ha)		Fodder yield (t/ha)	
			2014	2015	2014	2015
Cover Crops						
Bajra	94.18	2.21	1.45	1.51	20.52	20.57
Maize	91.15	2.16	1.37	1.41	19.38	19.42
Sorghum	90.34	1.99	1.01	1.05	18.11	18.18
CD (P=0.05)	1.95	0.16	0.21	0.20	NS	NS
Time of Chopping (days)						
25 DAS	89.08	2.02	1.19	1.25	18.60	18.68
35 DAS	91.96	2.13	1.26	1.30	19.10	19.15
45 DAS	94.63	2.20	1.40	1.42	20.31	20.34
CD(P=0.05)	1.17	0.07	0.09	0.11	1.34	1.33

cover crops. It has been observed that plant height of baby corn at 45 DAS was significantly higher after bajra as compared to maize and sorghum. Time of chopping had significant affect on the dry matter accumulation at various growth stages. The dry matter accumulation at 45 and 60 DAS was significantly more after bajra crop, but was statistically at par after chopping of maize crop. It could be due to higher LAI and high PAR interception after 45 and 60 DAS of main crop. Dry matter accumulated at 15 DAS after chopping 45 days cover crops was higher, but was found to be non significant. Highest dry matter was accumulated at 30, 45, and 60 DAS with chopping of 45 days of cover crops. Yield of baby corn was significantly affected cover crops and their time of chopping in 2014 and 2015. The highest baby corn yield was observed after bajra, which was at par after maize but significantly higher than sorghum cover crop. Time of chopping of cover crops also affected significantly on the baby corn yield and significantly more baby corn yield was recorded at 45 days after chopping as compared to 35 and 25 days after chopping but yield recorded at 25 and 35 days after chopping was mutually at par with each other. Fodder yield of baby corn was not influenced by the cover crops. The fodder yield was significantly higher at 45 days of chopping when compared with 25 and 35 days of chopping timing and produced 20.30 t/ha and 20.34 t/ha of green fodder yield, but it was at par with 35 days of chopping. Green fodder produced from the treatments of 25 and 35 days of chopping was 18.6 and 19.1 t/ha in 2014 and 18.8 and 19.2 t/ha in 2015.

CONCLUSION

On the basis of above findings it can be conclude that highest baby corn yield was observed after bajra, which was at par after maize crop, significantly higher than sorghum cover crop. Time of chopping of cover crops was also affected significantly on the baby corn yield and significantly more was recorded at 45 days after chopping as compared to 35 and 25 days after chopping.

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Effect of conservation tillage practices and residue cover on weed-wheat ecosystems

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Conservation agriculture is a set of technologies, including minimum soil disturbance, permanent soil cover, diversified crop rotations, and integrated weed management aimed at reducing and/or revertingthe negative effects of conventional farming practices. Chemical weed control is the most effective weed management option in CA; Residue retention strongly impacts weed emergence; several factors determine the extent of this influence including type and quantity of residue, nature of the residue, soil type, weather conditions, and prevailing weed flora. Crop residues directly affect weed germination and the bioavailability of herbicides such as trifluralin. Residue retention strongly impacts weed emergence; several factors determine the extent of this influence including type and quantity of residue, nature of the residue etc. Phenolics in the surface residue may reduce the weed infestation (Farooq *et al*. 2011) in CA systems, besides the residues may reduce the persistence and efficacy of soil-applied herbicides (Potter *et al*. 2008). The experiment was carried out with the objective of studying the effect of residue cover and tillage practices on weed-wheat ecosystems.

METHODOLOGY

Anexperiment was conducted at ICAR- Indian Institute of Soil Science, Bhopal farm during 2015 with 3 Tillage prac-

Table 1. Effect of tillage and residue cover on density of *A. sessilis*

Treatment	8 DAS	15 DAS	23 DAS	30 DAS	37 DAS	44 DAS	51 DAS
Tillage							
No tillage	-	-	-	4.19 (20.47)	5.62 (31.80)	4.11 (16.80)	4.01 (18.13)
Reduced tillage	-	-	-	4.12 (19.20)	3.85 (16.07)	3.26 (10.93)	3.09 (11.40)
Conventional tillage	-	-	-	2.33 (6.27)	3.06 (9.20)	2.40 (5.60)	2.29 (5.73)
CD (P=0.05)	-	-	-	0.45	0.30	0.56	0.95
Residue level							
No residue	-	-	-	6.12 (39.00)	5.38 (29.89)	4.24 (18.67)	4.95 (24.89)
25% residue	-	-	-	4.10 (17.67)	4.43 (21.00)	3.36 (10.22)	4.32 (19.67)
50% residue	-	-	-	2.94 (9.22)	4.13 (17.44)	3.03 (9.44)	2.34 (5.56)
75% residue	-	-	-	2.42 (6.22)	3.90 (16.89)	2.74 (7.89)	2.22 (5.11)
100% residue	-	-	-	2.14 (4.22)	3.05 (9.89)	2.91 (8.33)	1.82 (3.56)
CD (P=0.05)	-	-	-	0.41	0.37	0.28	0.44

Original values (parenthesis) were transformed = $\sqrt{X+0.5}$ where X is original value

tices viz., T1- No till (no primary tillage), T2- Reduced tillage (only primary tillage), T3- Conventional till (primary and secondary tillage) and 5 residue (flat) cover viz., M1- No residue, M2- 25% residue cover, M3- 50% residue, M4- 75% residue, M5- 100% residue with test crop Durum Wheat or (Malwa Shakti HI 8498). The recommended dose of fertiliser viz., 110, 50 and 50 kg/ha of N, P and K respectively was applied uniformly. Half of total nitrogen and full dose of phosphorus and potash were applied as basal at the time of sowing and remaining half dose of nitrogen in the form of urea was top dressed in two equal splits after first and second irrigation. Three replications were maintained and the treatments were imposed in a split-plot design. An area of 1.00 m^2 was selected randomly at two spots by throwing a quadrate. Data on weed population was recorded from 8 to 51 DAS from this area and expressed in No. m^{-2} and dry weight was also recorded.

RESULTS

Only broad broad leaved weed species viz., *Alternantherasessilis, Tridoxprocumbens, Sonchusarvensis and Partheniumhysterophorus* were noticed in the wheat crop. However no sedge and grassy weeds were reported from the field. Further, only the density of *A.sessilis* was influenced by tillage practices and residue cover. Minimum density of *A.sessilis* was recorded under conventional tillage which was significantly lower than the no tillage and reduced tillage. Among the crop residue levels, application of above 50% residuereduced density of *A.sessilis*significantly than no residue. Conventional till wheat recorded significantly lower density of total weeds at all stages as compared to no till during 23 to 51 DAS which was at par with reduced tillage at 23 DAS. Conventional till wheat was most effective in minimizing total weed dry weight 50% to 100% residue level significantly reduced weed dry weight at all the growth stages. The weed control efficiency was worked out at 30, 37, 44 and 51 DAS revealed conventional till wheat crop establishment method recorded higher weed control efficiency as compared to zero till and reduced till at 30 DAS but at 37, 44 and 51 DAS reduced till had higher values over others. Among weed management practices, application of 100% residue recorded higher WCE value at 37 and 51 DAS while 75% residue cover recorded higher WCE value at 30 and 44 DAS.50% and above ground cover caused maximum reduction in density and dry weight of weeds due to soil surface shading and weeds were not able to germinate. Hence, it is concluded that residue cover in conservation could help to a great extent in minimizing the weed incidence in wheat crop under central Indian conditions.

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Impact of conservation tillage on soil properties and rice yield of rice- rice cropping system

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Conservation tillage practices generally result in higher amounts of soil organic matter (OM), reduced erosion, increased infiltration, increased water stable aggregates and greater microbial biomass carbon when compared to conventional tillage systems (Reeves, 1997). The soil's ability to function as a component of an ecosystem may be degraded, aggraded or sustained as use-dependent properties change in response to land use and management. Therefore, to achieve sustainable higher productivity, efforts must be focused on reversing the trend in natural resource degradation by adopting efficient resource conservation technologies and one among them is Conservation tillage (Singh and Kaur, 2012). Information on changes in soil physical properties, especially in heavy clayey soil, due to tillage practices is limited. Therefore, this study was performed at TRRI, Aduthurai for three consecutive years during *Kharif* 2013, 2014 and 2015and Rabi 2013-14, 2014-15 and 2015-16 to determine the effects of conventional, minimal and no-tillage practices on soil bulk density , penetration resistance infiltration and percolation rate.

METHODOLOGY

Theexperiment was conducted in split-plot design with three crop establishment methods *viz.* Conventional tillage (CT), Zero tillage (ZT) and Minimal tillage (MT) in main plots and two cultivars (ADT 43 and CORH 3) in sub plots. The variety ADT 43 was tried in *Kharif* season, while it was replaced with ADT 45 in *Rabi* season due to seasonal influence. Conventional tillage involvesone dry ploughing and two passes of cage wheel puddling combined with pre-emergence application of butachlor@ 1.25 kgai/ha on 3 DAP. In minimum tillage, one dry ploughing with cultivator was donefollowed by pre-emergence application of butachlor@ 1.25 kga.i./ha on 3 DAP. In zero tillage, the rice stubbles were sprayed with glyphosate @ 10 ml/litre of water + 2 % Ammonium sulphate. The stubbles were completely dried within 7 days and paddy transplanting was done in the decomposed stubbles without any preparatory cultivation and this was followed by pre emergence application of butachlor @ 1.25 kg ai/ha on 3 DAP. In both conventional and minimal tillage treatments, two hand weeding was done on 20 and 45 DAP.The bulk density was measured by the core method and soil penetration resistance was determined by a hand-pushing electronic cone penetrometer (EijkelkampPenetrologger) following ASAE standard procedures. The infiltration and percolation rates were determined using a double ring infiltrometer.

RESULTS

Tillage largely influences pore size distribution. In the present study, the bulk density was higher with Zero tillage as compared to minimal and conventional tillage (Table 1). Soils under conventional tillage generally have lower bulk density and associated higher total porosity within the plough layer than under zero tillage. The changes in total porosity are related with alterations in pore size distribution. The penetration resistance of four layers (0-10 cm, 11- 20 cm, 21-30 cm and 31-45 cm) were the highest under no-tillage followed by minimal tillage and the lowest values of penetration resistance were obtained in conventional tillage methods. The increase in bulk density and penetration resistance under zero tillage and minimal tillage indicated probable soil compactions. Lower bulk density and penetration resistance obtained in conventional tillage might be attributed to short term loosening effect of tillage, and incorporation of stubble/stover to soil surface layers.The study showed that there is a significant effect of tillage methods on soil infiltration and percolation rates. The soil infiltration and percolation rates under different tillage treatment followed the order conventional tillage > minimal tillage > Zero tillage. Though greater infiltration due to greater contribution of flow-active macro-pores in zero tillage is expected, in the present study reverse trend of result was observed. Greater infiltration of soil under conventional tillage than zero tillage might be due to relatively high soil organic matter and associated low susceptibility to sealing that could stop the entry of water to the high interaggregate flow-active porosity inconventional tillage. The results of the study further indicated that though the grain yield was highest with

Table 1. Impact of conservation tillage on soil properties and rice yield

Treatments	Bulk density (g/cc)		Penetration resistance (MPa)		Infiltration rate (cm/hr)		Percolation rate (cm/hr)		Panicles/m^2		Grain yield (kg/ha)		BCR	
Kharif	CORH3	ADT 43	CORH3	ADT 43	CORH3	ADT 43	CORH3	ADT 43	CORH3	ADT 43	CORH3	ADT 43	CORH3	ADT 43
CT	1.14	1.14	303	309	0.22	0.22	0.14	0.14	321	310	4.66	4.46	1.98	1.90
ZT	1.34	1.36	309	314	0.11	0.12	0.09	0.10	311	301	4.41	4.25	2.01	1.93
MT	1.12	1.14	324	333	0.20	0.20	0.12	0.12	314	302	4.58	4.34	2.01	1.94
Mean	1.20	1.21	312	319	0.18	0.18	0.12	0.12	315	305	4.55	4.35	2.00	1.92
LSD(0.05)	0.17		2.45		0.08		0.04		NS		0.12			
Tillage	NS		NS		NS		NS		NS		NS			
Variety	NS		NS		NS		NS		NS		NS			
Tillage x	NS		NS		NS		NS		NS		NS			
Var. Var. x Tillage	NS		NS		NS		NS		NS		NS			
Rabi	CORH3	ADT 45	CORH3	ADT 45	CORH3	ADT 45	CORH3	ADT 45	CORH3	ADT 45	CORH3	ADT 45	CORH3	ADT 45
CT	1.14	1.14	93.8	96.8	0.22	0.22	0.15	0.14	285	272	4.46	4.19	1.89	1.78
ZT	1.34	1.36	118.8	118.4	0.11	0.12	0.09	0.10	278	268.	4.21	3.98	1.94	1.83
MT	1.12	1.14	99.7	98.1	0.20	0.20	0.13	0.14	276	270	4.32	4.04	1.93	1.80
Mean	1.20	1.21	104.1	104.4	0.18	0.18	0.12	0.13	280	270	4.33	4.07	1.92	1.80
LSD(0.05)	0.18		1.38		0.08		0.05				0.11			
Tillage	NS		NS		NS		NS		NS		NS			
Variety	NS		NS		NS		NS		NS		NS			
Tillage x Var.	NS		NS		NS		NS		NS		NS			
Var. x Tillage														

conventional tillage, the net return and BCR was highest with minimal and zero tillages.

CONCLUSION

It was concluded that since no marked yield reduction in minimal and zero tillageshas been observed, zero tillage and minimal tillage could be an alternate tillage options inorder to reduce the time lag in land preparation besides conserving the physical properties of the soil for increasing the rice productivity in the rice-rice cropping system.

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Smart water management practices for direct-seeded and puddled transplanted rice under conservation agriculture in Indo-Gangetic Plains (IGP) of India

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Conservation agriculture (CA), a management system with minimum mechanical disturbance of soil, keeping rational amount of crop residues as permanent soil cover and using efficient and diversified rotations, has emerged as a new paradigm to achieve goals of sustainable agricultural production. It is a major step towards transition to sustainable agriculture. The Indo-Gangetic Plains (IGP) of South Asia is one of the world's major food grain producing regions and home to nearly one billion people, about 40% of whom live in extreme poverty. Rice (*Oryza sativa* L.) is the world's most important crop and a staple food for more than half of the world's population. Worldwide, rice is grown on 161 mha, with an annual production of 678.7 mt of paddy. About 90% of the world's rice is grown and produced (143 million hectares of area with a production of 612 million tonnes of paddy) in Asia. It occupies a pivotal place in Indian agriculture and is the staple food for more than 70 % of population. It is grown on an area of 44 million hectare in the country with total production of 102.7 million tonnes and productivity of 2334 kg/ha in 2011-2012 (Mahapatra *et al.,* 2012).

METHODOLOGY

The field experiment was conducted at participatory strategic research and learning platform for climate smart agriculture, Taraori (29°48'51 N latitude, 76°55'26 E longitude) and 256 meters above mean sea level, Karnal, Haryana during Kharif season of 2012 and 2013 collaboration with CIMMYT under Wheat CRPs-CGIAR Research Programme on WHEAT (CRP 3.1). The climate of the area is semi-arid, with average annual rainfall about 750 mm (75–80% of which is received during June–September and the rest during the period between October and May and daily minimum temperature of 0–4 %C in January, daily maximum temperature of 35–44 %C in June throughout the year, respectively. The soil of experimental field was clay loamy in texture. The experiment was conducted in a Split-plot Design with three replications, the effects of tillage practices, namely {Rice-wheat (CT), Rice-wheat (ZT)} and Residue, water management, Legume viz. {Farmer Practice with green gram, Improved Practice with green gram, Farmer Practice without green gram and Improved Practice with without green gram} on irrigation water use and water productivity of rice (*Oryza sativa* L.). The experiment was conducted on the same layout during both the years. Rice cv 'Arize 6129'was used during both the crop seasons.

RESULTS

Similar grain yield was recorded under PTR and DSR, while irrigation water required in ZT DSR was lower than in CT TPR, 29.7-35.0 % during both years (Table 1). The WP_I of rice in CT TPR was significantly lower than in ZT DSR. The highest WP_I (0.64 kg m^{-3}) was recorded under ZT DSR which was significantly higher than CT TPR (Table 1).The significantly irrigation water saving 15.71 % and water productivity (WP_I) 37.96 % highest under tensiometer based irrigation and residues management with green gram than farmer practice. Sudhir-Yadav *et al.* (2011) reported DSR with (20 kPa) reduced the irrigation input by 63-73%, while maintaining yield, in comparison with continuously flooded PTR, and by 30-53% in comparison with PTR-20 kPa and reduction in the number of irrigations in DSR compared with PTR depended on the weather conditions, especially rainfall, and it will also depend on other factors such as sowing date, crop growth, crop duration, soil permeability and water table depth. Irrigation water productivity of DSR-20 kPa was much higher than that of PTR-20 kPa due to a 30–50% reduction in irrigation input, while yield was maintained reported by Sudhir-Yadav *et al.* (2011).

CONCLUSION

This study evaluated a set of CA-based improved management practices to address the emerging and growing challenges of labour shortages, depleting water resources and increasing cultivation costs in a rice–wheat rotatin of Western

Table 1. Grain yield, Irrigation water and water productivity as affected by different tillage, residues and crop establishment method of rice

Treatment	Grain yield (t/ha)	Rainfall (mm)	Irrigation water (mm/ha)	WP_I (kg grain/m^3)
Cropping system and tillage practice				
CT (R-W)	6.88	499.60	2194.87	0.42
ZT (R-W)	6.87	499.60	1653.78	0.64
CD (P=0.05)	0.058	-	22.60	0.005
Residue, water management and Legume				
FP+GG	6.77	499.60	2083.65	0.46
IM+GG	7.06	499.60	1760.60	0.62
FP	6.69	499.60	2088.83	0.45
IM	6.98	499.60	1764.20	0.61
CD (P=0.05)	0.075	-	6.94	0.008

IGP making system unsustainable. The grain yield was almost similar under PTR and DSR, while irrigation water required in ZT DSR was lower than in CT TPR, 29.7-35.0 % during both the years. The WP_I (30-42 %) was recorded significantly higher under tensiometer based irrigation at -20 kPa and residues management with green gram than farmer practice during both the years.

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Effect of crop residue management on yield and economics of soybean-based cropping system

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In India, soybean is grown on 108.83 lakh ha area with a production of 104.36 lakh MT and productivity of 959 kg/ ha. In vidarbha, area under soybean is 19.31 lakh ha with a production of 14.75 lakh MT and productivity of 776 kg/ ha.(Anonymous,2014).Crop residues (stover) have many potential uses by society: food, feed, shelter, fuel, and soil amendment. Use of residues for purposes other than as a soil amendment may have serious negative consequences on crop productivity. (Wilhelm *et al.*, 1986).This review reveals that crop residues of common cultivated crops are an important resource not only as a source of significant quantities of nutrients for crop production but also affecting soil health. Nitrogen benefits and nitrogen recoveries from residues show that a considerable potential exists from residues, especially leguminous residues, not only in meeting the N demands of the succeeding crops, but also in increasing the long term fertility of the soils, Hence the present investigation was taken.

METHODOLOGY

A field experiment was carried out during *kharif* and *rabi*2003-04 to 2013-14 at Agriculture Research Station, Buldana, (Maharashtra) to study the effect of recycling of soybean crop residue on the yield of succeeding *rabi* crops and on soil health. The main plot treatments comprised four crop residue management, *viz.* wheat with residue incorporation, wheat with no residue incorporation, chickpea with residue incorporation, chickpea with no residue incorporation and sub-plot treatment were fertilizers i.e. 50,75 and 100% recommended dose of fertilizers for *rabi* crops were arranged in a split–plot design with three replications. Soybean 'JS-335' was sown in *kharif* season with all recommended package of practices for soybean residue only. After harvesting crop well dried soybean crop residue (SCR) was applied on each residue incorporation plot @ 3.90 kg/plot (2.0 t/ha).The harrowing was undertaken to incorporate the residue in the soil. The seed–bed was prepared; the plots were irrigated prior to cultivation of both rabi crops. Wheat 'AKW-1071' and Chickpea 'JAKI-9218' were sown in row space 22.5 cm and 30 cm respectively in the last week of November and harvested in end of March to middle of April during every year. As per treatments recommended dose of fertilizer for wheat 120:60:60 kg NPK/ha and chickpea 25:50:00 kg NPK/ha were applied to crop and data on yield and economics were recorded.

RESULTS

On the basis of ten years study reflected that, incorporation of SCR significantly recorded the highest yield *viz* wheat (3.15 t/ha.) and chickpea (3.08 t/ha.) crops as compared to no residue incorporation treatments. Linear and significant grain yield increase was observed with increase in fertilizer dose in both the crops. The application of 100 % dose of fertilizer to wheat and chickpea recorded significantly highest grain yield (3.29 t/ha) than the 75% recommended dose of fertilizer (3.02 t/ha.) and 50% recommended dose of fertilizer (2.45t/ha.) The pooled data revealed that grain yield of wheat and chickpea was significantly increased due to combined effect of SCR incorporation and fertilizer doses applied to both the crops. Incorporation of SCR showed higher wheat and chickpea grain yield (3.47 and 3.56 t/ha. respectively) with 100 % RDF than with 50 % RDF and at par with 75 % RDF. Addition of SCR and its subsequent decomposition improved the organic matter status,soil health and released nutrients through the crop growth period that helped to increase the growth and yield of chickpea which ultimately resulted in higher chickpea grain yield as compared to no SCR treatment. These findings are closely associated with Karunakaran and Behera (2013).The incorporation of SCR recorded higher GMR, NMR than no residue incorporation in both the *rabi* crops. However, B: C ratio was recorded higher under no incorporation treatments. Among *rabi* crop crops, chickpea recorded highestGMR, NMR and B: C ratio as compared to wheat.The application of 100 % recommended dose of fertilizer to both crop recorded overall higher GMR, NMR and B: C ratio as compared to 75 and 50 % recommended dose of fertilizer.Data presented in Table 1 revealed that, The GMR and NMR of wheat and chickpea was significantly increased

Table 1. Pooled grain yields (Wheat equivalent) and economics as influenced by different treatments. (2003-04 to 2013-14)

Treatments	Grain yield (t/ha)	Gross monetary return (₹/ha)	Netmonetary return (₹/ha)	B:C ratio
Main Plot [Crop Residue]				
WI-Wheat with incorporation	3.15	43336	22569	2.09
WN -Wheat with no incorporation	2.82	38509	20747	2.23
CI-Chickpea with incorporation	3.08	41348	23832	2.39
CN-Chickpea with no incorporation	2.62	34914	20278	2.49
SEm±	0.021	261	261	
CD (P=0.05)	0.071	886	901	
Subplot [Fertilizer dose]				
F_1 50 % RDF	2.45	32920	16132	2.04
F_2 75 % RDF	3.02	41153	23512	2.38
F_3 100 % RDF	3.29	44507	25928	2.48
SEm±	0.017	222	222	
CD (P=0.05)	0.051	665	768	
Interactions				
SEm±	0.034	445	443	
CD (P=0.05)	0.102	1331	1536	

due to incorporation of SCR on decomposition released nutrients to soil slowly throughout the growth period of chickpea and wheat plants resulted in increasing the value of yield, GMR,NMR and B:C ratio of chickpea and wheat. In both the crops, chickpea recorded significantly higher GMR (47812), NMR (29593) and B: C ratio with incorporation SCR along with 100 % RDF as compared to restof treatments. These results are closely resembled with those of Karunakaran and Behera (2013).

CONCLUSION

It was concluded that, application of soybean crop residue (2.0 t/ha) along with 100% recommended dose of fertilizer to wheat and chickpea was recorded maximum grain yield, gross and net monetary return, improve organic carbon content in soil.

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Soil organic carbon pools and carbon management index in conservation vis-à-vis conventional agricultural practices under cotton-wheat, maize-wheat and pigeonpea-wheat cropping system in a sandy clay loam soil

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The conversion of natural vegetation to agricultural ecosystems and increase in tillage intensity can deplete the soil organic carbon (SOC) pools and exacerbate the GHGs emissions (Lal *et al*., 1998; Lal, 2000). The strategy to reverse these trends and sequester C in agricultural soils depends on a balance between C additions from crop residues and organic amendments and losses mainly through decompositions, erosion and leaching. Conservation agriculture practices involving minimum tillage, crop residue retention and crop rotation is an approach to sequester soil organic carbon and improve soil health. Keeping this in view, the objective of this study was to study the effect of different conservation agriculture practices on soil organic carbon pools and carbon management practices under three irrigated wheat based cropping systems viz., cotton-wheat, maize-wheat and pigeon pea-wheat cropping systems.

METHODOLOGY

Field experiments were conducted during 2010-2016 at the Research Farm of the ICAR-Indian Agricultural Research Institute, New Delhi (77°89' E Longitude, 28°37' N Latitude and 228.7 m above mean sea level), Delhi, India to study the impact of conservation agriculture practices *vis-à-vis* conventional agriculture practices on carbon sequestration in three irrigated wheat based cropping systems i.e. cotton-wheat, pigeon pea-wheat and maize-wheat cropping systems. The treatments include : (T1) conventional tillage and flat-bed sowing without residue recycling (CT), (T2) zero tilled permanent narrow-bed sowing without residue retention (PNB), (T3) zero tilled permanent narrow-bed sowing with residue retention (PNB + R), (T4) zero tilled permanent broad-bed sowing without residue retention (PBB), (T5) zero tilled permanent broad-bed sowing with residue retention (PBB + R)] arranged in a randomized block design (RBD) with three replications during 2010-11. In the next year onwards, two additional treatments, (T6) zero tilled flat bed sowing without residue retention (ZT) and (T7) zero tilled flat bed sowing with residue retention (ZT + R) were employed. The soil (0-15 cm layer) of the experimental site was sandy clay loam in texture, with pH 7.7, Walkley-Black C (oxidizable SOC) 5.2 g/kg, EC 0.64 dS/m, $KMnO_4$ oxidizable N 182.3 kg/ha, 0.5 M $NaHCO_3$ extractable P 23.3 kg/ha and 1 N NH_4OAc extractable K 250.5 kg/ha. After the fifth year of cropping, soil samples were collected and analyzed for soil organic carbon pools through a modified Walkley and Black method as described by Chan *et al*. (2001). In this method the total soil organic

Table 1. Carbon management index at 0-30 cm soil depth as influenced by tillage and cropping system

Treatment	Cotton-wheat	Maize-wheat	Pigeon pea-wheat	Mean
Zero tillage (ZT)	187.5a*	187.0c	140.2d	171.6
ZT + Residue	184.6a	255.4a	234.1a	224.7
BB + Residue	156.7b	212.8b	186.8b	185.4
Broad bed (BB)	157.2b	200.5b	157.8c	171.9
NB + Residue	146.9c	212.4b	186.7b	182.0
Narrow bed (NB)	161.8b	193.1c	167.9c	174.2
Flatbed	181.3a	182.0c	182.8b	182.0

* Numbers followed by same letters are not significantly different as per Dunkan Multiple Range Test

carbon was fractioned into four different pools of different oxidizability i.e. Very labile, Labile, Less labile and non-labile pools. Then using these data the Carbon lability index, Carbon pool index and Carbon management index were computed (Blair *et al*., 1995; Venkatesh *et al*., 2013).

RESULTS

It was observed that in all the three cropping systems, maximum soil organic carbon was found in the very labile pool followed by labile, non-labile and less labile pool. Averaged over tillage systems, Total organic carbon at 0-30 cm soil depth was the maximum in the cotton-wheat system followed by pigeon pea-wheat and maize-wheat system. Among the tillage treatments, across the cropping systems, the maximum total organic carbon pool was recorded in the zero tilled flat bed sowing with residue retention (ZT + R) treatment. In cotton-wheat system, Very labile pool of SOC was maximum under ZT + R system, Labile pool was maximum under ZT system, Less labile pool was maximum under NB+R system and non-labile pool was maximum under NB system. In maize-wheat system, Very labile pool and Labile pool of SOC was maximum under ZT + R system, less labile pool was maximum under BB system and non-labile pool was maximum under ZT system. In pigeon pea-wheat system, very labile pool of SOC was maximum under ZT + R system, labile pool was maximum under BB system, less labile pool was maximum under ZT system and non-labile pool was maximum under ZT+R system. It was observed that the carbon lability index was maximum for zero tilled flat bed with residue application (ZT+R) and among the cropping systems; it was maximum for pigeon pea-wheat system for 0-30 cm soil depth. The carbon pool index was maximum for zero tilled flat bed with residue application and among the cropping systems, it was maximum for maize-wheat system for 0-30 cm soil depth. However, the carbon management index, which is based on the carbon pool index and carbon lability index, was maximum in the Zero tilled flat-bed with residue (ZT+R) in 0-30 cm soil depth (Table 1). Application of residues improved the carbon management index in all the conservation tillage treatments. Among the cropping systems, maize-wheat cropping system registered the highest carbon management index in 0-30 cm soil depth.

CONCLUSION

It may be concluded that zero tilled flatbed with residue retention under maize-wheat rotation may be practiced to improve carbon management index in sandy clay loam soil of Indo-Gangetic plain region.

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Effect of tillage and crop establishment techniques on the performance of cotton-wheat cropping system in North-West India

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Cotton–wheat cropping system now occupies an important place in the agricultural economy of this region, covering 1.7 M ha in North-west India (Monga *et. al*., 2009).There is already a greater emphasis on crop diversification due to growing concerns about the unsustainability of rice–wheat system in this region. In this context, a crop like *Bt* cotton has emerged as the promising alternative for rice in *Kharif*season. Keeping this in view, the present study wasconducted to find out the effect of differenttillage and crop establishment techniques on the performance of cotton–wheat cropping system.

METHODOLOGY

Four tillage and crop establishment techniques treatments were allotted in main-plot while four residue management treatments in sub-plot.For the residue management in cotton, wheat residue @ 5 t/ha uniformly applied in wheat residue alone and cotton + wheat residue treatment plots while in wheat the cotton residue was applied @ 2.5 t/ha in the plots of cotton residue only and cotton+wheat residue treatments.The sowing of cotton cv. 'MRC 7017'('Nikki') was done by dibbling method with row spacing of 70 cm and plant to plant spacing of 60 cm. The wheat cv. 'HD 2932' crop was sown at a row spacing of 18 cm in conventional tillage flat and zero tillage flat treatments by multi-crop planter. While bed-planter was used to establish three rows of wheat crop on top of the raised beds (35 cm). The data recorded for different parameters were analysed with the help of analysis of variance (ANOVA) technique for a split-plot design using MSTAT-C software.

RESULTS

Tillage and crop establishment practices brought about a significant influence on number of bolls and yield performance of cotton in all the years. In general, conventional tillage resulted in higher bolls/plant and yields of cotton than zero–tillage. Further, bed planting was superior to flat sowing under both the tillage practices. In 2008, CT–flat and CT–bed had equal number of bolls/plant as with ZT–bed; all of which were significantly superior to ZT–flat. This was reflected on the yield, which was also the lowest under ZT–flat conditions. The highest yields of seed cotton as well as the stalk were under CT–bed, which were however, on par with CT–flat and

Table 1. Number of bolls/plant and yields (t/ha) of cotton as influenced by tillage and crop establishment, and residue management

Treatment	2008			2009			2010		
	No. of bolls/ plant	Seed cotton yield	Stalk yield	No. of bolls/ Plant	Seed cotton yield	Stalk yield	No. of bolls/ plant	Seed cotton yield	Stalk yield
Tillage and crop establishment									
CT–flat	40.5	3.35	6.58	23.9	1.44	3.87	31.9	2.33	4.87
CT–bed	42.3	3.60	6.68	29.0	1.77	4.00	34.9	2.62	4.95
ZT–flat	35.3	3.06	6.00	22.3	1.42	3.50	30.3	2.19	4.41
ZT–bed	40.9	3.53	6.56	24.5	1.56	3.65	33.4	2.61	4.85
LSD (P=0.05)	3.95	0.28	0.34	1.99	0.14	0.34	2.21	0.13	0.23
Residue management									
No residue (R_0)	39.3	3.30	6.33	22.9	1.40	3.17	30.6	2.15	4.23
Cotton residue (Rc)				25.3	1.54	3.72	33.1	2.32	4.79
Wheat residue (Rw)	40.2	3.46	6.58	25.4	1.55	3.74	33.1	2.57	4.77
Cotton+ wheat residue (Rcw)				26.2	1.70	4.39	33.6	2.71	5.28
LSD (P=0.05)	NS	0.13	0.24	1.37	0.10	0.19	1.48	0.10	0.21

Table 2. Yield and yield attributes of wheat as influenced by tillage and crop establishment, and residue management

Treatment	Nos. of spikes/m^2			Nos. of grains/spike			Grain yield (t/ha)		
	2008–09	2009–10	2010–11	2008–09	2009–10	2010–11	2008–09	2009–10	2010–11
Tillage and crop establishment									
CT–flat	314.5	285.6	297.2	48.4	45.1	48.4	4.45	4.34	4.25
CT–bed	289.0	280.2	307.3	46.3	44.9	37.9	4.39	4.09	4.06
ZT–flat	243.1	253.0	277.0	44.0	42.7	47.0	4.21	4.08	4.00
ZT–bed	281.5	272.1	309.1	42.0	41.6	37.3	4.14	3.92	3.97
SEm±	5.14	6.10	5.76	0.60	0.62	0.80	0.07	0.06	0.06
LSD (P=0.05)	17.79	21.11	19.94	2.07	2.16	2.76	0.23	0.22	0.20
Residue management									
No residue (R_0)	267.2	256.3	279.2	43.9	42.3	40.5	4.01	3.76	3.85
Cotton residue (Rc)	283.0	270.5	292.4	45.0	44.2	42.8	4.39	4.23	4.12
Wheat residue (Rw)	290.2	274.2	300.5	44.8	43.0	42.3	4.28	4.02	4.01
Cotton+ wheat residue (Rcw)	302.8	289.9	318.4	47.0	44.9	45.0	4.52	4.43	4.31
SEm±	4.57	4.59	4.50	0.59	0.40	0.85	0.04	0.06	0.05
LSD (P=0.05)	13.35	13.40	13.12	1.73	1.15	2.48	0.13	0.18	0.13

ZT–bed. In 2009 and 2010, the number of bolls/plant and seed cotton yield were maximum under CT–bed, which was significantly more than all other treatments but being on par with ZT–bed in 2010. Number ofspikes/m^2 and grains/spike were significantly influenced due to tillage and crop establishment, and residue management (Table 2.). Number of grains/ spikes was maximum under CT–flat, which was on par with CT–bed in 2008–09 and 2009–10 but significantly more in 2010–11. ZT resulted in significantly lower grains/spike than CT both under flat and bed planting under first two cropping cycles. In general, the lower number of grains/spike under ZT–bed was associated with high number of spikes/m^2 however; the trend was reverse under ZT–flat condition. Yield attributes of wheat showed a significant improvement with residue management in all cropping cycles. Grain yield was highest under CT–flat, nearly followed by CT–bed. The grain yield under ZT was comparatively lower than CT under both flat and bed sowing. ZT–flat resulted in significantly lower grain yield than CT–flat but on par with CT–bed. However, ZT–bed was significantly inferior to CT–flat and CT–bed, while on par with ZT–flat. Similarly, the straw yield was lowest under ZT–bed, which was on par with ZT–flat, but significantly lower than CT–flat and CT–bed conditions.

CONCLUSION

Wheat yield was more stable in 3 cropping cycles (4.0–4.5 t/ha), and was comparatively lower under bed than flat sowing. The grain yield of wheat under ZT–flat along with residue of both crops was equal to that under CT–flat, indicating essentiality of residue application under zero-till conditions.

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Influence of crop residue and potassium management under conservation agriculture on the productivity of maize-wheat cropping system

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Crop residues are important natural resource for the stability of agricultural ecosystems. About 75% of potassium (K) uptake by cereal crops can be retained in crop residues, making them valuable nutrient sources (Singh, 2003).Potassium fertiliser cost has increased considerably over the past few years and sharp increase in prices has raised doubts about the profitability of potassium application in cereals where the minimum support prices (MSP) is low. On-farm K response studies in rice, wheat and maize, spread across the Indo-Gangetic Plains (IGP), highlighted that grain yield response to fertiliser K is highly variable and is influenced by soil, crop and management factors. Average yield losses in maize and wheat in farmer's fields due to K-omission were 700 and 715 kg/ha, respectively. This suggests that skipping application of K in these cereal crops will cause variable yield and economic loss to the farmers of the region and will affect overall cereal production in the country. Besides nutrient management, need of alternative cropping system like maize–wheat system over the popular rice–wheat system under IGP tracts of India is very much realized mainly due to its lower water requirement and better effects on soil health and climate change (Singh *et al.,*2013).

METHODOLOGY

The field experiments were conducted during two *kharif* and *rabi* seasons(2014-16) at the research farm of ICAR-IARI, New Delhi located at 28.35°N latitude and 77.12°E longitude and 228.6 m above mean sea level (MSL). The experiment was laid out in split plot design with four crop residue (CR) management practices (No CR, 25% CR, 50% CR and 75% CR) in main plot and five potassium management practices (No K, 50% RDK (Recommended dose of Potassium), 100% RDK, 150% RDK and 50% RDK+KSB (Potassium solubilising bacteria) in sub plots and replicated thrice.Maize (PMH 4) and wheat (HD CSW 18)were sownat 60 x 30cm and 20 cm,respectively with the help of zero seed

Table 1. Effect of crop residue and potassium management practices on yield (t/ha) of maize and wheat in conservation agriculture based maize- wheat cropping system (mean of 2 years)

Treatment	Maize				Wheat			
	Grain	Stover	Biological	Harvest index (%)	Grain	Straw	Biological	Harvest index (%)
Crop residue management practices								
No CR	5.26	7.76	13.01	40.18	5.22	7.72	12.94	39.93
25% CR	5.91	9.16	15.07	39.04	6.02	9.27	15.29	39.04
50% CR	7.00	11.75	18.75	37.13	7.05	11.80	18.85	37.26
75% CR	6.43	10.28	16.72	38.35	6.58	10.43	17.01	38.59
SEm±	0.04	0.03	0.07	0.05	0.04	0.04	0.09	0.06
LSD (P=0.05)	0.12	0.12	0.24	0.16	0.15	0.15	0.30	0.20
Potassium management practice								
No-K	4.59	8.17	12.76	36.12	4.80	8.39	13.19	36.28
50% RDK	5.74	9.32	15.06	38.22	5.55	9.14	14.70	37.94
100% RDK	6.99	10.58	17.57	39.92	7.16	10.75	17.90	40.09
150% RDK	6.29	9.88	16.17	39.04	6.13	9.72	15.85	38.80
50% RDK+KSB	7.14	10.74	17.88	40.07	7.44	11.03	18.46	40.41
SEm±	0.06	0.06	0.12	0.08	0.11	0.11	0.22	0.15
LSD (P=0.05)	0.17	0.17	0.34	0.24	0.32	0.32	0.64	0.44
CRM X PM	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

CR: Crop residue for both crops, RDK: Recommended dose of potassium, KSB: Potassium solubilising bacteria, Sig.: Significantly different

drill with seed rate of 20 kg/ha for maize and 100 kg/ha for wheat. Recommended dose of fertilizer for both crops (150:80:60 kg N, P_2O_5 and K_2O/ha) was placed below the seed zone at sowing as per the treatment. Seeds of both maize and wheat crops were treated with potassium solubilising bacteria (KSB) @ 50 ml/acre as per treatment. Sundried chopped residues of the wheat and maize crops of previous season were applied at different levels to maize and wheat crops respectively by retaining on the soil surface as mulch in all treatments except control after sowing of crops.Samples of maize and wheat crop were harvested manually from the central net area for yield assessment. The mean grain, straw, biological yield and harvest index of two years datawere subjected to standard statistical analysis.

RESULTS

The mean data of two years pertaining to maize and wheat grain, straw, biological yield and harvest index are presented in table 1. The treatments applied with crop residue and potassium management practices showedsignificant improvement in different parameters over control in both maize and wheat crops. The treatment 50% CRwas found significantly superior with respect to grain, straw and biological yield as compared to No CR.Application of 50% RDK + KSB showed superiority over other treatment for grain, straw and biological yield of maize and wheat which was on par with 100% RDK.Significantly lower grain, straw and biological yield in maize and wheatwere observed in K control. The higher harvest index(HI) was found withNo CR in maize and wheat and lowest in 50% CR (37.2 and 37.3%) where as among different K doses higher HI values were found in 50%RDK+KSB followed by 100% RDKin both the crops. The interaction effect of crop residue and potassium management practices showed significant difference for different parameters in both the crops.

CONCLUSION

Crop residue and potassium solubilising bacteria along with inorganic potassium fertilizer had a significant effect on grain, straw and biomass yield under zero till maize- wheat cropping system. Microbial inoculation of potassium solubilising bacteria could be an alternative andviable technology to solubilise insoluble K into solubleform and could be efficiently used as a source of potash fertilizerfor sustaining crop production and maintainingsoil potassium under maize-wheat cropping system.

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Studies on the effect of herbicide combinations for control of complex weed flora in wheat

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Wheat (*Triticum aestivum* L.) has commanding position in the agriculture economy of India, being a major food crop of India, cultivated on an area of about 30.97 million hectare, producing 94.0 million tones of grains with the productivity of 3.16 t/ha during 2012-13. More than 80% of the wheat production is obtained from northern India, comprising Punjab, Haryana, Uttar Pradesh, Bihar, Rajasthan and Madhya Pradesh. Weeds are one of the major constraints in affecting potential yield of wheat. The losses caused by weeds vary depending on the weeds species, their density and environmental factors. Due of high cost of labour for manual weeding and its lower efficacy, the farmers, are relying heavily on herbicides for effective weed control in wheat. About 34-40% yield losses due to grassy and broad leaf weeds have been reported by Katyal *et al.* (1980). Wheat fields are infested with diverse weed flora and for their effective management, combination of herbicides either as ready mixture, if idosulfuron with Metsulfuron (Malekian *et al.,* 2013) are required.

METHODOLOGY

The investigation was carried out during the r*abi,* season of 2014-15 at Crop research farm of C.S. Azad University of Agriculture and Technology, Kanpur (U.P.). The experimental farm falls under the Indo-Gangetic alluvial tract and irrigated by tube well. To study the effect of herbicides under sole as well as in combinations against control of complex weed flora in wheat crop, twelve treatments comprised of T_1-Pendimethalin (1.5 kg/ha) PE, T_2-Sulfosulfuron (0.025kg/ha) PE, T_3-Metribuzin (0.21 kg/ha) PE, T_4-Pendimethalin+ Metribuzin (1.0+0.175 kg/ha) PE, T_5-Pendimethalin + Sulfosulfuron (1.0+0.018 kg/ha) PE, T_6-Sulfosulfuron + Metsulfuron (Total) (0.04 kg/ha) 5 WAS, T_7- Pinoxaden + Metsulfuron (Premix) (0.06+0.004 kg/ha) 5WAS, T_8-Idosulfuron (12.0 g/ha) + Metsulfuron (2.4 g/ha) 5WAS T_9-Clodinafop propargyl + Metsulfuron Methyl (0.060 kg/ha) 5 WAS, T_{10}-Pinoxaden (0.50 g/ha) 5WAS, T_{11}-twice hand weeding (30 and 60 DAS) T_{12}-weedy check were replicated

Table 1. Weed dry weight, grain, straw yield and economics of treatment influenced by different treatments

Treatment	Weed dry weight (g/m²)		Grain yield (t/ha)	Straw yield (Rs/ha)	Gross return (Rs/ha)	Net return (t/ha)	B:C ratio
	Grassy	Broad leaf					
Pendimethalin (1.5 kg/ ha) PE	2.91 (8.03)	5.05 (25.2)	3.33	4.10	65577	40711	2.64
Sulfosulfuron (0.025 kg/ ha) PE	3.24(10.10)	6.50 (41.8)	2.99	3.73	58949	33889	2.35
Metribuzin (0.21kg/ha) PE	3.03 (8.82)	5.09 (25.6)	3.02	3.87	60040	35156	2.41
Pendimethalin + Metribuzin (1.0+0.175 kg /ha) PE	2.82 (7.47)	4.54 (20.1)	3.42	4.23	67326	42385	2.70
Pendimethalin + Sulfosulfuron (1.0+0.018 kg/ha) PE	2.57 (6.12)	4.11 (16.4)	3.48	4.31	68500	43216	2.71
Sulfosulfuron + Metsulfuron (Total) (0.04 kg/ha) 5 WAS	2.35 (5.04)	2.60 (6.2)	3.54	4.37	69813	44344	2.74
Pinoxaden + Metsulfuron (Premix) (0.06+0.004 kg/ha) 5WAS	2.46 (5.56)	3.80 (14.0)	3.48	4.32	68569	42848	2.67
Idosulfuron (12g/ha)+Metsulfuron (2.4 g/ha) 5WAS	2.28 (4.71)	2.54 (6.0)	3.61	4.41	71237	45782	2.80
Clodinafop propargyl+Metsulfuron Methyl (0.060 kg/ha) 5 WAS	2.45 (5.33)	2.77 (7.20)	3.50.	4.33	69028	44754	2.84
Pinoxaden (0.50 g/ha) 5WAS	3.16 (9.52)	5.28(27.50)	3.02	3.74	59544	35224	2.45
Weed free	0.70 (0.0)	0.70 (0.0)	3.64	4.45	71319	46529	2.87
Unweeded Control	3.44(11.35)	9.39(87.70)	2.82	3.72	56383	33203	2.44
CD (P =0.05)	0.15	0.18	0.11	0.16	6034	1043	0.24

thrice in randomized block design. Wheat variety K-1006 was sown on 22nd November, 2014 with row spacing of 20 cm apart.

RESULTS

Results revealed that weeding condition prevailed throughout the crop period caused, on an average, yield reduction of 23%. The weed free treatment provided maximum grain yield, straw yield net return and B:C ratio and minimum in unweeded control plots. Among the herbicide treatments Idosulfuron+ Metsulfuron (12+2.4 g/ha) recorded significantly the highest grain yield, straw yield of wheat, net income and B:C ratio followed by under application of Sulfosulfuron + Metsulfuron (0.04 kg/ha) grain yield, straw yield, net income and B:C ratio. Dry weight of grassy weed especially *P. minor* was effectively controlled with the use of Idosulfuron + Metsulfuron followed by Sulfosulfuron + Metsulfuron. Whereas, dry weight of broad leaf weeds were found minimum at 60 DAS and at harvest when Idosulfuron + Metsulfuron applied followed by treatment where Sulfosulfuron + Metsulfuron were applied.

CONCLUSION

The minimum dry weight of grassy and broad leaf weeds were recorded under the application of Idosulfuron + Mesusulfuron followed by Sulfosulfuron + Metsulfuron. The maximum yield (3.61 t/ha), net income (Rs 55050/ha) and B:C ratio (2.12) obtained with application of Idosulfuron + Metsulfuron.

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Soil fungal diversity in different scenarios of conservation agriculture

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This study aimed to assess the diversity of soil fungal species in different agriculture management scenarios based on wide range of indicators (crop rotation, tillage, crop establishment, crop, water and residue management). The four scenarios *viz.*, Rice (CT/TPR)-wheat (farmers practice) rotation (scenario I); Rice-wheat-mungbean (CT/TPR-ZT-ZT) with residue retention/incorporation (scenario II);Rice-wheat-mungbean (ZT-ZT-ZT) with residue retention (scenario III), Maize-wheat-mungbean (ZT-ZT-ZT) with 65% maize and 100% wheat-mungbean residue retention (scenario IV). As most of the biochemical decomposition of organic plant biomass is carried out by heterotrophic microorganisms, among which fungi are an important. Soil microbial abundance study was carried out using molecular toolof high through put sequencing technology (pyrosequencing/next gen sequencing), which allows obtaining thousands of sequences from a single soil DNA sample which may helped better assessing the huge diversity of soil microbial communities. Based on the fungal taxonomic diversity results, it was found that dominant phyla belongs to the Ascomycota (55–73% of all fungal sequences), followed by Basidiomycota (0.17-3% of all fungal sequences) and Glomeromycota(0.16-3% of all fungal sequences). Higher abundance (73.57%) of Ascomycota was found in scenario IV as compare to scenario I (55.43%), II (68.05%) and

III (71.39%) respectively. These Ascomycota and Basidiomycota phyla are dominating fungi insoils and mainly belong to the saprotrophic soil fungi and are responsible decomposition of organic residues. Diversified cropping systems (maize-wheat-mungbean) in IGP with CA based best management practices showed the positive effect on residue decomposing microbial community. In total 11 classes were observed in all scenarios but these classes were not evenly distributed among all scenarios.*Sordariomycetes*was found in all scenarios at highest abundance followed by *Dothideomycetes* and *Eurotiomycetes.* Relative abundance of different species was studied in all scenarios and it was found that 54, 91, 85 and 95 types of species were found respectively in scenario I, II, III and IV. Diversity indices such as species richness, evenness (E) and Shannon-Wiener diversity index (H) were also calculated and it was found in order of scenario IV>II>III>I. Result indicates that CA with all the 3-principles (No-tillage, residue retention and crop diversification) found better infungal diversity and species richness which may ultimately reflect in the crop productivity.

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Looking for breakthrough in rice establishment methods in Eastern Indo-Gangetic Plains of India

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Agricultural labor is becoming scarce and costly. The crop establishment is hampered by this shortage. Late transplanting of rice leads to late sowing of wheat. The prospectus of profitable rice-wheat cropping system (RWCS) therefore, rests on timely establishment of rice. The shifting of manual transplanting to mechanical transplanting or direct seeding with a reorganization of land and labor resources have brought higher levels of farm productivity and income (Ibrahim *et. al.,* 2014). There are two remedies to address these issues. We may reduce this problem and associated yield losses in RWCS by mechanical transplanting of rice in non-puddled rice (MTNPR) or by adopting direct seeded rice (DSR). The shifting of manual transplanting to mechanical transplanting or direct seeding with a reorganization of land and labor resources have brought higher levels of farm productivity and income.

METHODOLOGY

The study was conducted for three years at farmers' fields across hub districts of Bihar and Eastern UP and for two years in the replicated experiment at Indian Agriculture Research Institute (IARI) research station, Pusa, Samastipur. Data on paddy yield was averaged over sites for analysis. System of rice intensification (SRI) and manual transplanting under puddled condition (PTR) were the standard checks.

RESULTS

The introductions of MTNPR and DSR have created a new niche by replacing manual transplanting. Based on the average of three years, paddy yields of rice hybrids across Bihar and EUP were; 6.3, 5.7 and 5.6 tonnes/ha under MTNPR, DSR and PTR. The paddy yield from hybrids tends to be markedly higher than the varieties (Fig. 1). The paddy yields of rice hybrid (Arize-6444) in 4 crop establishment methods were statistically same ranging from 7.3 to 8.5 t/ha with an edge for MTNPR. However, by cutting the labour cost, the net profits (Fig. 2) from MTNPR, DSR, SRI and PTR were 1032, 838, 822, 741 $/ha, respectively. CSISA is now doing more to ensure the success of MTNPR or PTR by introducing the concept of community nursery.Rice can also be grown

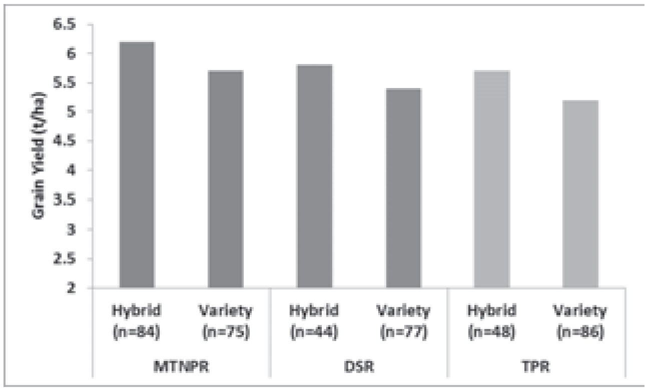

Fig. 1. Crop-cuts from CSISA hubs during 2013 and 2014

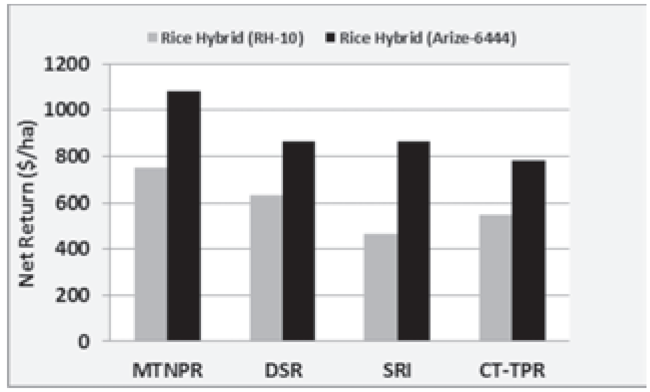

Fig. 2. CSISA Research trial at IARI, Pusa, Bihar, 2013

after transplanting in no-till conditions.For wider adoption by farmers we focused on DSR because its adoption is likely to be more useful for small and marginal farmers. Machine transplanting has created a new niche by replacing manual transplanting. It will cover whole IGP provided the nursery raising becomes mechanized and a commercial venture. Both these technologies helped in the optimization of RWCS. Performance of hybrids in both DSR and MTNPR was better than varieties. Hybrids reduced the vulnerability to drought which has affected rice productivity during last 5 years.

CONCLUSION

Introducing MTNPR or DSR will result in farmers improving their incomes. This will also result in optimizing the RWCS with improved system productivity. Both technologies need advocacy.

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Tillage practices and intensified cropping systems: Effect on yield attributes and yields of maize in North-Western India

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Adoption of alternate tillage practices in rice-wheat cropping systems could be the major option for sustainability of existing cropping system, while the diversification of rice with maize is another alternative cropping systems which are of more environmentally friendly. Under the recent climate change scenario maize will be a better alternative to *kharif* (rainy) season rice of this region to enhance the crop as well as system productivity, and sustain soil health.The introduction of single cross hybrid (SCH) technology and development of different maturity high yielding maize hybrids provided genotypic options for crop diversification. Maize, an important crop for food security in India, is grown throughout the year in diverse agro-ecological conditionin the country on an area of 8.67 M ha with production of 25.08 MT. In present scenario, to explore maximum yield potential of SCH maize in conservation agriculture (CA) based crop production technologies are catching attention of the growers in this region. Furthermore, the intensive traditional tillage practices lead to reduction in soil organic matter because of more oxidation and breakdown of organic carbon and ultimately degrade soil properties. Adoption of CA principles would be helpful in expansion of maize area in North-Western India. So, to generate the new information for sustainable intensification of maize based systems in North-Western India, a long-term study was initiated at ICAR-IIMR research farm, New Delhi to evaluate the impacts of tillage and crop establishment practices on the performance of intensified maize based cropping systems.

METHODOLOGY

A long-term field experiment established in the *kharif* (rainy) season of 2008 at the research farm of the ICAR-IIMR, Pusa Campus, New Delhi, India. The soil of experimental site (before kharif 2008) was sandy loam (Typic Haplustept) in texture with pH 7.8, EC 0.32 dS/m, KMnO4 oxidizable N 158.4 kg/ha, 0.5 M $NaHCO_3$ extractable P 11.6 kg/haand 1 N NH_4 OAC extractable K 248.4 kg/ha. The experiment was conducted in split plot design with three main-plot treatments consisting tillage practices [zero tillage (ZT), permanent bed (PB) and conventional tillage (CT)] and four sub-plot intensified maize based cropping systems [maize-wheat-mungbean (MWMb), maize-chickpea-*Sesbania* (MCS), maize-mustard-mungbean (MMuMb) and maize-maize-*Sesbania* (MMS)] with three replications. Quality protein maize hybrid HQPM-1 was used in experiment. All recommended package of practices (POP) were used except treatments. All data related to yield and yield attributes were recorded and analyzed with the help of analysis of variance (ANOVA) technique for split-plot design using SAS 9.3 software. The least significant difference test was used to decipher the main and interaction effects of treatments, respectively at 5% level of significance ($P<0.05$).

RESULTS

Critical examination of data showing that the maximum values of cobs/m^2 (7.8) cob length (18.3 cm), cob girth (13.2 cm), grain rows/cob (13.8) and grains/row (35.6) were recorded under ZT than rest of the crop establishment treatments, while CT resulted in minimum values. All the yield attributes were not significantly influenced due to diversified cropping systems, however the numerically higher values of cobs/m^2, cob length, grain row/cob and grains/row were observed in maize-chickpea-*sesbania* (MCS) cropping system. The better crop growth at 30-60 DAS under CA practices lead to enhancement in crop CGR and RGR as well as the yield governing attributes of maize, because this is the crucial stages in deciding the number of grains/row and grain rows/cob of the maize plant. The tillage and cropping systems had significant ($P<0.05$) interaction effect on harvest index ofmaize, while nointeraction effect was observed on yield attributes. The harvest index of maize in PB-MMuMb treatment increased by 34.1% compared to lowest treatment of CT-MMuMb.The tillage had significant ($P<0.05$) effects on maize yields (cob and biological) and yield attributes (Table 1). However, maize planted on PB and/or ZT flat remained at par with respect to yields (cob and biological) and yield attributes. PB and ZT registered increase in cob yield (3.8 to 14.9%), biological yield (6.2 to 13.7%), cobsm^{-2} (13.6 to 14.8%), cob length (5.0 to 8.4%), grain row/cob (4.8 to 7.9%) and grains/row (8.4 to 13.0%) compared to CT. The diversified cropping systems hadsignificant ($P<0.05$) effects onmaize yields (cob and biological) and maximum were recorded in MCS sequence which were 5.8, 8.9 and 10.9%, higher as compared to MWMb, MMuMb and MMS, respec-

Table 1. Effect of long term tillage and diversified cropping systems on yield attributes and yields of maize after six cropping cycles

Treatments	Cobs	Cob length	Cob girth	Grain rows/ Cob	Grains/ row	100-grain weight	Cob yield	Biological yield	Shelling	Harvest index
Tillage practices	–m^{-2}–	——m——			–g–	——kg/ha——	–%–			
Permanent bed	7.7a	0.177ab	0.129	13.4ab	34.2ab	26.7	5368b	16215b	80.6	27.0
Zero tillage flat	7.8a	0.183a	0.132	13.8a	35.6a	25.6	5939a	17351a	77.3	26.5
Conventional tillage	6.8b	0.169b	0.125	12.7b	31.5b	27.1	5169b	15264c	77.8	26.5
Cropping systems										
MWMb	7.4	0.177	0.131	13.7	34.0	25.9	5530ab	16660ab	78.8	26.4
MCS	7.6	0.181	0.130	13.2	34.5	26.2	5851a	17203a	78.6	26.7
MMuMb	7.3	0.174	0.128	13.1	33.8	26.8	5374b	15924bc	78.8	26.8
MMS	7.2	0.172	0.126	13.0	32.8	27.0	5214b	15320c	78.2	26.8
						LSD $_{0.05}$ [c)]				
Tillage practices	0.68	0.0104	NS	0.75	3.04	NS	461	839	NS	NS
Cropping systems	NS	NS	NS	NS	NS	NS	367	1032	NS	NS

[c)] Least significant difference at the 0.05 probability level.

tively. The maize yields were highest in ZT planting compared to CT. Our findings of higher yields and yield attributes under ZT of maize crop are in agreement with Jat *et al*. (2013). The higher yield of maize in ZT system could be due to the compound effects of additional nutrients (Kaschuk *et al*., 2010), reduced competition for resources due to lesser weed population (Chauhan *et al*., 2007), improved soil physical health (Jat *et al*., 2013) and enhancements in soil carbon (Parihar *et al*,. 2016). Among the cropping systems, irrespective of tillage and crop establishment practices the seventh monsoon (*kharif*) season maize cob, biological yields, energy-use efficiency and plant nutrient content were higher with MCS system plots than that of the other three (MWMb, MMuMb, MMS) cropping systems plots. This might be due to inclusion of two legumes (one winter and another in summer) compared to only summer legume in other cropping systems (Congreves *et al.,* 2015).

CONCLUSION

The analysis of seventh *kharif* season study at fixed plots on tillage practices and diversified maize based cropping systems indicated that under the multiple challenges (yield plateau, water and labour shortages, high energy costs, diminishing farm profits and climatic change induced variability) sustainable intensification of maize systems (with legume inclusion) using CA based management (ZT and PB) are alternate potential practices for achieving the higher growth, yield, soil organic carbon and water and energy-use efficiency of *kharif* maize in North-Western India.

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Performance of multicut fodder sorghum (*Sorghum bicolour* (L.) varieties as influenced by nutrient management and biofertilizers

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The field experiment was conducted in 2015 at Research Farm of Forage Research and Management Centre, National Dairy Research Institute (NDRI), Karnal to study the growth and yield performance of multicut fodder sorghum (*Sorghum bicolour* (L.). The research farm was located at latitude 29°45', North longitude 76° 58'East and altitude at 245m above mean sea level falls under subtropical climatic condition. The experiment was laid out in split-plot design with three treatment of varieties (V1=CSH 20MF,V2= CSH 24MF,V3= CO (FS)29) in main plots, five nutrient management with biofertilizers (NM1= control, NM2= RDF-N:P_2O_5-90:40 kg/ha; NM3= RDF+BF-N:P_2O_5-90:40 kg/ha+ Azotobacter & Azospirillum, NM4= N:P_2O_5-60:40 kg/ha+ Azotobacter & Azospirillum, NM5=P_2O_5-30:20 kg/ha+ Azotobacter & Azospirillum) in sub plots with three replications in total 45 numbers of plots. The seeds were inoculated with biofertilizers viz. Azotobacter & Azospirillum. The crop was planted at spacing of 40 cm row to row with seed rate 25 kg/ha. The uniform dose of K_2O (20 kg/ha) applied in all plots.

The results were revealed that the plant height recorded highest in variety V1 and differ significantly at first cutting and V2 at third cutting with NM3. The number of leaves were significantly differ by both the treatments and marked variety V2 found superior with NM3 at first and second cutting. The number of tillers were counted in V3 and significantly difference was found between V1 and V2 with NM3 in first cutting. The leaf : stem ratio differed significantly between all varieties and nutrient management. The fodder yield were recorded highest 88.5 ton/ha by V3 upto three cuts with NM3.The dry matter showed similar tend as the green fodder yield. The green fodder yield was found 40 % superior by V3 over to V1 and 51% over to V2.

Among the three sorghum fodder varieties CO(FS)29 produced highest green fodder yield and dry matter yield with the application of nitrogen 90 kg/ha and P_2O_5 40 kg/ha with biofertilizers harvested in all three cuttings of fodder sorghum .The variety may be advised for dairy farmers as to grow multicut sorghum variety.

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Conservation agriculture for enhancing water productivity

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Water is a key driver of agricultural production and its scarcity can seize production and adversely impact food security. Irrigation has helped to boost agricultural yields and outputs in semi-arid and even arid environments and stabilized food production and prices. They observed that failure in water policy reform would result in decline of global grain production by 10% by 2025, which would cause malnutrition, health risks and damages to the environment. Increased water use in the future will largely be driven by urbanization, population growth, industrialization and environmental need. Increased water competition and diversion from irrigation will reduce irrigated area and diminish crop yields and seriously limit food production. According to the Comprehensive Assessment of Water Management in Agriculture (Molden *et al.*, 2007) today's food production requires a consumptive water use of about 6800 km^3/year. Out of this, 1800 km^3/year are supplied by irrigated water (i.e. blue water resources). To feed humanity by 2050 on 3000 kcal per person per day, an additional 5600 km^3/year will be required; out of which a maximum of 800 km^3/year will come from blue water resources while the remaining 4800 km^3 will have to come from new green water resources (e.g. from horizontal expansion or from turning evaporation into transpiration). There is a possibility that improved efficiency in rainfed areas will result in saving of 1500 km^3/year. This means that there will be a gap of about 3300 km^3/year which can be further mitigated by increasing water productivity. Conservation agriculture (CA)-based resource-conserving technologies (RCTs) helps for enhancing water productivity. Concepts of reducing tillage and keeping soil covered came up and the term conservation tillage was introduced to reflect such practices aimed at soil protection. It is a relative term referring to the benefits derived from unit volume of water. It is a ratio referring to the unit of output (s) per unit of input (s).Water productivity depends on- crop, genetic material, water management practices, agronomic practices, Economics and policy incentives to produce. The key principles for improving water productivity at field, farm and basin level, which apply regardless of whether the crop is grown under rainfed or irrigated conditions, are: (i) Increase the marketable yield of the crop for each unit of water transpired by it.(ii) Reduce all outflows (e.g. drainage, seepage and percolation), including evaporative outflows other than the crop stomatal transpiration; and(iii) Increase the effective use of rainfall, stored water, and water of marginal quality. Conservation Agriculture (CA) is defined as a "*concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment"* (FAO 2007). The three basic principles of conservation agriculture include:(i) Zero or minimum tillage, (ii) Retention of crop residues on the soil surface and (iii) Crop diversification. Compared with conventional till (CT) systems, double zero tillage (ZT) consumed 12-20% less water with almost equalsystem productivity and demonstrated higher water productivity (Jat *et al* 2009). Mulching helps in saving of water in the range of 25-100 mm resulting in less number of irrigations and reducing irrigation time by about 17% (Samra and Sharma, 2010).

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Mineralization of carbon and its stability in reclaimed alkali soils under different tillage and management practices

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A laboratory incubation experiment was carried out to study the carbon mineralization in soils under varying tillage, depth and crop management practices at 25^0 C and 35^0 C at field capacity moisture. The soils samples varying in depth 0-15, 15-30, 30-45 and 45-60 cm were collected from four different treatments (scenarios) and uncultivated sites of conservation agriculture field of Cereal System Initiative for South Asia (CSISA) project, CSSRI, Karnal. CO_2 evolution was estimated by alkali trap method at different time interval (7, 15, 30, 45, 60, 75, 90 days). The results revealed that C mineralization increased with the advancement of incubation period from 7 to 90 days, irrespective of treatments. The C mineralization increased with the passage of time, but the rate of increase in C mineralization decreased with the progress of incubation, indicating that C mineralization was faster at the initial period of incubation and then slowed down gradually as the time progressed. Per cent (%) TOC mineralized during 90 days incubation studies revealed that carbon mineralization was significantly higher (4.88 %) at 35^0C than that of 25^0 C (4.48%). Cumulative carbon dioxide evolved during incubation period revealed that highest and lowest CO_2 was released by integrated crop and resource management of rice-wheat-mungbean (scenario 2) & uncultivated soils, respectively at both the temperatures up to 30 cm soil depth. At lower depth (30-45 & 45-60 cm) cumulative carbon dioxide evolved was highest for farmers' practice of rice-wheat (Scenario 1) and lowest for scenario 3 or uncultivated soils. Data obtained from carbon mineralization were well fitted to the first–order exponential equation to get carbon mineralization constant of soil organic matter decomposition and to assess the stability of organic matter in different scenarios and in uncultivated soil. Highest carbon mineralization was observed in integrated crop and resource management of rice-wheat-mungbean (scenario 2) followed by farmers practice of rice-wheat (Scenario 1). Lowest carbon mineralization was observed in uncultivated soil (UnK). Conservation agriculture based system of rice-wheat-mungbean (scenario 3) showed significantly lower carbon mineralization than futuristic and diversified (maize-rice-mungbean) system based on principles of CA (scenario 4). Thus, both conservation based system of scenario 3 and scenario 4 resulted in significantly lower carbon mineralization than scenario 2 and scenario 1. Uncultivated soils showed significantly higher carbon stability over all other treatments. Conservation agriculture based system (Scenario 3) resulted in significantly higher carbon stability over farmers practice (Scenario 1) and integrated crop and resource management (Scenario 2) and at par with futuristic and diversified system based on principles of CA (Scenario 4). Stability of carbon was significantly higher at lower temperature (25^oC) than higher temperature (35^0C).

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Carbon sequestration and soil properties changes in simarouba (*Simarouba glauca* d.c.) based agroforestry system under north Gujarat agro climatic conditions

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A field experiment entitled "Carbon sequestration and soil properties changes in simarouba (*Simarouba glauca* D.C.) based agroforestry system under North-Gujarat agro climatic conditions" was conducted at Research Farm, Centre for Agroforestry Forage Crops and Green Belt, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha in a randomized block design during the *Rabi* season of 2010-11. The soil of the experimental field was low in nitrogen (organic carbon 0.17% and available nitrogen 159.23 kg N/ha), medium in available phosphate (Olsen's P 30.23 kg P_2O_5/ha), medium in potash (187.55 kg K_2O/ha) and alkaline (7.82) in reaction. Simarouba + mustard with and without fertilizer combinations were tried with 7 treatment combinations in replicated four times. The maximum plant height at 60 DAS and at harvest, branches/plant, siliqua/plant and test weight, simarouba tree maximum height, collar diameter and diameter at breast height, fresh and dry fruit weight (2221. 91 and 902.70 kg/ha), above, below and total ground level weight in kg/tree(112.12, 22.42 and 134.54 kg/tree)and t/ha(46.72, 9.34 and 56.06 t/ha), oil content (39.91%) and oil yield (768.05 kg/ha), oil content (56.57%) and oil yield (514.67 kg/ha) noted under simarouba + mustard with 100% RDF. Significantly higher seed, stover and total biomass yield of mustard as intercrop (1924.00, 4760.50 and 6684.50 kg/ha) were registered under the treatment of mustard sole with 100% RDF.The higher available soil nutrients after harvest N (172.50 kg/ha) P (36.80 kg/ha) and K (192.57 kg/ha) were registered under simarouba sole. After harvest, low bulk density (22.26%), EC (0.21dS/m) and pH (7.24) but higher soil porosity and water holding capacity in soil were noted under simarouba sole and maximum under mustard sole with 100% RDF. The soil organic carbon

(0.29%), total biomass of mustard crop, carbon storage (42.61%) were significantly higher under simarouba + mustard with 100% RDF. The carbon content in seed, stover and total biomass of mustard crop maximum (845.92, 1964.86 and 2848.97 kg/harespectively) were noted under the treatment of mustard sole with 100% RDF. The maximum carbon content in leaves, branch, trunk, root and whole plant of simaruba tree (42.74, 43.89, 41.52, 42.01 and 42.54% respectively) were registered under the treatment of simarouba + mustard with 100% RDF. Significantly higher carbon content (41.78 %), litter fall production (5984.00 kg/ha) and carbon storage (2499.64 kg/ha) in simarouba tree were found under the treatment of simarouba + mustard with 100% RDF. Maximum carbon storage (2.85 t/ha) in mustard crop was noted under mustard sole with 100% RDF. Significantly higher carbon storage in litter fall (2.50 t/ha) and simarouba tree (23.84 t/ha) was registered under simarouba + mustard with 100% RDF. The higher SOC stock (6.73t/ha), net SOC stock (2.70 t/ha) and total carbon store in the system (38.40 t/ha) was registered under simarouba + mustard with 100% RDF. The maximum CO_2 sequestration in mustard crop(10.43 t/ha) was found under the treatment of mustard sole with 100% and in simarouba tree (87.26 t/ha) and litter fall (9.15 t/ha) found under simarouba + mustard with 100% RDF. Significantly higher net soil CO_2 stock (9.87 t/ha) and CO_2 content potential (115.89 t/ha) were registered under simarouba + mustard with 100% RDF. Simarouba tree improves the soil health with agrisilviculture (Tree + Field crop) system. The simarouba with mustard based agrisilviculture system is eco-friendly, environment safe and conserve natural resources.

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Resource conservation technology for sustainable agriculture

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The indiscriminate use, rather misuse, of natural resources especially water has led to the groundwater pollution as well as depletion of ground water resources. Presently we are sitting on the volcano and if the situation is not improved we will face water wars in the near future, the sign of which are quite visible in the surface water dispute between Punjab and Haryana and some other states in India. Depleting soil organic carbon status, decreasing soil fertility and reduced factor productivity are other issues of concern. These evidences indicate that rice-wheat system has weakened the natural resource base. If we continue to exploit the natural resources, the productivity and sustainability is bound to suffer. Therefore, in order to meet the aim of sustainable yields over time it is the need of the hour to avoid further degradation of the natural resources. Moreover, in the face of World Trade Organisation (WTO) regime, we must produce at lower cost to be competitive in the international market being India already a surplus state in food-grain production. To meet these needs, the agricultural system must develop cost effective technologies suitable for harnessing the untapped potential especially in the north eastern parts of the Indo-gigantic Plains (IGP) .The resource conservation technologies to economise on cost of production and need for conservation agriculture has assumed lot of significance. During the World Food Summit of 2002, the world leaders vowed to reduce this number to half by 2015. The UN Millennium Development Goals called for ensuring food as well as environmental security for all and can be achieved by increasing the crop productivity per unit of inputs (seed, fertilizer, water and land etc.) and there is an urgent need to arrange a square meal for every one without deteriorating natural resource base. The article discusses the various resources conserving technologies for wheat, rice and for rice-wheat cropping system. The possibilities of RCTs in reclaim alkali soils have been also discuss. Various new machines have been described for better resource conservation in crop cultural practices.

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Impact of conservation tillage and weed management practices on soil properties in rice-wheat-mungbean cropping system

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Wetland rice culture destroys soil structure and creates poor physical condition for the following wheat crop. Conservation tillage results higher amounts of soil organic matter (OM) and improve soil physical, chemical and biological property when compared to conventional tillage systems (Reeves, 1997). Weed control is the major constraint under conservation agriculture. Use of herbicides in aforesaid cropping system affect the micro flora population which carry out the critical soil functions and supports the soil health besides enhancing the system productivity. Since, the information on impact of tillage and weed management practices on soil properties in rice-wheat-mungbean cropping system is very meagre for this region. Hence forth, the present investigation entitled on impact of conservation tillage and weed management practices on soil properties in rice-wheat- mungbean cropping system was proposed.

METHODOLOGY

The field experiment was conducted during 2014-15 and 2015-2016 at *Directorate of Weed Research*, Jabalpur. The experiment consisted of fifteen treatments comprising of five tillage as main-plot treatments (T_1- Conventional tillage in rice + sesbania - conventional tillage in wheat-zero tillage in green gram, T_2- conventional tillage in rice + sesbania + previous crop residues – conventional tillage- + rice residues in wheat-zero tillage in green gram, T_3- zero tillage in rice + sesbania - zero tillage in wheat-zero tillage in green gram, T_4- zero tillage in rice + sesbania +previous crop residues - zero tillage + rice residue in wheat-zero tillage in green gram, T_5- transplanted rice-conventional tillage in wheat) and three weed control as sub plot treatments (W_1- weedy check, W_2- continuous use of same herbicide in both crops, W_3 - Herbicide rotation in both crops), were laid out in split plot design with three replications. The soil of experimental field was clay loam in texture (Typic chromusterts) up to 0–15 cm surface layer and clayey in sub soil (15–75 cm depth) with neutral in reaction (7.3 pH), EC 0.22 dS/m, 0.54% organic carbon, nitrogen (238 kg/ha), phosphorus (16.5 kg/ha) and potassium (342 kg/ha).

Table 1. Impact of conservation tillage on bulk density and soil microbial population in rice-wheat- greengram cropping system.

Tillage practice	Bulk Density (g/cc)	Bacteria (10^6 cfu/g dry weight of soil)	Fungi (10^4 cfu/g dry weight of soil)	Actinomycetes (10^3 cfu/g dry weight of soil)	Dehydrogenase activity (µg TPF/soil/2hr)
CT (DSR)+S-CT(Wheat)-ZT (Green gram)	1.37	17.99	10.06	9.91	28.27
CT (DSR) +R+S-CT+R(Wheat)-ZT (Green gram)	1.31	18.63	12.78	11.95	29.63
ZT (DSR)+S-ZT(Wheat)-ZT (Green gram)	1.34	23.61	13.04	12.92	30.72
ZT (DSR) +R+S-ZT+R(Wheat)-ZT (Green gram)+R	1.32	26.69	15.83	14.90	32.88
CT(TPR)-CT(Wheat)	1.40	15.90	8.31	8.73	27.44
SEm±	0.01	0.46	0.23	0.38	0.11
LSD (P= 0.05)	0.02	1.49	0.76	1.25	0.37
Weed control					
Weedy check	1.35	23.35	16.54	15.42	30.92
Continuous use of same herbicides	1.35	21.04	13.19	12.16	29.48
Herbicides rotation	1.34	17.42	7.28	7.46	28.97
SEm±	0.00	0.29	0.10	0.80	0.21
CD (P=0.05)	NS	0.84	0.30	1.66	0.61

RESULTS

Tillage and weed management practices significantly influenced the bulk density and microbial population in soil. Higher bulk density (1.40 g/cc) was recorded in transplanted rice-conventional tilled in wheat (T_5). The lowest bulk density (1.31 g/cc) was found under conventional tillage with crop residues (Table 1). However, weed management practices did not affect the bulk density of soil. Maximum microbial population of bacteria 26.69 (10^6 cfu/g dry weight of soil), fungi 15.83 (10^4 cfu/g dry weight of soil), actinomycetes 14 .90 (10^3 cfu/g dry weight of soil) and dehydrogenase activity 32.88 (µg TPF/ soil/2hr) was found in plots receiving zero tillage in rice + sesbania +previous crop residues - zero tillage + rice residue in wheat-zero tillage in green gram (T_4). On the contrary, the lowest population of bacteria 15.90 (10^6 cfu/g dry weight of soil), fungi 8.31 (10^4 cfu/g dry weight of soil), actinomycetes 8.73 (10^3 cfu/g dry weight of soil) and dehydrogenase activity 27.44 (µg TPF/ soil/2hr) was found in transplanted rice-conventional tillage in wheat (T_5) due to poor aeration in soil due to puddling of soil. Weed control measures also influenced the soil microbial population. Among the weed management practices, weedy check plots had higher population of bacteria 23.35 (10^6 cfu/g dry weight of soil), fungi16.54 (10^4 cfu/g dry weight of soil), actinomycetes 15.42 (10^3 cfu/g dry weight of soil) and dehydrogenase activity 30.92 (µg TPF/ soil/2hr). Herbicide rotation in rice-wheat-mung bean cropping system had lower population of bacteria 17.42 (10^6 cfu/g dry weight of soil), fungi 7.28 (10^4 cfu/g dry weight of soil), actinomycetes 7.46 (10^3 cfu/g dry weight of soil) and as well as dehydrogenase activity 28.97 (µg TPF/ soil/2hr) respectively. Increased microbial population and dehydrogenase activity under weedy check plot was attributed to more increase in microbial biomass, as it is positively correlated with weed biomass because of high decomposability (Wardle *et al.,* 1999).

CONCLUSION

Crop residue retention/incorporation reduced bulk density in conventional tillage as well as in zero tillage, and also enhanced the soil microbial activities.

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Effect of mechanization and non-mechanization practices on yield and quality of soybean-safflower seed

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A field study was undertaken during *kharif* and *rabi* seasons of 2013-14 and 2014-15 on clayey soil at experimental farm of Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani to study the effect of mechanization and non-mechanization practices on yield and quality of soybean (*Glycine max* L. Merill)–safflower (*Carthamustinctorius* L.) seed under varying spacing and nutrient management. The field experiment treatments consisted of twelve combinations of two practices of mechanization and non-mechanization (sowing, spraying and harvesting) in main plots, two spacing (45 cm x 5 cm , 60 cm x 5 cm for soybean and 45 cm x 20 cm , 60 cmx 20 cm for safflower in sub plots and three levels of nutrient management (RDF, RDF + foliar application of 0:52:34@ 1.5 kg/ha at 35 DAS and RDF + foliar application of 0:52:34 @ 1.5 kg/ha at 35 and 55 DAS) in sub-sub plots for soybean in *kharif* and after that for safflower in *rabi* season were assigned in a split-split plot design with three replications. The results revealed that application of mechanization practices in soybean-safflower cropping systems recorded significantly higher seed, straw and biological yields than non-mechanization practices under two row spacing and foliar spray of nutrients. Quality parameters such as protein and oil content of soybean-safflower were not significantly influenced by mechanization and non-mechanization practices.

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Conservation agriculture based technologies - adoption and its impact in Madhya Pradesh

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Agriculture is the predominant sector of the MP state with more than 75% of the population dependent on it. Rice-wheat is the major cropping system in the Indo-Gangetic plains, but it also followed in central and eastern part of the Madhya Pradesh state. Rice-wheat system under conventional practice involves sowing of seeds in fine seedbed prepared by 4-5 tillage operations, which take 10-15 days' time and 1,200-1,500/ acre financial liability for land preparation, but, tillage operations increases the cost of production and hardly have any effect on increasing grain yield. Further, there is a great concern about reduction in soil fertility, scarcity of farm labour, declining water table and high cost of production under conventional agriculture. Farm mechanization and non availability of labors lead to use of combines for harvesting of most of the crops, which leaves the threshed crop residue in the field itself. The left over crop residue creates a problem of straw management and leads to burning. This practice is not only threat to an environment but also deteriorates the soil health and looses the plant nutrients. Additionally due to the rising of cultivation cost, the profitability margins are generally low (Rs. 10,000 to 20,000 per ha per annum). Conservation agriculture (CA) is a holistic approach towards increased productivity and improved soil health. Keeping this in view, it was felt to promote the adoption of resource conservation technologies for reducing the cost of cultivation and improving soil health, besides other environmental benefits.

METHODOLOGY

Directorate of Weed Research, Jabalpur took initiatives to introduce happy seeder machine to demonstrate the conservation agriculture technology among farming community for sowing of wheat and greengram under On Farm Research (OFR) programme during 2012. Initial survey on farmer's knowledge level regarding conservation agriculture based technologies was done. CA technology for wheat crop was demonstrated initially at four farmer's field of Panagar block of Jabalpur in 2012-13with economic assurance if it the technology fails. To control the weeds, glyphosat and clodinofop + metsulfuron herbicide molecules were chosen on the basis of the weed flora prevailing in the concerned fields. The same experiments were continued up to 2013-14. Accordingly from 2014 onwards, OFR trial on CA based technology was expanded under Mera Gaon Mera Gaurav programme in different adjoining districts (Mandla, Seoni, Narsinghpur and Katni), which are about 80-100 km away from Jabalpur district headquarter. In each locality/ district, 5 villages and 7-8 farmers from each locality were identified and selected based on the interest of farmer's and suitability of the land. Resource conservation technologies such as direct-seeding of rice, brown manuring with *Sesbania*, zero-till sowing of crops, residue retention on soil surface, growing of summer legumes like greengram or *Sesbania* in the crop rotation, and integrated weed management technologies were demonstrated in diversified cropping systems.

RESULTS

The initial survey on farmer's knowledge level revealed that, 99 percent of the farmer's has not been aware about the CA technology and expressed their serious doubts about the success of technology under no-till/minimum tillage conditions.Due to disbelief and lack of confidence toward the technology even after the economic assurance, one of the farmers from Panagar block of Jabalpur (OFR trials conducted during 2012-13), had tilled the land and practiced a conventional method. The better crop emergence, higher yield (4.0-4.5 t/ha) and less number of weed populations were observed in CA than in conventional practices (crop yield was 2.4-3.0 t/ha). It was also recorded that higher income with lower production cost resulting a sharp increase in benefit:cost ratio under CA system. After the successful demonstration of the technology at farmer's fields of Jabalpur region, very encouraging responses were observed from the different stake holders. Later the CA technologies have been extended to 10 famer's fields on participatory mode to sow the wheat and greengram in the same locality during 2013-14. Trials on 1 acre of land for wheat and greengram were conducted on 10 and 5 farmer's fields respectively.The same experiments have been continued under Mera Gaon Mera Gaurav programme in different adjoining districts of Jabalpur (Mandla, Seoni, Narsinghpur and Katni) from 2014 onwards.Farmer's participatory approach adopted under OFR-cum-demonstration proved to be an accurate guide to its subsequent adoption by farmers in Madhya Pradesh. After the successful introduction of this technology, area under zero tillage had been rapidly increased and previous crop residue burning was stopped completely. The farmers are highly enthusiastic about wheat and greengram sowing under conservation agriculture. The CA based technology has made significant impact on farmers of the Jabalpur region. Saving of time, labour cost, fuel during land preparation, and overall profitability gains by CA have shown a positive change in the attitude of the farmers towards the adoption of technology. Due to the positive impact of the CA technology, it has been spread to more than 1200 ha of land in MP state within a span of 4 years.

CONCLUSION

There is a need for analysis of factors affecting adoption and acceptance of no-tillage agriculture among farmers. Directorate of Weed Research, along with some other institutes have taken lead in developing and promoting conservation agriculture - based technologies in diversified cropping systems in the vertisol soil region of Central India. The CA technology in MP is spreading in a faster manner to grow wheat and chickpea in the winter season, and greengram in the summer season. The farmers after having some initial apprehensions are fully convinced with the technology to adopt it.

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Impact of tillage practices and nitrogen management on maize performance and soil physical properties under rainfed conditions

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In India, 2/3rd of total cultivated land is rainfed which contributes about 44% of the country's food requirement. In such areas crop production becomes relatively difficult due to irregular weather conditions, degraded soil having low inherent fertility and low water holding capacity (WHC). Maize–wheat is the traditional cropping sequence in rainfed areas of Jammu region (Jamwal, 2000). But yield of crops in rainfed areas remains stagnant due to water stress and seasonal agricultural drought owing to low and erratic rainfall, high runoff water losses and high evaporation. These soils are light textured, infertile and deficient in nitrogen, phosphorus and sulphur. Tillage is one of the most effective ways to re-duce soil compaction (Daniells 2012). Soil physical properties and crop growth are affected by tillage systems (Mosaddeghi *et al,*. 2009). Conservation tillage provides the best opportunity for improving soil quality and enhancing crop productivity (Carter, 1998). Soil physical properties represent a group of properties having a substantial impact on the different physical, chemical and biological processes in soil and hence they should be kept optimal (Lal, 1991). The objective of the study was to investigate the impact of tillage and N levels on soil physical properties and maize yields.

METHODOLOGY

The experiment was conducted at the Dryland Research Sub-Station of the Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu during 2003-2005 under rainfed conditions. The soil was sandy loam (64.4% sand, 17% silt and 18.6% clay) in texture having pH (6.8), EC (0.32 dSm^{-1}) organic carbon (0.34%), available N (159 kg /ha), available P (18 kg /ha) and available K (124 kg /ha). The soil was low to very low in moisture retention capacity at ("0.03 MPa) 13.0% and at ("1.5 MPa) 4%. Rainfall in rainfed areas of Jammu occurs from July to November followed by cool to warm period from December to June. The experiment consisted of two tillage systems (conventional and minimum tillage) and four nitrogen levels (0. 30, 60 and 90 kg/ha). The trial was laid out in split plot design with three replications.

Table 1. Effect of tillage and fertilizer N (kg/ha) on bulk density (Mg/m^3) and infiltration rate (mm/day) at the harvest of maize

Nitrogen	Tillage					
	bulk density			infiltration rate		
	CT	MT	Mean	CT	MT	Mean
0	1.55	1.53	1.54	76.5	86.4	81.4
30	1.54	1.52	1.53	100.5	115.2	107.8
60	1.53	1.51	1.52	144.0	146.4	145.2
90	1.53	1.52	1.52	146.4	156.3	151.4
Mean	1.54	1.52		116.8	126.1	
CD (P=0.05)	T=0.01	TxF=NSF=NS		T=3.6	TxF=4.1F=4.0	

Table 2. Effect of tillage and fertilizer N (kg/ha) on grain yield (t/ha) and sustainable yield index (SYI, %) of maize

Nitrogen	Tillage			Error		SYI	
	CT	MT	Mean	CT	MT	CT	MT
0	1.05	1.15	1.10	0.19	0.22	36.7	39.3
30	1.75	1.86	1.81	0.19	0.22	66.3	69.4
60	2.14	2.28	2.21	0.19	0.22	82.8	87.2
90	2.32	2.36	2.34	0.19	0.22	90.5	90.6
Mean		1.91	0.19				
CD (P=0.05)	T=NS	TxF=NSF=480					

The dimensions of individual plots were 4m×3m. Tillage treatments were placed in the main plots and N levels in the sub-plots. Maize hybrid 'kanchan 517'' were sown. Sampling for bulk density (core sample) determination was taken at all experimental plots in surface layers (0–0.05m) at the time of crop harvest. The infiltration rate was measured as quasi steady infiltration by using the double ring infiltrometer at harvest of the crop.

RESULTS

It was observed that the conventional tillage gave a significantly higher bulk density (BD) as compare to the minimum tillage. Application of N had no significant effect on BD however it was maximum in control plots. The conventional tillage caused a significant reduction in infiltration rate. The reduction was 8% higher in conventional tillage as compare to the minimum tillage. The infiltration rate was highest (156.3mm/day) with the application of 90 kg N /ha followed by 60, 30 and 0 kg N /ha. The lowest IR was observed in control (witout N application, 81.4 mm/day). The results are close conformity with Sharma et al. (2011) who concluded that minimum tillage provide more favourable physical conditions for maize growth under rainfed conditions than conventional tillage. The sustainable yield index (SYI) of tillage and N treatments using mean yield of a treatment, prediction error and maximum yield attained indicate that application of 90 kg N /ha with minimum tillage gave maximum SYI of 90.6% followed by conventional tillage with 90 kg N/ha. The lowest SYI was observed with conventional tillage without N application (10.5).

CONCLUSION

Application of 90kg N/ha in combination with minimum tillage proved superior in terms of maize grain yield and soil physical health.

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Effect of tillage, crop establishment and weed management methods on energy budgeting of rice under rice based conservation agricultural system

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Agriculture is the most important sector in Indian economy and agriculture is basically an energy conversion industry. Sufficient availability of the right energy and its effective use are prerequisites for improved agricultural production. It was realized that crop yields and food supplies are directly linked to energy. In the developed countries, increase in the crop yields was mainly due to increase in the commercial energy inputs in addition to improved crop varieties (Panjabrao, 2010). Further, an optimum blend of renewable and non-renewable energy source is essential to maintain and boost crop productivity.

METHODOLOGY

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu during *kharif* and *rabi* seasons of 2012-14. Transplanting with conventional tillage for *kharif* and *rabi* rice (T_1), Transplanting with conventional tillage *kharif* and zero tillage *rabi* rice (T_2), Transplanting with zero tillage + crop residue for *kharif* and *rabi* rice (T_3), Direct sowing with conventional tillage for *kharif* and *rabi* rice (T_4), Direct sowing with conventional tillage *kharif* and zero tillage *rabi* rice (T_5) and direct sowing with zero tillage + crop residue for *kharif* and *rabi* rice (T_6) were in main plots with rice fellow summer green gram with zero tillage. Recommended herbicides (Transplanted rice - PE butachlor 1.0 kg/ha for *kharif*, PE pretilachlor 1.0 kg/ ha for *rabi* and direct seeded rice - PE pretilachlor (S) 0.45 kg/ha) (W_1), Integrated weed management (Transplanted rice - PE butachlor 1.0 kg/ha for *kharif*, PE pretilachlor 1.0 kg/ha for *rabi* and direct seeded rice - PE pretilachlor (S) 0.45 kg/ha +

Table 1. Tillage, crop establishment and weeds management methods on energy indices in rice based conservation agriculture system

Treatment	Input energy (MJ/ha)				Output energy (MJ/ha)			
	W_1	W_2	W_3	Mean	W_1	W_2	W_3	Mean
2012-13								
T_1- TR (CT-CT -ZT)	60401	61196	60114	60571	419088	472115	307533	399579
T_2- TR (CT-ZT -ZT)	57021	57816	56734	57190	400722	457097	273685	377168
T_3- TR (ZT+CR - ZT+ CR-ZT)	178640	179435	178353	178810	377117	442891	239335	353115
T_4- DSR (CT-CT -ZT)	62259	63054	62104	62473	384887	456389	246328	362535
T_5- DSR (CT-ZT -ZT)	58879	59674	58724	59092	348958	398884	228798	325547
T_6- DSR (ZT+CR - ZT+ CR-ZT)	180498	181293	180343	180711	267118	321791	209886	266265
Mean	99616	100411	99395		366315	424861	250927	
2013-14								
T_1- TR (CT-CT -ZT)	60664	61459	60377	60833	427840	483359	294568	401922
T_2- TR (CT-ZT -ZT)	57280	58075	56993	57449	409915	465147	272982	382681
T_3- TR (ZT+CR - ZT+ CR-ZT)	178758	179553	178471	178927	386979	459291	245439	363903
T_4- DSR (CT-CT -ZT)	62434	63229	62279	62647	404202	472677	254654	377178
T_5- DSR (CT-ZT -ZT)	59050	59845	58895	59263	360798	412937	229076	334270
T_6- DSR (ZT+CR - ZT+ CR-ZT)	180528	181323	180373	180741	271967	346963	209879	276270
Mean	99786	100581	99565		376950	440062	251100	

Data not statistically analyzed;TR-Transplanted rice; DSR-Direct sown rice;CT-Conventional tillage; ZT-zero tillage; W_1-Recommended herbicides; W_2- Integrated weed management; W_3 -Unweeded check; CR-Crop residue.

inter crop with *Sesbania* incorporation and mechanical weeding on 35 DAS/T)(W_2) and unweeded check (W_3) were in sup plots. Rice variety ADT (R) 45 for *kharif* 2012 and 2013 and CO (R) 50 during *rabi* 2012-13 and 2013-14 were raised. Greengram CO6 was used during 2013 and 2014. The trial was layout in strip plot design with three replications.

RESULTS

Direct sown rice under zero tillage + crop residue in ZT+CR-ZT+CR-ZT system with PE pretilachlor 0.45 kg/ha + inter crop with dhaincha incorporation and mechanical weeding on 35 DAS (T_6W_2) and direct sown rice under zero tillage+ crop residue in ZT+CR-ZT+CR-ZT system with unweeded check consumed more input energy and lower output energy compared to other tillage, crop establishment and weed management methods during both the years. Lower labour and input requirement might have led to lesser energy consumption recorded in transplanted rice under conventional tillage in CT-ZT-ZT system with PE butachlor 1.0 kg/ha for *kharif* and PE pretilachlor 1.0 kg/ha for *rabi* and transplanted rice under conventional tillage in CT-ZT-ZT system with unweeded check. Higher energy efficiency, net energy and energy productivity were recorded in transplanted rice under conventional tillage in CT-CT-ZT system with PE butachlor 1.0 kg/ha for *kharif* and PE pretilachlor 1.0 kg/ha for *rabi* + inter crop with dhaincha incorporation and mechanical weeding on 35 DAT and transplanted rice under conventional tillage for *kharif* and zero tillage for *rabi* in CT-ZT-ZT system with PE butachlor 1.0 kg/ha for *kharif* and PE pretilachlor 1.0 kg/ha for *rabi* + inter crop with dhaincha incorporation and mechanical weeding on 35 DAT compared with other treatments during both the years. Similar result was reported by Sarma and Gautam (2010)**.**

CONCLUSION

In the above studies, Higher energy efficiency, net energy and energy productivity were recorded in transplanted rice under conventional tillage in CT-CT-ZT system with PE butachlor 1.0 kg/ha for *kharif* and PE pretilachlor 1.0 kg/ha for *rabi* + inter crop with dhaincha incorporation and mechanical weeding on 35 DAT (T1W2) and transplanted rice under conventional tillage for *kharif* and zero tillage for *rabi* in CT-CT-ZT system with PE butachlor 1.0 kg/ha for *kharif* and PE pretilachlor 1.0 kg/ha for *rabi* + inter crop with dhaincha incorporation and mechanical weeding on 35 DAT.

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Residue management in wheat under rice- wheat cropping system

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The rice residue availability in India under rice- wheat cropping system is about 120 million tons per year. Farmers deals with this residue in various manner *viz.* burning, removal (for utilization as animal fodder, FYM preparation, etc.), incorporation into the soil and surface retention in succeeding wheat crop. The proper method of using this residue has its own value because it affects the different soil properties, nutrient availability, moisture holding, *etc.*

METHODOLOGY

To optimize soil properties with higher wheat yield in rice-wheat cropping system, an experiment was conducted in Norman E. Borlaug Crop Research Centre, GB Pant University of Agriculture and Technology, Pantnagar during the year 2008-09 in randomized block design with three replications and 9 treatments of previous rice crop residue management as in Table 1. The *Sesbania* was grown in respective plots as per treatment and its residue at 50 days after sowing was incorpo-

Table 1. Effect of different rice residue management practices on growth and yield of wheat

Treatment	Plant height (cm)	Dry matter (g/m^2)	Grain yield (t/ha)	Earhead/m^2	Grains/ earhead	1000 grain weight (g)
DSR (Removal)- wheat	93.6	1005.8	4.69	390	42.7	39.3
DSR (Incorporation)- wheat	95.0	1114.8	4.75	405	44.7	40.2
DSR (Incorporation+ 25% N more)- wheat	96.8	1140.4	5.03	497	45.7	41.1
DSR (Burning)- wheat	94.1	1042.1	4.6	385	42.0	39.6
DSR (Surface retention+ 25% N more)- wheat	96.4	1135.2	4.93	487	45.5	41.7
DSR (Surface retention+ Sesbania)- wheat	98.2	1279.8	5.15	580	48.6	42.4
DSR (Surface retention+ no fertilizer)- wheat	69.7	757.0	2.23	300	38.3	34.2
DSR (Removal+ no fertilizer)- wheat	65.9	703.9	2.09	285	34.3	33.0
Transplanted rice (Removal)- wheat	93.9	1089.9	4.58	390	40.4	39.7
CD (P= 0.05)	1.9	233.1	0.40	26	5.8	2.0

(DSR: Direct seeded rice)

rated in- situ before sowing of direct seeded rice. The rice residue was incorporated *in-situ* two weeks before wheat sowing @ 4 t/ha in that particular treatment.

RESULTS

Wheat cultivation in plots where *Sesbania* is cultivated and incorporated as in situ after 50 days of planting followed by direct seeded rice (DSR) cultivation and surface retention of this rice residue after harvest was found to be more superior over all the other treatments because it produced higher growth attributes (*viz*. plant height and dry matter) and yield characters (*viz*. earhead/m^2, number of grains/earhead and 1000 grain weight) and yield of wheat. The treatment produced 110% and 112% of higher wheat grain yield over commonly followed practices of previous rice cultivation with residue removal *i.e*. direct seeding and transplanting, respectively. The higher values of growth and yield characters and yield of wheat observed might be because of better nutrient availability with *Sesbania* and early mineralization of rice residue in this treatment which was also earlier reported by Singh and Yadav (2006).

CONCLUSION

Growing of wheat after in situ incorporation of *sesbania* followed by residue retention of directly seeded rice may produce higher grain yield in Pantnagar condition.

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Response of conservation tillage on biomass available for *in-situ* recycling of pigeon pea based inter cropping system under rainfed condition

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An experiment was conducted at Agronomy farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during *kharif* season of 2012-13 on medium deep black soil to find out effect of conservation tillage on dry matter partitioning of pigeonpea based intercropping system under *rainfed*. The soil of experiment field was clayey in texture class, alkaline in reaction (pH 7.85), low in available N (212 kg/ha), P_2O_5 (15.5 kg/ha), high in K_2O (321 kg/ha), medium in organic carbon (0.51%) and with electrical conductivity of 0.28 dS/m. The experiment was laid out in factorial randomized block design with four replication consisting two tillage practices conventional tillage and minimum tillage and four levels of cropping system viz., Sole pigeonpea, Pigeonpea + soybean (1:2), Pigeonpea + Sunnhemp (1:2), Pigeon pea + soybean (1:5). Pigeonpea variety PKV-Tara, Soybean variety JS-335 and sunhemp local variety was used. In situ green manuring of sunhemp was done at 40 DAS and after hand weeding weeds were used as mulch in all plots. The higher total leaf biomass added (3149 kg) were found in conventional tillage over minimum tillage (2736 kg). In case of soybean reverse result was observed. The weed biomass was maximum (1211 kg/ha) in minimum tillage. The total leaf biomass (3043 kg) through pigeonpea + soybean (1:2) was higher when compared with other treatments. The total root biomass was found maximum in pigeonpea + soybean (1:5) treatment as compared to other treatments. The highest weed biomass (1186 kg/ha) was found significantly in pigeonpea + soybean (1:5) when compared with other treatments as maximum space was available in between two pigeonpea rows where 5 rows of soybean planted and after harvest of soybean weed growth was observed and pigeonpea growth was slow upto 60 DAS due to that weeds were maximum in pigeonpea sole. The highest biomass was available due to addition of sunhemp green manuring and shed biomass in pigeonpea + sunhemp (1:2) and lowest with sole pigeonpea (3885 kg/ha). Pigeonpea equivalent yield was not influenced by tillage practices. However, numerically higher value was fond in conventional tillage. Pigeonpea equivalent yield was maximum in pigeonpea + soybean (1:2)

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Evaluating impact of tillage and crop residue management practices in groundnut- based cropping systems in vertisols of Saurashtra region

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By adopting best management practices some progressive farmers have been able to harvest as high as 7-8 t pods/ha but the national average productivity of groundnut in India is only 1.4 t pods/ha. Soil moisture stress and poor soil quality has been reported among the major factors responsible for lower productivity of groundnut in the country. Therefore, there is need to develop and disseminate production technologies which not only help conserve natural resources but also give higher yield of groundnut on sustainable basis in the face of tangible climate change effects on crops during recent years. Conservation agriculture (CA), which consists of minimum mechanical soil disturbance, soil cover with crop residues or cover crops, and crop rotations, helps conserve soil and water, and improves soil fertility. CA has been reported to help adapt to climate change related variabilties by maintaining higher soil water balance (Hobbs and Govaerts, 2010). Therefore, we attempted to evaluate the potential of CA for developing sustainable and climate change resilient groundnut-based cropping systems.

METHODOLOGY

A field experiment was conducted during *kharif* 2015 at Research Farm of ICAR- Directorate of Groundnut Research, Junagadh, India to study the effects of tillage and residue management practices in two groundnut-based cropping systems. The soil of the experimental field was Typic Haplustepts, moderately calcareous, slightly alkaline (pH 7.6), low in organic carbon (0.46 %) and available nitrogen (140 kg/ha), and medium in phosphorus (11.6 kg/ha) and potash (280 kg/ha). The treatments consisted of four levels of tillage in main plots viz. normal tillage, minimum tillage, zero tillage and rota-tillage; two levels of residue management practices in sub-plots viz. no residue application and residue application; and two cropping systems in sub-sub-plots viz. groundnut+pigeon pea intercropping system and groundnut+ cotton intercropping system. The experiment was laid out in split-split plot design with four replications. In normal tillage, plots were prepared conventionally as per farmers' practice in the region, in rota-tillage only rotavator was run once, and in case of minimum tillage only cultivator was run once, while in zero-tillage no tillage operation was done prior to sowing of crops. In case of 'residue application' plots cotton and pigeonpea residues were applied and mixed in soil or retained on soil surface as per treatments. Sowing of groundnut 'TG

37A' and intercrops of pigeonpea 'BDN 2' and Bt-cotton was done following recommended package of practices.

RESULTS

Pod and haulm yield of groundnut was not significantly affected by tillage practices. However, rota-tillage gave slightly higher pod yield compared to other tillage practices. Haulm yield was higher in conventional tillage compared to other tillage practices. Application of crop residues improved pod yield but differences were not significant at 5% probability. Groundnut pod yield was significantly higher, while haulm yield was slightly higher, in groundnut+ cotton intercropping system as compared to groundnut+ pigeon pea intercropping system. Pigeon pea seed yield was not significantly affected by tillage practices; however, minimum tillage gave higher yield over other tillage practices. Stover yield of pigeonpea was significantly higher with conventional tillage, and was lowest with zero tillage. Application of crop residues was not found to affect seed and stover yield of pigeon pea positively. Seed cotton yield was slightly higher with minimum tillage when compared with conventional tillage, zero tillage and rota-tillage. While cotton stalk yield was slightly higher under rota-tillage, but differences in both seed cotton yield and stalk yield due to tillage practices were statistically non-significant. Application of crop residues marginally increased seed cotton yield. Groundnut pod equivalent yield (GPEY) was not significantly affected by tillage practices; however, minimum tillage gave higher yield compared to other tillage practices. Application of crop residues marginally improved GPEY. Groundnut+ pigeon pea intercropping system gave significantly higher GPEY over groundnut+ cotton intercropping system. Tillage practices failed to significantly affect soil moisture, but minimum tillage and zero tillage were found to have higher soil moisture content in 0-15 and 15-30 cm soil depth, respectively. Application of crop residues significantly improved soil moisture content in 0-15 and 15-30 cm soil depth. Groundnut+ cotton intercropping system was found to have significantly higher soil moisture content in 0-15 and 15-30 cm soil depth as compared to groundnut+ pigeon pea intercropping system. Conventional tillage and minimum tillage was found to have lesser soil temperature in both 0-15 and 15-30 cm soil depth compared to zero tillage and rota-tillage. Application of crop residues also reduced soil temperature in 0-15 and 15-30 cm soil depth over no crop residue application. Soil temperature was found lesser in groundnut+ cotton intercropping system compared to groundnut + pigeon pea intercropping system. Number of weeds and their total dry weight was significantly higher under zero tillage compared to other tillage practices. Application of biomass slightly reduced weed number and their total dry weight. Groundnut+ pigeon pea intercropping system had lesser weed number and their total dry weight.

CONCLUSION

Reducing tillage intensity does not significantly reduce yield, soil moisture and temperature during first year of shifting to CA. Zero tillage was found to have significantly more weeds. Retention of crop residues could not significantly affect yield but improved soil moisture significantly, and lowered soil temperature and weed infestation slightly. Groundnut pod yield was significantly higher under groundnut+ cotton intercropping system but, groundnut+ pigeon pea intercropping system gave significantly higher GPEY.

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Long-term fertilization effects on soil aggregation, carbon sequestration and natural ^{13}C and ^{15}N abundances in soils under a wheat based cropping system in an Inceptisol

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The complex problem of soil C storage can only be studied by long-term fertility experiments (LTFEs), as soil C pools (especially the recalcitrant ones) take long time to change (Bhattacharyya *et al.,* 2009). This study evaluates long-term fertilization impacts under a wheat based cropping systems on soil aggregation, labile and recalcitrant C pools within bulk soils and aggregates and natural ^{13}C abundances.

METHODOLOGY

In April 2015, triplicate soil samples were collected at wheat harvest from the individual plots from 0-15, 15-30, 30-45, 45-60, 60-75 and 60-90 cm soil layers following standard procedures from a LTFE in IARI, New Delhi. Aggregate stability, mean weight diameter (MWD), water soluble carbon (WSC), soil microbial biomass carbon (MBC), particulate organic matter associated C (POM-C) (Cambardella and Elliot 1992), permanganate-oxidizable organic C ($KMnO_4$-C) (Tirol-Padre and Ladha 2004) and carbon management index (CMI) were measured. Labile and recalcitrant C pools and within bulk soils of all layers and soil aggregates (of 0-15 and 15-30 cm layers) were estimated using modified Walkley and Black method. Carbon contents and their isotopic values of bulk soils of aforesaid layers and aggregates of 0-15 and 15-30 cm soil layers were determined using an IRMS (Isoprime 100; ÒIsoprime UK) coupled with an Elemental Analyser. Total glomalin concentrations of soil samples and aggregates in the 0-15 and 15-30 cm soil layers were extracted as described by Wright and Upadhyaya (1996).

RESULTS

Results revealed that C accumulation and sequestration in plots with recommended NPK and farmyard manure (NPK + FYM) over unfertilized control were 0.69 and 0.23 Mg C/ha/yr, respectively, in 0-90 cm soil layer with >50% of the accumulated C in deep soil layers (30-90 cm). In 0-15 cm layer, despite NPK + FYM and NPK plots had similar soil macro-aggregates, microaggregates were 27% higher with NPK + FYM than NPK, causing higher aggregate stability. Plots with NPK + FYM had ~41% higher glomalin related soil protein than NPK in soil surface. Plots with NPK, NPK + FYM and 150% NPK had more labile:recalcitrant C ratios in bulk soils than unfertilized control, NP and N. Sensitivity analysis indi-

Table 1. $\delta^{13}C$ (‰) and total soil organic carbon within bulk soils of different layers as affected by 44 years of fertilization under a wheat based cropping system in an Inceptisol.

Treatment	$\delta^{13}C$(‰)				Total soil organic carbon (g/kg)			
	0–15 cm	15–30 cm	30–60 cm	60–90 cm	0–15 cm	15–30 cm	30–60 cm	60–90 cm
Control	-19.4f	-19.1d	-15.4d	-14.8d	3.29e	2.13d	1.92e	1.74d
N	-18.3e	-17.9c	-15.1d	-13.9c	4.05d	2.64d	2.33d	1.94d
NP	-17.8d	-17.4c	-14.9c	-13.4c	3.93d	3.33c	2.94c	2.22c
NPK	-16.8c	-16.8bc	-13.2b	-13.0b	6.57bc	4.06b	3.75c	2.43c
150% NPK	-16.2b	-15.5ab	-12.6ab	-11.8ab	7.02b	4.51ab	4.14b	2.91b
NPK + FYM	-15.8a	-14.3a	-11.4a	-10.6a	7.82a	5.02a	4.42a	3.13a

cated water soluble C fraction was most sensitive. Fertilization also significantly increased recalcitrant C pools within soil aggregates, with NPK + FYM and 150% NPK treated plots had highest non-labile C pools within macro- and microaggregates. The lower-negative ä^{13}C values indicated higher C stability in lower soil depths and soils under NPK + FYM were enriched with ^{13}C by 19 and 25% in 0-15 and 15–30 cm layers over control (Table 1). Overall, NPK + FYM management practice not only had higher C accumulation and sequestration, but also had ~26% better carbon management index than NPK in soil surface and hence should be adopted. However, GRSP increased with fertilization in bulk soils as well as in both aggregate size fractions. Macro- and microaggregates of NPK + FYM plots had 51 and 62% higher GRSP than NPK plots. Similar trend of GRSP was observed in the sub-surface soil layer. Results revealed that all C pools of bulk soils and Pool 1, Pool 2 and Pool 4 of macro- and microaggregates of both surface and sub-surface soil layers had significant positive relationships with CMI and SYI ($P < 0.01$ and $P < 0.05$). There were no significant contributions of less labile C pool (Pool 3) of aggregates to CMI and SYI in surface soils, although the reverse was true in the sub-surface soil layer. This sort of observations lead to the concept of dynamic equilibrium of the C pools and depletion of one pool is replenished by SOC from the adjacent pools in the soil surface only. Cultivation for 44 years has caused humification of SOC, which led to negative correlations between transitory pool of SOC (Pool 3; less labile C) and SYI and also between less labile C pool and CMI.

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Impact of different conservation practices on radiation use efficiency of pigeon pea (*Cajanus cajan*)

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Improving food security and environmental conservation should be the main targets of innovative farming systems. Conservation agriculture (CA), based on minimum tillage, crop residue retention and crop rotations has been proposed against poor agricultural productivity and soil degradation. Scopel *et al.* (1998) studied the effect of the mulch on radiation in their experiment and found that interception was significant and varied with residue quality and with the percentage of soil cover. CA has significant potential to improve rainfall-use efficiency through increased water infiltration and decreased evaporation from the soil surface, with associated decreases in runoff and soil erosion (Thierfelder and Wall, 2009). This research paper mainly for analysis of radiation use efficiency (RUE) in pigeon pea crop under different conservation practices.

METHODOLOGY

The present study was carried out in the experimental farm of Indian Agricultural Research Institute (IARI), New Delhi. During *kharif season* 2014-15, Pigeon pea(*Cajanuscajan* L.)

variety Pusa 992shown on 30th may.The field experiment was conducted with seven treatment combinations [conventional tillage and flat-bed sowing without residue recycling (CT), zero tilled permanent narrow-bed sowing without residue retention (PNB), zero tilled permanent narrow-bed sowing with residue retention (PNB + R), zero tilled permanent broad-bed sowing without residue retention (PBB), zero tilled permanent broad-bed sowing with residue retention (PBB + R), zero tilled flatbed without residue (ZT FB), zero tilled flat bed with residue (ZT FB+R)] arranged in a randomized block design (RBD) with three replications.For Radiation use efficiency measurement the incoming photosynthetically active radiation (PAR) was measured throughout the season using line quantum sensor (LICOR- 3000, U.S.A.). Three set of such measurements were recorded in each plot and averaged to represent these plots. The above measurements were taken at weekly/10days intervals on clear days between 12:00 and 13:00 hours IST (around local solar noon). These data were further used to derive radiation use efficiency.

RESULTS

Different tillage practices and crop residues alter the surface properties of soils affecting both shortwave albedo and long wave emissivity. Under different Conservation practices Radiation use efficiency and Intercepted Photoactive radiation had more value as compared to corresponding value of conventional treatment. Maximum RUE among different treatments under zero tillage broad bed plus residue (ZT BB+R) followed by zero tillage narrow bed plus residue (ZT NB+R),zero tillage flatbed plus residue (ZT FB+R), zero tillage broad bed (ZT BB), zero tillage flatbed (ZT FB) and zero tillage narrow bed (ZT NB) (Table 1). Among different tillage practices zero tillage broad bed plus residue (2.21t/ha) show highest yield and minimum yield under conventional treatment (1.816 t/ha).Higher grain yield in these treatments might be the result of decrease in soil compaction, better root proliferation, more uniform distribution of nutrients in soil profile(RaimbaultandVyn, 1991). Yield was increased due to efficient utilization of precipitation and soil moisture, in no tillage+ residue treatment compared to the residue-removed treatment. Baumhardt and Jones (2002) found that the no-tillage+cropresidue management to be potentially better than tillage for dry land crop production.Conservation treatments also gave significant effect on the number of seed per one hundred pods, filled and unfilled pods and number of pods per plant (Table 2). This conforms to observations recorded by Patel and Patel (1995).

CONCLUSION

Retention of crop residues in no-tillage treatment provide favourable environment and enhanced the pigeon pea yield. Conservation practices modifies the soil physical environment and may be due the better soil physical environment, zero tillage broad bed plus residue treatment as well as other conservation practices had better radiation interception, radiation use efficiency, crop growth and yield as compared to the corresponding value in the conventional tillage.

Table 1. Radiation use efficiency (g/MJ) in pigeon pea crop at different days after sowing under different Conservation practices during *kharif* season 2014-15.

Treatment	38 DAS	75 DAS	105 DAS	140 DAS	175 DAS
CT	0.95±0.0083	1.48±0.012	1.78±0.0021	2.53±0.0031	1.06±0.0036
ZT NB	0.97±0.0014	1.68±0.0018	1.96±0.044	2.86±0.0145	1.83±0.0162
ZT NB+R	1.17±0.0011	2.12±0.004	2.24±0.0053	3.01±0.0123	2.52±0.0181
ZT BB	1.05±0.091	1.82±0.002	1.91±0.0031	2.89±0.0131	2.11±0.0123
ZT BB+R	1.33±0.031	2.22±0.019	2.38±0.0045	3.21±0.0033	2.79±0.0063
ZT FB	0.92±0.022	1.46±0.0152	1.91±0.0066	2.89±0.0076	2.05±0.0112
ZT FB+R	1.07±0.091	1.82±0.027	2.27±0.009	3.03±0.0131	2.51±0.011

Table 2. Yield and yield attributes of pigeon pea in under conventional and conservation treatments.

Treatment	No. of Seeds/ 100 Pods	Filled pods/ 100 pods	Unfilled pods/ 100 pods	No. of pods/plant	Yield (t/ha)
CT	326.13 ± 14.53	60.57 ± 7.78	39.43 ± 4.92	78.5 ± 7.1	1.816 ± 0.0703
ZT NB	386.67 ± 11.23	80.59 ± 3.67	19.41 ± 2.13	101 ± 4.56	2.032 ± 0.0576
ZT NB+R	394.52 ± 8.82	90 ± 1.41	10 ± 2.45	125.5 ± 3.86	2.072 ± 0.0445
ZT BB	390.00 ± 7.86	88.57 ± 5.98	11.43 ± 3.21	118.5 ± 6.12	2.035 ± 0.0337
ZT BB+R	395.12 ± 10.4	92.83 ± 6.12	7.17 ± 4.76	135 ± 3.12	2.21 ± 0.0983
ZT FB	376.56 ± 7.71	80.19 ± 5.45	19.80 ± 4.13	86.3 ± 4.76	1.992 ± 0.0603
ZT FB+R	393.33 ±9.83	89.68 ± 6.12	10.32 ± 4.65	123 ± 2.13	2.064 ± 0.0748
LSD (P=0.05)	31.21	17.65	14.37	9.43	1.996

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Conservation practices to sustain yield, improve soil and strengthen resilience in rice based cropping systems of Indo-Gangetic plains

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Rice (*Oryza Sativa* L.) and wheat (*Triticum aestivum* L.) is a pre-dominant system in IGP however, recent evidence from long-term experiments across this region shared that productivity and sustainability of this system is threatened as yields of both rice and wheat are either stagnant. Moreover, there has been enormous damage to crops and natural resources due to changing patterns of climate in the recent past. Hence, the development of new integrated resource management strategies is need of hour for sustainable crop production in the region. With above mindset, we designed agronomically efficient and economically viable cropping systems and evaluated their performance under different conservation technologies such as reduced tillage and crop residue mulches for resource conservation and counteracting adverse effects of climate change.

METHODOLOGY

The present investigation was conducted during *kharif*, *rabi* and *zaid* season of 2011-12 and 2012-13 at Norman E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar with treatments consisting of two levels of tillage systems (conventional tillage and zero/reduced tillage) with and without mulching in main plots and three diversified cropping systems [rice-wheat (CS_1), rice-vegetable pea-green gram (CS_2) and rice-potato-maize (CS_3)] and two level of fertility (100 and 75% RDF) in sub plots laid out in factorial split plot design with three replications. This experiment was laid in split plot design and replicated thrice. Since data followed the homogeneity test, pooling was done over the years and mean data are given.

RESULTS

Rice grown under DSR produced grain yield comparable to TPR however; was significantly higher when legumes were included in crop rotation (rice-vegetable pea-greengram system, CS_2). Total rice equivalent yield of *Rabi* and summer crops was 9 and 20% higher in reduced tillage and mulched plot, respectively than conventional tillage and un-mulched field whereas among cropping system, rice-potato-maize (CS_3) significantly increased 25-30 and 54-56% higher total REY than CS_2 and CS_1, respectively during 2011-12 and 2012-13. Combined application of RCT practices consumed 6-10% less energy while generated 99-143 and 25-52% higher output energy in CS_3 and CS_2, respectively over conventional practices in rice-wheat system (CS_1). Moreover, combined application of RCT practices improved soil physical characteristics such as bulk density, soil temperature and soil moisture conservation and chemical properties such as

Table 1. Rice equivalent yield (t/ha) and total system productivity (t/ha) as influence by different treatments (pooled data of 2 years)

Treatment		Rice Equivalent Yield(t/ha)			Total System Productivity (t/ha)
		Kharif	Rabi	Spring/ Summer	
Tillage x Cropping System					
Dry seeding/ Reduced tillage/ Zero Tillage (ZT)	CS_1 (Rice-Wheat)	4.45	0.66	-	10.07
	CS_2 (Rice-Veg. Pea-Moong)	4.57	5.62	2.73	28.02
	CS_3 (Rice-Potato-Maize)	3.98	20.71	8.62	37.75
Conventional Tillage (CT)	CS_1 (Rice-Wheat)	4.13	25.16	-	9.52
	CS_2 (Rice-Veg. Pea-Moong)	4.61	5.39	3.09	28.57
	CS_3 (Rice-Potato-Maize)	4.00	20.88	9.39	37.50
CD (P=0.05)		NS	24.11	0.96	3.41
Fertilizer x Mulch					
F_1 (100% RFD)	M_o (No mulching)	3.84	15.39	54.37	24.67
	M_1 (Mulching)	4.28	16.67	58.4	26.79
F_2 (25% Extra of RFD)	M_o (No mulching)	4.40	17.01	60.24	27.43
	M_1 (Mulching)	4.64	18.84	65.33	30.01
CD (P=0.05)		0.66	9.61	1.74	0.52

soil organic carbon %, available N, P and K. Conservation tillage system sequestered three times higher carbon than conventional tillage and mulching four times higher C sequestration than un-mulched condition in agricultural soils. Higher system returns, B: C ratio and profitability were earned in combined application of RCT practices and this was 2.5 and 3 times higher when followed in CS_2 and CS_3, respectively as compared to rice-wheat (CS_1) system under conventional practices.

CONCLUSION

Conservation practices in rice-wheat system of Indo-Gangetic plains can be agronomical efficient, economically attractive, practically feasible and ecologically resilient when adopted holistically for long-term.

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Retention of crop residues improves soil hydro-mechanical regime under two contrasting tillage practices

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No-tillage reduces the sub-surface compaction, but the effect varies cross soil types, agroclimatic conditions and the duration of the practice. Effect of no-tillage on soil physical condition may be realized over long time (>10 years) of adoption, although it is difficult to sustain this practice over long period due to problems associated with weeds, soil-borne pathogens and management of residues. However, the short-term no-tillage practice (~5 yrs) can provide useful information on many aspects, especially on modifying soil hydro mechanical regime, which is key to other changes viz., root water uptake and nutrient nobilities in soil. Although conventional and no-tillage practices behave very differently, how residue modifies the hydro-mechanical properties of the soil under these practices. We hypothesize that residue has a decisive role to the extent that the contrasting tillage (conventional vs. no tillage) practices might not be differentiated over a short period.

METHODOLOGY

The present study pertains to a continuous field experiment from2004 to 2011 on a sandy loam soil (Typic Haplustept) at IARI, New Delhi. The design is a split-plot with tillage and residue management as the main plot [CT+R: Conventional tillage and residues incorporated; NT+R: No-tillage and residues retained as mulch; CT-R: CT+ residues removal; and NT-R: NT+ residues removal); and three cropping systems (pigeon pea-wheat, P-W; cotton-wheat, C-W; and maize-wheat, M-W), all replicated thrice. Observations were recorded in wheat in March 2011 (7 years after the start of the experiment).Core method was used to determine soil bulk density (BD), while soil resistance to penetration (PR) was measured by using Rimik cone penetrometer (model no. CP20), and was synchronized with the soil moisture content measurement. Aggregate stability (0-15 cm) was measured by the routine wet sieving method. We used both the field-moist and air-dried (at room temperature for 7 days) soils for this analysis. A 50 g of the aggregate mass (3-5 mm) was wet-sieved through a collection of 2, 0.25 and 0.053 mm sieves to separate the large (>2 mm) and small (0.25-2 mm) macro-aggregates, micro-aggregates (0.053-0.25 mm) and silt + clay sized particles (<0.053 mm).

RESULTS

Bulk density values were similar between the tillage practices or the cropping systems irrespective of the soil depth (Fig. 1). At the surface (0-7.5 cm layer), higher BD (1.50 Mg/m^3) was recorded in CT-R., however, below the surface (7.5-15 cm), NT+R recorded a BD of 1.60 Mg/m^3, which was marginally lower than CT+R and CT-R (1.66 Mg/m^3). Similar trend was observed at 15-30 cm layer, indicating sub-surface compact layer due to tillage. It appears that long-term adoption of no-tillage may considerably reduce the sub-surface compaction compared to conventional practice. The effect, however, is site- and management-specific. Contrary to BD, NT+R at 0-10 cm layer had significantly lower PR, contributed to greater soil moisture content (data not presented). The CT-R showed higher PR values, but was at par with CT+R and NT-R. Role of residue is apparent, as CT+R registered marginally lower values than CT-R in this layer. Higher soil resistance in conventional compared to no-tillage in the plough layer has been reported earlier (e.g. Jat *et al.*, 2009; Gathala *et al.,* 2011). Tillage, cropping system and their interactions had significant impact on soil aggregates at 0-7.5 cm layer (Table 1). Higher MWD was obtained in NT+R and in P-W rotation. Residue incorporation in CT+R also resulted in higher macro-aggregate fractions, and thereby higher MWD. The subsurface layer (7.5-15 cm) had dominant micro-aggregate fractions (<0.25 mm), which was still higher in CT-R. However, tillage effect could not be distinguished at this layer, except for air-dry aggregates >0.25 mm. For field-moist aggregates, tillage effect was significant in 2-0.25 and

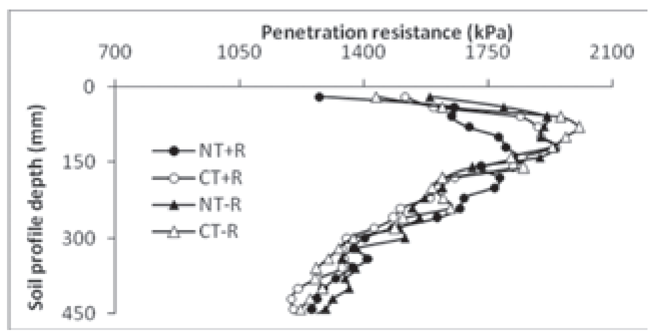

Fig. 2. Average soil resistance to penetration at various depths under tillage and residue management

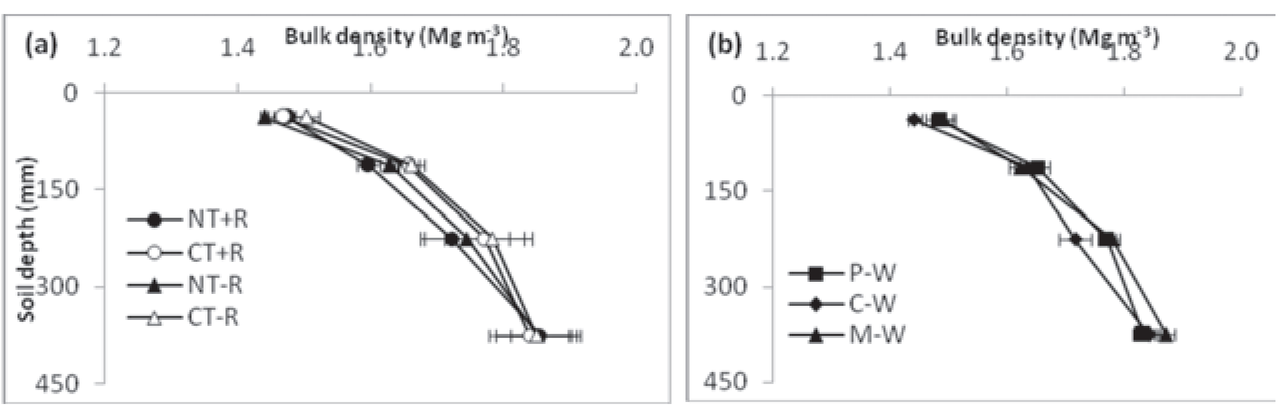

Fig. 1. Soil bulk density under different (a) tillage and residue management, and (b) cropping systems

Table 1. Relative size distribution (g 100/g) and mean weight diameter of air dried and field-moist soil aggregates under different tillage and residue management practices in three different cropping systems

Tillage/CS	0-7.5 cm				7.5-15 cm			
	>2 mm	2-0.25 mm	<0.25 mm	MWDmm	>2 mm	2-0.25 mm	<0.25 mm	MWD mm
Field moist soil								
CT+R	8.55	41.56	49.89	0.83	8.38	41.08	50.54	0.82
NT+R	8.43	42.34	49.23	0.83	7.64	41.48	50.87	0.80
CT-R	7.99	37.49	54.52	0.77	7.02	40.61	52.37	0.77
NT-R	7.62	39.60	52.77	0.78	7.14	38.44	54.42	0.75
P-W	8.72	40.55	50.72	0.82	6.98	40.69	52.33	0.77
C-W	7.26	41.45	51.29	0.78	7.84	39.86	52.29	0.79
M-W	8.46	38.74	52.80	0.80	7.82	40.65	51.53	0.80
LSD (P=0.05)								
Tillage	NS (0.35)	3.3.7 (0.05)	2.93 (0.01)	0.04 (0.01)	0.95 (0.04)	NS (0.62)	NS (0.39)	NS (0.08)
CS	0.74 (<0.01)	NS (0.13)	NS (0.29)	NS (0.08)	0.62 (0.01)	NS (0.85)	NS (0.86)	NS (0.31)
Interaction	NS (0.66)	NS (0.56)	NS (0.40)	NS (0.29)	1.24 (0.01)	NS (0.70)	NS (0.51)	NS (0.13)
Air dried soil								
CT+R	7.79	41.38	50.83	0.80	7.78	40.46	51.76	0.79
NT+R	8.44	43.41	48.15	0.84	7.42	41.40	51.18	0.79
CT-R	7.37	39.17	53.47	0.77	6.67	41.93	51.40	0.77
NT-R	7.79	39.58	52.64	0.78	6.99	38.17	54.83	0.74
P-W	8.55	40.48	50.96	0.82	6.83	40.41	52.76	0.76
C-W	6.76	42.95	50.28	0.78	7.43	40.67	51.91	0.78
M-W	8.22	39.21	52.57	0.79	7.39	40.40	52.21	0.78
LSD (P=0.05)								
Tillage	0.52 (0.01)	1.50 (<0.01)	1.39 (<0.01)	0.02 (<0.01)	0.67 (0.03)	NS (0.13)	NS (0.11)	NS (0.06)
CS	0.50 (<0.01)	2.15 (0.01)	NS (0.07)	0.02 (0.01)	0.41 (0.01)	NS (0.96)	NS (0.68)	NS (0.09)
Interaction	1.00 (0.04)	NS (0.07)	3.98 (<0.01)	0.04 (0.01)	0.82 (0.02)	NS (0.06)	NS (0.05)	0.04 (0.03)

<0.25 mm fractions (also MWD) at 0-7.5 cm, while at 7.5-15 cm layer, it was only significant in >2mm fraction. The NT+R in P-W rotation had the largest MWD of field-moist aggregates than any other tillage-CS combination. Irrespective of aggregate moisture content prior to fractionation, MWD was higher in NT+R and CT+R. No-tillage increased the aggregate stability by 4-8%, while residue management increased the aggregate stability by 10-19%irrespective of tillage, suggesting that the residue plays a larger role in formation and stability of aggregate than the tillage treatment per se.

CONCLUSION

Cropping system, tillage and residue management put forth a notable influence on soil mechanical impedance and water stability of aggregates. Although the period of experimentation was short (7 years), effect of residue was evident and the effect was larger than the tillage. No-tillage can be an alternative to CT, with residue intensifying the benefits.

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Effect of conservation agricultural practices on rainfed pigeonpea production

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Conservation agriculture (CA) has potential for conserving the resources and enhancing productivity to achieve the goals of sustainable agriculture. Tillage interventions are reduced to the bare minimum besides low external inputs, which will lead to better biological processes in the soil. Very meager work is done and major bottlenecks in adopting CA in semiarid tropics, especially under dryland conditions with insufficient amount of residue due to water shortage, degraded nature of soil resource and resource poor smallholder farmer. CA practices are likely to address problems of dry land agriculture if adopted on a long-term basis. The pulse production in India is 19.77 Mt from an area of 24 Mha, to meet the requirement, every year India is importing 3 - 4 Mt of pulse. Pigeonpea is fifth prominent grain legume crop in world and in India it occupies second position among the pulse crop after chickpea. So the experiment was planned on permanent site for sustainable production of pigeonpea under dryland conditions in conservation agricultural practices like zero tillage and raised bed systems with mulch retention management.

METHODOLOGY

The experiment was conducted at ARS, Bheemarayangudi on shallow depth sandy loam soils. The fixed site experiment was started since 2009. The field was first leveled with laser land leveler in CA practices except farmer's practice. Experiment was laid with five main treatment consist T1; farmers practice, T2: Zero till - Raised bed with mulch of previous crop residue on field, T3: Zero till- Raised bed without mulch, T4: Zero till- Flat bed with mulch of previous crop residue on field, T5: Zero till- Flat bed without mulch. Raised beds were formed of size 120 cm bed and 60 cm furrow in North-South direction. Every year crop was sown after receipt of rain during June or July month with help of Zero till machine. Basal dose of fertilizer was applied during sowing. During initial year the residues were not available so external mulching was done with weeds like Cassia and others. Subsequent years the mulch not applied only the crop residue were retained and the residue from non retained plot were also applied to retained plot and residue applied was quantified. Normal package was followed as per recommendation. Every year growth and yield parameters and yield observation were collected and after fifth year experiment soil physical parameters were analyzed

RESULTS

The results of sixth year experiment indicated that the Zero till CA plots (Table 1) were given sustainably higher yield compared to farmers practice. Zero till- raised bed with mulch retention recorded higher yield (1430 kg/ha) and next Zero till- Flatbed with mulch retention (1425 kg/ha), zero till-raised bed (1246 kg/ha) and zero till-flat bed (1215 kg/ha) without mulch retention in both the plots compared to farmer's practice (955 kg/ha). The results were due to higher moisture content and improved soil properties in zero till practices helped the crop to improve growth and yield parameters. The pooled results of six year trials indicated that zero till plots given more yield than farmers practice (872 kg/ha) and among the zero till plots raised bed with mulch retention recorded higher yield (1165 kg/ha) and next flatbed with mulch retention (1160 kg/ha), raised bed (1066 kg/ha) and flat bed (1031 kg/ha) without mulch retention. The higher yield was due to increased yield characters like number of pods/ plant and yield per plant and test weight (Sepat *et al*. 2015). The moisture content (%) (Fig.1) was collected after fourth year of experiment at different depth (cm) 0-15, 15-30, 30-45 and 45-60. The results indicated that Zero till plots were higher moisture compared to farmer's practice. Farmer's practice shown a normal trend of increasing the moisture content with depth, but residue retention plots were shown increased moisture at 15-30 cm and decreased to lower depth because the soil was shallow. The improvements in growth and yield parameters of pigeonpea ascribed to higher moisture in residue retained plots as residue cover conserved the soil mois-

Table 1. Pigeonpea yield levels, yield parameters and economics (pooled over six year) as influenced by different tillage and residue management practices.

Treatment	2014-15 (kg/ha)	Pooled (kg/ha)	No. of pods/ plant	Test weight (g) 100 seeds	NDVI values	Gross returns (Rs./ha)	Net returns (Rs./ha)	B: C ratio
Farmers' practice (CT)	955	872	57	9.10	0.7259	31349	11290	0.59
Zero till-Raised bed with mulch	1480	1165	138	9.47	0.7367	42447	24180	1.32
Zero till-Raised bed without mulch	1246	1066	95	9.35	0.7340	38277	20178	1.11
Zero till-flat bed with mulch	1425	1160	111	9.31	0.7432	42252	24152	1.32
Zero till-flat bed without mulch	1215	1031	89	9.24	0.7396	37675	19486	1.08
SEm±	82	54	3.3	0.41	-	3169	3085	0.15
CD (P=0.05)	246	162	9.9	NS	-	9510	9261	0.45

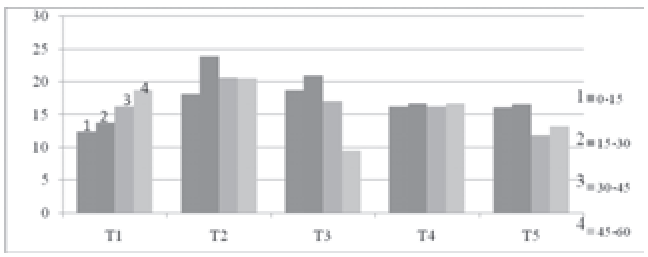

Fig. 1. Soil moisture content (%) as influenced by tillage and residue management practices at different depth

ture. The results are in close conformity with the findings of Choudhary *et al.* (2016). The pooled result of economics also shown higher gross returns (Rs. 42447/ha) and net return (Rs. 24180/ha) and B:C ratio (1.32) in zero till raised bed with mulch retention practice compared to farmers practice gross return (Rs. 31349 /ha), net return (Rs. 11290/ha) and B:C ratio (0.59). Jat *et al.* (2014) also reported lower cost of production and higher net returns in zero tillage than conventional tillage.

CONCLUSION

On the basis of experimentation, it can be concluded that sowing of pigeonpea under zero tillage with mulch retention could be recommended for sustainable productivity and profitability under rainfed conditions.

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Post adoption behavior of farmers towards soil and water conservation technologies in a Chinnatekur watershed in semi-arid tropics of south India

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Model watersheds programmes were implemented in the country from time to time to disseminate the resource conservation technologies to the farmers. Government of India in 1984 planned to develop 43 watersheds to serve as model watersheds in the country. Chinnatekur watershed in Kurnool district of Andhra Pradesh is one of the watersheds developed and monitored during 1984-1992 in drought prone semi-arid region (653.9 mm mean annual rainfall) by ICAR-Indian Institute of Soil and Water Conservation Research Centre, Ballari in collaboration with DRDA, Kurnool through multidisciplinary approach involving different line departments. Undulating topographic area (1120 ha) of the watershed is covered by red and black soils which has been subjected to various degree of degradation due to absence of conservation measures. To demonstrate the impact of conservation measures in arresting land degradation and improving economic prosperity through various engineering, agronomic and horticulture/forestry interventions viz., graded bund with waste weir, farm pond, diversion drain plus diversion bund, *nala* bund, arch weir/rock filled dams, supply channel from irrigation tank, border strip, compartmental bunding and improved crop cultivars and cropping system such as groundnut variety TMV-2, groundnut + redgram intercropping in 11:1 ratio, hybrid sunflower, *rabi* sorghum (M35-1/SPV-86), jasmine and guava plantation on riverbank sand dunes, mulberry, afforestation with staggered contour trenches on hillock, grass soding, avenue plantation and pisciculture were introduced and implemented. Watershed was revisited during 2013 to assess the behaviour of farmers towards adopted soil and water conservation (SWC) technologies implemented basically under three categories viz, engineering, agronomy and horticulture/forestry which tend to undergo changes over time during the post adoption phase of the watershed.Hence, it was found necessary to analyze the post adoption behavior of selected watershed farmers with reference to these SWC technologies.

METHODOLOGY

Questionnaire enabling to capture socio-economic and behavioural factors influencing adoption decision with reference to the selected technologies was prepared and data were collected from 51watershed respondents. The collected data were analyzed using a set of behavioural indices developed for this purpose.

RESULTS

The specific results showed that rate of continuance adoption were comparatively high in the case of horticulture and forestry technologies (87%), followed by engineering measures (78%) and agronomic measures (51%).Overall disadoption index for agronomic measures is 49%, followed by engineering measures (22%) and horticulture and forestry measures (13%). The rate of complete adoption of technologies was higher in horticulture and forestry technology (65%) followed by agronomic (38%) and engineering measures (10%). Technological gap observed was comparatively more in engineering interventions (68%) followed by horticulture and forestry (22%) and agronomic (14%) interventions, whereas overall technological dissemination index was highest inhorticulture and forestry technologies (26%) followed by engineering (18%) and agronomic measures (12%). Preference of SWC measures, continuance as such adopted or with some technological gaps or discontinuance altogether mainly rely on nature of respective technologies (Bagdi *et al*., 2016). Adoption of improved technologies will neither improve food security nor reduce poverty if barriers to their continued use are not overcome (Oladele, 2005) and technology if not widely diffused. The probable reasons behind their behavioral pattern might disclose some ideas to help redesigning these technologies or at least the approach, for an effective transfer and sustainability (Loganandhan *et al*., 2015).

CONCLUSION

It is concluded that, apart from mere transfer and demonstration of technologies in the field, farmers have to be trained on skills of maintenance, in case of engineering technologies. With reference to agronomical measures, a contingency plan to try different options, as per the situations, must be a part of the package of practices. Adoption of recent technologies for rainwater conservation and production agronomic practices, especially use of improved crop cultivars, integrated nutrient and pest management are essential for sustaining crop yields and income of the farmers. Thus farmers swap from one agronomic practice to another from time to time to withstand capricious weather conditions.

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Productivity, profitability and quality of lentil under zero till condition in rice (*Oryza sativa*)-lentil (*Lens culinaris*) cropping sequence

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Rice- fallow areas which are about 11 million hectares in eastern India alone should be brought under cultivation with pulse crops that can survive in residual moisture to increase land productivity for food and nutritional security. In Bihar and Jharkhand *kharif*-rice area is 2.74 and 1.69 m ha, respectively, and rice fallow as of *kharif* rice is 36.8%. Lentil is the second most important winter legume crop of India and contains high amount of digestible protein,micronutrients, particularly Iron and Zinc and Vitamins, thus providing nutritional security to consumers. Zero or minimum tillage provide adequate time for planting after long duration rice crop in preceding season and beneficial in terms of utilize residual moisture from previous crop and reduced planting cost with better economics (20% higher B:C ratio) after the harvest of rice. The interactions among biofertilizers and plants are still not well understood in minimum tillage ecosystem. Hence, keeping these views in mind the present investigation was made with objective to study the effect of biofertilizers (phosphate solubilizing bacteria and *Rhizobium*) inoculation with fertilizers levels under zero tillage condition on productivity, soil andplant quality and resource use efficiency in rice-lentil cropping system.

METHODOLOGY

A field experiment was conducted at Ranchi, Jharkhand during 2015-16 in rice-lentil cropping system on acidic upland soil with pH 5.0 and 0.51% organic carbon. Ten nutrient management practices (Table 1) comprising different combinations of biofertilizers (*Rhizobium* + Phosphate solubilizing bacteria) used as seed inoculation along with levels of chemical fertilizer (NPK)were accommodated in randomised block design with three replications in a fixed layout for rice and lentil.The harvesting of the rainy season (*kharif*) rice was done manually by leaving about 20 cm standing stubbles in the field. After harvesting of rice, lentil crop (cv. KLS 212) was sown under zero-till system. Lentil was sown by opening a narrow furrow in between two rows of rice using a manual furrow opener. The levels of recommended dose of fertilizerswere applied in furrows before sowing of biofertilizers treated lentil seeds and covered the seed with soil to give a good seed-soil contact. The crop was raised with residual soil moisture and twolifesaving irrigation was provided for better growth at pre-flowering and anthesis stage. The crop harvested from net plot area (18 m^2) used to express grain yield in t/ha. Economic analysis was done based on pre-

Table 1. Effect of nutrient management practices on productivity, economies and quality of lentil under minimum tillage after rice harvest

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)	Protein concentration (%)	Net Returns (10^3₹/ha)	B:C ratio
Control	0.395	0.940	30.0	22.54	15.85	1.08
Rhizobium	0.553	1.090	33.6	23.15	27.34	1.87
PSB	0.545	1.123	33.2	23.27	26.85	1.83
Rhizobium + PSB	0.627	1.262	33.2	23.83	33.00	2.25
$N_{10}P_{20}K_{10}$ + Rhizobium	0.625	1.281	33.0	24.25	32.32	2.11
$N_{10}P_{20}K_{10}$ + Rhizobium + PSB	0.688	1.435	32.5	24.52	37.11	2.42
$N_{15}P_{30}K_{15}$+ Rhizobium	0.727	1.547	32.0	24.92	39.93	2.56
$N_{15}P_{30}K_{15}$ + Rhizobium + PSB	0.796	1.584	33.4	25.26	44.82	2.86
$N_{20}P_{40}K_{20}$ + Rhizobium	0.803	1.614	33.3	26.10	45.07	2.83
$N_{20}P_{40}K_{20}$ + *Rhizobium* +PSB	0.845	1.636	34.1	26.23	48.08	3.01
SEm±	0.035	0.086	2.5	0.32	2.38	0.15
CD (P= 0.05)	0.106	0.258	7.5	0.96	7.10	0.47

vailing market prices of the prevailing year. The data recorded for different parameters were analysed with the help of analysis of variance(ANOVA) technique for randomised block design using MSTAT – C software. The results are presented at 5% level of significance (P=0.05).

RUSULTS

The grain and stover yield of lentil cultivar under investigation responded statistically significant due to different combinations of biofertilizers (*Rhizobium* and phosphate solubilizing bacteria) with different levels of recommended nitrogen (N), phosphorous (P) and potassium (K) fertilizers (Table 1). Results revealed that combined seed inoculation with *Rhizobium* and Phosphate solubilizing bacteria along with 15kg N, 30 kg P, 15 kg K/ha fertilizers application produced higher lentil grain and stover yield and it remains at par with 20 kg N, 40 kg P, 20 kg K/ha + biofertilizers (*Rhizobium* + phosphate solubilizing bacteria) inoculation, both of treatment were superior over remaining combinations in respect of yield parameters and yields (Mishra *et al*., 2011). Combined use of biofertilizers culture, dual inoculation of *Rhizobium*and PSB resulted in higher net returns and B:C ratio due to saving in money in terms of reduced fertilizer cost and marginally higher yield productions. The net returns and B:C ratio under various integrated nutrient management practices in combination of biofertlizers along with different levels of NPK fertilizers differed significantly. Maximum net returns (48.08 x 10^3Rs./ha) and B:C ratio (3.01) was recorded under treatment 20 kg N, 40 kg P, 20 kg K/ha + *Rhizobium* + PSB and remains at par with 15 kg N, 30 kg P, 15 kg K/ha + *Rhizobium* + phosphate solubilizing bacteria, both the treatments were superior in monitory terms over the remaining combinations of biofertilizers and levels of NPK fertilizers (Sanghmitra *et. al*,., 2014). Application of *Rhizobium* and PSBsignificantly enhanced the protein content in seed by various integrated nutrient management practices. maximum protein contents (Table 1) in seedswerefound in treatment 20 kg N, 40 kg P, 20 kg K/ha + *Rhizobium* + PSB and remains at par with 15 kg N, 30 kg P, 15 kg K/ha + *Rhizobium* + phosphate solubilizing bacteria and 20 kg N, 40 kg P, 20 kg K/ha + Rhizobium compared with the other integrations of biofertiliser and levels of chemical fertilizers (Chhaya and Jain, 2014).

CONCLUSION

Based on the above mentioned findings it may be concluded that 25% substitution of recommended dose of nitrogen and phosphorouschemical fertilizers with the biofertilizers (*Rhizobium* and PSB) in lentil crop perform well in respect of yields and monetary returns and it remains at par with 100% recommended dose of NPK fertilizers along with biofertilizers. Proper agronomic management, use of bio-fertilizers and resource conservation technology, may not only improve production and productivity but also help to bring large area under lentil in rice fallow cropping system and provide food and nutritional security.

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Long-term effect of pulses in cereal based cropping system on crop productivity and soil health

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Presently, cereal-cereal rotations of Indo-Gangetic plain (IGP) is under threat with decline in total factor productivity and sustainability (Ladha *et al.* 2003). Diversification of cereal based system is one of the potential approaches for sustaining cereal based rotations. Being a true complementary for cereals, pulses with their unique ability of biological N fixation, short duration, deep root system, and easy to accommodate under diverse agro-ecosystems, would be better choice for diversification of cereal-based cropping systems (Hazra *et al.* 2014). In this perspective, two long-term experiments were initiated in 2003 to assess the long-term inclusion effect of pulses/legumes in cereal based rotation on soil health, crop productivity and system sustainability.

METHODOLOGY

Two long-term trials were initiated during 2003 at ICAR-Indian Institute of pulses research, Kanpur to examine the legume inclusion effect in conventional cereal-cereal rotation on soil health and crop productivity. In experiment 1, we have evaluated four cropping system [(1) rice–wheat (RW), (2) rice–chickpea (RC), (3) rice–wheat–mungbean (RWMb) and (4) rice–wheat-rice–chickpea (RWRC)] and three fertility level (1) control (2) inorganic (NPKSZnB) and (3) organic [crop residues + biofertilisers + Farm Yard Manure (FYM) @ 5 t/ha]. Similarly in experiment 2 four different cropping system [(1) maize–wheat (MW), (2) maize–wheat–maize–chickpea (MWMC), (3) maize–wheat–mungbean (MWMb), (4) pigeon pea–wheat (PW)] and three fertility level (1) control (2) inorganic (NPKSZnB) and (3) organic [crop residues + biofertilisers + Farm Yard Manure (FYM) @ 5 t/ha] was evaluated.

RESULTS

The outcomes revealed that after nine years of cropping, pulses (chickpea, mungbean, pigeon pea) inclusion in cereal based rotation significantly (P≤0.05) improved the productivity of cereal crops and the effect was more conspicuous for summer mungbean inclusion. Inclusion of mungbean in summer fallow of RW rotation improved the rice yield by 8.1 per cent and wheat yield by 6.5%. Likewise, in upland maize-wheat rotation, summer mungbean increased the maize and wheat yield by 16 per cent and 5.6%, respectively. Long-term inclusion of pulses in RW and MW rotations significantly increased soil organic C (SOC) and available N, P, K, S and DTPA extractable-Zn and subsequently increased the nutrient uptake by cereal component crops. Long-term cultivation of mungbean enriched the SOC by 12.0 and 12.5% in MW and RW rotation, respectively proposing the significance of fallow management for SOC management in tropics. Among the four C fractions estimated, very labile (C$frac_1$) constituted the greater part of TOC in the upland maize-based system, while in lowland puddled rice-based system less-labile (C$frac_3$) was dominant. Considering the relative efficiency in SOC management the crop rotation was found in the order of maize-wheat-mungbean>pigeonpea-wheat>maize-wheat-maize-chickpea>maize-wheat. Besides this, greater improvement in soil biological properties (soil microbial biomass C and dehydrogenase activity) was also apparent with inclusion of pulses in the study. The study also revealed that, cereals are highly responsive to inorganic fertilization. Whereas, all pulses (chickpea, mungbean, pigeonpea) were found invariably more responsive to organic treatment over recommended inorganic fertilization.

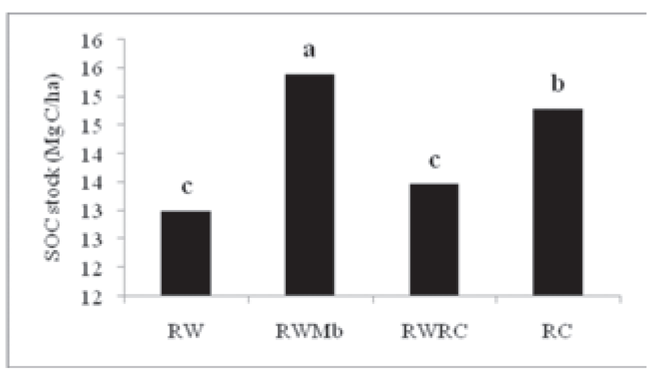

Fig. 1. Effect of pulses inclusion in RW cropping system on SOC stock (MgC/ha)

CONCLUSION

Diversification/intensification of cereal based rotations of IGP with pulses can increase system productivity, and improve SOC and available plant nutrients. Thus, the study affirmed that inclusion of pulses in conventional cereal based rotation can sustain the productivity and could mitigate he second generation problems associated with continuous cultivation of cereal based rotations.

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Effect of tillage and residue management practices on yield of rice under rice-wheat cropping system

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Rice-wheat cropping system is one of the major agricultural systems of south Asia. It is the source of livelihood, employment and income for hundreds of millions of rural and urban poors. The rice-wheat system occupies 24-26 million ha in Asia, mainly with 13.5 M ha in the Indo-Gangatic plains (IGP); covering around 32% of the total rice area and 42% of the total wheat area in four IGP countries *viz.* India, Pakistan, Bangladesh and Nepal (Saharawat *et al*., 2012). Rice and wheat together contribute more than 70% of total cereals production in India with production of 104.4 & 92.5 million tonnes, respectively. A decline in land productivity under rice-wheat system has been observed over past few years despite application of optimum levels of inputs. Intensive tillage and residue burning have led to depletion of soil organic carbon, resulting in decreasing soil fertility and factor productivity. Declining/stagnating crop and factor productivity and a deteriorating resource base in cereal systems such as rice–wheat have led to the promotion of conservation agriculture. Conservation tillage involves zero or minimal tillage followed by row seeding using a drill. Conservation tillage, when utilizes crop residue as mulch with improved crop and resource management practices, is termed CA or integrated crop and resource management (ICRM) (Ladha *et al*., 2009). To realize the full benefits of zero tillage, which otherwise are lost by doing puddling in rice, serious efforts are being made to develop zero-tillage rice followed by zero tillage wheat commonly referred to as "double zero tillage."

METHODOLOGY

A field experiment was conducted during the rainy season of 2012-13 and 2013-14 at Borlaug Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar. The soil of experimental field was sandy clay loam with pH 7.95. The chemical analysis of top 15 cm of soil showed that it was rich in organic matter, low in available nitrogen, medium in phosphorus and potassium and neutral to slightly alkaline in reaction. The experiment was laid out in the split-split plot design having tillage systems (3) in main plots, rice varieties (2) and residue (2) in sub-sub plot.

RESULTS

Lower grain yield was recorded during second year as compared to first year of rice cultivation. In 2012, rice crop was sown conventionally and difference was due to only rice varieties. There was no residue mulch also. During second year, sowing was done by different tillage practices and residue of wheat crop was applied. During first year shortly higher yield was recorded with conventional tillage (CT) followed by minimum tillage (MT). In 2013, significantly higher grain yield was obtained with CT (5.44 t/ha) and MT (5.39 t/ha) which were statistically at par to each other and significantly higher than ZT (4.62 t/ha). Lower grain yield was observed with ZT (5.54 t/ha and 4.62 t/ ha in 2012 and 2013 respectively) during both the years. Higher grain yield under conventional tillage and minimum tillage might be due to better yield contributing characters. In conventional tillage soil become soft during field preparation. Under soft soil the roots of crop grow better as compared to zero tillage. Better root growth helps the plant to extract more nutrients from the soil and more nutrient uptake was there by the crop. In zero tillage higher immobilization and C: N ratio may be the reason of lower yield during second year. In case of varieties, grain yield produced by hybrid rice, Pant Sankar Dhan 3 (5.63 t/ha, 5.08 t/ha in 2012 and 2013 respectively) and HYV, Pant Dhan 16 (5.78 t/ha and 5.23 t/ha in 2012 and 2013 respectively) were statistically at par during both the years, however grain yield produced by HYV (Pant Dhan 16) was higher than hybrid rice (Pant Sankar Dhan 3). Interaction effect of tillage and rice variety was found non-significant. HYV (Pant Dhan 16) recorded higher yield than hybrid rice (Pant Sankar Dhan 3) which might be due to high potential of HYV (Pant Dhan 16) to perform under aerobic condition than hybrid rice (Pant Sankar Dhan 3). Lower yield in hybrid rice may be due to more sterility percentage than HYV. Hybrid rice is sensitive to variation in weather condition. Aberrant weather conditions like rain fall during flowering and lower temperature during grain filling are mainly responsible for sterile grains during maturing.

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Impact of conservation technologies on soil organic carbon pools in rice-mustard cropping system of western Indo-Gangetic Plains

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The dilemma of soil erosion, soil quality deterioration due to decline in the groundwater table, increased sub-soil compaction, atmospheric pollution, multi-nutrient deficiencies and decline in quantity and quality of soil organic matter (SOM) become visible in a large extent in recent years and therefore there is a need of such a management system, which aims at higher productivity and profitability through rational and sustainable use of available resources on a long-term basis. Here comes the importance of conservation agriculture (CA)-based technologies which increase the SOC content, improve nutrient cycling and soil aggregation and nutrient storage through Zero tillage practices along with retention of crop residues. But the information on impact of CA on soil C accumulation and distribution of C pools in the north-western Indo-Gangetic Plains (IGP) is meagre, therefore, the present study was undertaken in an on-going 5-year old experiment with the objectives of understanding the effect of CA practices on (i) total SOC contents, and (ii) distribution of SOC into different pools of varying lability after in rice-mustard cropping system of the western IGP.

METHODOLOGY

The experiment was carried out at the at the experimental farm of ICAR-Indian Agricultural Research Institute (IARI), New Delhi, India (28º35'N, 77º12'E, altitude 228 m above mean sea level). New Delhi has a sub-tropical and semi-arid climate with hot and dry summers and cold winters. The CA experiment is continuing since 2009–10 in rice (*Oryza Sativa* L.)-mustard (*Brassica nigra* L.) system. The soil is sandy clay loam in texture. The treatments were: T_1, Moong Bean Residue (MBR) + Zero-Till Direct Seeded Rice (ZTDSR)–Rice Residue(RR)+ Zero-Till Mustard(ZTM)+ Zero-Till Moong Bean (ZTMB); T_2, Moong Bean Residue (MBR) + Zero-Till Direct Seeded Rice (ZTDSR) -Zero-Till Mustard (ZTM) + Zero-Till Moong Bean (ZTMB); T_3, Mustard residue (MR) + Zero-Till Direct Seeded Rice (ZTDSR)–Rice Residue (RR)+ Zero-Till Mustard (ZTM); T_4, Zero-Till Direct Seeded Rice (ZTDSR) - Zero-Till Mustard (ZTM); T_5, Mustard Residue (MR) +Zero-Till Direct Seeded Rice (ZTDSR) + Brown Manuring (BM) – Rice Residue (RR) + Zero-Till Mustard (ZTM)

T_6, Zero-Till Direct Seeded Rice (ZTDSR) + Brown Manuring(BM) - Zero-Till Mustard (ZTM); T_7, Transplanted Rice (TPR) - Zero-Till Mustard (ZTM); T_8, Transplanted Rice (TPR) – Conventional tillage Mustard (CTM). Soil samples were collected from 0–5 cm and 5–15 cm layer during January 2016, and analyzed for total C using CHN analyzer (EuroVector Instruments, EA 3,000 Italy). Total soil inorganic C (SIC) was measured titrimetrically by digesting the soil with dilute HCl and then back titrating the excess HCl with dilute NaOH. Total soil organic carbon (TOC) concentrations were then computed by subtracting total SIC from total C concentrations. Different fractions of SOC with varying lability were estimated following Chan et al. (2001) using 5, 10, and 20 mL of concentrated (18.0 mol/L) H_2SO_4 and $K_2Cr_2O_7$ solution.

RESULTS

In top soil total SOC concentration nonsignificantly varies from 0.75% to 0.87% and in lower depth i. e. 5–15 cm layer it significantly varies from 0.74% to 0.84 % (Fig. 1). Treatment with Moong Bean Residue (MBR) + Zero-Till Direct Seeded Rice (ZTDSR)-Rice Residue(RR)+ Zero-Till Mustard(ZTM) + Zero-Till Moong Bean (ZTMB) recorded 14.23% higher TOC at 0–5 cm depth than control i. e. Transplanted Rice (TPR) – Conventional tillage Mustard (CTM), while in 5–15 cm depth the per cent increase was 11.54%. High TOC in top soil might be due to crop residues left on soil surface implying much slower stubble incorporation and decomposition and reduced rate of leaching leads to build up of TOC in CA plots (Bhattacharyya et al., 2015). Residue amended CA plots also have higher TOC at both the layer might be due to the fresh organic matter input which led to the formation of particulate organic matter which is not subjected to rapid oxidation and loss. Also, maintenance of a low temperature regime and increased water retention slow down decomposition of soil organic matter (SOM) under CA plots (Chivenge *et al.,* 2007). In case of carbon pools, CA plots have significant impact on very labile and labile carbon pools and not on less labile and nonlabile carbon pools at 0–5 cm layer. However treatment with Moong Bean Residue (MBR)

Table 1. Impact of conservation technologies on organic carbon (%) pools at the 0-5 cm soil layer in rice-mustard cropping system

TREATMENT	Very Labile	Labile	Less labile	Non- labile
MBR+ZTDSR-RR+ZTM-WR+SMB	0.241a	0.254a	0.123a	0.259a
ZT-DSM-ZT+SMB	0.212ab	0.254a	0.084a	0.286a
MR+ZTDSR-RR+ZTM	0.183b	0.246ab	0.141a	0.255a
ZTDSR-ZTM	0.183b	0.234ab	0.110a	0.280a
MR+ZTDSR+BM-RR+ZTM	0.180b	0.228b	0.153a	0.230a
ZTDSR+ BM-ZTM	0.178b	0.199c	0.104a	0.282a
TPR-ZTM	0.171b	0.190cd	0.178a	0.229a
TPR-CTM	0.160b	0.172d	0.195a	0.227a

Similar lowercase letters are not significantly different at P<0.05

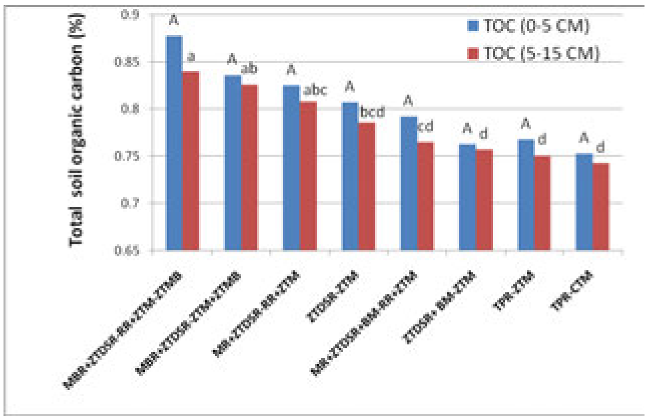

Fig. 1. Impact of conservation technologies on total soil organic carbon concentration (%) in rice-mustard cropping system. Bar followed by similar letters within a soil depth are not significantly different at P<0.05.

+ Zero-Till Direct Seeded Rice (ZTDSR)–Rice Residue (RR)+ Zero-Till Mustard (ZTM) + Zero-Till Moong Bean (ZTMB) has significantly higher very labile carbon concentration than rest of the treatments in top soil (Fig. 2). The treatment with Moong Bean Residue (MBR) with and without residue also recorded significantly higher labile carbon pools than rest of the treatments. High labile carbon pools were also observed in residue amended plot. Similar results are also reported by Bhattacharyya et al., 2015. This might be due to higher top soil microbial population in residue amended plots which quickly mineralise C and N added through residues resulting in higher labile carbon pool without affecting the recalcitrant pool. But in case of lower layer at 5–15 cm depth, there was no significant effect of CA treatments on labile as well as recalcitrant pools of carbon and this might be due to lesser microbial population in that layer.

CONCLUSION

It can be concluded from the study that CA plot have significant impact on labile carbon pools but not on recalcitrant pools at the top layer. Residue amended plots have higher soil organic carbon than the conventional plots. The treatment with Moong Bean Residue (MBR) + Zero-Till Direct Seeded Rice (ZTDSR)–Rice Residue(RR) + Zero-Till Mustard(ZTM) + Zero-Till Moong Bean (ZTMB) is the most effective treatment from carbon sequestration point of view because of its increased biomass production and SOC accumulation without impairing soil health under rice-mustard cropping system of western Indo-Gangetic Plains.

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Water budgeting in direct seeded rice under conservation agriculture

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Rice (*Oryza sativa* L.) is a staple food which consumes large quantity of irrigation water, ranging between 1500 and 3000 mm. There are twin challenges of producing more rice per unit area with less water as it is essential for food security in many Asian countries including India in general and North-Western (NW) India in particular. During the past 30 years or so the question of production sustainability in canal and tube well irrigated area has been raised as increasing use of groundwater for rice cultivation has led to a decline in the water table by 0.1 to 1.0 m year^{-1}, resulting in water scarcity and increased cost for pumping water (Hira, 2009; Rodell *et al*., 2009; Humphreys *et al.*, 2010; Jat, *et al.,* 2012 and Mahajan *et al.*, 2012). Therefore, the sustainability of rice production and the overall environment in these areas are most threatened. There is plenty of literature available on the water requirements of crops of rice, but insufficient information available when grown in a system *viz.* rice-mustard-moongbean and also the interactive impacts of crop irrigation scheduling's are hardly known. Understanding the magnitude and dynamics of various components of the crop, water balance is essential to develop technological options for viable management of soil and water resources. On the other hand there is insufficient work has been done in regards to measure the actual water balance in direct-seeded rice field in rice-mustard-mungbean cropping system under conservation agriculture. There is the majority of need to measure the actual water balance components in the rice to reduce the plenty application of irrigation water into the field as well as to maintain the crop growth at optimum level for achieving the high yield.

METHODOLOGY

The experiment was carried out on a clay loam soil at the Research Farm (14-B block) of ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India during the *kharif* season of 2015 in an on-going experiment started from 2009-10. The experiment was laid out in randomized complete block design with eight treatments and three replications under irrigated condition. Different treatments tried were: ZT DSR – ZTM: zero till direct seeded rice (ZT DSR) – zero till mustard, ZT DSR + BM – ZTM: DSR + Sesbania brown manuring – ZTM, MR (mustard residue) + ZT DSR – RR (rice residue + ZTM, MR + ZT DSR + BM – RR + ZTM, MBR (mungbean residue) + ZT DSR – ZTM – SMB (summer mungbean), MBR+ ZT DSR – RR + ZTM + MR – SMB, TPR (transplanted rice) – ZTM, and TPR – CTM (conventional till mustard). For irrigation scheduling, soil moisture content was measured periodically by gravimetric method from 0-15, 15-30, and 30-45 cm soil depth and it was scheduled as per the soil moisture depletion method. The irrigation water, puddling and ponding which were applied to the experiment plots, were measured by star flow meter Values of surface runoff from the rainfall data were estimated on daily basis using SCS curve number technique (Bhattacharya and Michael, 2010).The Penman–Monteith equation was used for calculating the reference crop evapotranspiration (ET_0) from available climatic, crop, and soil parameters. Deep percolation and effective rainfall were estimated using FAO equations. Water productivity was estimated by taking the data on grain yield from each treatment and dividing with total water applied (i.e. irrigation water and effective rainfall).

RESULTS

The results indicated that in MBR+ ZT DSR – RR + ZTM + MR – SMB, there was the highest available soil moisture content correlated to all other treatments at initial, development, mide-season and late-season stages and this might be due to the addition of the three types of resdues such as mungbean, rice and mustard residues, which can able to conserve more and more irrigation water and save it for longer time compare to other treatments.The effective rainfall during the crop growing season was 495 mm.The total irrigation water applied to the all treatments were varying from MBR+ ZT DSR – RR + ZTM + MR – SMB treatment compared to all other treatments, where less amount of irrigation water (893 mm) has been applied and correlated to all the treatments. There was 86.8 & 86.8, 8.4 & 20, 38.7 & 40.4 and 3.5 & 3.1 % less irrigation water applied in MBR+ ZT DSR – RR + ZTM + MR – SMB treatment compare to the TPR – ZTM, and TPR – CTM treatments at the initial, development, mid-season and late-season stages, respectively. The amount of water used for saturating the soil measured as 135 mm, whereas for ponding it was 94 and 98 mm in TPR – ZTM and TPR – CTM treatments respectively. It was found that deep percolation in different DSR treatments varied from 5.8 to 6.2 mm day^{-1} and in TPR 7.5 to 7.8 mm day^{-1}. Water productivity was significantly higher in the MBR+ ZT DSR – RR + ZTM + MR – SMB treatment (3.27 kg ha-1mm-1) than all other DSR and TPR treatments.

CONCLUSION

Based on the above results, it was found that MBR+ ZT DSR – RR + ZTM + MR – SMB is the best treatment for conservation agriculture and DSR cultivation, DSR is more useful than TPR which saves 56% of water and water balance amount is site specific, so estimation of water balance for irrigation scheduling is essential.

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Effect of rice establishment, tillage and rice straw management on grain yield and nutrient uptakes in wheat under rice-wheat cropping system

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METHODOLOGY

A field study entitled 'Wheat yield and nutrient uptakes as influenced by rice establishment, tillage and rice straw management in rice-wheat system' was conducted on third wheat (2012-13) crop in an on-going experiment initiated during rice 2010 at the experimental area of Department of Soil Science, Punjab Agricultural University, Ludhiana. The experiment consisted of rice establishment methods, andtillage and rice straw management practices in wheat. These combinations comprised of four main plots of rice establishment methods (dry direct seeded rice under zero tillage and conventional tillage, direct transplanted rice and puddled transplanted rice) and three subplots in wheat (conventional tillage, zero tillage without rice straw and zero till wheat sown with Happy Seederretaining rice straw as mulch) with three replications in split plot design. Grain and straw samples of wheat were collected at harvest of wheat. The collected grain and straw samples were processed and analyzed for total N, P, K and micronutrient cations (Zn, Fe, Mn and Zn).

RESULTS

ZT wheat sown with HS produced significantly higher grain (15%) and straw (24%) yields as compared toZT-R. Even CT wheat produced significantly higher grain (6%) and straw (20%) yields than ZT-R. Highest straw yield was obtained in ZT wheatsown with HS following PTR and lowest straw yield was recordedi n ZT-R following PTR. Harvest index was significantly higher in ZT wheatsown with HS than ZT-Rand CT wheat. Thousand grain weight under ZT wheat sown with HS was significantly higher as compared to ZT-R and CT. Spike length under ZT wheat sown with HS and ZT-M was significantly higher as compared to CT wheat. Grains/spike and grain weight/spike under ZT wheat sown with HS were significantly higher as compared to ZT-M and CT wheat. Macronutrients (N, P and K) uptake in wheat grain and straw was not significantly affected by rice establishment systems, tillage and rice straw management practices in wheat. ZT wheat sown with HS significantly increased N, P and K uptake in grain, straw and total over ZT-R and CT. The interaction between rice establishment systems, and tillage and rice straw management practices was significant on straw N uptake. Highest straw N uptake was under ZT wheat sown with HS followed by PTR and lowest was recorded under ZT-R followed PTR. The results revealed that 16 to 23% N, 25 to 30% P and 74 to 80% K were retained in wheat straw. Grain Fe and Zn uptake was significantly higher under ZT wheat sown with HS than ZT-R. Even grain Fe and Zn uptake was significantly higher under CT wheat than ZT-R.The grain Mn uptake was significantly higher under ZT wheat sown withHS than ZT-Rand CT wheat. Micronutrient cations (Fe, Mn, Cu and Zn) uptake in wheat straw was significantly higher under ZT wheat sown withHS than ZT-R. Even micronutrient cations (Fe, Mn, Cu and Zn) uptake in wheat straw was significantly higher under CT wheat than ZT-R. The total micronutrient cations (Fe, Mn, Cu and Zn) uptake was significantly higher under ZT wheat sown with HS than ZT-R. Even total micronutrient cations (Fe, Mn, Cu and Zn) uptake was significantly higher under CT wheat than ZT-R. The results revealed that 84 to 87% Fe, 54 to 64% Mn, 42 to 54% Cu and 36 to 47% Zn were retained in wheat straw.

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Yield and economics of greengram (*Vigna radiata*) cultivars as influenced by integrated nutrient management

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Greengram is also known as mung, moong, mungo, goldengram, chickasaw pea and oregon pea. It contains about 25% protein, 1.3% fat, 3.5% minerals, 4.1% fiber and 56.7% carbohydrate. Although, chemical fertilizers are playing crucial role to meet the nutrient requirement of the crop. Use of organics or biofertilizers alone does not result in spectacular increase in crop yields, due to their low nutrient status. Therefore, the aforesaid consequences have paved way to grow greengram using organic manures and inorganic fertilizers along with biofertilizers.Substitution of chemical fertilizers with bio-fertilizers found cost effective and eco-friendly. Among various biofertilizers, *Rhizobium* inoculation is a cheapest, easiest and safest method of supplying nitrogen to greengram through well-known symbiotic nitrogen fixation process. In the light of above facts and paucity of adequate research evidences, the present experiment was carried out.

METHODOLOGY

A field experiment was conducted during *kharif*season of 2014 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The total rainfall received during kharif season was 622.9 mm in 2014. The soil of the experimental field was loamy sand in texture, low in OC (0.17%) and available N (160.7 kg/ha), medium in available P_2O_5 (38.9 kg/ha) and available K_2O (286.0 kg/ha) with 7.2 soil pH. Fourteen treatment combinations comprising of two varieties of greengram *viz*., Meha and GM 4 and seven treatments of integrated nutrient management viz., 100% RDF(20:40:0 kg NPK/ha), 75% RDF + 2 t FYM/ha, 75% RDF+Rhizobium+PSB, 75% RDF+ 2 t FYM/ha + Rhizobium+PSB, 50% RDF+4 t FYM/ha, 50% RDF + Rhizobium + PSB and 50% RDF + 4 t FYM/ha + Rhizobium + PSBwere evaluated in factorial randomized block design replicating three times. Recommended dose of phosphorus @40 kg P_2O_5/ha was applied at the time of sowing. The Rhizobium and PSB culture (*Bacillus coagulans*, PBA-16) was prepared by dissolving 100 g Jaggary in 1:1 of boiled cooled water followed by addition of Liquid agar slant PSB & Rhizobium culture @ 20 ml per one kg seed were sprinkled on seeds spread in thin layer and mixed then after dried in the shade before sowing.

Table 1. Yield and economics of greengram as influenced by integrated nutrient management.

Treatment	Yield (kg/ha) Seed	Yield (kg/ha) Stover	Gross realization (₹/ha)	Net realization (₹/ha)	BCR
Variety					
Meha	656	1693	46011	25038	2.19
GM 4	559	1468	39278	18305	1.87
SEm±	13	41			
CD(P=0.05)	39	120			
Integrated nutrient management					
100% RDF(20:40:0 kg NPK/ha)	565	1528	39770	20464	2.06
75% RDF+2 t FYM/ha	624	1621	43769	22414	2.05
75% RDF+*Rhizobium* + PSB	602	1559	42236	23223	2.22
75% RDF+2 t FYM/ha+*Rhizobium*+PSB	746	1806	52069	30456	2.41
50% RDF + 4 t FYM/ha	543	1404	38125	14723	1.63
50% RDF+*Rhizobium* + PSB	499	1435	35273	16813	1.91
50% RDF+4 t FYM/ha +*Rhizobium*+PSB	675	1713	47269	23609	2.00
SEm±	25	77			
CD (P=0.05)	73	225			

FYM: Farm yard manure, RDF: Recommended dose of fertilizer, PSB: Phosphate solublizing bacteria

RESULTS

The variety Meha registered significantly higher seed (656 kg/ha), stover yields (1693 kg/ha), gross realization (Rs. 46011/ha), net realization (Rs.25038/ha) and BCR (2.19) as compared to variety GM 4 (Table 1). Variety Meha increased the seed and stover yield to the tune of 17.3 and 15.3% over variety GM 4. This might be due to a variety of crop differed in its genetic built up and registered more numbers of pods per plant hence resulted in the yield potential. The above findings are in complete agreement with earlier work of Patel *et al.,* (2013), Gorade *et al.,*(2014) and Rathod *et al*., (2014). Maximum seed yield (746 kg/ha), stover yield (1806 kg/ha), gross realization (Rs.52069/ha), net realization (Rs.30456/ha) and BCR (2.41) of greengram were recorded from plot fertilized with treatment combination of 75% RDF+2 t FYM/ha + *Rhizobium* +PSB followed by 50% RDF+ 4 t FYM/ha + *Rhizobium*+PSB (Table 1). Both the treatments were found significantly superior over the rest of all other treatment for yield and yield attributing parameters. The highest seed yield per hectare gained under these treatments might be due to chemical fertilizer in conjunction with FYM and bio fertilizers might have provided favorable soil environment and nourishment for better plant growth resulted in maximum seed yield per hectare.

CONCLUSION

It is concluded that greengram variety Meha fertilized with 75% RDF (20:40:0 kg NPK/ha)+2 t FYM/ha along with seed inoculation of Rhizobium + PSB recorded maximum yield attributes, seed and stover yield in loamy sand soil during *kharif* season.

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Conservation agriculture in rainfed fodder sorghum based systems: Crop productivity and soil moisture

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Livestock rearing is an important occupation of farmers in India, but the total area under cultivated fodder is only 8.4 m ha (5.23%) which is static since last two decades. The scope for further increase in area under forages seems meagre due to demographic pressure of human population for food and other needs. In this context, following fodder-food crop rotations on the existing land resource can meet the nutritional requirement of human and livestock. Besides this, Introduction of conservation agriculture (Resource conserving technologies) in these crop rotations sustains the crop productivity, conserve natural resource base and economic growth of farmers. Sorghum for fodder purpose is grown widely in kharif season followed by rabi crops like wheat, oat, barley, chickpea, mustard etc on system basis in Bundelkhand region of central India. Resource conserving technologies (RCTs) has substantial potential for minimizing the cost of production, soil health hazards and the negative impacts on the succeeding crops. The amount and distribution of seasonal rainfall differ widely among regions as well as from year to year due to change in climatic scenario. Moreover, the soils of Budelkhand region of India are medium to low in fertility with low organic matter content and poor water holding capacity that limits the fodder and food productivity. Under this situation going for rabi season crop in this region is great concern due to inadequate soil moisture. Conservation agriculture practices (zero tillage, green mulch on soil surface) benefits the farmers in short term by growing second crop (rabi) with reduction in cost of cultivation but also in long term by improving the productivity and soil health in fodder sorghum based cropping systems.

METHODOLOGY

A fixed plot field experiment was started from 2013 at the research farm of the IGFRI, Jhansi and the experimental design was split plot. Cropping systems: Fodder sorghum – Chickpea+ *Sesbania* hedge rows, Fodder sorghum – Barley+ *Sesbania* hedge rows, Fodder sorghum – Mustard+ *Sesbania* hedge rows; Tillage: Conventional Tillage (CT)-Conventional Tillage (CT), Minimum tillage (MT)-Zero tillage (ZT), Conventional Tillage (CT)-Zero tillage (ZT); Moisture conservation: Control (Sesbania as fodder), Sesbania as mulch System productivity was worked out by adding wheat grain equivalent yield of kharif season crops to wheat grain yield. All the package of practices is followed according to treatments. Soil

Table 1. Fodder sorghum yield equivalent yield of *rabi* crops and total system productivity as influenced by tillage and mulching

Treatment	Fodder sorghum yield (t/ha)	Fodder sorghum equivalent yield rabi crops (t/ha)	Total System productivity (t/ha)
Fodder sorghum-Chickpea+Sesbania hedge rows	16.6	13.9	31.7
Fodder sorghum-Barley+Sesbania hedge rows	16.7	19.1	41.7
Fodder sorghum-Mustard+Sesbania hedge rows	15.7	24.7	44.4
SEM±	0.671	0.384	0.894
CD(P=0.05)	NS	1.50	3.51
CT-CT+ Without mulch	16.2	18.7	38.6
CT-CT+ With mulch	17.1	22.3	43.8
MT-ZT+ Without mulch	16.1	17.3	36.7
MT-ZT+ with mulch	16.6	20.9	41.6
CT-ZT+ Without mulch	15.8	16.9	35.9
CT-ZT+ with mulch	16.3	19.1	39.1
SEM±	0.539	1.18	1.61
CD(P=0.05)	NS	3.42	4.67

moisture content was recorded with gravimetric method.

RESULTS

In fodder sorghum based cropping systems comparatively highest sorghum green fodder yield was recorded in conventional tillage (CT)- conventional tillage (CT)+ Sesbania as mulch (17.1 t/ha) but comparable yield also recorded with other tillage treatments. Minimum tillage (*kharif)* - zero-tillage (*rabi*) + mulching with lopping of Sesbania recorded comparable fodder sorghum equivalent yield (41.6 t/ha) with conventional tillage (kharif) - zero tillage (rabi) (39.1 t/ha) and conventional tillage (kharif)-conventional (rabi) season (43.8 t/ha) (Table 1). Moreover, 2-3% higher soil moisture was observed in mulching with Sesbania loppings under minimum tillage (*kharif)* - zero-tillage (*rabi*) than without mulch which supported the crop growth and resulted in higher system productivity.

CONCLUSION

On the basis of this study it can be concluded that minimum tillage (*kharif)* – zero tillage (*rabi*)+ mulching with lopping of Sesbania recorded comparable fodder sorghum equivalent yield with conventional tillage (*kharif*)- zero tillage (*rabi*) and conventional tillage (*kharif*)-conventional (*rabi*) season. Moreover, 2-3% higher soil moisture was observed in mulching with Sesbania loppings under minimum tillage (*kharif)* – zero tillage (*rabi*) than without mulch which supported the crop growth and resulted in higher system productivity.

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Conservation agriculture effects on crop and water productivity, C-sequestration and mitigation and adaptation to climate change in rice-wheat cropping system

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Conservation agriculture (CA) with three principles, i.e. minimum mechanical soil disturbance, permanent organic soil cover with crop residue or cover crops, and diversified, economical and viable crop rotations provides enough opportunities towards saving of inputs, improving resource-use efficiency and mitigating green house gases (GHGs) emissions and adaptation to climate change (Pathak *et al*., 2011). The CA is being gradually adopted in the rainfed and irrigated eco-systems of the tropics, sub-tropics and temperate regions of the world and its area has increased to 156 m ha globally. Rice-wheat (R-W) cropping system is the backbone of food security of the South-east Asian countries, namely Bangladesh, Bhutan, China, India, Myanamar, Nepal and Pakistan. The yields of rice and wheat have reached to a plateau due to declining factor productivity, climate change and resource degradation under increasing intensification. Direct-seeded rice (DSR), brown manuring (BM) with *dhaincha* (*Sesbania aculeata*), rice residue (RR) retention, and zero-till wheat (ZTW) with residue retention are important CA practices, which can help to sustain the productivity of R-W system in North-western Indo-Gangetic plains of India, besides reducing greenhouse gases (GHGs) emission and enhancing carbon sequestration (Bhattacharyya et al., 2015). Therefore, CA-based crop management practices (Gupta and Sayre, 2007) are being adopted by the farmers in the rice-wheat belt of the Indo-Gangetic Plains to address several problems of the

R-W system. Accordingly, this study was designed with the objectives: i) to find out a suitable CA-based (DSR-based) R-W system alternative to conventional transplanted puddle rice-wheat system; and ii) to evaluate the CA-based R-W system for their potential to saving of water, C-sequestration and mitigation and adaptation to climate change.

METHODOLOGY

An experiment was carried out at the Indian Agricultural Research Institute, New Delhi, India during 2010-2015 to evaluate the crop & system productivity, water productivity, C-sequestration and reduction in GHGs emission in CA-based R-W systems. The soil was clay loam with pH 8.3, organic C 0.60 % and EC 0.69 dS/ m. It was low in $KMnO_4$-oxidizable N (166.2 kg/ha), medium in Olsen's P (23.5 kg/ha) and NH_4OAc-extracable K (276.4 kg/ha). Eight CA-based tillage and residue management, *viz*., i) ZT direct-seeded rice (DSR) – zero-till wheat (ZTW); ii) WR (wheat residue) + ZT DSR – rice residue (RR)+ZTW; iii) ZT DSR + *Sesbania*brown manuring (BM) – ZTW; iv) WR+ZT DSR + BM – RR+ZTW; v) ZT DSR – ZTW - ZT summer mungbean (SMB); vi) Mungbean residue + ZTDSR– RR+ZTW -WR+ ZT SMB; vii) Transplanted rice (TPR) – conventional-till wheat (CTW); and viii) TPR – ZTWwere laid out in a randomized block design with three replications.

RESULTS

It was observed that mungbean residue + ZTDSR– RR+ZTW - WR+ ZT SMB gave similar rice yield with transplanted puddled rice (TPR) + ZTW/CTW (conventional till wheat) system from second year onwards. This treatment caused an increase in rice yield by 23, 12 and 14.3% in second, third and fourth year, respectively over that in 2010. This also increased wheat yield by 0.8-1.0 t/ha in 2^{nd}, 3^{rd}, and 4^{th} year compared to TPR-CTW. As a result, this treatment resulted in highest system productivity, net returns, B:C, followed by this treatment without RR, and DSR + BM – RR+ZTW and DSR +BM–ZTW+RR. It gave higher system water productivity. Soil physical health (penetration resistance & bulk density) was significantly improved in DSR-ZTW with residue of mungbean, *Dhaincha* or rice than in TPR-CTW/ZTW, resulting in less compaction. MBR+DSR–RR+ZTW-SMB resulted in higher Walkley and Black carbon and very labile carbon than TPR-CTW. Compared to TPR, DSR reduced methane emission by 64% and global warming potential (GWP) of the R-W system.

CONCLUSION

Thus, ZT direct-seeded rice with mungbean residue and rice residue retained on the surface in zero-till wheat, followed by wheat residue retention in ZT summer mungbean out-performed TPR-CTW and could be a possible alternative to TPR-CTW system in the North-western Indo-Gangetic plains of India.

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Effect of tillage and mulching on productivity of maize-based cropping systems

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The rice-wheat cropping sequence of north-west India though provide food security in the country, but the over exploitation of natural resources have led to falling water table and other issues (Yadav *et al.,* 2016). Conventional crop management practices augmented the exploitation of natural resources and un-efficient use of inputs. The sustainability of rice-wheat system can be maintained either through adoption of alternate management practices or diversification of rice-wheat cropping system with other environment friendly cropping systems. In recent years with the introduction of single cross hybrid technology and development of different maturing (extra early, early, medium and late) high yielding maize hybrids provided better alternative to rice in this region to sustain soil health and environmental quality. Inclusion of pulses, oilseeds and vegetables in the cropping system is more beneficial than cereals after cereals, and such inclusion in a sequence changes the economics of the crop sequences. The conventional practice of excessive tillage consumes a high proportion (25–30%) of the total operational energy of crop production. So, zero/minimum tillage practices can be an alternative over traditional tillage practices because of their potential to reduce production costs, less energy requirement, less weed problem, better crop residue management and higher or equal yield and benefit for the environment (Prasad *et al.,* 2014).

METHODOLOGY

The study was conducted at the research farm of the Department of Agronomy, Punjab Agricultural University, Ludhiana, India during 2013-14. The experiment was laid out in split-plot design with four replications. The main plot treatments consist of combination of tillage *viz*. minimum tillage (MT) and conventional tillage (CT)and cropping systemsrice-wheat, maize-vegetable pea-spring maize, maize-toria-spring maize, maize-potato-spring maize, whereas, in sub plots were the combination of fertilizer and mulch *viz*. recommended dose of fertilizers (RDF), 75 % RDF + 25 % N through organic manure with mulch and without mulch. After the complete emergence of crop, mulching was done as per the treatment combination. Crop residue of preceding crops was used on succeeding crops @ 5 t/ha. All the crops in different cropping systems were raised in accordance with recommended package of practices. The cropping systems were compared by converting the economic yield under different sequences into rice-equivalent yield using prevailing market prices of the component crops.

RESULTS

The field experiment was conducted to develop efficient resource conserving cropping systems under different tillage, mulch and nutrient management practices. The productivity was greatly influenced by tillage, mulch and nutrient management practices. The tillage increased the yield of all the crops as well as the REY. The rice-equivalent yield was highest in maize-vegetable pea- spring maize cropping system (21.4 t/ha) followed by maize-potato- spring maize (18.0t/ha), maize-toria- spring maize (13.8 t/ha) and rice-wheat (11.7 t/ha) cropping systems under conventional tillage. Among fertilizer and mulch treatments, application of 100% recommended dose of fertilizers along with mulch leads to higher yield as compared to other treatments. The highest REY was obtained in maize-vegetable pea-spring maize cropping system (21.6 t/ha) in conventional tillage along with 100% recommended dose with mulch as compared to other treatments.

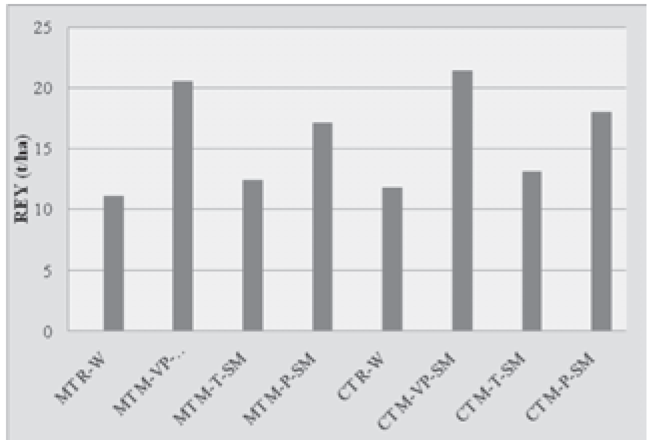

Fig. 1. Effect of tillage and cropping systems on rice equivalent yield
(MT- minimum tillage, CT- conventional tillage, M-maize, SM-spring maize, VP- vegetable pea, P- potato, T- toria, R- rice, W-wheat)

CONCLUSION

It can be concluded from the experiment that the maize-based cropping systems can be viable option for diversification of rice-wheat cropping system.

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Weed management for sustaining rice-wheat production through conservation agriculture

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Rice-wheat cropping system is one of the major dominating agricultural systems in India occupying 13.5 mha,covering about 32% and 42% of rice and wheat total acreage in the IGP India.In recent years, the rice-wheat cropping system fatigue intensive tillage and residue burning has weakened the natural resource base, which hampers the crop yield, soil health and disturbed the environment. Weeds are one of the responsible factors for production of rice-wheat cropping system, causing enormous losses in yield and quality of crop if not managed substitute methods are required to reduce cost of production, conserve natural resources, enhance productivity, and ensure environmental safety. Thus, RCT (conservation agriculture) like direct seeding of rice and zero till wheat along with retention of residues and manuring of (Sesbania) are being promoted in rice-wheat cropping under irrigated ecosystem. A field experiment was conducted in strip plot at N.E.B. CRC of GBPUA&T, Pantnagar, during 2012-13 to 2014-15.In rice, total grassy weeds were controlled under DSR(ZT)- wheat(ZT)- {Sesbania}(ZT) among different establishment system during 2013-15, while the BLWs and sedges were successfully controlled under TPR(CT)-wheat(ZT)-{Sesbania}(ZT) andTPR(CT)-wheat(CT), respectively. The average total biomassof weeds was found lowest under TPR(CT)-wheat(ZT)- {Sesbania}(ZT) from 2013-15. The yield was gradually increased with TPR(CT)- wheat(CT) during 3 years study while the average was achieved highest under TPR(CT)- wheat(ZT)- {Sesbania}(ZT) and it have highest B:C ratio i.e. 2.33. Among different weed management practices, there was lowest density of grassy, BLWs and sedges with their biomass and highest rice yield under IWM (bispyribac-Na 20 g/ha + 1 HW) and have maximum B:C ratio (2.3) over the last 3 years. In wheat, the average total density and biomass of grassy and non grassy weeds was found lowest under DSR(ZT)+R- wheat(ZT)+R- {Sesbania}(ZT). The density ofgrasses decreased gradually under DSR(CT)-wheat(CT)- {Sesbania}(ZT) over the 3 years while, the sedges were completely disappeared after Istunder different establishment methods of wheat and weed management practices. The yield of wheat gradually increased after Ist year under DSR(ZT)- wheat (ZT)- {Sesbania}(ZT) cropping system with maximum B:C ratio 2.29 during 3 years while average of 3 years in respect to highestyield was recorded under DSR(ZT)+R- wheat(ZT)+R- {Sesbania}(ZT). Among the weed management practices, IWM (clodinafop+MSM @ 60+4 g/ha) resulted in lower total density and biomass of weeds achieving highest yield with average B:C ratio(2.2) which was equally effective to sole application of herbicide. Note: DSR- direct seeded rice, TPR- transplanted rice, ZT-zero tillage, CT- conventional tillage, R- residue retention, IWM- integrated weed management, HW- hand weeding.

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Optimization of head feed combine parameters for harvesting of paddy varieties Pusa-1121

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Paddy is one of the most important crop for food security in India, contributing significantly towards providing food and livelihood for 130 million people. The area under paddy cultivation in India is around 44 million ha with production of 105 million tons in 2014 (Anonymous, 2015). Combine harvesters are mainly used for harvesting of wheat and rice in India. In head feed combine only the head parts are involved in the threshing device. The head feed combine also overcomes the problem of straw. It can process paddy straw in different ways, windrow them in an orderly manner or in bundles or cut them in even length and spread them uniformly on ground which will work as a mulch for succeeding crop. The performance of modern combines depends critically on straw throughput and grain losses. The threshing effectiveness and losses of combine harvester are greatly influenced by machine parameters viz. cylinder type, cylinder speed, number of crop rotation, feed rate, method of feeding and forward speed of operation. Crop parameters viz. moisture content of grain and straw, grain-straw ratio. Thus, a need to test and evaluate the head feed combine for efficient harvesting is initiated for its performance and economic feasibility in scented and non scented paddy varieties.

METHODOLOGY

The head feed combine (DSM 72) having loop type threshing mechanism was tested and the parameters (grain moisture, cylinder speed and forward speed) were optimized to achieve higher grain recovery and better quality with minimum cost of operation in paddy variety Pusa 1121. The combine was tested at three levels of moisture content (18.1, 20.3 and 22.4%), cylinder speed (14.42, 15.53 and 16.64 m/s) and forward speed (3.5, 4 and 4.5 km/h). The performance was analyzed based on threshing efficiency, cleaning efficiency and overall total grain losses. The study was conducted at farmers field in Tohana, Fatehabad, Haryana during 2014-15. Soil moisture content varied from 15.2 to 15.5% whereas grain moisture content varied from 18.1 to 22.4 %. Bulk density of the paddy fields varied from 1.48 to 1.50 g/cm3. Straw moisture content varied from 52.2 to 53.1%. Straw grain ratio was in the range of 1.26 to 1.45.

RESULTS

The threshing efficiency was directly proportional to cylinder speed and it was negatively correlated with moisture content and forward speed. It increased from 97.176 to 99.808% as the grain moisture decreased from 22.4 to 18.1% and cylinder speed increased from 14.42 m/s to 16.64 m/s at forward speed of 4.5 km/h. The cleaning efficiency was minimum at higher moisture content, forward speed and lower cylinder speed. Cleaning efficiency increased as the grain moisture content decreased from 22.4 to 18.1% and forward speed decreased from 3.5 to 4.0 km/h and cylinder speed increased from 14.42 to 15.53 m/s, but as cylinder speed increased from 15.53 to 16.64 m/s and forward speed increased from 4.0 to 4.5 km/h, the cleaning efficiency decreased. The total grain losses were maximum at higher moisture content and it decreased as the grain moisture content decreased from 22.4 to 18.1%. The total grain losses decreased as we increase the cylinder speed from 14.42 to 15.53 m/s at all levels of moisture content. Total grain losses increased as we increased the cylinder speed from 15.53 to 16.64 m/s at 18.1% moisture content.

CONCLUSION

Moisture content of 18.1%, cylinder speed of 15.53 m/s and forward speed of 4.0 km/h was found optimum for harvesting of scented paddy variety Pusa – 1121.

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Sustainable intensification of rice-fallow through conservation agriculture based management practices in Karnataka

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With the development of irrigation infrastructure in canal command areas of Karnataka, India; the irrigated puddled transplanted rice-rice rotation has been a major production system which contributes bulk of food and income in the state. However, the recent trends of climatechange induced weather aberrations and higher coefficient of variability inrainfall in terms of time, space and amount coupled with water, energy and labor scarcity and their higher costs have led to a paradigm shift in rice production from intensive tillage based transplanted rice to direct dry seeded rice (Pandey and Velasco, 2002; Jat *et al*., 2016).With the development and validation of DSR package of practices by University of Agricultural Sciences (UAS) Raichur and CIMMYT in collaboration with State Department of Agriculture, Government of Karnataka and other stakeholders' especially innovative farmers of the state; DSR now occupies large acreage in kharif season especially in tail end commands of Tungabhadra having large impact at scale. However, the growing water scarcity during winter, the farmers are compelled to keep their field fallow after *kharif* rice (12 m ha rice-fallow in India) led to bringingdown the copping intensity to half in these areas. This has large socio-economic implication on the farmers as well as on food and fodder security per se in the state. For achieving food, income and livelihood security of the farmers of the region; rice-fallow have to be sustainably intensified using conservation agriculture based management practices capturingresidual soil moistureand have shown tremendous potential in the study area. Keeping this in view we conducted two set of participatory multi-location validation trials on sustainable intensification of DSR-fallow using suitable oilseeds and pulses in Tungabhadra command of Karnataka, India.

METHODOLOGY

Participatory validation trials were conducted during 2015-16 in north-eastern dry agro-ecological zone of Karnataka, India. Soils of the region are calcareous vertisols with alkaline (pH8.01) to reaction, low in nitrogen (135 kg/ha), high phosphorous (255 kg/ha) and medium to high K (260kg/ha) status. Under the aegis of CGIAR-GoK consortium led by ICRISAT, two sets farmer's participatory validation trialswere conducted involving DSR-zero till mungbean (n=08) and DSR-zero till mustard (n= 56) and compared with DSR-fallow system in respective locations. Both mungbean and mustard crops were raised under residual moisture using zero tillage drilling or broadcasting of seeds in standing rice (relay cropping) after last irrigation or just before harvest of DSR when soil moisture was optimum. Both crops received no additional care of either nutrients or irrigation. A supervised harvest of the crops was conducted and whole plot yield was recorded and used for computation of economics using standard parameters and methodology of production economics.

RESULTS

Results of the participatory trials pertaining to crop yields, system (rice equivalents) yield, cost of production and net returns under DSR-fallow as well as sustainable intensification practices; DSR-ZT mungbean and DSR-ZT mustard are presented in Table1. The results revealed that in DSR-fallowsystem, the rice yields were recorded at 5.52-5.75 t/ha with net profits ranging from INR 67974 ± 7903 to 81319 ± 15173. However, sustainable intensification of DSR-fallow with zero till mungbean and mustardled to 0.56 and 0.32 t/ha mungbean and mustard seeds yields, respectively resulting in significant increase in system productivity (rice equivalent yield) (Table 1). The respective net returns under sustainable intensification of DSR-mungbean and DSR-mustard were increased by INR 10957 and 16791 compared to DSR-fallow. It is interesting to note thatabout 70% DSR fallows in the study area are now under DSR-Mustard that shows socio-economic impact of the technology. Such sustainable intensification approach not only provides higher income but also contribute to pulses and oilseed pool of the country.

CONCLUSION

Conservation agriculture based management practices enabled introduction of short duration high value crops like mungbean and mustard in residual moisture of rice-fallow systems and have helped to increase system productivity and

Table 1. Grain yield, cost of production and net returns of rice based systems with and without sustainable intensification of rice-fallow in Karnataka, India

	Grain yield (t/ha)			Total cost of cultivation (INR/ha)			Net returns (INR/ha)		
	Rice	Mungbean/ Mustard	System (REY)	Rice	Mungbean/ Mustard	System	Rice	Mungbean/ Mustard	System
Set-1 participatory trials (n=08)									
Rice (DSR)-Fallow	5.75 ± 0.30	0	5.75 ± 0.30	44809 ± 3230	0	44809 ± 3230	81319 ± 15173	0	81319 ± 15173
Rice (DSR)-ZT Mungbean	5.75 ± 0.30	0.56 ± 0.10	6.79 ± 0.31	44809 ± 3230	12078 ± 535	56887 ± 3327	81319 ± 15173	15957 ± 4368	97276 ± 14741
Set-2 participatory trials (n=56)									
Rice (DSR)-Fallow	5.52 ± 0.40	0	5.52 ± 0.40	47955 ± 2990	0	47955 ± 2990	67974 ± 7903	0	67974 ± 7903
Rice (DSR)-ZT Mustard	5.52 ± 0.40	0.32 ± 0.08	6.68 ± 0.39	47955 ± 2990	7484 ± 850	55439 ± 3312	67974 ± 7903	16791 ± 5170	84765 ± 8411

DSR-direct dry seeded rice with dry tillage, ZT-Zero tillage, REY-rice equivalent yield

farm profitability while producing additional oilseeds and pulses which can potentially contribute to making India self-sufficient in oilseeds and pulses.

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Symposium 9
Innovation Systems and Last Mile Delivery

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Evaluation of Crop Syst model for water productivity of *Bt* cotton

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Cotton popularly known as "White Gold" is grown mainly for fiber. In addition to this, cotton seed is second important source of the edible oils. To introduce improved production methods, knowledge is required on how the agro-ecosystem would respond to other alternatives. For this assessment, dynamic simulation models such as the crop soil simulation model CropSyst are useful tools. CropSyst (Stockle and Nelson, 1999) is a process-based model to simulate crop growth and water dynamics in the soil-plant atmosphere continuum. It has been widely used for cereals and other cropping systems (Stockle *et al.,* 1994). The accuracy of these predictive models depends upon the proper identification of input parameters.

METHODOLOGY

Field experiment was conducted at farmer's field of village Menawali in Hanumangarh district of Rajasthan during *kharif* 2012. The soil of the experimental site was brown to greyish brown in colour, besides being calcareous and slightly alkaline in reaction having 71.04, 10.5 and 18.4 % of sand, clay and silt, respectively with pH 7.9 and low soil organic matter content. *Bt* cotton cultivar Sarpas-7007 were sown @ 80 kg/ha in lines spaced at 60 cm x 45 cm on 05 May, 2012. Nitrogen @ 100 kg/ha and P_2O_5 @ 40 kg/ha were applied to the crop. Entire phosphorus was applied at the time of sowing of the crop, whereas half of the nitrogen was applied at the time of first irrigation and remaining half at flowering stage of crop.

RESULTS

The simulate yield (2066 kg/ha) of cotton were closer to the observed seed cotton yield of 1963 kg/ha as it is evident from the 13% RRMSE (Table 1). Simulations of early cotton aboveground biomass development matched the field data reasonably well. Final aboveground biomass, however, was overestimated by the model. The drop in aboveground biomass of the *Bt* cotton around late August was not properly captured by the model. As it was set for optimal conditions, CropSyst could not properly simulate the late season plant stress that impaired growth on these sites. The simulated N-uptake (101 kg/ha) was higher than observed N-uptake (77.61 kg/ha) with 25% RMSE. Correlation coefficient of 0.46 and Index of agreement of 0.42 observed for N-uptake of cotton. Increased uptake of N seems to be due to the fact that uptake of nutrient is a product of biomass accumulated by particular part and its nutrient content (Singh *et al.,* 2011). The total

Table 2. Soil water balance components, yield and water productivity of cotton

Component	Cotton
Inputs	
Irrigation (mm)	408.2
Rainfall (mm)	318.5
Total (mm)	726.7
Losses	
ET (mm)	558.6
Drainage (mm)	146.1
Stored soil moisture (mm)	22
Yield and water productivity	
Seed cotton yield (kg/ha)	1963
Water productivity (kg/ha mm)	2.7

Table 1. Quantitative measures of model performance for yield, AGB and N-uptake of cotton

Particular	Observed	Simulated	Root Mean Square Error	Correlation coefficient	Index of agreement
Seed yield	1963	2066	246	0.46	0.66
AGB	7474	7721	1068	0.34	0.61
N-uptake	77.61	101	25	0.46	0.42

water applied in *Bt* cotton was 727 mm out of this 559 mm may consume in ET (Table 2). Thus, ET constituted 77% of total water applied and deep drainage constituted 20% and rest 3% stored as residual soil moisture. Results showed that 1/5th of total water applied lost by deep drainage with crop water productivity of 2.7 kg/ha mm.

CONCLUSION

The calibrated CropSyst model (version 4.15.24) predicted the above ground biomass and economic yield better compared to N-uptake.

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Effect of seaweed saps on productivity and profitability of soybean (*Glycine max*)

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Soybean (*Glycine max* (L.) Merrill.) is an important nitrogen fixing leguminous crop grown as a rainfed *Kharif* (wet season) crop in Chotanagpur region of Jharkhand. However, inspite of all sorts of efforts its area and production could not be increased in the state due to poor exploitation of production technique. To enhance the productivity of soybean farmers used chemical fertilizers in great quantities and its long term use has damaged the physio-chemical character, microflora and their micro-ecology of soil. Chemical fertilizer killed many soil organisms that are responsible for decomposition and soil formation. Today there is growing concern that environmental pollution caused by imbalanced use and misuse of chemical fertilizer is directly or indirectly related to human health problem. But, unlike chemical fertilizers extracts derived from seaweeds are biodegradable, non-toxic, non-polluting and non-hazardous to humans, animals and environment. Seaweeds are the macroscopic, multi cellular marine algae that commonly inhabit the coastal regions of the world's ocean. Seaweed extracts contains major and minor nutrients, amino acids , vitamins, cytokinins, auxin and abscisic acid like growth promoting substances and have been reported to stimulate the growth and yield of plants develop tolerance to environmental stress, increase nutrient uptake from soil and enhances antioxidant properties. So, utilization of seaweed sap will be useful for achieving higher agricultural production. Therefore, it is high time to strengthen the research programme on such sources which may prove an important substitute for chemical fertilizer for not only to maximize production but also to make the environment sustainable.

METHODOLOGY

The field experiment was conducted during the *kharif* season of 2012 at Birsa Agricultural University, Ranchi, Jharkhand. The experiment was conducted in Randomized Block Design with 17 treatments replicated thrice. Treatment consists of seaweed sap of *Kappaphycus alvarzii* (K-sap) and *Gracillaria edulis* (G-sap) each of which is applied at five concentration level viz., 2.5, 5.0, 7.5, 10 and 15% with 100% recommended dose of fertilizer (20:80:40 kg N:P_2O_5:K_2O/ha) and three concentration level *viz.,* 7.5, 10 and 15% with 50% recommended dose of fertilizer along with one control plot with 100% recommended dose of fertilizer. The seaweed sap was sprayed at 30, 45 and 60 days after sowing as per the treatments. Soybean variety RKS-18 was selected for the experimental study.

RESULTS

Result revealed that application of 100% recommended dose of fertilizer (Table 1) with 7.5% K sap concentration produced significantly higher grain yield (1.67 t/ha) and straw yield (2.14 t/ha) than all other combination of seaweed sap

Table 1. Effect of seaweed sap on productivity and profitability of soybean

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Net return (Rs/ha)	Benefit: cost ratio
100% RDF + water spray	1.20	1.77	8307	0.45
100% RDF + 2.5% K sap	1.35	1.85	10548	0.53
100% RDF + 5% K sap	1.47	1.94	12014	0.58
100% RDF + 7.5 K sap	1.67	2.14	15476	0.70
100% RDF + 10% K sap	1.55	2.03	11686	0.51
100% RDF + 15% K sap	1.42	1.99	6531	0.26
50% RDF + 7.5 K sap	1.01	1.63	3599	0.19
50% RDF +10% K sap	1.15	1.75	5518	0.27
50% RDF +15% K sap	1.29	1.88	6515	0.29
100% RDF +2.5% G sap	1.27	1.85	8634	0.44
100% RDF + 5% G sap	1.39	1.93	10351	0.50
100% RDF +7.5% G sap	1.51	2.02	11764	0.53
100% RDF +10% G sap	1.67	2.13	14244	0.62
100% RDF +15% G sap	1.54	2.03	9150	0.36
50% RDF +7.5% G sap	1.00	1.61	3343	0.18
50% RDF +10% G sap	1.12	1.71	4992	0.25
50% RDF+15% G sap	1.27	1.88	6005	0.27
SEm±	0.05	0.07	1114	0.05
CD (P=0.05)	0.15	0.21	3267	0.15

concentration either with 100 or 50% RDF as well as control except 10% K sap, 10% G sap and 15% G sap with 100% RDF. Increase in K sap concentration beyond 7.5% sap concentration, led to decline in grain yield up to 15% K sap concentration. Similarly, increase in G sap concentration with 100% RDF increased the grain yield and highest grain yield was recorded at 10% G sap concentration thereafter grain yield decline at higher concentration of 15% G sap. Grain yield (1.66 t/ha) and straw yield (2.13 t/ha) at 10% G sap was found significantly superior over lower concentration of G sap and water spray but remained at par to its higher concentration i.e. 15% G sap. The net return (Rs. 15476/ha) and B:C ratio (0.70) was also recorded highest with the application of 7.5% K sap with 100% RDF. Significant effect of K sap on productivity and profitability was also reported by Singh *et al.,* (2015).

CONCLUSION

Application of 7.5% K sap along with 100% recommended dose of fertilizer proved to be more productive and economically viable for soybean cultivation in rainfed areas of Jharkhand.

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Enrichment of wheat grains with zinc through agronomic biofortification across Northern states of India

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For the last about two decades, Zn deficiency is receive an increasing attention not only by agronomists, nutritionists, medical scientists, but also by social economists. It has been recognized as a serious threat to human health, especially to women and child nutrition. Zinc deficiency along with vitamin A deficiency, has been considered as the priority problem facing the world currently by eight worldwide distinguished economists (including five Nobel Laureates) at the Copenhagen Consensus Conference. Worldwide, out of three major cereal crops, wheat (*Triticum aestivum* L.) represents a main dietary source of calories, proteins and micronutrients for the majority of world's population, especially in the developing world (Zou *et al.*, 2012).

METHODOLOGY

Wheat (*Triticum aestivum* L.) crop (HD 2967) was grown in twenty five different locations across four Northern states of India namely, Uttar Pradesh, Himachal Pradesh, Punjab and Haryana during *rabi season* 2014-15. Experimental design was randomized complete block design with three replications. Wheat was grown under three different Zn applications rates as follows: i) nil (no Zn treatment), ii) soil Zn application, iii) foliar Zn application. The soil Zn treatment consisted of 50 kg $ZnSO_4.7H_2O$/ha applied to the soil before sowing. The foliar Zn treatment, a 0.5% (w/v) aqueous solution of $ZnSO_4.7H_2O$ was sprayed on the standing crop. Foliar Zn applications were realized 2 times: first at anthesis stage and the second one at early milk stage (after 90-95 and 110-115 days of sowing). All grain samples were carefully and thoroughly washed by tap water and then distilled water before drying at about 65 °C. The samples were digested with di-acid HNO_3:$HClO_3$ (9:4 ratio) and the Zn concentration in the digested solution was measured using Atomic Absorption Spectrophotometer (AAS).

RESULTS

Zinc concentration in wheat grain varied significantly at different locations and the lowest and highest increment of Zn concentration in grain as compared to control are presented in Table 1. In the control treatment, when Zn was not applied, the grain Zn concentrations varied from 14.6 to 23.3 mg/kg with an average of 19.3 mg/kg. The foliar Zn application resulted in significant increase in grain Zn concentration at all locations. On an average, for all experimental locations, the grain Zn concentrations ranges from 26.3 mg/kg to 43.9 mg/kg by foliar Zn application.

CONCLUSION

In conclusion, foliar Zn application to wheat at two stages of growth *i.e.* the booting and milk stages, represents an effective agronomic practice to contribute increase in Zn concentration in wheat grain. Foliar spray Zn significantly increased grain Zn concentrations and this positive impact occurred consistently over a wide range of environments.

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Table 1. Summary of percentage increase of Zn concentration in wheat grain across four states of India during *rabi* 2014-15

	Control (mg/kg)	Zn + (Soil) (mg/kg)	Zn conc. increase (%) over control due to soil Zn	Zn+ (Foliar) (mg/kg)	Zn conc. increase (%) over control due to foliar Zn
Min	14.6	14.9	0.1	26.3	47.6
Max	23.3	23.5	6.3	43.9	93.7
Average	19.3	19.6	1.6	33.5	74.0

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Agronomic bio-fortification of zinc in wheat grainsin north-western plains of India for nutritional security

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Introduction of high yielding dwarf wheat varieties during green revolution and continuous efforts of management practices, in relation to fertilizers, irrigation and pesticides etc. resulted in tremendous increase in wheat production of India. However, low density of micronutrients like zinc (Zn) in wheat grains is a serious issue to be concerned in regard to nutritional quality. Zn is one of essential micronutrients for humans as well as plants.Deficiency of Zn in soils of Punjab and other adjoining states (Haryana and Uttar Pradesh) is decreasing because of use of zinc sulphate fertilizer in rice by farmers.More than 30% world's population suffers from Zn deficiency. Zinc plays a part in the basic roles of cellular functions in all living organisms and is also involved in improving the human immune system.Zn plays very important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fractions and synthesis of cytochrome. The Zn is required for integrity of cellular membranes to preserve the structural orientation of macromolecules and ion transport systems.Bio-fortification of zinc in food grain crops like wheat can be achieved by breeding zinc rich wheat genotypes (Genetic biofortification) and through application of foliar zinc sulphate fertilizer on the crop anthesis and early milk stage (Agronomic bio-fortification). Zinc biofortified wheat genotypes using wild germplasm through breeding approaches and screening of high zinc varieties have been carried out in various international research programmes. But enhancement in uptake potential of wheat would be advantageous only if the soil has sufficient zinc pool. Genetic biofortification is long-term and permanent approach to alleviate zinc deficiency in human being. Application of zinc containing fertilizer through soil and foliar means is the only shot-gun and cost effective approach to solve the above issue.

METHODOLOGY

The field experiment was conducted at four location in RDB with four treatments (No zinc application, soil zinc application @62.5 kg/ha, one foliar application of 0.5% zinc sulphate heptahydrate at milking stage and two foliar zinc sulphate hepta-hydrate application at anthesis and milking stage). All other agronomic practices were followed as per recommendation of the Punjab Agricultural University, Ludhiana, India. The data on grain yield and grain zinc concentration was generated and analyzed as per standard statistical methods at p=0.05.

RESULTS

Studies have shown that application of zinc sulphate in soil and foliar zinc application in early stages of the crop growth cannot enrich the grains with zinc (Fig 1).Many studies conducted in Punjab have shown shows that foliar application of 0.5% zinc sulphate (Zn 21%) at the time of athesis and near early milk stages of wheat crop can enrich the grains. The results shows that application of zinc in soil could not increase the zinc content in the wheat grains but when the 0.5% zinc sulphate (Zn 21%) was applied at the anthesis and early milk stages, the grain zinc was enriched by 42% over the control plot where no zinc was used. Ram *et al.* (2015) also reported enhanced zinc content in wheat grains with foliar application at early milk development stages. Basic aim of such a bio-fortification strategy is to provide bio-fortified food to populations of India and to alleviate the zinc malnutrition in human being.

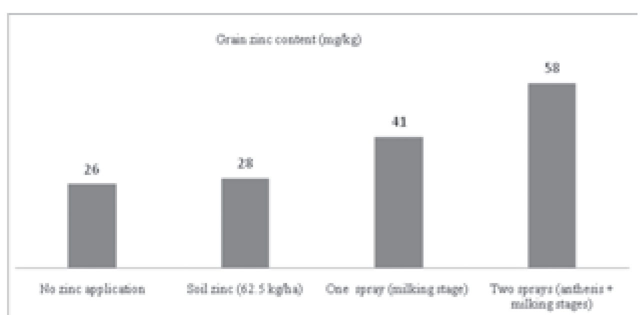

Fig. 1. Enrichment of wheat grain with zinc by foliar application of 0.5% zinc sulphate (21% Zn) Foliar application of 0.5% zinc sulphate (Zn 21%) at the anthesis and early milk stages in wheat can enhance the grain zinc in wheat.

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Impact of technology adoption on increasing area and productivity of sugarcane in Bijnor district

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Krishi Vigyan Kendra, Nagina, Bijnor (U.P.) popularizing the so many newly developed technology among the farmers through different extension tools, one of them cultivation of sugarcane through trench method extensively focussed by KVK scientists during last 4-5 years. Cultivar variety Co–0238 (Karan-4) was also popularized. The impact of this particular technology (trench method) on sugarcane growers was very impressive. The data, average yield, yield increase percent of demonstration plot against traditional practice were worked out. The increasing of area under adopted technology in district also worked out. The results of study on average basis, revealed that yield obtained under demonstrated plots were 1050 quintal/ ha over traditional method 585 quintal/ ha and farmer get 465 quintal/ha as additional yield of sugarcane in case of September planting. The average productivity of sugarcane was increased 79 % by adoption of this technology. The result clearly showed the positive effect over the existence practices towards the enhancing the productivity of sugarcane in Bijnor district. Benefit cost ratio was also higher under this technology against traditional practices during the years of technology demonstration. The area under this technology has now spread to more than 35000 ha and successfully 18% area of traditional method was replaced in district by this technology. Farmers are highly satisfied with the yield of this technology.

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Innovative farming practices under the changing climate in the North Western Himalayan region, India

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The transformation of atmospheric carbon (C) to plant biomass and soil organic matter along with reducing green house gas (GHG) emission has become a worldwide strategy to mitigate the effect of climate change. The great potential of C sequestration in cropland has provided a promising approach to reducing the atmospheric concentration of CO_2. Furthermore, reduced tillage, nutrient management etc. are some management practices that can be implemented to promote C sequestration. Adoption of zero/minimum tillage, residue retention/ incorporation and crop diversification could be a viable alternative for better resource conservation and overcome the imposed constraints of the climate change and high input costs. At the same time, crop diversification and intensification which include legumes, oilseeds, vegetables, high-value crops and employment-generating crops can improve the economic condition of small and marginal farmers owing to higher price and higher volume of their main and byproducts. Conventional tillage is known to decrease the soil organic matter because of more oxidation and breakdown of organic C and ultimately degradation of soil properties (Gathala *et al.,* 2011). While, zero/minimum tillage can minimize the rapid breakdown of plant residues, reduce CO_2 emission and can increase productivity and soil quality, mainly through soil organic matter (SOM) build-up and higher soil organic carbon (SOC) (Parihar *et al.,* 2016) as compared to conventional tillage. Similarly, cropping intensity and residue retention tends to increase SOC and microbial biomass. To identify the best management practices for improvement in productivity and soil health under the changing climate this study was undertaken.

METHODOLOGY

A field experiment was carried out at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, India, situated at $32^0 6'$ N and $76^0 3'$ E and 1290 m amsl during *kharif* 2012–*rabi* 2014. The experiment was laid out in split-plot design with three replications. The treatments in main plot were the combinations of two tillage methods *viz.,* minimum/zero tillage (ZT) and conventional tillage (CT), three cropping systems *viz.,* maize-wheat (M-W), baby corn+frenchbean - pea - summer squash (BC+FB-P-SS) and maize+soybean - gobhi sarson+toria (M+S-GS+T). The treatments in sub-plot were the combinations of two mulch levels *viz.,* no mulch (NM) and crop residue mulch (CRM) @ 5 tonne/ha, and two fertilizer levels *viz.,* recommended dose of fertilizers (RDF) and 75% of RDF + 25% N through FYM (INM). For comparison between crop sequences, the yields of crops were converted into maize-grain equivalent yield (MGEY) on prevalent market price basis and expressed as tonne/ha. Chemical analyses of plants were done by following the standard procedures.

RESULTS

Table 1 revealed that ZT resulted in significantly higher Cu and Mn after completion of experiment as compared to CT. Less oxidation of *in situ* organic matter (roots, etc.) due to the absence of soil redistribution and increased microbial population might have increased micro nutrient status in the soil. Similarly, INM resulted in significantly higher Fe content as compared to recommended dose of fertilizer. The results are in accordance with Nasrat *et al.* (2013) from Bangalore. CT produced significantly higher MGEY owing to higher production of individual crops due to better pulverization of soil resulting in better air exchange and high nutrient availability over ZT. However, ZT was comparable to CT in influencing the biological yield and overall C fixation. Among cropping systems, BC+FB-P-SS gave higher MGEY (190.8%) over the traditional M-W cropping sequence. Higher production and higher market value of vegetables like baby corn, French bean, pea and summer squash was the main reason of higher MGEY. However, M-W produced the significantly highest dry biomass as compared to M+S-GS+T and BC+FB-P-SS. So, producing more biomass, CO_2 can be removed from the atmosphere and converted to organic C through the process of photosynthesis and can drastically increase the amount of C stored in soils through voluminous root system. These results clearly indicated that the conventional M-W system cannot be completely given up for want of higher income from the new vegetable based cropping systems. Application of crop residue mulch increased MGEY by 7.5% over the yield obtained in plots without mulch. Improvement in moisture with re-

Table 1. Effect of resource conservation technologies on soil micro nutrients (ppm) after completion of experiment, MGEY (tonne/ha) and biological yield [Dry weight basis (tonnes/ha)]

Treatment	Zn	Cu	Fe	Mn	MGEY	Biological yield
Tillage						
ZT	1.59	0.92	25.32	1.66	13.18	16.78
CT	1.64	0.99	26.23	1.75	14.66	17.54
SEm±	0.03	0.02	0.50	0.03	0.29	328.39
CD (P=0.05)	NS	0.05	NS	0.09	0.92	NS
Cropping system						
M-W	1.58	0.95	25.10	1.68	8.04	20.72
BC+FB-P-SS	1.64	0.95	26.14	1.71	23.38	11.32
M+S-GS+T	1.63	0.97	26.07	1.72	10.34	19.44
SEm±	0.04	0.02	0.61	0.03	0.36	0.40
CD (P=0.05)	NS	NS	NS	NS	1.13	1.27
Mulch						
NM	1.58	0.95	25.57	1.70	13.43	17.18
CRM	1.66	0.96	25.97	1.71	14.42	17.14
SEm±	0.03	0.01	0.14	0.02	0.12	0.15
LSD (P=0.05)	NS	NS	NS	NS	0.34	NS
Fertilizer						
RDF	1.59	0.95	25.48	1.69	13.63	16.75
INM	1.65	0.96	26.07	1.71	14.22	17.57
SEm±	0.03	0.01	0.14	0.02	0.12	0.15
CD (P=0.05)	NS	NS	0.41	NS	0.34	NS

duced water evaporation losses and fluctuations in water availability, heat and air regime and weed suppression favoured the crop growth, hence higher yield (Kumar *et al.,* 2013). Improvement in soil fertility with addition of organic manure in INM resulted in significantly higher MGEY (4.3%) over pure inorganics. Further, replacing 25% N through FYM resulted in overall higher dry biological yield of crops as compared to alone application of fertilizers. One of the primary sources of GHGs in agriculture is the production of nitrogen based fertilizers (fossil fuel consumption in manufacturing fertilizers). So, replacing fertilizers with FYM can act as mitigation strategies for GHGs emission.

CONCLUSION

From the above results, it was concluded that CT proved to be best in terms of MGEY than ZT. But, ZT was as good as CT in influencing the biological yield and C fixation. Further, diversifying the existing cropping system with vegetable based cropping system can be more profitable to the hill farmers. However, the conventional M-W system cannot be completely given up but should be proportionally diversified so both livelihood and environmental security can be achieved.

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Enhancing productivity of sesame (*Sesamum indicum)* utilizing seaweed sap

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The productivity of sesame grown during kharif season is very low due to poor agronomic management practices and use of low yielding cultivars. With the growing health consciousness, the international demand and export of sesame are continuously increasing. To enhance the production of sesame, the technology needs reorientation and refinement. Seaweed (Kappaphycus alvarezii and Gracillaria edulis) extract has been found rich in nutrients and plant growth regulators i.e. IAA, kinetin, zeatine and gibberellins (Zodape et al., 2009). Recently, seaweed fertilizers are preferred not only due to cheaper source of nutrients but also the presence of plant growth regulators. Seaweed extract can be used as an alternative liquid fertilizer for improvement in yield and quality of crops (Shah et al., 2012). Seaweed fertilizer could be easily absorbed by plant and safe to human, animals and environment. Hence, marine algae particularly seaweeds have vital role to play in agriculture especially in third world countries, where irrational use of chemical fertilizers and pesticides is a cause of concern.

METHODOLOGY

A field experiment was carried out at Birsa Agricultural University, Ranchi, Jharkhand with an average annual rainfall of 1450 mm to find out the suitable concentration and species of seaweed along with chemical fertilizers for enhancing growth and yield of sesame (Cv. Gujrat Til 1) during rainy season. The soil of experimental site was sandy-loam with pH 5.0, low in organic carbon 4.1 g/kg, and available N (225 kg/ha), medium in available P (13.4 kg/ha) and available K (150 kg/ha). Treatments comprised of seaweed sap of *Kappaphycus* and *Gracilaria spp*. each of which was applied at five concentrations *i.e.* 2.5%, 5%, 7.5%, 10% and 15% with 100% RDF and three concentration level *i.e.* 7.5%, 10% and 15% with 50% RDF along with two control plots with 100% RDF and 50%. The experiment was laid out in randomized block design with eighteen treatments replicated thrice. The recommended fertilizer dose of 40 kg N, 40 kg P_2O_5 and 20 kg K_2O/ha was applied to sesame as per the requirement

Table 1. Yield of sesame as affected by seaweed sap, its concentration and fertilizer levels

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
T_1: 100% RDF + Water spray	602.56	2063.63	22.66
T_2: 50% RDF + Water spray	413.75	1401.11	22.78
T_3: 100% RDF + 2.5% K sap spray	644.49	2067.39	23.78
T_4: 100% RDF + 5% K sap spray	668.36	2120.23	23.97
T_5: 100% RDF + 7.5% K sap spray	709.85	2226.42	24.16
T_6: 100% RDF + 10% K sap spray	795.51	2391.99	24.97
T_7: 100% RDF + 15% K sap spray	737.70	2284.00	24.40
T_8: 50% RDF + 7.5% K sap spray	483.65	1512.75	24.36
T_9: 50% RDF + 10% K sap spray	526.85	1634.36	24.45
T_{10}: 50% RDF + 15% K sap spray	562.65	1717.33	24.68
T_{11}: 100% RDF + 2.5% G sap spray	642.22	2052.57	23.81
T_{12}: 100% RDF + 5% G sap spray	654.72	2084.91	23.91
T_{13}: 100% RDF + 7.5% G sap spray	676.32	2108.79	24.29
T_{14}: 100% RDF + 10% G sap spray	704.73	2157.10	24.62
T_{15}: 100% RDF + 15% G sap spray	746.22	2251.60	24.90
T_{16}: 50% RDF + 7.5% G sap spray	452.39	1400.17	24.59
T_{17}: 50% RDF + 10% G sap spray	509.23	1578.90	24.39
T_{18}: 50% RDF + 15% G sap spray	524.57	1605.88	24.62
SEm±	34.43	119.37	0.51
CD (P=0.05)	100.98	350.12	NS

the treatments. Half amount of N as urea with full dose of P as single super phosphate (SSP) and K as muriate of potash (MOP) were applied as a basal and remaining N at 25 days after sowing. All the materials like seaweed saps were received from Central Salt and Marine Chemicals Research Institute (CSMCRI). Standard agronomic practices were followed uniformly for all the treatments.

RESULTS

Data pertaining to yield revealed that concentration of seaweed sap and fertilizer level significantly influenced the seed and stover yield of sesame (Table 1). Application of 100% recommended fertilizer dose followed by 10% K sap concentration produced maximum seed yield which was significantly higher than all other concentrations of seaweed saps either with 100 or 50% recommended fertilizer dose (RDF) except 7.5%, 15% K sap and 10% and 15% G sap with 100% RDF. Increase in K sap concentration beyond 10%, led to decline in seed yield. In case of G sap application, there was a steady increase in seed yield up to 15% sap concentration. The application of 10% K sap and 15% G sap with 100% RDF brought 32.02% and 23.84% increase in seed yield of sesame over 100% RDF with water spray. Results also revealed that maximum improvement in growth, yield attributing characters, content and yield of protein and oil in sesame, net return *etc*. recorded at 10% concentration of K sap with 100% RDF. Application of 10 % K sap remained at par with the application of 15% G sap in similar combination with fertilizer with regards to growth, yield and nutrient uptake.

CONCLUSION

It may be concluded that application of 100% RDF (40 kg N, 40 kg P_20_5 and K_20/ha) followed by spraying of 10% K sap would be a viable option for improving productivity, quality and economics of sesame in rainfed areas of Jharkhand.

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e- Kapas: An Innovative Delivery System of CICR for Cotton Farmers

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Among agricultural crops, cotton is one of the principal cash crops of India and plays a vital role in the country's economic growth by providing substantial employment and making significant contributions to export earnings (Nolkha, 2013). India ranked top in world acreage of cotton and second in production, however, our productivity 481 kg/ha is lower than the world average (763k1i/ha). Even the yield of cotton in China is 2.7 times more than that of India (DES, 2014). To disseminate advanced agriculture including cotton technological information to its 120 million farm holding ,we require at least 1.3 to 1.5 million extension personnel against which the present availability is only 0.1 million (GOI, 2007). ICTs can strengthen agriculture sector through facilitating timely information (Rao, 2007, Balaji e/ *at.,* 2007, Sarvanan, 2010, Karthikeyan, 2015). 'e Kapas' which refers to utilization of infoririatioii and communication technologies (ICTs) for delivering cotton based technologies to farmers, extension workers and other development workers engaged in cotton system benefit to improve the efficiency of the current system to save money and time in comparison to manual systems. It is the 'anywhere and anytime' availability of cotton technologies and services to users and connecting the cotton growers nationally for timely and relevant information (Wasiiik e/ *at.,* 2014). The main objective of the study was to deliver location specific, time sensitive and important alerts based on cotton technologies to farmers, extension workers and other development workers engaged in cotton system and to improve the efficiency of the current system to save money and time in comparison to manual systems. Utilization of e-Kapas services and feedback of farmers towards delivery of voice messages was also gathered during the study.

METHODOLOGY

ICAR-Central Institute for Cotton Research, Nagpur introduced a novel extension mechanism 'e- Kapas Network' project nationally from April, 2012. The project was implemented at 18 centres in eleven cotton growing states of the country with CICR Nagpur as Lead centre. The other participating centres included CICR Regional station Coimbatore (TN); CICR Regional station Sirsa (Haryana) and 14 AICCIP- SAUs centres '.e UAS, Dharwad (Karnataka); JAU, Junagarh (Gujrat); MPAUT, Banswara (Rajsthan); RAU, SrigangaNagar (Rajsthan) ; ANGRAU, Lam Guntur (AP) ; NAU, Surat (Gujrat) ; CCSHAU, Hisar (Haryana); Faridkot PAU, Ludhiana (Punjab) ; PDKV, Akola (MS); OUAT, Bhawanipatnam (Orrissa) ; RVSKVV, Khandawa (MP); VNMKV, Parabhani (MS) ; MPKV, Rahuri (MS), UAS Raichur (Karnataka) and DOR, Hyderabad (Telangana). These centres caters the need in local language and provides opportunities to the cotton growers to get relevant, location

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Livelihood Security and Farmers Prosperity

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Smallholder agriculture in Eastern India: Trends, constraints and opportunities

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Smallholder agriculture continues to play a key role in Indian agriculture.Smallholder farmers can be categorized on the basis of: (i) the agro-ecological zones in which they operate; (ii) the type and composition of their farm assortment and landholding; or (iii) on the basis of annual income they generate from farming activities. In these agriculture-based economies, smallholder farming accounts for about 78 percent of the country's farmers, but own only 33 percent of the total cultivated land; they nonetheless produce 41 percent of the country's food-grains. Population increase, urbanization and income growth will drive the demand for food while high energy prices, stress on natural resources, and climate change may act to constrain supply. India's small-holder farmers (those owning less than 2.0 ha of farmland) comprise. Smallholder families organize more than half of the national population. It is thus disappointing that nevertheless their substantial and increasing contribution to the national food supply and to agricultural GDP, these small-holder families nonetheless constitute more than half of the nation's totals of hungry and poor.Revitalizing the agricultural sector, and in particular smallholder agriculture, is a precondition for achieving high and sustainable growth, poverty reduction and food security in Eastern India. Despite its enormous potential, however, the performance of agriculture (including smallholders) has so far been disappointing. Recent growth acceleration in West Bengal and a few successful sub-sectors in other studied countries notwithstanding, contributions of smallholder farming, and agriculture in general, to the region's recent rapid growth during 2005 - 08 have remained limited. The sector has so far failed to provide the basis for development, including through industrialization, in spite of a series of reform attempts undertaken in these countries. The concerted efforts of all stakeholders, including governments, NGOs, and development practitioners are needed to remove the existing bottlenecks to productivity growth in smallholder agriculture and progress with the region's development agenda.

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Farming for livelihood security in tropical islands of India

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The two union territories of India i.e. Andaman & Nicobar Islands (ANI):a group of 572 islands of which 38 are inhabited (3, 79,994 people; 2011 census) located in the Bay of Bengal and Lakshadweep islands (LDI):a group of 36 islands of which 10 are inhabited (64,429 people; 2011 census) and is located in the Arabian sea are of immense strategic importance to the country. The livelihoods of the people of both the islands are intrinsically linked to the coastal artisanal fishing mixed farming system. In ANI, artisanal fishing (14,839 fisherman in 2013-14), crop production (often multi-storied coconut, areca nut plantations with spices, root crops as inter crops, cashew nut, oil palm, rubber are also seen in small scale and fruits on 28, 129 ha; and rice and or vegetable cultivation on 14, 710 ha by 21,339 farmers in 2013-14) and animal husbandry activities (piggery, goatery, poultry, dairying; by 68,713 households in 2013-14)contribute 9.2% of total GDP. In LDI, artisanal fishing (8.060 fisherman in 2012), crop production (coconut plantations on 2,579 ha by 10,209 farmers in 2003) and animal husbandry activities (goatery, poultry, dairying by 13, 224 households in 2012) forms the most important source of income (>50% of total GDP) and thus their livelihoods. Tourism forms the backbone of ANI economy than that of LDI. The animal products production is exclusively done for the local consumption in both the islands while marine fishing (tuna) is done to cater to the needs of both local consumption as well as export to the main land.Rice (in *kharif*) and vegetables (throughout the year) are produced to meet the local demand while the deficit of these items and other food articles are brought from mainland in ANI. In LDI as coconut is the only crop cultivated all food items including rice are brought from mainland. The islanders have an annual income of Rs. 89, 259 in 2012-13 in ANI and 51, 320 in 2011 in LDI. The livelihoods of the island farmers and thus the consumers to some extent are threatened by the following developments and suitable corrections evolved at the CIARI are discussed below.

The Tsunami of 26th December, 2004 in ANI inciting a death toll of 10,136 peoplelives has resulted in a drastic decline in decadal population growth rate (from 26.94 during 1991-2001to 6.68 during 2001-11). Lakshadweep also has a slow growth rate (6.2% during 2001-11). The sea water ingress (both surface and underground) on to farmlands under impact of tsunami led to their salinization and these lands were left fallow as reclamation is uneconomical and many other socio-economic reasons. This loss in productive lands from Tsunami coupled with the 2003 ban on clearing forests for logging and agriculture by Supreme Court has closed scope for horizontal expansion of farming to meet local agricultural products demand. Though, there is not much variation in acreage of perennial crops (especially plantation crops) in the Islands in the aftermath of Tsunami, annual food crop of rice has recorded a complete shift of its cultivation from South Andaman district (this has recorded a submergence of land by over 1 m) to North & Middle Andaman district (recorded uplift of land from sea). Development of salt tolerant varieties in the islands (CARI Dhan 4 & 5) or their introduction (CSR 23 & 36) from main land with higher productivity has been exploited for enhancing productivity of Tsunami affected saline lands. By altering the land shape through formation of broad bed and furrows, rice and fish (furrow) and vegetables (on bund) are cultivated and the cultivation of vegetables was found more attractive farmers of South Andaman. The land use for agriculture in LDI is at its peak and no scope lies for its expansion. The rise in sea level is an impeding threat to the farming and thus the livelihoods of LDI all together and in Andamans (South Andaman & Nicobar districts) to a small extent.

Incomplete reliance oneither organic or inorganic mode of farming is hindering the farmers from realizing sustainable yields and income. In selected locations (Neil island), organic farming is being taken up to tap the potential organic market of the country. In other areas, inorganic farming can be braced up to strengthen the farmer's pockets. Low level of mechanization and escalating labour costs are eroding the profitability of farming. The agriculture department initiative to supply tractors, power tillers and other farm machineries (paddy reaper, paddy transplanter, palm climbers, tree pruners / trimmers, copra driers) to the farmers on loan/cash-cum-subsidy basis and to organize demonstrations and trainings for their increased use aregradually addressing the problem of labour shortage and its high cost issues. Concentration on primary production with little value addition andfacing plethora marketing constraintsthe livelihood security of farmers of the islands is threatened. To step up the processing in the islands, through RKVY, 2 cashew nut processing units(at Diglipur and Kamorta), virgin coconut oil extracting unit (at Chouldhari), 10 copra driers(to Tribal councils) and cold room chambers (27 at various Gram Panchayats, Tribal Councils and ANCOFED) with a storage facility of 68 tons have been established. Milk collection and processing plants establishment by Andaman and Nicobar Islands Integrated Development Corporation Limited (ANIIDCO)is a welcome development for boosting dairy sector in the islands. Development of low cost and locally manufactured feeds is a impediment to progress of both animal husbandry and fisheries sector in the islands. Utilizing the local agricultural farm products, many value added products are developed on research mode and the same was transferred to farmers through organizing trainings to stakeholders by CIARI under Ministry of Food Processing Industries (MOFPI) supported project that will go a long way in strengthening the post harvest activities in the islands and broadening the islands livelihood base.

Climate is changing slowly and continually in the islands that is evident from the increasing sea / land surface temperatures and shifting rainfall patterns. Rice and coconut, the main crops of islands being C_3 crops were found to gain in productivity from changing climate is a great relief to the ecosystem and farmers with little adaptive / mitigative capabilities. Increasing sea surface temperatures unabated may lead to outmigration of fishes. High land temperatures enhancing evaporation form farm landscapes may call for protective irrigation or moisture conservation for success. With shift in rainfall (no or little rain during January-April) patterns,in rice based systems, use of medium duration rice cultivars becomes inevitable for its rotation with vegetable cultivation. Zero tillage cultivation may come handy in shortening the turnover periods between rice and vegetable/other crops. Livestock and fresh water aquaculture may need alternate reliable sources of water for their success.Insurance of farming may become essential. To implement the Weather Based Crop Insurance scheme, 30 automatic weather stations were installed across the Andaman and Nicobar Islands.CIARI has prepared contingency plans for all the three districts of the islands to tackle the possible eventualities of farming. The farming systems evolved at CIARI will also cater to overcome the shocks of farming in the islands. The livelihoods of islands are threatened with rapid changes in the ecosystem and by adapting suitable strategies; the threats on farming can be minimized and the livelihoods can be sustained.

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Multi-enterprise agriculture for sustaining livelihood security of small farmers in Indo-Gangetic plains

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Nearly half of the total geographical area of Indo-Gangetic Plains (IGP) of South Asia is devoted to agriculture which provides livelihood and employment to 1.8 billion people (Gupta and Seth, 2007). The region is characterized by lowest per capita availability of land, inequitable agrarian structure and resource poor farmers (Singh *et al*, 2011).Under frequent occurrences of climate change trigged natural calamities, livelihood security of the farmers and increased demand for food are the major challenges in this region.Continuity of Rice-wheat system in IGP of India has raised serious concerns on degradation of soil health and shrinking fresh water resources. Integration of various farm enterprises in the form of multi-enterprise farming system may offer sustainable solutions to these problems, especially for the increasing number of small holders in the region. Study on multi-enterprise agriculture to improve theagricultural productivity and profitability per unit area was carried out for six years (2007-13) at ICAR-Central Soil Salinity Research Institute, Karnal, India in reclaimed sodic environment. This pilot study explored the integration and synergies that can take place in integratedfarming and evaluated the role of these systems to enhance the availability of and access to food and increase household incomes and employment of smallholders.

METHODOLOGY

Out of the total 2.0 hectare study area (average land holding in the region); 1.0, 02, 02, 02, 02 and 02 hectare was allocated to each of grain crops, fodder, vegetables, horticulture, fish pond and livestock+ poultry with biogas plant and compost pits, respectively.The allocations of different crops/ agricultural enterprises adopted in the integrated farming system are described in Table 1. Fruit trees like guava, banana, karaunda, aonla were planted on pond dykes and understory inter-spaces between these plants were used for raising seasonal vegetables round the year.Each component was evaluated at the field and farm level for its profitability, sustainability and resource use efficiency in comparison to prevalent rice-wheat system after six years of studies (2007-2013).

RESULTS

Multi-enterprise agriculture is a unique and reasonably stable arrangement of farm enterprises that the household manages for achieving its goals and preferences according to available physical, biological, and economical resources and existing socio cultural environment. The productivity in different cropping systems was worked out on the basis of marketable produce from 2007-08 to 2013-14. It represents the yieldin terms of grain, green fodder, green vegetable and fresh fruitin the case of grain crops, fodder crops, vegetables and fruits, respectively (Table 2). In food-grain production, the highest system productivity in terms of rice equivalent yield (REY) was recorded with rice-wheat-moong cropping system (12.2 t /ha) followed by rice-wheat (11.1 t /ha) and maize-wheat-moong (7.0 t /ha). However, the lowest rice equivalent yield (3.7 t/ha) was recorded in winter maize-soybean cropping system with low net returns of $151/- because of foggy weather conditions which resulted in frequent attack of diseases (mildew, blight and rust) during flowering to ripening. In other cropping systems, some crops were used for green manuring and some as fodder, so comparison between system productivity was not possible. Under grain production components, rice-wheat and maize-wheat-moong cropping system was compatible with each other in terms of production and

Table 1. Different crop/agricultural enterprise rotations followed within each production system

Crop components	Horticulture			Subsidiary components	
Grain production (1.0 ha)	Fodder (0.2)	Vegetables (0.2)	Fruit trees (0.2)	Livestock /Poultry (0.2)	Fisheries (0.2)
Rice-Wheat (0.2) Rice-Wheat-Moong Maize-Wheat-Moong 0.2 WinterMaize-Soybean0.2 Pigeonpea-Mustard-Fodder maize0.2	Sorghum- Berseem 0.2	Cabbage- Tomato-Khira (0.1) Bottlegourd- Cauliflower (0.1) Potato-Onion-Okra	Guava + Papaya + Banana	3 Buffaloes + 2 Cows 120 Birds	Catla Rohu Mirgal Common carp Grass carp

Table 2. Average Rice Equivalent yields and income generated by various components fromtheir respective area during 2007-08 to 2013-14.

Component	Area (Ha)	Rice equivalent yield (t/ha)	Gross income US$	Expenditure US$	Net income US$	B:C ratio
Rice-Wheat	0.2	11.1	755	290	465	2.6
Rice-Wheat-Moong	0.2	12.2	833	302	531	2.8
Maize-Wheat-Moong	0.2	7.0	479	180	299	2.7
WinterMaize-Soybean	0.2	3.7	250	99	151	2.5
Pigeonpea-Mustard-maize	0.2	4.3	295	134	161	2.2
Fodder	0.2	4.4	297	103	194	2.9
Vegetables	0.2	6.4	434	225	209	1.9
Fruit trees	0.2	6.6	451	108	343	4.2
Livestock	0.2	67.7	4602	2070	2532	2.2
Fisheries	0.2	9.3	631	153	478	4.1
Enterprise Mix Diversification	2	13.3	9027	3664	5363	2.5

profitability. The average net income from crop and subsidiary components together was $ 5363/-, out of which $1801/- came from crop (including fodder), $552/- from vegetables and fruits and $3010 from subsidiary components from an area of 2.0 ha, which was substantially higher than conventional rice-wheat cropping system ($4650/-). Among all the systems, fruit and fisheries production were found more remunerative with a B:C ratio of more than 4, whereas, vegetable production system generated lowest B:C ratio (1.9) due to involvement of higher input cost and labor in this system. The higher net returns from multi-enterprise comes from reduced costs of various enterprises and consistent with the earlier studies (Chan *et al.,* 1998). The reduced net returns variability and income was due to extended trade-offs among various agricultural enterprises.

CONCLUSION

The multi-enterprise agriculture can be an efficient and remunerative alternative to rice-wheat cropping system on reclaimed sodic soils small holdings .This system may help to gain confidence of small and marginal farmers in agriculture by increasing productivity, profitability and sustainability.

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Enhancing wheat productivity through crop intensification in furrow irrigated raised bed planting

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Wheat (Triticum aestivum) and soybean (Glycine max) is an important cropping system which occupies major area in plan zone of southern Rajasthan and Madhya Pradesh and both crops are highly valuable to food security of the country. Studies in previous years indicated that sustainability of wheat crop in the canal command area has been at rick mainly due to seepage and water logging from lateral movement of water from canal which coincided with decline organic matter content and nutrient availability, increase soil salinization. However, water management may become a major limiting factor for sustained productivity of wheat crop grown in the canal commanded area during the winter season. Therefore, research efforts are urgently needed to develop and promote new technologies to enhance the productivity of wheat with judicious use of water. Keeping in view the above points, a study was conducted to compare furrow irrigated raised bed planting system of wheat with different intercrops in land configurations with flat planting. Different planting patterns were assessed for wheat and water productivity.

METHODOLOGY

A field experiment was conducted at Agricultural Research Station, Borwat farm, Banswara during *rabi* 2012 to *kharif* 2014. The soil of experimental site was clay loam in texture having organic carbon (0.36%), and available P (8.9 kg/ha) and high in available K (398 kg/ha) with 8.8 pH. The experiment comprised five planting systems viz. T_1, wheat + sugarcane (FIRB); T_2, wheat + berseem (FIRB); T_3, wheat + spinach (FIRB); T_4, traditional wheat and T_5, traditional sugarcane. In furrow irrigated raised bed planting system, the wheat crop was planted on the top of beds in bed configurations of 72 cm bed with 4 rows at 18 cm spacing and intercrops were planted in the furrow of 18 cm width between 2 raised beds of 15 cm height. In flat planting, a uniform row-to-row distance of 22.5 cm was maintained. The sugarcane planted in furrows in the month of February in standing wheat crop whereas berseem and spinach also seeded in furrow at the same time of wheat sowing. Sugarcane crop is standing in the kharif season and harvested in the month of October while soybean sown after wheat harvesting during kharif season. The experiment was layout in RBD with four replications. Nutrients were applied on the basis of fertilizer recommendations of crops.Data were collected and analysed with standard statistical method and economics of treatments was calculated on the basis of current market prices of inputs and produce.

RESULT

The pooled data on 2 years clearly revealed that the productivity of wheat varies with the planting method. The highest yield of sugarcane was obtained in both the years from sole sugarcane. In wheat based cropping systems, sugarcane planted in the furrow of FIRB wheat gave significantly more wheat equivalent yield (WEY) than sole sugarcane and wheat. The maximum rotational (2012–13) WEY (136.63 q/ha) in wheat + sugarcane (FIRB) which calculated 16.10, 15.90, 10.25 and 5.22% significantly superior over sole sugarcane (92.50 q/ha), sole wheat (118.54 q/ha), wheat + spinach

Table 1. Effect of planting pattern (FIRB) on wheat equivalent yield (q/ha) of wheat based cropping system.

Treatment	WEY (q/ha) 2012–13	WEY (q/ha) 2012–13	Pooled WEY of both year 2012–2014
Wheat + sugarcane (FIRB)	136.50	113.15	124.83
Wheat + Berseem (FIRB)	122.67	122.63	122.65
Wheat + Spinach (FIRB)	123.87	122.91	123.39
Traditional wheat	118.54	91.94	105.24
Traditional sugarcane	95.50	84.31	88.41

(123.83 q/ha) and wheat + berseem (122.67 q/ha) respectively. Similar results obtained in second year (2013–14), wheat equivalent yield significantly higher obtained in FIRB planting than sole crop's planted in traditional methods. The pooled mean of both the year (201–2014) revealed that the maximum WEY (124.83 q/ha) found significantly higher over sole sugar cane and wheat but statistically at par with all crops in FIRB method. The results suggested that furrow raised beds planting system gave more yield production through full population of the main crop and additional yield was also obtained through extra planted intercrops in furrow and yield maximization in cropping system was obtained from succeeding crop of soybean. Similar results were reported by Kumar *et al.,* (2010) and Singh *et al.,* (2012).

CONCLUSION

On the basis, 2 years data it can be concluded that furrow irrigation raised bed (FIRB) system for wheat with intercrops provides to be sustained the crop productivity, through better utilization of resources in the canal commended area.

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Bamboo+ chickpea based agroforestry model as sustainable livelihood option for farmers of semi-arid tropics

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Bamboo is playing a significant role in the Indian economy and is providing livelihood support to millions of people. Bamboo being one of the fastest growing plant, perennial nature and ability to produce culms every year, gives very high return in comparison of timber trees (Pilliere, 2008). The demand for bamboo was 26.9 million tonnes against the supply of 13.47 million tones with almost 50% deficit. Bamboos have the potential to be incorporated into agroforestry systems in thesemi-arid tropics in place of conventional tree species due to their adaptability and versatility. ICAR-Central Agroforestry Research Institute (CAFRI), Jhansi initiated a bamboo coordinated research project in 2007 on "Development of bamboo based agroforestry systems for six agro-climatic zones". A field study was carried out to develop bamboo based agroforestry systems suitable to semi-tropic environment conditions.

METHODOLOGY

A field study was carried out during 2007 to 2012 at the research farm of ICAR-CAFRI, Jhansi (U.P.), India. Soil of the experimental site was inter-mixed red and black with 6.54 (pH), 0.180 dS/m(EC), 3.92/kg(SOC), 213 kg/ha (available N), 5.28 kg/ha (available P) and 185 kg/ha (available K). The experiment was laidout in randomized block design with three replications and five treatments *viz*., T_1: 10m x10m bamboo + chickpea; T_2: 12m x 10m bamboo + chickpea; T_3: 10m x10 m pure bamboo; T_4: 12 mx10 m pure bamboo and T_5: pure crop (chickpea). Observations were recorded at a distance of 1.0, 2.0, 3.0 and 4.0m (considering as sub plot treatments) from bamboo clumpand were analyzed under split plot design.Chickpea crop was grown during *rabi* (winter) seasons as intercrop as per treatments with standard package of practices.

RESULTS

On an average, each clump had 3.01, 13.02, 19.88, 27.05 and 30.68 number of culms during 1st to 5thyear, respectively. No. of culm/clumpvaried from 2.14 to 3.88 (1st year); 11.23 to 14.82 (2nd year); 18.08 to 21.70 (3rd year); 25.37 to 29.01 (4th year) and 29.07 to 32.15 (5th year *i.e.*, at harvest stage). Sig-

Table 1. Number of culm/clumpof *D. strictus* under agroforestry system

Treatment	1st year	2nd year	3rd year	4th year	5th year	Culms/ha on 5th year
T_1-10m x 10m bamboo+chickpea	3.88	14.39	21.34	29.01	32.15	3215
T_2-12m x 10m bamboo+chickpea	3.75	14.82	21.70	28.60	32.05	2670
T_3-10m x 10m pure bamboo	2.26	11.64	18.65	25.37	29.46	2946
T_4-12m x 10m pure bamboo	2.14	11.23	18.08	26.19	29.07	2422
SEm±	0.10	0.40	0.61	0.63	0.78	
CD (P= 0.05)	0.33	1.39	2.12	2.16	2.69	

T_1: 10m x10m bamboo + chickpea; T_2: 12m x 10m bamboo + chickpea; T_3: 10m x10 m pure bamboo; T_4: 12 mx10 m pure bamboo

Table 2. Plant population and seed yield of chickpea under bamboo based agroforestry system

Treatment	Plant population/m^2					Seed yield (t/ha)				
	2007-08	2008-09	2009-10	2010-11	2011-12	2007-08	2008-09	2009-10	2010-11	2011-12
Main (Bamboo spacing)										
M1: 10m x 10m	32.1^a	35.5^a	33.8^b	32.8^b	31.6^b	1.80^a	1.75^a	1.37^c	1.33^c	1.27^c
M2: 10m x 12m	34.2^a	33.7^a	34.6^b	32.3^b	32.8^b	1.76^a	1.77^a	1.46^c	1.47^c	1.41^c
M3: Pure crop	33.6^a	34.0^a	36.9^a	33.8^a	35.2^a	1.81^a	1.76^a	1.85^a	1.81^a	1.70^a
Sub (Distance from bamboo clump)										
S1: 1.0m	32.3^a	33.5^a	31.9^b	30.7^b	30.0^b	1.77^a	1.71^a	1.28^c	1.28^c	1.21^c
S2: 2.0m	32.8^a	34.0^a	33.0^b	31.8^b	31.3^b	1.76^a	1.72^a	1.45^c	1.37^c	1.36^c
S3: 3.0m	33.6^a	35.1^a	35.3^a	34.5^a	33.5^a	1.80^a	1.76^a	1.56^b	1.54^b	1.50^b
S4: 4.0m	34.0^a	35.8^a	36.5^a	35.1^a	33.9^a	1.83^a	1.79^a	1.77^a	1.76^a	1.64^a

[a,b,c] Within column, value represents with different letter indicate significant difference (p= 0.05)

nificantly more number of culm were obtained in T_1 (bamboo–10m x 10m + chickpea) over the years as compared to pure bamboo at both the spacing (Table 1). A total of 3215 (10m x 10m); 2670 (10m x 12m) culms/ha were observed in AFS, while 2946 and 2422 culms/ha were observed in sole bamboo at the same density.Plant population of chickpea was not influenced by bamboo spacing or distance from the bamboo clump during initial two years of bamboo establishment. During third year, chickpea intercrop at both the spacing (M_1 and M_2) had significantly lower plant population than pure crop, however (M_1 and M_2) were at par with each other. In both the spacing of bamboo (M_1: 10m x 10m, and M_2: 10m x 12m), reduction in chickpea plant population of 13.6, 10.6, 4.3 and 1.1% were observed at a distance of 1.0, 2.0, 3.0 and 4.0m, respectively from the clump, as compared to pure crop. During 4th and 5th year of bamboo plantation, plant population of chickpea followed similar pattern as observed in 3rd year of bamboo plantation (Table 2). Seed yield of chickpea recorded variation of 1.70 to 1.85 (sole crop), 1.27–1.80 (M_1) and 1.41-1.77 t/ha (M_2). No significant variation in seed yield was observed during first two years as bamboo plants did not impose any competition to the intercropped chickpea. However, seed yield was 25.95 (M_1) and 21.08% (M_2) lower as compared to sole chickpea during 3rd year. Seed yield was observed 27.6,18.08 and 11.86% (1, 2 and 3m distance from bamboo clump, respectively) lower than the seed yield (1.77 t/ha) recorded at 4.0m during 3rd year of bamboo plantation (Table 2). By and large similar trend was observed in seed yield during 4th and 5th year of plantation. The reduction in plant population under AFS and nearer to the bamboo clump may be due to allelopathic effect of bamboo or shade besides increased competition for resources (Rahangdale *et al.,* 2014). The reduction in seed yield of chickpea may be attributed to reduced PAR (Photosynthetic Active Radiation) under bamboo canopy and competition for various other resources *viz*., water, nutrients, space etc. in comparison to sole crop of chickpea (Chauhan *et al.,* 2010).

CONCLUSION

Bamboo based agroforestry system produced bamboo stock as well as sustained crop production over the years. Due to increase in number of bamboo culms over the years, and increased competition for resources, the chickpea yield got reduced gradually, however, the crop loss may be compensated by the higher number of bamboo culms. Bamboo based AFS is not only advantageous economically but environmentally as well, therefore could be one of the best alternative livelihood options for the farmers of semi-arid tropics.

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Impact of alkali land reclamation on livelihood security of small farmers in India

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In India, 6.73 Mha landsare salt-affected, out of which 3.77 Mha are alkali soils and 2.96 Mha are saline soils (Mandal *et al*.,2010).India loses annually 16.84 million tons of farm production valued at 230 billion due to salt-affected soils (Sharma *et al*., 2015). Reclamation of salt-affected agricultural land has assumed paramount importance due to ever-growing food demand. Over the past few decades, chemical amelioration for alkali soils in Indo-Gangetic regions of Punjab, Haryana and Uttar Pradesh has been well standardized. With the support of World Bank, European Union and other developmental agencies, India hasreclaimed 2 Mha of salt-affected lands, which include 1.94 Mha of alkali lands(CSSRI, 2015).

METHODOLOGY

The study was carried out in Uttar Pradesh state as it has highest area of 1.35 M ha under alkali soils in India. A total of 120 farmers from the villages of Unnao, Hardoi and Raibareli districts were selected to collect the information using personal interview method. The data were analyzed using budgetary method and discounted cash flow techniques.

RESULTS

Investment on alkali land reclamation involve short to medium gestation periods. The economic feasibility analysis assuming 12% opportunity cost of capital indicated the benefit-cost ratios varyfrom1.36 to2.47. The internal rates of return vary from40 to 67% and payback periodfrom 3 to 4 years.The rice yield losses were ranged from 39.43% to 100% in pre-reclamation period compared with normal land. The yield losses were reduced and ranged from 5.24% to 21.45% in post-reclamation period. Similarly, wheat yield losses were varied from 22.74% to 100% in pre-reclamation period. The losses were substantially reduced and ranged from 6.82% to 26.60% after reclamation. In the 'severe' soil sodicity category, net income was 31527 /hawhich was left fallow in pre-reclamation period. It indicated that income could be generated by reclamation of severely degraded barren land.Farmers opined that the entire scenario has changed after land reclamation due to increase in crop productivity as well as profitability. They could even sell excess rice and wheat in the market (Table 1). Irrespective of farm-size, farmers have acknowledged the land reclamation technology is a big innovation in bringing improvement in their food- security status and standard of living. The household expenditure pattern has been influenced by the enhanced farm incomedue to land reclamation.The majority of farmers (92%) opined that purchasing of foodgrain, especially of rice and wheat, from the market had declined. A considerable number of farmers (65%) opined that the purchasing of non-food commodities like cloths and other household items has increased after reclamation. A rise in expenditure on house construction and children education was also reported after reclamation. Hence, land reclamation made a substantial improvement in the well-being of the farm families in the salt-affected regions.The reclaimed salt-affected lands produced 4.30 million tons of additional food grains per annum and contributing around 2% to the India's total food grain production. Besides this, land reclamation in Uttar Pradesh contributed highest business transaction in foodgrain agri-business sector annually (59114 million) which accounted 71% in the total contribution. It generated additional employment of 94 million

Table 1. Impact of land reclamation on household's food-security status

Farmers Category	Food grain	Pre-reclamation period (2000)		Post-reclamation period (2013)	
		Deficit (%)	Excess (%)	Deficit (%)	Excess (%)
Marginal	Milled rice	26.3	73.7	0.0	100.0
	Wheat	68.4	31.6	15.8	84.2
Small	Milled rice	16.7	83.3	0.0	100.0
	Wheat	20.8	79.2	0.0	100.0
Medium	Milled rice	0.0	100.0	0.0	100.0
	Wheat	0.0	100.0	0.0	100.0

man-days (14083 million) per annum which is next major contributor accounted 17%. The land reclamation has generated large business opportunities to other agri-business sectors like seed (4194 million), fertilizers (5230 million) and pesticides (914 million) industry sectors.

CONCLUSION

Over the past few decades, with the support of World Bank, European Union and other developmental agencies, India has reclaimed 1.94 Mha of alkalisoils, which contributed enormous socio-economic benefits and livelihood security to millions of resource-poor farmers living in the salt-affected regions. The impact of land reclamation showed a significant scope for poverty reduction in the rural sector. It is suggested that the large tracts of salt-affected farm lands are still barren in India which should be considered for reclamation on priority to improve the livelihood security of resource-poor farmers.

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Assessment of productivity of cotton-based intercropping systems under dryland condition

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Under dryland situation, it has been experienced that sole cropping does not assure satisfactory and stable crop yield due to fragile environment. Intercropping has been used as an effective tool for risk aversion. In widely spaced and long duration crops viz. pigeonpea, cotton, sorghum intercropping has been found feasible. Cotton being most important cash crop of Maharashtra State and intercropping has been studied by research workers. Comparative status of intercropping vs. sole cropping has been also reported. Intercropping in cotton has various benefits associated with it *viz.,* better utilization of resources, soil moisture, nutrients, space, stable returns and reduced risk of crop failure due to insect pests, diseases, weeds and climatic vagaries. An attempt has been made to show how far the intercropping system affects important parameters and to what extent it is beneficial as compared to sole cropping. During the course of present investigation, the different intercrops studied include greengram, blackgram, soybean, cowpea and clusterbean in the cotton underdryland situation.

Table 1. Seed cotton yield, intercrop yield, seed cotton equivalent yield, gross monetary returns, net monetary returns and benefit: cost ratio as influenced by different treatments

Treatment	Seed cotton yield (kg/ha)	Intercrop yield (kg/ha)	Seed cotton equivalent yield (kg/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio
Sole cotton	1266	-	1266	50006	17672	1.55
Sole greengram	-	2090	880	34448	10301	1.43
Sole blackgram	-	493	787	26067	10212	1.64
Sole soybean	-	1086	915	35901	5202	1.17
Sole clusterbean	-	3346	1409	54699	20669	1.61
Sole cowpea	-	3466	1460	56629	21017	1.59
Cotton + greengram (1:1)	1048	872	1484	55677	20056	1.56
Cotton + blackgram (1:1)	1039	243	1494	58534	25815	1.79
Cotton + soybean (1:1)	992	492	1406	55188	19970	1.56
Cotton + clusterbean (1:1)	1139	1881	1931	75275	33361	1.80
Cotton + cowpea (1:1)	1114	2004	1958	76302	34066	1.81
S.E.(m)±	40.3	-	46.1	1742	1742	-
CD (P=0.05)	126	-	136.1	5138	5138	-

METHODOLOGY

The field experiment was conducted during *kharif* seasons of 2014-15 at the Research Farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra). The soil of experimental plot was clayey in texture, slightly alkaline in reaction, medium in organic carbon and in available nitrogen and low in available phosphorus but having fairly rich status of available potassium. The experiment was laid out in randomized block design, replicated thrice with eleven treatments. The treatments were T1-Sole Cotton; T2-Sole greengram; T3-Sole blackgram; T4-Sole soybean; T5-Sole clusterbean; T6-Sole cowpea;T7-Cotton + greengram (1:1); T8-Cotton + blackgram (1:1); T9-Cotton + soybean (1:1); T10-Cotton + clusterbean (1:1) and T11-Cotton + cowpea (1:1). American cotton variety AKH 9916 was sown as base crop for all the treatments under investigation. During the *kharif* season of 2014-15, the total rainfall received 588.2 mm in 32 rainy days.

RESULTS

Data on seed cotton yield, intercrop yield, seed cotton equivalent yield, gross monetary returns, net monetary returns and benefit : cost ratio as influenced by various treatments are presented in Table 1. Treatment of sole cotton recorded significantly higher seed cotton yield (1266 kg/ha). However, among the intercropping systems, cotton + clusterbean (1:1) recorded significantly higher seed cotton yield (1139 kg/ha) over cotton + soybean (1:1) (992 kg/ha) and found at par with rest of the intercropping treatments. In general, it was observed that there was significant reduction in seed cotton yield due to all the intercrops. Average seed cotton equivalent yield was 1363 kg/ha. Cotton + cowpea (1:1) and Cotton + clusterbean (1:1) intercropping remained at par by recording significantly higher seed cotton equivalent yield (1958 and 1931 kg/ha, respectively) over remaining intercropping systems as well as the sole crops. Prasad *et al.* (2000) at New Delhi reported the highest average seed cotton equivalent yield when cotton was sown with the intercrops viz., blackgram, greengram, soybean and clusterbean.As far as gross monetary returns (GMR) are concerned, cotton + cowpea (1:1) and Cotton + clusterbean (1:1) intercropping remained at par by recording significantly higher GMR (76302 and 75275 Rs/ha, respectively) over other intercropping systems and the sole crops. Similar trend was also observed in respect of net monetary returns and it was significantly higher with cotton + cowpea (1:1) (34066 Rs/ha) and Cotton + clusterbean (1:1) (33361 Rs/ha) intercropping systems. Intercropping of cotton + cowpea and cotton + clusterbean registered greater values of B:C ratio i.e. 1.81 and 1.80, respectively. Higher productivity of these intercropping systems was mainly due to the vegetable intercrops *viz.,* cowpea and clusterbean and their higher market rates reflected in obtaining the higher value of B:C ratio in these intercrops in cotton.

CONCLUSION

Sole cotton recorded significantly higher seed cotton yield of cotton variety AKH-9916 than rest of the treatments. Among the intercropping system, cotton + cowpea (1:1) and cotton + clusterbean (1:1), both being statistically identical, recorded significantly higher cotton equivalent yield, gross monetary returns, net monetary returns and benfit:cost ratio than cotton + greengram, cotton + blackgram and cotton + soybean intercropping systems.

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Impact of technological interventions on shifting cultivation *(Jhum)* practices for livelihood security in Eastern Himalayan Region

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Shifting (*Jhum*) cultivation is a primitive practice of cultivation in the States of North Eastern Hill Region of India occupying more than 80% (0.76 m ha) of land out of 0.94 mha of shifting cultivation land in India. Initially, when shifting cultivation cycle was long and ranged from 20 to 30 years, the process worked well. However, with increase in human population and increasing pressure on land, shifting cultivation cycle reduced progressively (4-5 years) causing problem of land degradation and threat to ecology of the region at large. At the same time, shrinkage resources like arable land, water and energy, there is a dire need to design and develop new methods and cropping pattern of crop production to meet the increasing demand for food, feed and forage through effective utilization of *jhum* lands.

METHODOLOGY

Field experiments were conducted in the Shifting cultivation lands in Manipur during 2013 and 2014. In general the soil of the experimental sites were sandy loam in texture, acidic in reaction (pH 5.2±3), medium to low in Nitrogen (156±10.5 kg/ha), medium in phosphorus (15.22±2.2 kg/ha) and low in potassium 93.00±7.0 kg/ha). Two experiments were conducted in randomize block design with three replications in each experimental sites. The first experiment consists of two treatments, improved crop management practices (seed biopriming with *Azotobacter* and PSB @ 250g/10 kg of seed each) + Micro-dosing NPK 20-20-20 @ 3g/plant) and traditional Shifting cultivation practices (without application of any nutrient). The four crop components such as Rice, Maize, Groundnut and Soybean as sole crop were taken for the study as these crops are most popular among the farmers of the state. In the subsequent study a diversified cropping system was undertaken as treatments where improved crop management practices (Seed biopriming with Azotobacter and PSB) + Micro-dosing NPK 20-20-20 @ 3g/plant) with strip cropping of Rice + soybean, Rice+ groundnut, Maize + soybean, Maize + groundnut were compared with traditional *jhum* practices (Mix cropping - mixing of all the seeds and sowing without any row arrangement in the field). In this experiment land allocated for the cereals was altered with legumes in subsequent years to maintain soil fertility. Observations on yield and yield attributes of all the crops were recorded at proper time with the following of recommended procedures.

RESULTS

The results showed that among all the sole and strip cropping systems, the maximum rice equivalent yield was recorded with groundnut crop (6.99 t/ha) followed by maize + groundnut (4.82 t/ha), rice + groundnut (4.64 t/ha) and sole soybean (3.64 t/ha). The lowest rice equivalent yield was obtained from traditional *jhum* practices (2.63 t/ha), where all the four component crops were shown as mix cropping. The results indicated that among all the sole and inter-strip cropping systems, inclusion of groundnut as sole or component crop showed its superiority over other cropping under the study. This might be due to better performance of groundnut with the application of biofertilizers and micro-dosing of NPK under improved *jhum* management and finally higher market value of groundnut as compared to that of other component crops. The results showed that growing of sole groundnut under improved *jhum* management recorded maximum gross return (Rs. 91600/-), net return (67000/-), return per rupee invested (Rs. 3.72), and crop profitability (654 Rs./ha/day). Growing of maize + groundnut and rice-groundnut as inter-strip cropping of the *jhum* lands though recorded lower economic benefit than that of sole groundnut, yet both the cropping systems provided significantly greater economic benefit than that of other cropping systems in *jhum* lands under the study . Sole soybean also provided greater economic return and higher profit than that of sole rice, sole maize and traditional *jhum* practices. The traditional *jhum* practices (mixed cropping) recorded the economic benefit comparable to that of sole rice that fetched the lowest economic benefit among all the cropping systems in *jhum* lands under the study. The organic carbon, microbial carbon and available N, P and K contents of the experimental soil were estimated after two years cropping cycle to study its fertility status under *jhum* cultivation practices. The highest amount of OC (1.8 ± 0.4%), MOBC (97.5 ± 0.58 mg/g soil), available N (186.8 ± 7.2 kg/ha), available P (12.54 ± 1.5 kg/ha) and available K

(147.0±9.8 kg/ha) were recorded with sole groundnut cropping and was closely followed by sole soybean cropping under improved *jhum* management of the study. Intercropping of legumes with cereals in the *jhum* lands also considerably increased all the above fertility parameters when compared to those of sole cropping of cereals and traditional jhum practices. Seed inoculation with biofertilizers might increase the symbiotic N fixation by legumes and micro-dosing of NPK might increase the availability of NPK to the crops for greater root activity and higher biomass production that help in increasing soil fertility status (Chaturvedi *et al*., 2010). The results indicated that growing of sole groundnut under improved management of the *jhum* lands was most beneficial. Maize + groundnut and rice-groundnut inter-strip cropping on the *jhum* lands also paid greater economic benefit and better soil health than that of the other cropping systems under the study.

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Greengram livelihood security in Pali district through front line demonstrations

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Pulses are important food crops for human consumption and animal feed. The total production of pulses in the world was 14.76 billion tones from the area of 14.25 billion hectares in the year 2014-15 while in India total pulses production was 18.58 million tons from the area of 23.63 million hectares in the year 2014-15 (DES 2015). Greengram (*Vigna radiata* L. Wilczek.) is the third important pulse crop in India. It can be grown both as *kharif*greengramand summer green gram. With the advent of short duration, MYMV (Mungbean yellow mosaic virus) tolerant and synchronous maturing varieties of green gram(55-60 days), there is a big opportunity for successful cultivation of greengramin green gram-wheat rotation without affecting this popular cropping pattern. Keeping in view the present study was done to analyze the performance and to promote the FLD on greengramproduction.

METHODOLOGY

In total 40 frontline demonstrations were conducted on farmers' field in five adopted villages in Jaitaran block of Pali district of Rajasthan, during *kharif* season 2009-10, 2011-12, 2012-13, 2013-14 and 2014-15 in raifed condition. Each demonstration was conducted on an area of 0.4 ha, and 1.0 ha area adjacent to the demonstration plot was kept as farmers' practices. The package of improved technologies like line sowing, nutrient management, seed treatment and whole package were used in the demonstrations. The variety of greengramIPM 02-03 was included in demonstrations methods used for the present study with respect to FLDs and farmers' practices.

RESULTS

Evaluation of findings of the study (Table 1) stated that an extension gap of 284 to 320 kg/ha was found between demonstrated technology and farmers' practice and on average basis the extension gap was 267 kg/ha. The extension gap was highest (315 kg/ha) during 2013 and lowest (135 kg/ha) during 2012. Such gap might be attributed to adoption of improved technology especially high yielding varieties sown with the help of seed cum fertilizers drill with balanced nutrition, weed management and appropriate plant protection measures in demonstrations which resulted in higher grain yield than the traditional farmers' practices. The study further exhibited a wide technology gap during different years. It was lowest (305 kg/ha) during 2013 and highest (430 kg/ha) during 2012. The

Table 1. Technology gap, extension gap and technology index in Green gram in Pali district of Rajasthan

Year	Area (ha)	Number of FLDs	Potential yield (kg/ha)	FLD yield (kg/ha)	F Pyield (kg/ha)	% increase	EG (kg/ha)	TG (kg/ha)	TI (kg/ha)
2012	05.5	10.5	1350	920	785	17.2	135	430	31.9
2013	10.5	15.5	1350	1045	730	43.2	315	305	22.6
2014	10.5	15.5	1350	980	750	30.2	230	370	27.4
Average	08.8	08.8	1350	982	755	35.4	267	368	27.3

EG= Extension gap; TG= Technology gap; TI= Technology index; FP= Farmers practices

Table 2. Economic analysis of FLD's in Greengram in Pali district of Rajasthan

Year	Cost of cash input (Rs./ha)		Additional cost in demo. (Rs./ha)	Sale price (MSP) of grain (Rs./t.)	Total returns (Rs./ha)		Additional returns in demo.(Rs./ha)	Effective gain (Rs./ha)	IBCR
	IP	FP			IP	FP			
2012	6000	4500	1500	45000	41400	35100	6300	4800	4.2
2013	6300	5000	1300	46200	48510	39726	8784	7484	5.7
2014	7000	5200	1800	50000	49000	41500	7500	5700	3.1
Average	6433	4900	1533	47060	46303	38775	7528	5995	4.3

IT= Improved Technology; FP= Farmers Practices; IBCR= Incremental benefit cost ratio

average technology gap of all the years was 368 kg/ha. On the basis of three years study, overall 27.3% technical index was recorded, which was reduced from 31.9%, 22.6 and 27.4 during 2012, 2013 and 2014, respectively.Different variables like seed, fertilizers, bio-fertilizers and pesticides were considered as cash input for the demonstrations as well as farmers practice and on an average additional investment of Rs. 1533 per ha was made under demonstrations. Economic returns as a function of gain yield and MPS sale price varied during different years. The maximum returns (Rs. 8784) during the year 2013 were obtained due to high grain yield and higher MPS sale rates as declared by GOI. The higher additional returns and effective gain obtained under demonstrations could be due to improved technology, non-monetary factors, timely operations of crop cultivation and scientific monitoring. The lowest and highest incremental benefit cost ratio (IBCR) were 5.7 and 3.1 in 2013 and 2014, respectively (Table 2) depends on produced grain yield and MPS sale rates. Overall average IBCR was found 4.3.

CONCLUSION

The frontline demonstrations conducted on greengram at the farmers' field revealed that the adoption of improved technologies significantly increased the yield as well as yield attributing traits of the crop and also the net returns to the farmers. So, there is a need to disseminate the improved technologies among the farmers with effective extension methods like training and demonstrations. The farmers' should be encouraged to adopt the recommended package of practices realizing for higher returns.

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Promoting livelihood security & food safety in farming communities by increasing pigeonpea production under technological interventions

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The implementation of on farm technological evaluation programme was conducted five consecutive years during *kharif* season of 2010-11 to 2014-15 in farmers' participatory mode at different villages of district Azamgarh. This district located in the VIII eastern plain zone with MSL 77.65 m at 82^0 40' - 83^0 52' E, locally equipped with 8 Tahsil, 22 Blocks and around 3721 villages. The average annual precipitation is 1031 mm while temperature ranges in between 45.1 ^{0}C to 5.8 ^{0}C during summer and winter. In general the soils under study were sandy clay loam in texture with neutral in reaction (7.2 to 7.6 pH). The available nitrogen, phosphorus and potassium were low to medium only and also deficient in sulphur status. The main objective of demonstration programme is to disseminate the latest interventions made for boosting pigeonpea production in farming communities and minimizing the food safety risk and trade in respect to kept pulse prices under purchasing power of common men's. Considering the facts of low yield of pulses due to technological gap and various other constraints, the Krishi Vigyan Kendra, Azamgarh of Uttar Pradesh (India) executed frontline demonstration in five consequently years on improved agricultural technologies of pigeonpea. An area of 45.0 ha covered in selected seven villages of 125 farm families in the district. The results on yield under demonstration reveals on average basis of 1.57 T/ha and observed to be 0.56 T/ha higher along with ability to make changes in yield from more than fifty percent (54.6%) in comparison to traditionally produced pigeonpea. The yield advantage of 62.8% with pigeon pea yields 2.12 T/ha was noticed during 2010-11. The variation in the per cent increase in the yield was found due to variation in agro-climatic parameters under rainfed condition. Analysis of technology gap reveals that initial two year registered markedly narrower gap in comparison to last three succeeding years of demonstration. A descending trend of technology gap reflects the farmers' cooperation in carrying out such demonstrations. Benefit: cost ratio (BCR) under technological interventions was proved most remunerative and economically feasible against traditional production system.

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Agri-horti systems for sustainable rural livelihoods under arid regions of India

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Sustainable livelihoods in arid eco-systems are mainly constrained by climatic, edaphic, anthropogenic and socio-economic factors. Low and erratic rainfall, high temperature, high potential evapo-transpiration, sandy and sandy loam soils with poor fertility and low water holding capacity results in frequent droughts, consequently leading to often crop failure (Rao and Singh, 2008). However, income obtained by arable cropping alone is hardly sufficient to sustain the livelihoods of farmers under arid region. Under such situation, there is a need to bring individual approach together to overcome the impact of harsh climatic condition. Agri-horti system of *Zizyphus*+greengram not only provide sustainable yield of fruit, food, fodder, fuel wood and employment round the year during the average rainfall conditions, but also during the below average rainfall year under arid condition (Sharma and Gupta, 2001). Keeping the above facts in view, a field study was undertaken to find out the effect of agri-horti systems on the sustainable livelihoods of the farmers under arid regions of India.

METHODOLOGY

The field study was conducted during 2012 to 2014 in Utamber village, which was adopted by Central Arid Zone Research Institute Jodhpur under On Farm Assessment of Integrated Farming Systems project. The village Utamber is located in district Jodhpur (Rajasthan), India and situated at 26^0 90’ N latitude and 76^0 90’ E longitudes at an elevation of 273 m abovemean sea-level. The soil of the field was sandy loam having low organic carbon (0.22%), available N (137 kg/ha), available P (12.3 kg/ha) and high in available K (279 kg/ha). Total rainfall received during 2012, 2013 and 2014 was 462, 479 and 352 mm, respectively. The village survey was carried out through participatory rural appraisal (PRA) methods and using well-structured and pre-tested interview schedule to identify opportunities for sustaining farmer’s livelihood. After identification of agri-horti system as one of foremost intervention, a field experiment was conducted using a five years old *ber* (*Zyziphus mauritiana*) and *lasora/ gonda* (*Cordia myxa*) orchard in the adopted village. Both horticultural crops*ber* and *gonda* were already planted at a spacing of 6mX6m and 8mX8m, respectively. Green gram ‘RMG 62’ was sown as sole as well as intercrop in between two rows of *ber* and *gonda*at the onset of monsoon in the first week of Julyin rows at 45 cm apart using seed rate of 12 kg/ ha. A uniform basal dose of 20 kg N and 40 kg P_2O_5/ha were applied to green gram, whereas 750 gram N and 250 gram P_2O_5/plant were applied to *ber* and *gonda* fruit crops. The economics was worked out on the basis of prevailing market prices of inputs and produces of fruit crops and green gram in local market.

RESULTS

All the respondents stated that severe moisture stress is the most important constraint for the successful cultivation of arable crops in arid region. Arable crops frequently fail due lack of adequate moisture, which results low income and unemployment, consequently poor socio-economic status and livelihood insecurity of farmers. Majority of the respondents felt that alternate land use system could be appropriate technological solutions to overcome the risk of frequent crop failure, which take place due to vagaries of weather.

It is evident from the table 1 that in agri-horti system, intercropping of greengram with *gonda* resulted in highest greengram equivalent yield, which was 26.95, 74.55, 16.77 and 43.41% higher over *ber*+greengram, greengram , sole *gonda* and *ber*, respectively. Highest greengram equivalent yield with *gonda*+greengram might be attributed to the improvement of availability of moisture and nutrients to the crops due to association of woody plants (Rao *et. al*. 1998). Sole *gonda*and ber recorded 69.42 and 55.0%, higher green gram equivalent yield, respectively over sole greengram. Among all the treatments, highest net returns was obtained with *gonda*+green gram intercropping system, but highest B:C ratio (7.27) was fetched by sole *gonda* followed by *gonda*+greengram intercropping systems. Intercropping of green gram with *gonda* and *ber* resulted in 80.2 and 69.9%, respectively higher net returns over sole greengram and 13.7 and 19.1% higher over sole *gonda* and *ber*, respectively. This indicates that integration of arable crops with perennial components like *gonda* and *ber* not only provide higher yield and income, but also stabilize farm income (Meghwal, 2007) and conserve the natural resources. This ultimately helps in poverty eradication and achievement of sustainable livelihoods of the farmers.

Table 1. Effect of agri-horti systems on the productivity and economics

Treatment	Yield of fruit trees (t/ha)		Seed yield of green gram (t/ha)	Greengram equivalent yield (t/ha)	Economics	
	Fruit yield	Other produces (fodder+fuel wood)			Net returns ($\times10^3$ /ha)	B:C ratio
Horticultural crops						
Ber	5.66	1.23+1.42	-	1.89	77.46	4.56
Gonda	6.52	1.44+1.26	-	2.78	122.58	7.21
Arable crop						
Green gram	-	-	0.79	0.85	28.10	1.95
Agri-horti systems						
Ber + Green gram	5.45	1.00+1.37	0.58	2.44	95.80	3.68
Gonda + greengram	6.24	1.50+1.20	0.62	3.34	142.00	5.68

CONCLUSION

It could be inferred that moisture stress is the most important constraint for crop production in arid region. Adoption of intercropping of arable crops with perennial components like *gonda* and *ber* proved most efficient production systems to achieve stabile productivity and income as well as sustainable livelihood of farmers under arid regions of India.

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Livelihood security and farmers prosperity in SAT agriculture

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The semi-arid tropics (SAT) in Asia and sub-Saharan Africa (SSA) are inhabited by more than 2 billion people, 800 million of whom are the poorest of the poor. Degradation of natural resources, coupled with high population growth, food insecurity and climate change are the major development problems in the SAT areas of SSA and Asia. In India 41% of the rural poor live in SAT regions with the majority relying on agriculture and natural resource base for their livelihoods. Rainfed agriculture is a typical land use system in SAT with poor soil fertility, scarcity of water (low and variable rainfall), underdeveloped markets, infrastructure and institutions making it inherently risky. If future agricultural growth is to benefit the poor and contribute towards equitable economic growth, it is important to design suitable adaptationstrategies and policies for stimulating sustainable productivity and income growth in these regions.

METHODOLOGY

In this paper, we discuss the major drivers of change in complex dryland farming systems.

RESULTS

Though, the relative income and employmentfor SAT farmers remain very low, analysis of 40 years of panel data (1975-2015) from village level studies ((http://vdsa.icrisat.ac.in/)) in SAT India indicates that diversifying to commercial crops supported with policies and market linkages, access to non-farm income, higher integration of livestock, capacity strengthening of men and women farmers and government supported safety nets have helped dryland smallholders to create better livelihoods. However, poor access to improved technologies and information, high transactions costs, insecure land lease markets, high financial and social capital needs for natural resource management interventions and gender inequity in dryland agriculture were identified as key constraints to progress. The paper argues for the need of an interdisciplinary and innovation systems approach to evaluate and design interventions for realizing the potential of dryland agriculture and improve the associated livelihoods. High diversity of livelihood assets across regions, villages and farmsunderline the need forcontext specific research for development (R4D) strategies and targeting of technologies. Many country-wide studies and the VDSA panel data collected in India identified community management of water resources and *in-situ* soil and water conservation packaged with appropriate productivity enhancing technologies and institutional arrangements as highpriority interventions. The paper discusses how innovation system approaches may be used to create inclusive value chains, increase access to technology and credit and mainstream gender that could lead towards prosperity of the livelihoods of SAT farm households.

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Open water cultivation in water hyacinth rafts for livelihood security to achieve zero hunger challenge under threat of sea level rise in Kuttanad conditions

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Kerala's tranquil stretches of emerald green backwaters is one among several locales on the western coasts facing threat from the rising sea level due to climate change. It is estimated that sea level rise by 3.5 to 34.6 inches between 1990 and 2100 would result in saline coastal groundwater, endangering wetlands and inundating valuable land and coastal communities (Anonymous,2012). Kuttanad is a delta region of about 900 sq. km situated in the west coast of Kerala State, India. The Kuttanad region encompasses vast stretches of backwaters, bordering mangrove formations, and rice fields, the latter mostly reclaimed from the shallow stretches of the lake during the recent past. The garden lands, or reclaimed purayidams or homesteads with coconut groves, fringed by canals and channels make this a land of richness and beauty. Kuttanad Below Sea-level Farming System (KBSFS) is unique, as it is the only system in India that practices rice cultivation below sea level. The conservation and refinement of KBSFS, a Globally Important Agriculture Heritage System is particularly important in this era of global warming, leading to a rise in sea level.However, with sea water levels across the globe rising steadily due to climate change, there was a need to strengthen and develop the technique of below sea-level farming and to evolve efficient methods to deal with food securityamong thesesmall farmers residing in outer bunds by the side of water ways where land is a limited resource for cultivation. South Asia is predicted to suffer severely from climate change, and food and water security,being the biggest casualties, productivity and profitability of small farms had to be enhanced along with livelihood security. The future of food security would be based on home-grown food.Water hyacinth(*Eichhorniacrassipes*) is an aquatic weed that creates potential threat to water bodies. The adverse impact of the weed menace can be eliminated by reducing the density of weeds. Plant consists of floating rosettes of leaves with inflated bladder like petioles. The plant achieves buoyancy by abundant arenchyma in petioles.Hence a study was undertaken to develop a technique for open water cultivation of vegetables by utilizing weed beds of water hyacinth as floating rafts and medium for farming.

METHODOLOGY

The experiment was carried out in the ponds of RARS

Kumarakom. The pond was of the size 32.5 m x 11 m and it was filled with the weed.Method I:The rafts were made of size 5m x 1.25 m with pipe frameof 4inch and shade net underneath to hold the weed. Water hyacinth was piled up on the raft to have a height of 60 cm and a thin layer of coir pith compost of height 10 cm were spread on the top to hold the amaranthus seedlings at a spacing of 15 cm. This has been replicated five times.Method II:Bamboo poles, immersed vertically into mud at the bottom of the water body along the borders of the weed bed, were used to fix it in position to avoid damage due to wave action or drifting and to define area of the required bed. Average dimensions of the freshly prepared platforms were 5.7 m (L) x 1.8 m (B) x 0.7 m (H). Within this area dense water hyacinth was allowed to stand on and more water hyacinth is piled up to make it compact. Red Amaranthus var. Arun was transplanted on a thin layer of coir pith compost over the bed. The seedlings were spaced closely at a distance of 5 cm since open water culture permits to trap maximum solar radiation**.** The plants were given foliar application of 19:19:19 @1% and supernatant filtered cow dung slurry at alternating weekly intervals to meet the nutrient requirement. The crop was harvested in 60 days. The nutrient content in the fresh as well as decayed water hyacinth, coir pith compost and amaranthus at harvest was recorded to evaluate the dynamics of nutrient absorption.

RESULTS

In the first method the fabrication of raft was found costly and in the field it had the risk of sinking in to water which may result in crop loss and cumbersomemanagement practices. The indigenous method tried with bamboo poles in live water hyacinth platforms turned to be more viable and profitable.For preparing such a platform weeds were collected from seven times the area of the bed so that we can get a height of 0.70 m above the water surface. Duration or stability of the floating bed depends on density of the first layer, which remains at the bottom. The thickness depends on the duration of crop as it needs to float for the whole time. The beds can be recycled as organic fertilizer in the next floating bed which is economical as well as environment friendly. In this system an yield of 17.4t/hahas been recorded which is comparable to potential yield of 20t/ha (Gopalakrishnan and Indira,2001) for Amaranthus var.Arun.

CONCLUSION

Floating cultivation can help to reduce the pressure on arable lands by turning the flooded and waterlogged areas into productive ones. Thus the novel concept of utilizing water hyacinth for open water vegetable farming in wetlands and waterways can provideecological balance, food safety and nutritional security.

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Analysis of farmers perception about agro-ecosystem in South-West coast of India

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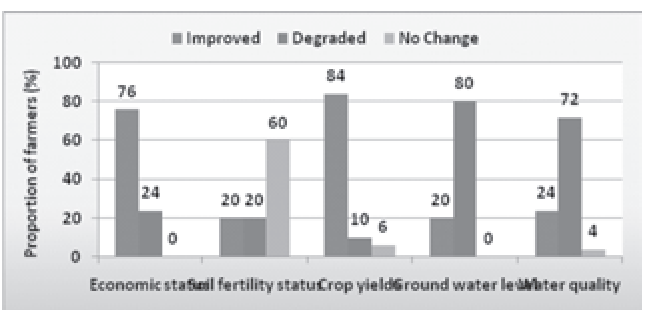
Today's farmers face the multifaceted challenges of providing food security for a growing population by supplying its demands for diverse crops and livestock, whilst protecting the environment. Rising temperatures and changing precipitation patterns are affecting crop growth, livestock performance, water availability and the functioning of eco-system services (IPCC, 2007). This study examined farmers' perception of agroecosystems over the last fifty years in south west coast of India which falls under agro-ecological region 19 of India. The analysis of farmer's perceptions about agro-ecosystem during the last fifty years revealed that there is an improvement in economic status and crop yields in the past 50 years.

METHODOLOGY

The study was conducted in North Goa District in Goa State, India, which lies between 15°49’N and 73°83’E. North Goa District was chosen as it falls within the hot humid pre humid eco-region. It lies largely in agro-ecological region 19 of India, a region that experiences the highest amount of rainfall of more than 3000 mm/year in most years.Pernem block in North Goa was selected randomly and again one village namely the Ibrahmpur village was selected randomly. A structured questionnaire was used to elicit information from 50 respondents. Quantitative data collected through the structured questionnaire was analysed using the Microsoft Excel. Tabular and graphical analysis was carried out to find out the patterns and trends of farmer’s data about agro-ecosystem and presented in the form of graphs.

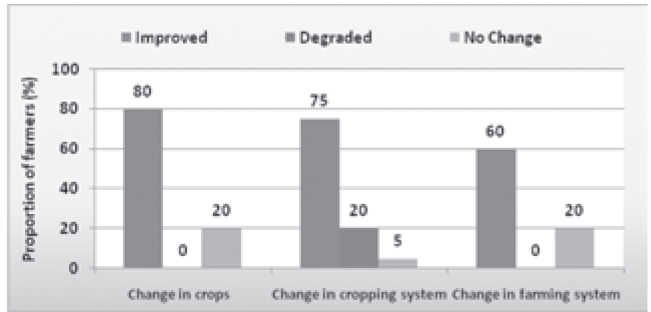
RESULTS

The figure 1 shows the respondent farmers’ perception about agro-ecosystem during the last fifty years. Around 76% and 84% of the respondents perceive that there has been an improvement in economic status and in crop yields, respectively in the past 50 years. The results also indicated that around 80 per cent and 72% of the respondents perceive that there has been degradation of ground water and degradation in water quality respectively, in the past 50years. This implies that the district is becoming moreand more prone to water quality degradation due to ground water degradation as perceived by the farmers. While 60%, 6% and 4% either perceive no change or do not know whether there were any changes in soil fertility status, crop yields and water quality respectively.



Source: Field Survey, 2015

Fig. 1. Farmer’s Perceptions about Agro-ecosystem over the last fifty years



Source:Field Survey, 2015

Fig. 2. Farmer’s Perceptions about Cropping System over the last fifty years

The results indicate that 80%, 75% and 60% of the farmers perceived that there is improvement in crops grown, cropping system and farming system, respectively over the past 50 years (Figure 2). This implies that the district is improving in farming system due to improvement in crops grown bythe farmers and cropping system. While, 20% either observed no changes or thought the crops grown had remained static and again 20% perceived that there non change in farming system. But 20% perceived that there is degradation in cropping system during the last fifty years.

CONCLUSION

In this study, the analysis of farmer’s perceptions about agro-ecosystem during the last fifty years revealed that there is an improvement in economic status and crop yields in the past 50 years and also improvement in farming system which may be due to improvement in crops grown bythe farmers and cropping system as perceived by the farmers.

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Symposium 11
Emerging Challenges for Agronomic Education

Extended Summaries Vol. 2 : 4th International Agronomy Congress, Nov. 22–26, 2016, New Delhi, India

Agronomy education in changed scenario

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Indian agriculture has made great strides. However, concern has now been expressed on the decline in agricultural growth. It is also stated that higher agricultural education has not been able to make any significant impact on rural development (Sinha, 2000). Further higher agricultural education is seen on fast track of deterioration (Tamboli and Nene, 2013). Agronomy continues to be a core branch of agriculture science. Up to the mid of the last century, agronomy contained several subjects like dairying, plant breeding, extension education, farm economics and so on. It implies that agronomy is mother of several new disciplines. Agronomy education in present scenario has taken new dimensions. It is not confined to soil, field and water management but agronomy education is focusing at more crop per drop, soil health management and ultimately at efficient energy management. Similarly crop production is not now solely dependent on monsoon but it is aimed at taming the weather or what is referred to as climate smart agronomy using agro advisories and models. The time of advocating general dose of nutrients has gone. Agronomy education should include the principles of precision farming using sensors for judicious use of costly inputs. The thrust on volume of produce is gradually shifting towards high value produce of required quality. Here the old principles of traditional integrated- and organic farming need to be inculcated in syllabi. The concepts of intensive agriculture are to be redefined in the light of conserving natural resources for sustainable production of food, feed, fiber and fuel. Agronomy education should also include excerpts from the time tested and expedience based wisdom. The knowledge contained in *Vedas* and folk literature and pristine sayings deserves to be rediscovered and taught in agronomy. To quote, Ojha (1942) in a book entitled "*Kadambini*" in sanskrit presented in a very orderly way, the knowledge of our ancients in the field of weather science. Agronomists have the onus of economic growth creating new agro-based demands and generating livelihood opportunities for the prosperity of farmers. It means the agronomy education deserves to be thoroughly revamped to cater to the needs of all stakeholders.

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Reorienting Agronomy education and research

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Agronomy is the biggest pillar of agriculture for crop production. Climate change, pollution of the environment, food contamination and health challenges, reduction of biodiversity, soil, water and nutrient erosion are among the unwanted and undesirable challenges before agronomy today. To meet these challenges, reoriented Agronomic education and research innovation to the interplay among scientific, social, and economic factors which will reflect its output in meeting global food security by 2050. Agronomy research has once again needed to gather momentum for facing number of emerging problems. Unfortunately, there is not yet any well-designed agenda for investing in research and technology in South Asian countries. The entire research sector in South Asia still suffers from various political and economic issues. Lack of agricultural researchers, research facilities causes poor implementation of long-term objectives, misallocation, and mismanagement of resources with many economic and environmental externalities. Private sector involvement is also crucial to tackle the emerging challenges for agriculture. Developing countries like in South Asia must therefore focus on capacity-building in research and innovation by their own effort.

Agricultural education and institutions face great difficulties in ensuring properly equipped laboratories and practice farms and fails to emphasize allocating resources on the emerging issues as government is the major funding source. (Ghose, 2014). Agricultural education has now to evolve in tune with fast changing national and international scenario. The present situation demands a renewed thrust for enhanced quality and relevance of higher agricultural education so as to facilitate and undertake human capacity building. Higher learning institutions should cross traditional disciplinary boundaries and they should become multidisciplinary, interdisciplinarity, and transdisciplinarity. (*Koutsouris,* 2009).

Farm holdings in India are shrinking and farmers have to rely on new technologies to advance production techniques. Large farms will specialize in the production of bulk commodities, leaving opportunities for smaller for integrated farming approach which will require agronomic research support to be successful to improve efficiencies, to maximize profitability and enhance sustainability. The effects of climate change will place increased pressure on farmers decisions production and resources. The effects of climate will introduce new plant diseases and pests requiring alternative pest management responses and agronomic research. In addition, there may be opportunities to grow new crops that previously could not be grown e.g. quinoa. Greater crop diversity will require new production techniques and agronomic research to rotate new crops efficiently and economically.To address future needs in agronomic research with focus on:A ‘Systems Approach’ to Agronomic researchwith minimal impacts on environment; integrating agronomy research with national and international food and nutritional; address research needs of various regions; identifybest grown crops in a changing climate and Explore opportunities from it; meta-data collection, analysis and management for decision making and application; needs of basic, applied and farm-based research with multidisciplinary approach and PG student research should be regional problem oriented with new kind of observations.

Collaborative research, involving public and private researchers must evolve cost-effective research initiatives across a number of commodity groups and stakeholders. There are 3 different stages of research – there is a need to understand these stages 1) discovery, 2) agronomics, 3) validation. Regardless of the size of the farm operation, the emerging potential for diverse crop types will result in important research needs to help farmers better understand implications of rotations, to determine the right crops for the right growing conditions, and to maximize profits. New technologies require additional research to determine the most effective and efficient use of the technology. To create a future-looking strategy good agronomic research continues to be a crucial factor in efficient and sustainable crop production. it is necessary to understand current and future research capacity as well as to have a good knowledge of the research needs of the agricultural industry. Agronomic research and education requires new initiatives in view of changes in production system, adequate funding in order to be able to address questions that will influence production. Support for innovative research is also important and there is need for funding for short-term, immediate concerns as well as for funding of innovation. Looking to the emerging challenges of Agronomy the universities and Government must focus on increasing investments in agricultural education and R & D for longterm productivity policy, facilitate the adoption of academic reforms, new technologies and implement efficient institutional reform both at national and regional level.

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Post graduate research productivity of Agronomy Theses awarded by Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during 2014 - 2015 : A study

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Research is of paramount importance to a university; research leads to knowledge development and facilitates qualitative development of both faculty and post graduate scholars. Research also leads to higher accreditation and in, reputation building of a university. In view of Perry *et al* (2000) academic staff viewed successful research as an important factor in evaluation, and believed that publications are an essential requirement for promotions and according to Creswell (1986) research productivity also includes working with post-graduate students on dissertations and class projects. In the words of Lee and Rhoads (2004), main core of a university or college is its faculty and promotion of competency and knowledge of faculty members is equal to increase in quality of university, hence it is essential to assess the productivity of faculty members so as to improve the quality of research and quality of higher education. The present study was planned to keeping in mind following objectives: to find out the number of year-wise distribution of theses, gender of authors, level of post graduation, number of pages per thesis, most prolific guide, hierarchy of guides and research topic based on crop.

METHODOLOGY

Data for the present study consisted of 51 theses awarded to post graduate scholars of Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur during 2014 and 2015 in the discipline,Agronomy. The data was collected from the reference section of Satyanarayan Sinha Central Library of JNKVV. The data was collected, compiled, tabulated, analyzed, interpreted and presented in the form of this manuscript.

RESULTS

It was observed from Table 1 that maximum numbers of theses were awarded by College of Agriculture Jabalpur (11 and 16) followed by College of Agriculture Rewa (4 and 10) and College of Agriculture, Tikamgarh (5 and 5) during the years 2014 and 2015 respectively. Highest numbers of theses were submitted by, College of Agriculture Jabalpur (27), followed by College of Agriculture, Rewa (14) and College of Agriculture, Tikamgarh (10) during the both the years. A total of 51 theses were awarded during the years.The data presented in Table 2 gives the details of gender wise authors of thesis, it was found that 8 and 10 females have done their postgraduate work in Agronomy during the years 2014 and 2015 respectively as compared to 12 and 21 males. Although the number of females was higher during 2015 but the percentage of females doing their post graduation was more during 2014.Table 3 gives an idea about the level of post graduation, in the year 2014 only one and in the year 2015 two students were awarded doctoral (Ph.D) degrees respectively where as in the year 2014 nineteen and in the year 2015 twenty nine students received their post graduate degree (M.Sc Ag.) in Agronomy. The data shows that very few students tend to do doctoral degree as compared to post graduate degree.

CONCLUSION

Males prefer to opt Agronomy as their main subject as compared to females and more scholars do post graduate study as compared to doctoral degree. The most preferred page length for theses was 71-90 pages The study gives us an

Table 1. Number of theses per year

College of Agriculture	Year			Total		
	2014	Percentage (%)	2015	Percentage (%)	Total	Percentage (%)
Jabalpur	11	55	16	52	27	53
Rewa	04	20	10	32	14	27
Tikamgarh	5	25	05	16	10	20
Total	20	100	31	100	51	100

Table 2. Gender of authors

Gender	Year				Total	
	2014	Percentage (%)	2015	Percentage (%)	Total	Percentage (%)
Female	8	40	10	32	18	35
Male	12	60	21	68	33	65
Total	20	100	31	100	51	100

Table 3. Level of post-graduation

Year	Post graduate level					
	Ph.D	Percentage(%)	M.Sc.	Percentage(%)	Total	Percentage(%)
2014	1	5	19	95	20	39
2015	2	6	29	94	31	61
Total	3	6	48	94	51	100

overview of post graduate research work going on in the field of Agronomy at the university; studies like this are likely increase research output by showcasing the overall scenario of post graduate research work.

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Symposium 12
New Paradigms in Agronomic Research

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Effect of PGR on growth and yield of *Bt* Cotton

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Plant growth regulators are considered as management tool to maintain ideal plant height and fruiting retention. Proper use of PGR can help balance vegetative and reproductive growth, in turn controlling plant maturity, improving square and boll retention and effecting plant height in cotton. Every cotton field is under different conditions so growth management strategies should be tailored to each field situation. Knowing the response to PGR can help growers to properly manage and improve cotton yield potential and harvest efficiencies. Timely application, number of applications and its dose is needed to manage growth. Thus, this experiment was conducted to study effect of different growth regulators on growth, yield and economics of *Bt.* cotton.

METHODOLOGY

Field experiment was conducted at Cotton Research Station, Nanded (VNMKV, Parbhani) in year 2014-15. The soil of experimental field was low in available N, medium in P_2O_5, high for K_2O and neutral in pH. The trial was conducted on Bt Cotton in Randomized Block Design with twelve treatments and three replications under rainfed condition. Plant growth retardents *viz*. Mapiquat Chloride (four treatments with 2 / 3 sprays at different stages), Etheral, Maliechydrazide and growth promoter Nitrobenzene (three treatments with 3 / 4 sprays at different stages) were evaluated and compared with detopping and control.

RESULTS

The treatment Mapiquat chloride in three sprays (at square, flowering and boll formation stages) recorded highest seed cotton yield (1.88 t/ha). It was on par with its other levels (T_1, T_2 and T_3), Cycocel (T_5), all Nitrobenzene spray treatments (T_6, T_7 and T_8) as well as detopping (T_{11}). The treatments Eherel (T_9) and Maleic hydrazide (T_{10}) recorded numerically lower seed cotton yield than control. The Mapiquat chloride treatments (at square formation stage) were found to increase the boll weight over control where as Nitrobenzene treatments has increased number of bolls over control. Increase in stalk yield was recorded due to Nitrobenzene sprays over spray of Mapiquat chloride at square, flowering and boll formation stages. Spraying of Mapiquat chloride at square formation stage (T_1, T_2 and T_4 treatments) found to reduce GOT than

Table 1. Effect of PGR on seed cotton yield, yield attributes and other characters of *Bt* cotton

Treatment	Seed cotton yield (t/ha)	No. of bolls/ plant	Boll weight (g)	Plant height (cm)	Stalk yield (t/ha)	Ginning out turn (%)	Mean internode length at harvest (cm)
T1- MC (SF)	1.75	24.9	3.81	72.33	6.13	34.83	3.50
T2- MC (SB)	1.73	24.5	3.58	79.40	6.25	34.32	3.70
T3 –MC (FB)	1.70	26.3	3.48	104.00	7.25	36.31	4.47
T4 –MC (SFB)	1.88	25.3	4.11	70.73	6.01	34.11	3.33
T5 – CCC (60 DAS)	1.70	25.4	3.52	102.73	6.73	35.33	4.55
T6 –NB (35, 60, 80 DAS)	1.82	28.7	3.25	107.33	7.69	36.23	4.74
T7 –NB (35, 75, 100 DAS)	1.78	29.5	3.23	105.33	7.62	36.73	4.86
T8 –NB (35, 60, 80, 100 DAS)	1.86	30.3	3.36	109.00	7.91	37.32	4.90
T9 –Etheral (60 DAS)	1.54	27.0	2.92	100.60	6.90	36.23	4.34
T10 –MH (60 DAS)	1.51	27.9	3.01	101.67	6.91	36.07	4.39
T11 – Detopping	1.68	28.1	3.24	99.87	6.68	36.47	4.70
T12 – Control (water spray)	1.65	26.3	3.14	106.00	6.92	36.16	4.65
CD (P=0.05)	0.213	3.47	0.61	12.80	1.14	1.45	0.57

(MC - Mapiquat chloride @ 50 g *a.i.* / ha ;CCC – Cycocel @ 60 g *a.i.* / ha at 60 DAS; NB – Nitrobenzene @ 2 ml / lit; Etheral – Etheral @ 45 PPM at 60 DAS; MH - Maleic Hydrazide @ 1000 PPM at 60 DAS; Detopping - at 110 DAS); (Application stages: S – Square formation; F – Flowering and B – Boll formation) control. Nitrobenzene spray treatments were found to increase days to 50 % boll bursting over treatments where Mapiquat chloride is applied at square formation stages. The mean internode length at harvest was significantly reduced in treatments where Mapiquat chloride was applied at square formation stage than control. Copur *et al*.(2010) also reported reduction in plant height due to Mapiquat chloride resulted from inhibition of gibberellic acid (GA) concentration. Increase in yield due to Mapiquat chloride is reported by Kumar *et al.* (2003) due to increased chlorophyll content and photosynthetic rate. Plant height was found to increase due to Nitrobenzene (3 and 4 sprays). Increase in growth on tomato due to Nitrobenzene was also observed by Deb *et al.* (2012). Stalk yield and ginning out turn were also increased due to Nitrobenzene over control.

CONCLUSION

Mapiquat chloride three sprays (at square formation and flowering stage) and Nitrobenzene (at 35, 60, 80 and 100 DAS) increased seed cotton yield over control. Mapiquat chloride decreased plant height, reduced mean internode distance and duration of cotton.

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Performance of late sown wheat (*Triticum aestivum* L.) in response to mitigation of high temperature stress through foliar applied synthetic compounds

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Sowing of wheat often gets delayed under rice-wheat cropping system due to late harvesting of paddy and consequently temperature rises abruptly beyond 20°C which coincides with anthesis and grain filling period of wheat (Tewolde *et al*. 2006). This leads to reduction of the photosynthetic activity of flag leaf during this period by degradation of chlorophyll mainly due to the production of reactive oxygen species (Cakmak, 2005) and ultimately yield declines. Discrete reports were available to show beneficial effects of some compounds like potassium nitrate, calcium chloride, glyceine betaine and arginine in many crops including wheat when applied exogenously under abiotic stresses like high temperature and drought. The principal role involved is to protect the photosynthetic apparatus of leaves, mainly chlorophyll, under stressful condition. Therefore, an attempt was made to test the efficacy of these synthetic compounds in improving grain yield and protecting chlorophyll content of flag leaf in late sown wheat facing high temperature stress.

METHODOLOGY

A field experiment was conducted in the sandy loam soil of the experimental farm of Bihar Agricultural University, Sabour, Bhagalpur during the *rabi* season of 2013-14. The soil was neutral in reaction with a pH 6.92, and 125.44, 18.05 and 118.95 kg/ha available N, P and K respectively. Meteorological data during the crop growing period reveals that the crop faced high temperature stress (Temperature beyond 20°C) from February 2nd week onwards which coincides with its anthesis and grain filling period. The experiment was carried out in the split-plot design replicated thrice. Two contrasting varieties of wheat, i.e., DBW-14 and K 307 meant for late and timely sown irrigated condition in the region were kept in main plots. Each main plot was further sub-divided into fourteen subplots and received foliar spray of different synthetic compounds either at higher dose in booting or in anthesis stage or at half the higher dose in both booting and anthesis stage in order to mitigate high temperature stress and were compared with control received no foliar spray as follows: No foliar spray; foliar spray of KNO_3 (1.0 %) at booting stage; foliar spray of KNO_3 (1.0 %) at anthesis stage; foliar spray of KNO_3 (0.5 %) both at booting & anthesis stage; foliar spray of $CaCl_2$ (0.2%) at booting stage; foliar spray of $CaCl_2$ (0.2%) at anthesis stage; foliar spray of $CaCl_2$ (0.1%) both at booting & anthesis stage; foliar spray of glycine betaine (100 mM) at booting stage; foliar spray of glycine betaine (100 mM) at anthesis stage; foliar spray of glycine betaine (50mM) both at booting & anthesis stage; foliar spray of arginine (2.5mM) at booting stage; foliar spray of arginine (2.5mM) at anthesis stage; foliar spray of arginine (1.25mM) both at booting & anthesis stage and foliar spray of water both at heading & anthesis stage. For assessing chlorophyll content in the flag leaf, sampling was done from each plot two days after each spray. The chlorophyll was extracted from flag leaf disc using 80% acetone solution and was estimated as described by Arnon (1949).

RESULTS

Grain yield was increased significantly and maximized when the crop, irrespective of varieties, received foliar spray of KNO_3 at the rate of 0.5% both during booting and anthesis stage over no foliar spray and was found to be statistically at par with single foliar spray of KNO_3 at the rate of 1% only during anthesis stage. These values, when compared with those obtained in response to foliar spray of $CaCl_2$ at the rate of 0.1% both at booting and anthesis stage and at the rate of 0.2% only at anthesis stage, no significant difference could be found. However, the degree of positive impact of KNO_3 and $CaCl_2$ was found to be more pronounced in DBW-14 than in K-307 (Table 1). Across the varieties, 10.99 % and 9.31% increment in grain yield was registered in response to foliar spray of KNO_3 at the rate of 0.5% both during booting and anthesis stage and at the rate of 1% only during anthesis stage, respectively over no foliar application (Fig. 1). NO_3^- ions delays abscisic acid synthesis and promotes cytokinin activity in leaves of cereals which maintains the normal physiological

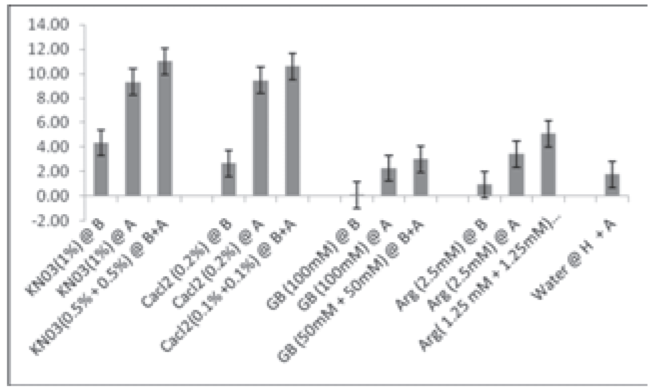

Fig. 1. % increase in grain yield of late sown wheat as affected by foliar application of synthetic compounds over control

Table 1. Grain yield (t/ha) and flag leaf chlorophyll content (mg/g of fresh weight) of late sown wheat as affected by foliar spray of synthetic compounds

Sub plots	Grain yield (t/ha)			Flag leaf chlorophyll content(mg/g of fresh weight)					
	Main plots		Mean	At anthesis			At grain filling		
	DBW14	K307		DBW14	K307	Mean	DBW14	K307	Mean
No Spray	3.01	3.11	3.34	4.85	4.84	4.84	3.42	3.42	3.42
KNO_3 Spray @1.0% at B	3.53	3.41	3.30	5.41	5.21	5.31	3.99	3.78	3.89
KNO_3 Spray @1.0% at A	3.60	3.61	3.76	5.88	5.43	5.66	4.46	4.01	4.23
KNO_3 Spray @ 0.5% each at B + A	3.62	3.69	3.78	6.03	5.68	5.86	4.61	4.26	4.43
$CaCl_2$ Spray @0.2% at B	3.17	3.41	3.19	5.44	4.83	5.14	4.02	3.40	3.71
$CaCl_2$ Spray @0.2% at A	3.49	3.62	3.76	5.48	5.17	5.33	4.06	3.74	3.90
$CaCl_2$ Spray @ 0.1% each at B + A	3.51	3.93	3.42	5.82	5.36	5.59	4.39	3.93	4.16
GB Spray @ 100mM at B	3.36	3.51	3.36	4.87	4.58	4.73	3.45	3.16	3.30
GB Spray @ 100mM at A	3.29	3.39	3.56	5.05	4.86	4.95	3.62	3.44	3.53
GB Spray @ 100mM each at B + A	3.38	3.39	3.47	5.02	4.93	4.97	3.59	3.50	3.55
Arg. Spray@ 2.5mM at B	3.45	3.37	3.39	4.50	4.56	4.53	3.08	3.14	3.11
Arg. Spray@ 2.5mM at A	3.54	3.21	3.48	4.73	4.80	4.76	3.30	3.38	3.34
Arg. Spray@ 2.5mM each at B + A	3.13	3.58	3.30	4.87	4.79	4.83	3.45	3.37	3.41
Water Spray at H + A	3.09	3.01	3.42	4.93	4.68	4.80	3.51	3.25	3.38
Mean	3.27	2.89	2.81	5.21	4.98		3.78	3.56	-
	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
Variety	0.025	0.156		0.063	NS		0.063	NS	
Foliar spray	0.063	0.18		0.121	0.34		0.121	0.35	
Interaction	0.089	0.255		0.171	NS		0.171	NS	

B=Booting stage; A= Anthesis stage; H= Heading stage; GB= Glycine betaine; Arg.= Arginine mM= Millimolar activity of flag leaf even under stressful situation which might have contributed towards higher grain yield with KNO_3. Significantly higher chlorophyll content in flag leaf under these treatments over control also supports the same fact and indicates that KNO_3 protects photosynthetic apparatus of leaves against high temperature stress (Table 1). The same trend was also noticed in case of foliar spray of $CaCl_2$ at the rate of 0.1% both at booting and anthesis stage and at the rate of 0.2% only at anthesis stage, which enhanced the grain yield of wheat to the tune of 10.60% and 9.45%, respectively and maintained significantly higher chlorophyll content in flag leaf over control (Table 1 and Fig. 1). This result is in concordance with the findings of Sarkar and Tripathy (1994), whereby they have reported that NO_3^- and its counter ions both K^+ and Ca^{++} had positive impact on grain filling and yield of wheat when sprayed at 50% flowering stage.

CONCLUSION

Foliar application of synthetic compounds like KNO_3 or $CaCl_2$ at the rate of 1.0% or 0.2%, respectively during anthesis stage is beneficial in improving yield of late sown wheat exposed to high temperature stress through its effect in maintaining higher chlorophyll content in flag-leaf. This strategy can be adopted in improving yield of late sown wheat under rice-wheat cropping system in India.

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Evaluation of establishment methods and N managementin rice

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Growing more rice with reduced cost of productionand maintaining soil health are the major concerns of rice farming. Good crop establishment is one of the vital components for efficient use of resources and desired level of productivity in rice. Establishing rice by manual transplanting is labour intensive and increasingly difficult due to higher cost and shortage of labour.Change in method of rice establishmentis inevitable to improve productivity, profits and sustainability. Direct seeding of dry seed, sowing of sprouted seed on to the prepared seed bed using drum seeder and machine transplanting are some of the methods of crop establishment which require less water and less reliant on labour compared to conventional practice of manual transplanting (Rao *et al*., 2015). As nitrogen is the king pin of rice nutrition, optimum nitrogen management is highly imperative to realize the full potential of improved methods of crop establishment because of variations in N dynamics under different establishment methods. Therefore a study was under taken to findout productive and remunerative and less water required rice establishment system with optimum N management.

METHODOLOGY

Field experiments were conducted during two consecutive *kharif and rabi*season of 2014 and 2015 at agricultural research station Ragolu, A.P. India .The soil was sandy clay loam having pH 7.3, CEC of 39.1 meq/100g of soil, organic carbon 0.49%, available nitrogen 211 kg/ha, available P_2O_5 29 kg/ha and K_2O 243 kg/ha. The top 30 cm soil had a bulk density of 1.46 g/cc.The trial was conducted in split plot design with three replications. Main plots consists four crop establishment methods viz., dry direct sown rice(DDS), sowing by Drum Seeder, machine planting, and normal transplanting. Sub plots consists four N management practices viz., N@80kg/ha, N@120kg/ha, N@120kg/ha (66% fertil-

Table 1. Effect of methods of rice establishment on productivity and profitability of rice

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Water Requirement (mm)	Gross Returns (Rs/ha)	Net Returns (Rs/ha)	RRI* (Rs/Rs)
Crop Establishment method						
M1-Dry direct sowning	6162	7137	983	92362	56513	1.58
M2- Drum seeding	5945	6861	1001	89207	46520	1.09
M3-Machine planting	6447	7588	1047	96751	50164	1.08
M4- Transplanted	6225	7102	1238	93123	43386	0.87
SEm±	143	203	-	2289	1081	0.023
CD (P=0.05)	492	698	-	7896	3728	0.08
N management practice						
N1-80kg/ha	5444	6267	-	81561	32411	0.66
N2-120kg/ha	6280	7242	-	94000	44263	0.89
N3-120kg/ha(INM)*	6279	7292	-	94133	38798	0.70
N4-120kgN/ha+FYM	6425	7445	-	96233	37737	0.65
SEm±	199	297	-	1584	981	0.021
CD (P=0.05)	581	868	-	4625	2864	0.06

*INM=66% fertilizer+33% thro' organics *RRI=Rupee returned by rupee invested

izer+33% thro' organic), N@120kg/ha+ FYM@ 10t/ha. Standard and recommended cultural and plant protection measures followed for respective establishment methods as per the treatments. Yanmar 8 row transplanter used for planting of tray raised 16 days old seedlings at a spacing of 30cm X 21 cm in case of machine planting. Organic manures were applied based on their nutrient content and incorporated three weeks before planting Water measured using water meter. Economics were worked out taking prevailing market price. Data were collected duly following standard procedureand analyzed using ANOVA and the significance was tested by Fisher's least significance difference (P= 0.05) by pooling two years data.

RESULTS

The two years pooled data revealed that, among different crop establishment methods of rice machine planting recorded significantly higher grain yield which was 8.44 percent higher compared to drumseeding. Uniform depth of planting with younger seedlings at wider spacing might have provided optimum growing conditions ultimately resulted into higher grain yield. Rao *et al.* (2015) also reported similar results of superior performance of machine planting over other methods of rice establishment. There was no measurable difference in grain yield among machine planting, dry direct sowing and transplanting. Among different establishment methods direct sowing by drum seeder resulted lesser grain yield, however, it was at par to dry direct sowing and transplanting. Rice establishment by DDS took 21% lesser water compared to transplanting and next best treatment was drum seeding with 19% water saving . Economics of rice showed that, though the gross returns were higher with machine planting, net returns and rupee returned by rupee invested was higher with DDS system due to conspicuously lesser cost of cultivation of DDS compared to other establishment systems. Murthy *et al.* (2015) reported similar findings of superior performance of alternate systems of rice establishment on crop and water productivity of in rice. Among N management practices studied, application of 120kgN/ha+ FYM@10t/ha recorded significantly higher grain and straw yield of rice and higher gross returns over N@ 80 kg/ha however, it was found on par to N@ 120kg N/ha and 120 kgN/ha (66% through fertilizer+33% through organic). Application of N@120 kg/ha recorded markedly higher net returns and rupee returned by rupee invested.

CONCLUSION

Among different crop establishment methods, machine transplanting proved as productive,dry direct seeding (DDS) emerged as remunerative and water savingmethod forrice.

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Improving fodder productivity through intercropping under temperate climate

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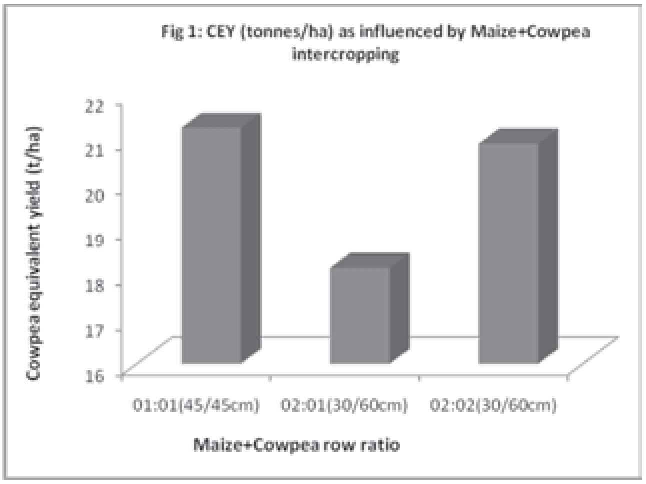
Livestock rearing is an integral part particularly of dryland farming systems. The area of 0.45 lakh hectare (6% of total cultivable area) under fodder cultivation in Jammu and Kashmir needs to be covered under high yielding varieties of fodder crops and efforts are to be made to increase this area to 1.00 lakh hectares by bringing more current fallow lands under fodder cultivation (Masoodi, 2003). Single crop cultivation is generally followed in the valley; where about 80 % cultivable lands are being occupied by paddy with assured irrigation. Some farmers grow fodder oats after rice during *rabi* season which mature during April–May. With limiting area under cultivated fodder, the yield along with quality of fodder crops can be improved through intercropping of botanically diverse forage species. Besides best utilization of all the resources, fodder cereals intercropped with fodder legumes can provide stability to production. The unirrigated tracts of Kashmir Valley during *kharif* season are suitable for growing maize, sorghum and cowpea as fodder crops and can provide nutritious fodder when grown in association. However, information is lacking on spatial arrangement under intercropping system with different fodder crops reflecting productivity and profitability in this region. Therefore, a rational approach is required on spatial arrangement of these fodder crops in an intercropping system as it has important effects of the balance of competition between component crops reflected by total productivity and profitability.

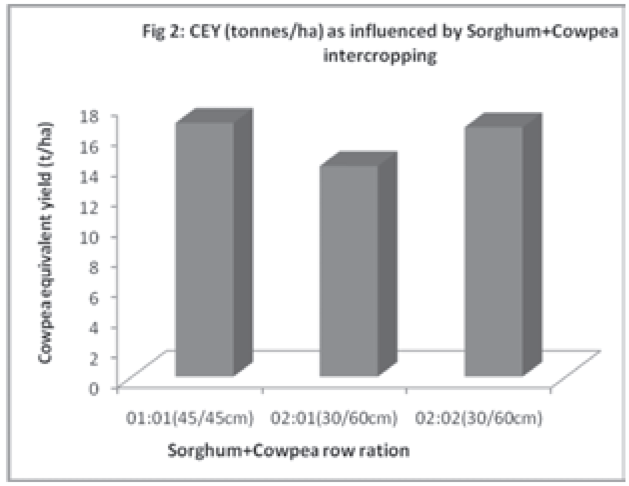
METHODOLOGY

The field experiments were carried out for two consecutive years at the research farm of Faculty of Agriculture (SKUAST-K), Wadura Campus, (latitude of 34° 21' N, longitude of 74° 24'E and altitude of 1,595 m above mean sea level) under dryland temperate condition of Kashmir valley. The soil was well drained, non-saline (EC 0.27 dS/m), neutral (pH 7.4) containing medium in organic carbon (0.63 %), available nitrogen (298 kg/ha) and available phosphorus (18.3 kg/ha) and high in available potassium (320 kg/ha). The crops were grown under rainfed condition with total rainfall received 483.3 mm and 495.2 mm during the crop period of first and second years, respectively. The experiment was consisted of nine treatments laid out in randomized block design with three replications. The treatments comprised of three sole crops of fodder 'African Tall' maize, fodder 'M.P. Chari' sorghum and fodder 'UPC 9202' cowpea and six additive intercropping systems of maize and sorghum each with cowpea *i.e.* uniform row series of 1:1, paired row series of 2:1 (30/60) and paired row series of 2:2 (30/60) of maize + cowpea and sorghum + cowpea. The seed rates of maize sorghum and cowpea in pure stands were 40, 15 and 60 kg/ha, respectively. The recommended rates of fertilizers were applied to the component crops. No additional fertilizers were added to the intercrop. The crops were sown in the first week of June and harvested at 75 DAS in the third week of August during both the years of experimentation. Samples of all the crops were harvested manually from the central net areas for yield assessment. Production efficiency was also calculated by dividing cowpea equivalent yield (CEY) by 75 days of total crop duration (Nedunchezhiyan, 2007).

RESULTS

Green and dry fodder yields were significantly influenced by different intercropping treatments. The total green and dry fodder yields were higher with uniform 1:1 row series of both maize + cowpea and that of sorghum + cowpea intercropping system, the latter being at par with the former. Both the uniform intercropping systems were also remained at par with the paired 2:2 rows series of maize + cowpea and sorghum + cowpea. System productivity in terms of cowpea equivalent yield (CEY) was highest (21.23 tonnes/ha) with uniform 1:1 row series followed by paired rows 2:2 series of maize + cowpea intercropping systems (Fig. 1). Both the above intercropping systems remained at par to each other. Similar trend was also observed in sorghum + cowpea intercropping system (Fig. 2), but significantly inferior to maize + cowpea intercropping systems. This might be due to higher market value of fodder maize compared to fodder sorghum. Production ef-





ficiency of maize + cowpea was also maximum with uniform 1:1 row series (283.06 kg/ha/day) followed by paired 2: 2 rows series (278.40 kg/ha/day).

CONCLUSION

During *kharif* season, one row of fodder cowpea in between two uniform rows of maize could be a productive and profitable intercropping system in dryland temperate condition of Kashmir Valley. However, two rows of cowpea in between two paired row of maize are also equally profitable. Sorghum + cowpea intercropping with the similar row arrangement has been found inferior to maize + cowpea intercropping systems.

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Status of insect-pests and natural enemies of direct seeded and transplanted rice

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Direct seeded rice (DSR) technique is becoming popular now a day because of its low-input demanding nature. This method has become inevitable for tail end farmers who receive less amount of irrigation water. The major insect pests attacking rice are rice leaffolder, *Cnaphalocrocis medinalis* (Guenee), brown planthopper, *Nilaparvata lugens* (Stal), whitebacked planthopper, *Sogatella furcifera* (Horvath) and yellow stem borer, *Scirpophaga incertulas* (Walker). The loss due to yellow stem borer ranges from 3 to 65% and that of 5 to 39% by leaf folder. A change from transplanting to direct seeding may affect the status of various pests. The main factors that influence pest status are exposure of very young seedlings to pests, longer plant duration in the field and higher plant density. This study describes possible changes in pest status and natural enemies in direct seeded rice field. It is felt that a complex and rich web of general and specific insect

Table 1. Status of insect-pests in direct seeded and transplanted rice ecosystems during 2013-14

Observation period	Ecosystem	Rice insect pests[#]					
		Leaf folder damage (%)	Dead heart (%)	White ear at pre harvest (%)	Green leaf hoppers/hill	BPH/hill	WBPH/hill
30 DAS	Direct seeded rice	1.77	3.04	0.00	1.20	0.00	0.00
	Transplanted rice	1.11	1.15	0.00	1.45	0.00	0.00
	't' value	1.04*	3.07*	0.00	2.24*	0.00	0.00
45 DAS	Direct seeded rice	3.36	4.23	0.00	2.51	0.00	0.00
	Transplanted rice	1.89	2.77	0.00	3.20	0.00	0.00
	't' value	2.89*	5.35*	0.00	4.06*	0.00	0.00
60 DAS	Direct seeded rice	3.88	1.11	0.00	2.83	0.55	0.96
	Transplanted rice	2.47	0.95	0.00	3.29	0.84	1.56
	't' value	1.79*	2.44*	0.00	3.09*	1.26*	2.89*
75 DAS	Direct seeded rice	5.03	0.00	2.20	2.72	1.49	1.48
	Transplanted rice	4.18	0.00	0.92	2.86	1.87	2.39
	't' value	2.16*	0.00	2.12*	5.29*	3.64*	4.61*
90 DAS	Direct seeded rice	3.41	0.00	5.54	1.70	2.38	3.42
	Transplanted rice	1.90	0.00	4.30	2.20	5.29	4.67
	't' value	2.48*	0.00	2.19*	3.39*	1.16*	7.68*
105 DAS	Direct seeded rice	2.08	0.00	9.01	1.38	1.37	2.69
	Transplanted rice	1.19	0.00	6.42	2.15	3.37	3.25
	't' value	3.69*	0.00	4.08*	1.16*	7.09*	4.75*
120 DAS	Direct seeded rice	1.43	0.00	9.65	0.80	0.96	1.14
	Transplanted rice	0.96	0.00	6.81	1.32	2.30	2.44
	't' value	3.05*	0.00	4.53*	4.22*	5.82*	5.75*

[#]Mean of 10 hills; *significant at 5% level; DAS: days after sowing

pests and natural enemies of direct seeded rice (DSR) ecosystem need to be studied.

METHODOLOGY

The treatments consisted of DSR (T_1) and transplanted (T_2) situation (PTR) under unprotected condition. The size of individual plot was 5 m × 4 m (20 m^2) in which the crop geometry for transplanting rice was maintained at 30 cm × 10 cm (row to row and hill to hill spacing) with three to four seeding per hill. In DSR plots, crop geometry was maintained at 22.5 cm × 10 cm (row to row and hill to hill) with single seedling per hill. The observation on status of insect-pests and natural enemies in DSR and PTR crop was recorded at 10 days interval. The per cent dead heart or white ears were calculated using following formula as suggested by Kaushik Chakraborty (2011). The number of motile stages (nymphs and adults) of green leafhopper and planthoppers (BPH and WBPH) from 10 randomly selected hills were counted by tapping and physical counting and expressed per hill. The common predator's *viz.,* spiders, mirid bugs and Coccinellids were counted on 10 hills in each plot and later averaged to per hill basis.

RESULTS

Rice leaf folder incidence was observed maximum during crop growth period in direct seeded rice under unprotected situation. However, peak incidence was noticed during 75 DAS (5.03%) and (4.18%) under unprotected condition of DSR and PTR (Table 1). These findings are in close conformity with the report of Mohan and Janarthanan (1985) who reported that peak activity of rice leaf folder was noticed between October and March. Per cent dead heart caused by YSB was noticed in vegetative phase of the crop, the maximum per cent dead heart was noticed the peak incidence of white ears was recorded in DSR (9.65%) followed by PTR (6.81%) under unprotected situation prior to harvest of the crop (Table 1). The green leafhoppers were active thought the crop period in season and highest green leafhopper, *Nephotettix virescens* (Distant) population was (3.29/hill) recorded in PTR under unprotected situation during 60 DAS (Table 1). Incidence of planthoppers (BPH and WBPH), *Nilaparvata lugens* (Stal) and *Sogatella furcifera* (Horvath) was found to be more in PTR under unprotected situation during crop growth period. During 90 DAS population of planthopper was higher in unprotected PTR situation (5.21 and 4.67/hill) (Table 1). Spider population (Tetragnatha sp and Lycosa sp) attained peak at reproductive phase of the crop and has maximum in PTR under unprotected condition (1.60/hill) followed by DSR unprotected condition (1.23/hill) at 105 days old crop (Table 2). Mirid bug (Cyrtohinus lividipennis Reuter) population was significantly higher in PTR under unprotected situation in both the season (4.63 adults/hill). Coccinelid (Coccinella

Table 2. Status of predators in direct seeded and transplanted rice ecosystems during 2013-14

Observation period	Predators[#]				
	Ecosystem	Spiders/hill	Mirid bugs/hill	Coccinellids/hill	Staphylinids/hill
30 DAS	Direct seeded rice	0.20	0.00	0.68	0.00
	Transplanted rice	0.32	0.00	0.93	0.00
	't' value	NS	0.00	1.96*	0.00
45 DAS	Direct seeded rice	0.42	0.00	1.31	0.00
	Transplanted rice	0.47	0.00	1.26	0.00
	't' value	NS	0.00	NS	0.00
60 DAS	Direct seeded rice	0.60	0.00	1.44	1.82
	Transplanted rice	0.88	0.00	1.90	1.40
	't' value	1.83*	0.00	1.64*	0.90
75 DAS	Direct seeded rice	0.70	0.73	2.16	2.66
	Transplanted rice	0.90	1.13	2.48	2.18
	't' value	1.97*	NS	1.54*	1.21*
90 DAS	Direct seeded rice	0.89	1.28	1.80	1.23
	Transplanted rice	1.10	1.87	2.01	0.94
	't' value	2.55*	NS	NS	0.99*
105 DAS	Direct seeded rice	1.23	3.45	1.53	0.00
	Transplanted rice	1.60	4.63	1.74	0.00
	't' value	2.35*	1.69*	1.12*	0.00
120 DAS	Direct seeded rice	1.18	1.90	1.29	0.00
	Transplanted rice	1.30	2.10	1.32	0.00
	't' value	NS	1.37*	NS	0.00

[#] Mean of 10 hills; *significant at 5% level; NS: non-significant; DAS: days after sowing

transversalis Fabricius) population reached peak (2.48/hill) during 75 DAS (Table 2). Activity of Staphylinids (Paderus fuscips Curtis) was found through the cropping period in both the season. There is a significantly deference between the beetle population in DSR and PTR situation under unprotected condition. Present findings are in agreement with Anon. (1988) who reported that the Staphylinid beetles were observed to the tune of one to three per hill in paddy ecosystem.

CONCLUSION

Rice leaf folder and yellow stem borer damage was found to be more in DSR than PTR in both the seasons. Maximum leaf folder *Cnaphalocrocis medinalis* (Guenee) (13.03%) damage and yellow stem borer damage (13.49%) of white ears was recorded during last week of October and second week of November in DSR under unprotected situation respectively.

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Evaluation of normal and transplanted pigeon pea under various planting methods in rainfed condition

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Pigeon pea (*Cajanuscajan* (L.) Millsp) was cultivated in the semi-arid areas of tropics and sub tropics. It is native of Africa and the early traders have introduced the crop in India. The ability of pigeon pea to produce economical yields under moisture deficit soil characteristics makes it an important crop of dry land agriculture. Farmer grows it an important crop using long established traditional practices. The yield of pigeon pea is limited by a number of factors such as Agronomic, Pathogenic, Entomological, Genetic and their interaction with environment. Among the different Agronomic practices, date of sowing and choice of a suitable geometry (row spacing) and plant population for a particular genotype are the important factors which is limiting the yield. Long duration pigeon pea can adjust to a wide range of population and spacing. In dry farming areas of Northern Karnataka, the rainfall is not only scanty but also erratic. Thus, soil moisture becomes the most limiting factor in production of pigeon pea. The present investigation was undertaken to assess the evaluation of normal and transplanted pigeon-pea under various planting methods in rainfed condition.

METHODOLOGY

The field experiment was conducted at the Research farm, AICRP on Dryland Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2014 and 2015. The experiment was consisted of three of planting system S_1: Normal planting), methods of planting i.e. M_1: (Ditch method), M_2: (BBF), M_3: (Flat bed), M_4: (Ridges & Furrow), M_5 (Opening of furrow) and M_6 (Set Row planting) in the investigation. The seedlings in polybags (22.5 cm × 15 cm) were raised for the purpose of transplanting wherein bags were filled with the mixture of Soil + FYM + Sand (7:2:1). Whereas in case of bed transplanting the seedlings were grown on beds. The seeds were placed on raised beds as nurs-

Table 1. Mean seed, stalk, bhoosa and biological yields and harvest index of pigeon pea as influenced by different treatments (2013-14)

Treatments	Grain yield (kg/ha)	Stalk yield (kg/ha)	Bhoosa yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Planting System					
S_1 – Normal planting	1340	3818	663	5821	23.02
S_2– Transplanting (Poly bag)	1890	5164	932	7986	23.67
S_3– Transplanting (Seedbed)	1180	3334	509	5023	23.49
SEm±	140.9	243.5	57.52	310.7	0.25
CD (P=0.05)	420.1	732.4	172.1	933.4	NS
Methods of planting					
M_1 – Ditch method	1885	5805	895	8585	21.96
M_2– Broad bed furrow	1600	4425	703	6728	23.78
M_3 – Flat bed	1150	3093	494	4737	24.28
M_4 - Ridges & furrows	1455	3914	647	6016	24.19
M_5 – Opening of furrow	1570	4222	701	6493	24.18
M_6 – Set Row planting	1210	3254	518	4982	24.29
SEm ±	101.7	151.1	72.90	664.6	0.91
CD (P=0.05)	305.3	452	218.7	1994	NS
Interaction (S x M)					
SEm±	68.33	81.70	57.16	255.4	3.47
CD (P=0.05)	205	244.3	171.5	766.4	NS

Table 2. Mean seed, stalk, Bhoosa and biological yields and harvest index of pigeon pea as influenced by different treatments (2014-15)

Treatments	Grain yield (kg/ha)	Stalk yield (kg/ha)	Bhoosa yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Planting System					
S_1 – Normal planting	1210	3448	599	5257	23.01
S_2– Transplanting (Poly bag)	1760	4809	868	7437	23.66
S_3– Transplanting (Seedbed)	1070	3024	462	4556	23.48
SEm±	123.30	196.4	27.00	249	61
CD (P=0.05)	370.6	582.0	80.14	738	NS
Methods of planting					
M_1 – Ditch method	1750	5390	831	7971	21.95
M_2– Broad bed furrow	1470	4066	646	6182	23.77
M_3 – Flat bed	1040	2798	447	4285	24.27
M_4 - Ridges & furrows	1330	3578	591	5499	24.18
M_5 – Opening of furrow	1440	3873	643	5956	24.17
M_6 – Set Row planting	1095	2945	469	4509	24.28
SEm±	96.66	458.3	63.04	598.1	0.71
CD (P=0.05)	290.1	1375	189.1	1794	NS
Interaction (S x M)					
SEm±	109	123.0	37.11	161.0	2.41
CD (P=0.05)	324	369.7	110.4	481.2	NS

ery of pigeon-pea, One month before normal onset date of monsoon. In set row planting paired row planting was done with same plant population.

RESULTS

The highest grain yield (pooled data 1825 kg/ha), stalk yield (pooled data 4986 kg/ha), bhoosa yield (pooled data 900 kg/ha) and biological yield (pooled data 7711 kg/ha) was recorded by transplanting (poly bag) system of planting (S_2) which was significantly superior over normal planting system (S_1) and transplanting (seed bed) system of planting (S_3). The yields were influenced by various methods of planting. Among the planting methods ditch planting method was found significantly superior in respect of grain yield (pooled data1817 kg/ha), stalk yield (pooled data 5597 kg/ha), bhoosa yield (pooled data 863 kg/ha) and biological yield (pooled data 8278 kg/ha) over rest of the treatments except that it was at par with broad bed furrow (M_2). The interaction effects of planting systems and methods of planting were found to be significant in influencing the various yield attributes, grain yield (kg/ha), straw yield (kg/ha), biological yield (kg/ha). The treatment combination of normal planting with ditch method recorded highest yield attributes, seed yield and straw yield over rest of all treatment combination except that it was at par with transplanting (poly bags) X ditch method and transplanting (poly bags) Xbroad bed furrow.

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Intercropping in sweet corn (*Zea mays*) at varying crop geometry for higher economic profitability in northern hills of Chhattisgarh

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Maize is the third most important cereal in the world. India ranks fifth in area and third in production and productivity among cereal crops. It is a versatile crop, which finds a place in the human diet, animal feed, fodder and industrial raw material. Recently specialty corn such as sweet corn and baby corn have emerged as alternative food sources, especially for affluent society. Maize growers are shifting towards specialty corn production due to higher returns and also opening opportunities for employment generation specially in peri-urban areas. Sweet corn (*Zea mays* L. *saccharata* Sturt) used as a human food in soft dough stage with succulent grain. The higher content of water soluble polysaccharide in the kernel adds texture and quality in addition to sweetness (Venkatesh *et al*., 2003). As it is harvested at green cob stage, much before maturity of the grain and intercropping will provide substantial yield advantage over sole crop owing to temporal and spatial complementarity and minimizing inter-or intra-specific competition (Chatterjee and Mandal, 1992). Further, the slow growth and wider space between the cereals during the initial stage of crop growth is fully exploited by short duration vegetable/legume crops like coriander (*Coriandrum sativum* L.), fenugreek (*Trigonella foenum-graeum* L.) and french bean (*Phaseolus vulgaris* L.). For successful and profitable intercropping system, there must be proper row ratio of component crop in order to avoid limitation of reduced plant population of base crop under traditional intercropping system (Pandey *et al*., 1999).

METHODOLOGY

The present investigation was conducted during winter (*rabi*) seasons of 2011-12 and 2012-13 at the Research Farm, RMD Collage of Agriculture & Research Station, Ambikapur (Chhattisgarh). The soil of experimental field was sandy loam in texture. Chemical analysis of the soil (top 15 cm) showed an acidic pH (5.7), organic carbon 0.52%, 234 kg/ha nitrogen, 8.4 kg/ha phosphorous, 268 kg/ha potassium. The study involved 13 treatments including 4 sole crop treatments of sweet corn, coriander, fenugreek, french bean whereas 3 treatments of sweet corn spaced 60 cm apart intercropped with coriander, fenugreek and french bean at 1:1 row ratio and 6 treatments of paired row of sweet corn spaced 45-90-45 cm apart intercropped with 2:2 and 2: 3 for coriander and fenugreek whereas 2:1 and 2:2 for french bean were taken for study. The experimental plots were 6 m long and 4 m wide, laid out in randomized block design and replicated thrice. The cultivars used in the study were 'Madhuri' (Sweet corn), 'Pant Haritima' (Coriander), 'RMT-305' (Fenugreek) and 'Contendor' (French bean). The package of recommended practices was adopted to maintain the crops. Immediately after sowing of the seed a light irrigation was given to the crop for uniform germination and next day pendimethalin (1.0 lit *a.i.*/ha) was applied to control weeds. In case of coriander and fenugreek, leaves were nipped 2 cm above ground after 4-5 weeks of sowing and whole plants were uprooted after 2-3 nipping bundled whereas picking of green pods of french bean were started after 5 weeks of sowing and continued up to 3-4 pickings. The sweet corn green cobs were harvested when the cobs had dried silk, green husk corn and soft kernel during first week of February in both the years. Gross returns, net returns and benefit: cost ratios were calculated on the basis of prevailing market price of inputs and produce. To compute the productivity of system, sweet corn-equivalent yield (SCEY) was obtained by dividing the economic value of the produce (yield of produce x price of produce) with the price of sweet corn. System productivity was worked out by adding sweet corn yield and sweet corn-equivalent yield of green fodder of sweet corn, coriander, fenugreek and french bean of respective year.

RESULTS

Intercropping sweet corn with different row arrangements significantly increased sweet corn-equivalent yield as compared to sole sweet corn (Table 1). Maximum sweet corn-equivalent yield (21.21 t/ha), net return (Rs. 175340.2/ha) and BC ratio (4.78) was recorded under paired combination of sweet corn and coriander (2:3) which was at par with paired combinations of sweet corn with fenugreek (2:3) and french bean (2:3) but significantly superior to other combinations and sole crops. All the intercropping combinations proved more advantageous in terms of equivalent yield, net return and

Table 1. Effect of intercropping sweet corn, coriander, fenugreek and french bean on sweet corn equivalent yield (SCEY), net return (Rs/ha), BC ratio and LER (pooled data of 2 years)

Treatment	Sweet corn equivalent yield of system (SCEY) (t/ha)	Net return (Rs/ha)	BC ratio	LER
Sweet corn sole	13.96	103561.8	2.88	
Coriander sole	11.45	89100	3.51	
Fenugreek sole	10.32	78400	3.16	
Fenugreek sole	6.75	39000	1.37	
Sweet corn + Coriander (1 +1)	17.22	134967.1	3.63	1.29
Sweet corn + Fenugreek (1 +1)	17.43	137138.6	3.69	1.33
Sweet corn + French bean (1 +1)	18.52	146409.6	3.78	1.53
Sweet corn + Coriander (2 +2)	19.64	159960.5	4.28	1.46
Sweet corn + Fenugreek (2 +2)	19.21	155285.5	4.22	1.46
Sweet corn + French bean (2 +1)	19.39	156757.5	4.19	1.77
Sweet corn + Coriander (2 +3)	21.21	175340.2	4.78	1.62
Sweet corn + Fenugreek (2 +3)	20.59	168898.8	4.56	1.48
Sweet corn + French bean (2 +2)	20.24	164189.4	4.30	1.84
CD (P=0.05)	1.75	18535.57	0.42	-

BC ratio than sole crops. Data further revealed that maximum LER (1.84) was recorded under paired combination of sweet corn and french bean (2:2) followed by paired combinations of sweet corn + coriander (2:3) and sweet corn + fenugreek (2:3) which had land equivalent ratio of 1.62 and 1.48, respectively.

CONCLUSION

It is concluded that for getting higher system productivity in terms of green cob of sweet corn, good quality forage along with highest economic return one should opt for growing paired row of sweet corn spaced 45-90-45 cm apart intercropped with coriander at 2:3 row ratio under northern hills of Chhattisgarh.

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Temporal and spatial variability of yellow mosaic virus outbreak in soybean in Bundelkhand agroclimatic zone of Madhya Pradesh

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In Bundelkhand Agro-Climatic Zone (BACZ) of Madhya Pradesh, griddle beetle, white fly and yellow mosaic virus in soybean has become a major biotic stress for its sustainable soybean production in this zone. Yellow Mosaic Virus (YMV) was not reported as devastating disease and causing a limited yield loss throughout this zone. But in recent year YMV become a devastating disease and its outbreak caused very severe yield loss (more than 80 %) during *kharif* 2015 in this zone. The inoculation rate is influenced by the number of white fly and monsoon phase. The virus transmission rates in crop to crop depend on ambient temperature conditions (Honda *et al.,* 1983). A multi level data on temporal and spatial scale has been collected to assess white fly incidence and YMV infection on soybean during 2015-16 to achieve the objectives. Weather parameters were characterized for their peak incidence and infections. Based on reported results a thumb rule for YMV outbreak has been developed for its wide scale management application. Objectives were (i) to assess the temporal and spatial scale variability of white fly and YMV in soybean. (ii) To characterize the critical weather limits for white fly incidence and YMV infection. (iii) To develop weather based prediction tool for YMV outbreak.

METHODOLOGY

To assess the temporal scale variability of white fly incidence and YMV infection multi dates (D1-30 June, D2-10 July and D3-20 July, 2015) field experiments on major cultivars (JS95 60, JS 93 05, JS 335, JS 20-29) of soybean were conducted at research farm of college of agriculture, Tikamgarh (24° 402 N lat., 77° 802 E long. and 324 meter above m.s.l.), during 2015-16. Farmers' field surveys were conducted from 21 villages of three districts of BACZ viz, Tikamgarh, Chhatarpur and Datia to collect weekly data on white fly incidence and YMV infection during 2015-16. Daily weather data were collected and correlated with white fly incidence and YMV infections. Percentage disease intensity (PDI) was calculated. The critical weather factors were screened and a predicting tool of YMV outbreak was developed. The significance of correlation was tested with help of t-test.

RESULTS

The temporal variability of white fly population per plant and percentage disease intensity (PDI) scores were collected and estimated on each soybean cultivars during 2015 at research farm of Tikamgarh. The temporal variation of mean white fly population is shown in figure 1 and spatial variation in figure 2. The spatial variability of peak white fly incidence period is wider than the temporal peak period. However, the peak period varied from 35 to 38th standard meteorological weeks (SMW). The preceding week's weather conditions have been observed to be responsible for sharp increase in the white fly population. Maximum temperature above 32°C greater than or equal to a week period and occurrence of light rain/drizzling are two weather factors congenial for sharp increase in number of white fly population. Relative humidity (50-70 %) and maximum temperature favored the multiplication of the white fly, which has increased (130 %) the white fly population. The significant correlation between maximum temperature and white fly, YMV was observed. After inoculation of virus strain it normally takes 17-28 day to develop the YMV symptoms on Soybean. The weather condition 18 to 20 days prior to highest YMV infection was screened and shown in Table 1. It was found that maximum temperature above 33°C greater than or equal to 5 days may be critical for its higher rate of virus transmission in soybean. They have reported that YMV disease development on soybean in

Fig.1 : Temporal variation of white fly in soybean during 2015 at Tikamgarh

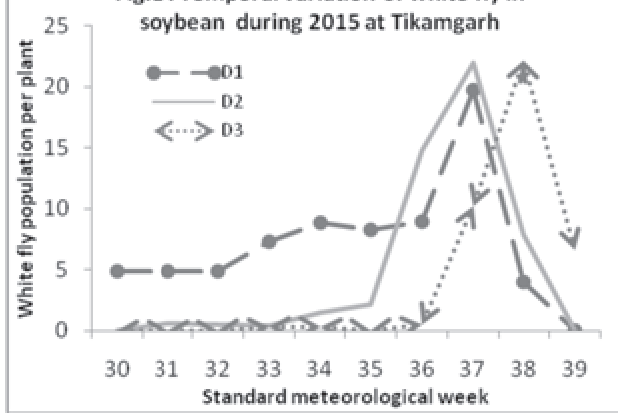

Table 1. Critical weather parameter for high incidence of YMV in soybean at Tikamgarh

Weather parameters	Maximum temperature (°C) Number of day above			Relative humidity (%)		Rainy days
SMW	33°C	34°C	35°C	Morning	Evening	Number
35	2 days	3 days	0 days	88	68	3
36	0 days	4 days	1 days	89	54	0
37	7 days	1 days	5 days	92	49	1

Jabalpur of Madhya Pradesh was high when maximum temperature and relative humidity ranged between 31.0°C-36.2°C and 62–75 per cent respectively. A thumb rule is proposed for outbreak prediction of YMV in soybean if satisfy the following conditions :White fly population per plant is above 12, maximum temperature above 32°C and passive phase of monsoon for more than a week is congenial for moderate YMV infection. The transmission rate was found to be higher when dry period coincide with maximum temperature above 33°C for greater than or equal to 5days. If the above conditions prevails than possibility of YMV outbreak in soybean may be possible. Through the extended range weather forecast information on weekly basis about active and passive phase on monsoon and temperature above normal may be used for prediction of outbreak of YMV in soybean.

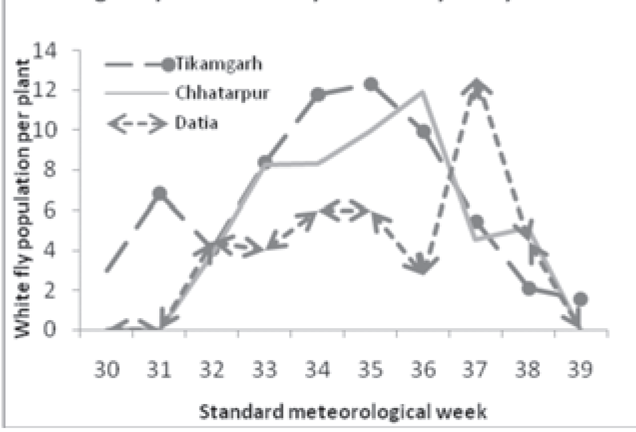

Fig. 2: Spatial variability of white fly in Soybean

CONCLUSION

White fly population, maximum temperature and monsoon phase were significantly influence the YMV infection and its transmission rate in soybean. The peak incidence and infection period of white fly and YMV was observed to be wider and lower on spatial scale. The number of day above 33°C and dry period is the necessary condition affecting transmission rate of YMV in soybean crop.

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Recovery rate of pigeonpea *dal* produced by PKV mini *dal* mill

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Pigeonpea occupies a prominent place among pulses in India. In India, split pigeon peas (toor *dal*) are one of the most popular pulses, being an important source of protein in a mostly vegetarian diet. Pigeonpea grains are milled to prepare *dal*. Milling also helps to improve storability and palatability besides cooking qualities and digestibility. Millers prefer pigeonpea genotypes having high *dal* recovery. Pigeonpea is generally consumed in the form of decorticated split cotyledons i.e. *dal*. Pigeonpea kernels while passing through the *dal* mill, is firstly converted to decorticated unsplit grains i.e.

Table 1. Graded *dal* recovery (kg) of different pigeonpea varieties

Variety	A - Grade	B- Grade	C- Grade	D- Grade	E- Grade	Total *Dal* recovery (A-,B-,C- grade)	Total (Col. 6+7+8)	Unavoidable loss(Col. 9-30 kg sample)
1	3	4	5	6	7	8	9	10
Asha (ICPL 87119)	5.958 (19.86)	5.812 (19.37)	11.33 (37.77)	0.530	4.412	23.100(77.00)*	28.042	1.958
C-11	8.334 (27.78)	4.69 (15.65)	10.54 (35.13)	0.480	4.398	23.566(78.55)*	28.444	1.556
PKV TARA	12.560 (41.87)	3.780 (12.60)	6.940 (23.13)	0.598	4.644	23.280(77.60)*	28.522	1.478
ICPH-2671	9.546 (31.82)	5.852 (19.51)	7.508 (25.03)	0.574	4.442	22.906(76.35)*	27.922	2.078
AKT-8811	9.800 (32.67)	3.290 (10.97)	8.452 (28.17)	1.032	4.296	21.542(71.81)*	26.870	3.130
Maruti (ICP 8863)	12.624 (42.08)	3.712 (12.37)	6.172 (20.57)	0.800	4.518	22.508(75.03)*	27.826	2.174
AKPHE 8-1	10.548 (35.16)	4.434 (14.78)	7.19 (23.97)	1.036	4.782	22.172(73.91)*	27.990	2.010

Figure in parenthesis indicate per cent grade *dal* recovery to total *dal* recovery
*Figure in parenthesis indicate per cent *dal* recovery to sample taken (30 kg)

gota. They are further put on elevator and dropped from a height of about 3 meters, which results in their split. This split *dal* is considered as top grade good quality *dal* called "*Fatka Dal*". The *dal* is subsequently graded into different sizes as large sized *dal* fetches premium price in the market. The *dal* miller strikes a balance between recovery rate and *dal* size. Pigeonpea suffers substantial milling losses which can be reduced to some extent by genetic and post harvest management practices. In the past, no effort has been made to evaluate pigeonpea genotypes with good *dal* recovery and high nutritional quality.

METHODOLOGY

The seed material for the present study consisted of seven newly developed varieties. Bulk sample of seed were assessed for their milling recovery using PDKV mini *dal* mill. The seed colour was estimated by visual evaluation Hundreds seeds were counted and weighted; average of two replicates of each variety was recorded. Seed samples were sundried to about 8% moisture level and graded to keep the uniformity of grain. The varieties were milled for 8 minutes in an especially designed pulse milling machine having speed of 1440 rpm, 2 HP motor and 220 V supply. This machine is especially designed for milling different pulses with minimum sample requirement of 30 kg, therefore, 30 kg grains of different varieties of pigeonpea were taken. On the basis of breakage of *dal*, the varieties were grouped into five grades i.e. A (*unbroken dal*), B (less than 25% breakage), C (25-75% breakage) and D (broken) and E (powder and husk).

RESULTS

The result showed that there was substantial variation for *dal* recovery among the genotypes (Table 1). Recovery of unbroken *dal* (A-grade) ranged from 5.958 kg (19.86%) in Asha to 12.624 kg (42.08%) in Maruti followed by PKV TARA 12.560 kg (41.87) while recovery of B-grade *dal* was in the range of to 3.290 kg (10.97%) in AKT-8811 to 5.852 kg (19.51%) in ICPH-2671 followed by Asha 5.812 kg (19.37%). In case of C-grade *dal* minimum recovery was obtained with Maruti 6.172 kg (20.57%) next to PKV TARA 6.940 (23.13%). Among the varieties with higher total *dal* recovery comprising A-, B- and C- grade was reported by C-11 23.566 kg (78.55%), PKV TARA 23.280 kg (77.60%) and Asha 23.100 (77.0%), However, minimum broken i.e. D-grade was obtained with C-11 followed by Asha and maximum with AKPHM 8-1 and AKT-8811. Besides these five grades there was certain unavoidable loss which was more in case of AKT-8811, Maruti and ICPH-2671. The results showed that varieties C-11, PKV TARA and Asha which had better milling characteristics can be used as donor in breeding programmes for improving milling quality.

CONCLUSION

Substantial variability was observed amongst different varieties of pigeonpea showing C-11, PKV TARA and Asha are the best. It is also reported that recommended varieties gives high quality *dal* with favourable characteristics. Therefore, it would be very important to consider the quality attributes and consumer acceptance before releasing pigeonpea varieties. C-11, PKV TARA and Asha recorded higher *dal* recovery and better milling characteristics can be used as donor in breeding programmes for improving milling quality.

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Optimizing the seed rate of rice varieties (*Oryza sativa*) under direct seeded aerobic condition

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Aerobic rice (*Oryza sativa* L.) production system is gaining importance for increased productivity and reduced water requirement and is expected to occupy 10-15% of the total area in India. In aerobic rice production system, total water usage can be reduced by 27-51% and water productivity can be increased by 32-88% (Bouman *et al*. 2005). Seed rate play an important role for adequate plant population and ultimately for yield maximization of riceespecially for hybrids owing to more seed cost. Suitable rice variety with optimum seed rate is significantly desirable to utilize available natural resources efficiently to getting maximum yield. Present study is carried out to study the yield and yield contributing characters of aerobic rice as affected by seed rate and varieties.

METHODOLOGY

The present investigation was conducted during *Kharif* season of 2014 at N.E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture & Technology, Pantnagar (Uttarakhand) with three varieties PAC 837 (Hybrid), PD 16 (HYV) and DRRH 3 (Hybrid) and four seed rates15 kg/ha, 25 kg/ha, 35 kg/ha and 45 kg/ha. Treatments were tested in a split plot design with three replications keeping varieties in main-plots and seed ratesin sub-plots. Proper package and practices were performed for cultivation of crop.

RESULTS

Different rice varieties had significant influence on the plant dry matter accumulation at harvest. Highest plant dry matter was recorded in variety DRRH 3 which was significantly higher than all other varieties. Significantly higher plant dry matter was produced with seed rate 35 kg/ha which was at par with seed rate 45 kg/ha. Different varieties did not have significant bearing on the number of panicle/m^2. However, the maximum number of panicle/m^2 (306) was obtained with variety DRRH 3. Increasing seed rates increased the number of panicle/m^2 up to 35 kg/ha. The effect of different varieties on sterility percent was found significant. The variety DRRH 3 had significantly lower sterility percent than that of all the other varieties and higher sterility percent was found in PD 16. There was no significant effect of seed rate on sterility percent. However, slightly higher sterility percentage was obtained with the 45 kg/ha seed rate than that of all the other

Table 1. Dry matter, yield attributes and yields of rice varieties as affected by seed rate.

Treatment	Dry matter at harvest (g/m^2)	Panicles/ m^2	Sterility (%)	1000-grain weight (g)	Grain yield (kg/ha)
Varieties					
PAC 837	917	305	21.41	24.35	4554
PD 16	900	300	22.71	25.36	4408
DRRH 3	929	306	19.69	21.58	4620
SEm ±	4.13	2.5	0.28	0.06	63
CD (P= 0.05)	12.61	NS	1.10	0.22	NS
Seed rate (kg/ha)					
15	860	273	21.54	23.94	4209
25	900	293	21.73	23.84	4491
35	956	331	21.38	23.65	4829
45	933	319	21.76	23.61	4581
SEm ±	8.87	2.7	0.18	0.09	66
CD (P= 0.05)	26.93	7.9	NS	0.27	198

seed rates and lowest with 35 kg/ha. Significantly higher 1000 grain weight was recorded with PD 16 followed by PAC 837. Among the different seed rates, 15 kg/ha had recorded significantly higher 1000 grain weight which was at par with seed rate 25 kg/ha. Variety DRRH 3 recorded maximum grain yield than all other varieties followed by PAC 837 and PD 16. There was significant variation in grain yields due to different seed rates. Among the different seed rates, significantly higher grain yield was obtained with 35 kg/ha than all other seed rates. Interaction effect was non-significant on grain yield.

CONCLUSION

Based on above results it could be concluded that hybrid rice variety DRRH 3 and PAC 837 were performed better under aerobic condition as compared to high yielding varieties of PD 16 with the seed rate of 35 kg/ha for the *tarai* region of Uttarakhand.

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Intercropping of greengram (*Vigna radiata*) with jute (*Corchorus olitorius*) for sustainable jute farming

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Currently jute cultivation is under severe threat due to its low profitability over other crops and accordingly its area is shrinking day by day. The national average jute fibre is around 2.4 t/ha. Large scale adoption of jute and green gram intercropping (1:1) may address this issue as the total return from intercropping system (2.7-3.4 t jute fibre and 0.6-1.0 t pulse grain/ha) is higher than sole jute (Gloria, *et al.,* 2010). Inclusion of pulses as intercrop in jute will smother dicot and sedge weeds, provide protein security, improve soil health and strengthen the economy of poverty stricken jute farmers. In this context it is imperative to mention that the supply of per capita pulse grain in rural sector is far below the prescribed level (60 g/head, ICMR 1984) and its cost has already reached to an alarming stage. Experiments were thus conducted at ICAR-CRIJAF, Barrcakpore, Kolkata, Bengal to sustain jute farming developing intercropping module by growing green gram as intercrop with jute.

METHODOLOGY

The experiment was conducted at ICAR-CRIJAF farm in Randomised Block Design (RBD) with eleven treatments (Table 1) replicated thrice during 2011-2013. The experimental soil was sandy clay loam in texture with 44 %per cent sand, 28 % silt and 28 % clay. Its available nitrogen, phosphorus & potassium content was 180, 34 and 133 kg/ha, respectively. The date of sowing varied from 19th to 23rd March in different years. For intercropping, jute cultivar JRO-204 and green gram cultivars of different maturity like Pant mung 4 (PM 4: 65 days), Pant mung 5 (PM 5: 55-60 days), RMG-62 (55-60 days), Sukumar (55-60 days) were sown alternately in 1:1 ratio at different spacing's (25-35 cm) in between jute row. Jute and green gram seed rates were 3.5 & 15-25 kg/ha, respectively. One post sowing irrigation was applied for proper germination of green gram and jute seeds. Butachlor 50 EC @ 1.0 kg/ha was used as pre-emergence herbicide in jute and green gram intercropping system. CRIJAF nail weeder (Patent application number: 386/KOL/2010, dated 5/4/2010) was used for composite weed control, soil mulching and line arrangement in broadcast jute. CRIJAF herbicide applicator (Patent application number: 319/KOL 2010 dated 28/3/2010) was used for directed application of glyphosate 41% SL in inter row space. For crop nutrition a basal dose of N: P: K: 20:70:70 was applied for intercrop. Top dressing of nitrogen was done @ 60 kg/ha after green gram harvest (55-65 days) with one irrigation. For sole jute dose of fertilizers was N:P:K::60:30:30. Plant protection measures: On the same day of sowing, chloro-pyriphos was sprayed to prevent loss of green gram seed from bird and insect damage. Bavistin @ 2g/

Table 1. Fibre equivalent yield and economics of jute and green gram intercropping system

Treatment	Fibre equivalent yield (t/ha)	Weed control efficiency (%)	Net returns (Rs./ha)	B:C ratio
Jute (30 cm) + PM-4 + Butachlor 50 EC @1kg /ha +1HW	4.95	71.61	90401	2.25
Jute (35 cm) + PM-5 + Butachlor 50 EC @1kg /ha +1HW	4.81	68.04	86814	2.23
Jute (30 cm) + Sukumar + Butachlor 50 EC @1kg /ha +1HW	4.71	82.19	840273	2.19
Jute (25cm) + RMG-62, Butachlor @ 50 EC 1 kg/ha +1HW	5.26	69.27	102213	2.46
Jute (25 cm)+ CRIJAF nail weeder twice (5and 21 DAS) +1HW	3.92	84.33	65615	2.07
Open furrow (25cm) sowing of jute+Butachlor 50 EC @1kg +1HW	3.59	57.19	52422	1.83
Butachlor 50 EC @1kg /ha + Glyphosate 0.8 kg SL/ha at 21 DAS (Directed spray using hood) + 1HW (25 cm)	3.77	82.19	62742	2.06
Two manual weeding in jute (25 cm), 15 and 21 DAS	3.90	63.62	56192	1.80
Jute + Okra (cv. Shakti) [(2:1, 25 cm, okra sown 3rd week of Nov). +2HW)	5.67	81.93	105766	2.31
Unweeded control (25 cm)	1.30	0	-19453	0.69
Glyphosate 1.23 l SL/ha by CRIJAF herbicide applicator at 20 DAS (25 cm) + 1HW	4.08	81.93	75464	2.28
CD (P=0.05)	0.21	15.25	11873	0.262

l and imidacloprid 0.3 g/l together were sprayed at 15 days intervals to save pulse crop from sucking insect attack and fungi attack. Emamectin benzoate was sprayed to control pod borer @ 0.3 g/lit. Deltamehrin @ 1.5 ml/l was sprayed to control pulse pod sucking bugs. Green gram was harvested by uprooting or picking pods at 90-100 per-cent pod maturity. Threshed grains were stored using Aluminium phosphide tablets (3 nos/100 kg seed) to prevent stored grain pest.

RESULTS

Jute-green gram intercropping system improved the system productivity. The jute equivalent yield varied from 47 to 53 q /ha where sole jute production is around 3.9 t/ha only (Table 1). Intercropping system recorded 28-30 q jute fibre/ha along with 7-10 q /ha pulse grain (depending on grain size). Intercropping system of jute (25 cm) + RMG 62 recorded significantly higher jute equivalent yield (JEY). The comparatively short stature of RMG-62 fitted well in normal jute spacing (25 cm). Weed control efficiency of the intercropping system was much higher (69-82%) than conventional manual weeding twice (63.62%). Benefit cost ratio under this system varied between 2.2 to 2.46 over 1.80 only in manual weeding process. CRIJAF nail weeder and herbicide applicator recorded higher weed control efficiency (82 to 84 %) and B:C ratio (2-2.28) over conventional manual weeding twice. The green gram in intercropping system produced 2 t/ha of green gram wastes (average nitrogen 2.35 %,) which is equivalent to 10 tonnes of farmyard manure (FYM). If incorporated in jute soil, it will improve the soil health. It can also be used as nutritious fodder.

CONCLUSION

Fibre equivalent yield of jute green gram intercropping system varied from 4.7 to 5.3 t/ha and it was only 3.9 t/ha from sole crop of jute. Benefit-cost ratio of jute and green gram intercropping system varied between 2.2 to 2.46 over 1.8 in conventional manual weeding twice. Weed control efficiency of the intercropping system was 69-82% over 63.6 % in conventional manual weeding twice. CRIJAF nail weeder and CRIJAF herbicide applicator recorded higher weed control efficiency (82 to 84 %) and B:C ratio (2-2.28) over conventional manual weeding twice (63.62% and 1.80). This jute and green gram intercropping system will improve jute farmers economy, provide protein security to rural mass, and take care of soil and animal health in rural sector. Currently jute cv. NJ -7005 and NJ- 7010 (DOS:10-15th March) &pulse varietiy TMB-37 (52-55 Days) is recommended for intercropping.

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Effect of varieties and crop geometry on seed yield and gum content of guar (*Cyamopsis tetragonoloba*) under rainfed condition of Chhattisgarh

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The guar is an annual, deep rooted, drought tolerant (low water requirement), hardy, low pest susceptibility, short duration (90 days) crop and can be grown on any land. Seeds of guar contains 28-33 % gum and the by product from gum extraction process is of a high value protein (40 %) feed for cattle (Selvaraj and Prasanna, 2012). The minimum profit of Rs. 35,000 to 90,000 per acre in 90 days can be obtained with guar cultivation. Guar gum, also called guaran, is a galactomannan. The guar gum emerged as an industrial product which increase its demand and price of guar seed (Prajapat, 2012). About 80 per cent area of total cultivated area is under rainfed in Chhattisgarh.

METHODOLOGY

An investigation entitled 'effect of varieties and crop geometry on seed yield and gum quality of guar (*Cyamopsis tetragonoloba* L. Taub)' was carried out during *kharif* seasons of 2015 at Research cum Instructional farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). The experimental soil was *Vertisols* in texture with pH 6.8, and low, medium and high in available nitrogen (220 kg/ha), phosphorus (12 kg/ha) and potassium (361.20 kg/ha), respectively. The treatments consisted of two varieties in main plots and three crop geometry in sub plots laid out in factorial randomized design with three replication. The crop was sown on 24th June 2015 and harvested on 3rd October 2015.

RESULTS

There was no significant difference in all growth and yield attributes viz. Plant population, plant height, number of clusters/plant, number of pods/plant, pod length and pod width due to varieties and crop geometry except number of pods/cluster due to varieties, and plant population, biological yield, grain and stover yield due to crop geometry (Table 1). The equal number of pods/cluster were recorded in both the varieties. The crop geometry 60 cm x 15 cm was significantly superior in plant population over other crop geometry. Minimum plant population was recorded under crop geometry of 30 cm x 15 cm. Only grain yield of clusterbean was significantly affected due to different varieties. Variety Ankur rani produced maximum grain yield (93.08 kg/ha) over variety Guar bahar (84.34 kg/ha). Significantly higher biological, grain and straw yield were recorded when guar grown at 60 cm x 15 cm crop geometry than 45 cm x 15 cm and 30 cm x 15 cm. Test weight (1000 grain weight) and gum per cent of guar seed were not affected significantly due to different va-

Table 1. Effect of crop geometry on growth, yield and gum content of cluster bean varieties under rainfed ecology of Chhattisgarh

Treatment	Number of pods/cluster	Number of pods/plant	Pod length (cm)	Grain yield (kg/ha)	1000 grain weight (g)	Gum %
Variety (V)						
Guar bahar	4	63	14.55	84.34	36.17	24.50
Ankur rani	4	68	13.94	93.08	35.91	24.46
CD (P=0.05)	0.46	NS	NS	7.60	NS	NS
Crop geometry (S)						
60cm x 15cm	4	63	14.97	112.65	36.94	24.27
45cm x 15cm	4	66	14.13	70.18	35.57	24.95
30cm x 15cm	4	63	14.26	74.57	34.29	24.15
CD (P=0.05)	NS	NS	NS	9.30	NS	NS
V x S						
CD (P=0.05)	NS	NS	NS	13.16	NS	NS

rieties and crop geometry. There was non-significant variation in galactomannan content between growing seasons of guar cultivation.

CONCLUSION

The variety Ankur rani and 60 cm x 15 cm crop geometry gave maximum grain yield. Gum quality did not influenced significantly due to varieties and crop geometry.

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Effect of seaweed saps on productivity and profitability of soybean (*Glycine max*)

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Soybean (*Glycine max* (L.) Merrill.)is an important nitrogen fixing leguminous crop grown as a rainfed *Kharif* (wet season) crop in Chotanagpur region of Jharkhand. However, in spite of all sorts of efforts its area and production could not be increased in the state due to poor exploitation of production technique. To enhance the productivity of soybean farmers used chemical fertilizers in great quantities and its long term use has damaged the physio-chemical character, microflora and their micro-ecology of soil. Chemical fertilizer killed many soil organisms that are responsible for decomposition and soil formation. Today there is growing concern that environmental pollution caused by imbalanced use and misuse of chemical fertilizer is directly or indirectly related to human health problem. But, unlike chemical fertilizers extracts derived from seaweeds are biodegradable, non-toxic, non-polluting and non-hazardous to humans, animals and environment. Seaweeds are the macroscopic, multi cellular marine algae that commonly inhabit the coastal regions of the world's ocean. Seaweed extracts contains major and minor nutrients, amino acids , vitamins, cytokinins, auxin and abscisic acid like growth promoting substances and have been reported to stimulate the growth and yield of plants develop tolerance to environmental stress, increase nutrient uptake from soil and enhances antioxidant properties. So, utilization of seaweed sap will be useful for achieving higher agricultural production. Therefore, it is high time to strengthen the research programme on such sources which may prove an important substitute for chemical fertilizer for not only to maximize production but also to make the environment sustainable.

METHODOLOGY

The field experiment was conducted during the *kharif*season of 2012 at Birsa Agricultural University, Ranchi, Jharkhand. The experiment was conducted in Randomized Block Design with 17 treatments replicated thrice. Treatment consists of seaweed sap of *Kappaphycusalvarzii*(K-sap) and *Gracillariaedulis*(G-sap) each of which is applied at five concentration level *viz.,*2.5, 5.0, 7.5, 10 and 15% with 100% recommended dose of fertilizer (20:80:40 kg N:P_2O_5:K_2O/ha) and three concentration level *viz.,* 7.5, 10 and 15% with 50% recommended dose of fertilizer along with one control plot with 100% recommended dose of fertilizer. The seaweed sap was sprayed at 30, 45 and 60 days after sowing as per the treatments. Soybean variety RKS-18 was selected for the experimental study.

RESULTS

Result revealed that application of 100% recommended dose of fertilizer (Table 1) with 7.5% K sap concentration produced significantly higher grain yield (1.67 t/ha) and straw yield (2.14 t/ha) than all other combination of seaweed sap concentration either with 100 or 50% RDF as well as control except 10% K sap, 10% G sap and 15% G sap with 100% RDF. Increase in K sap concentration beyond 7.5% sap con-

Table 1. Effect of seaweed sapon productivity and profitability of soybean

Treatment	Grain yield (t/ha)	Straw Yield (t/ha)	Net return(₹/ha)	B:C ratio
100%RDF + water spray	1.20	1.77	8307	0.45
100% RDF + 2.5% K sap	1.35	1.85	10548	0.53
100% RDF + 5% K sap	1.47	1.94	12014	0.58
100% RDF + 7.5 K sap	1.67	2.14	15476	0.70
100% RDF + 10% K sap	1.55	2.03	11686	0.51
100%RDF + 15% K sap	1.42	1.99	6531	0.26
50% RDF + 7.5 K sap	1.01	1.63	3599	0.19
50% RDF +10% K sap	1.15	1.75	5518	0.27
50%RDF +15% K sap	1.29	1.88	6515	0.29
100%RDF +2.5% G sap	1.27	1.85	8634	0.44
100%RDF + 5% G sap	1.39	1.93	10351	0.50
100%RDF +7.5% G sap	1.51	2.02	11764	0.53
100%RDF +10% G sap	1.67	2.13	14244	0.62
100%RDF +15% G sap	1.54	2.03	9150	0.36
50%RDF +7.5% G sap	1.00	1.61	3343	0.18
50%RDF +10% G sap	1.12	1.71	4992	0.25
50%RDF+15% G sap	1.27	1.88	6005	0.27
SEm±	0.05	0.07	1114	0.05
CD (P=0.05)	0.15	0.21	3267	0.15

centration, led to decline in grain yield up to 15% K sap concentration. Similarly, increase in G sap concentration with 100% RDF increased the grain yield and highest grain yield was recorded at 10% G sap concentration thereafter grain yield decline at higher concentration of 15% G sap. Grain yield (1.66 t/ha) and straw yield (2.13 t/ha) at 10% G sap was found significantly superior over lower concentration of G sap and water spray but remained at par to its higher concentration i.e. 15% G sap. The net return (Rs. 15476/ha) and B:C ratio (0.70) was also recorded highest with the application of 7.5% K sap with 100% RDF. Significant effect of K sap on productivity and profitability was also reported by Singh *et al*. (2015).

CONCLUSION

Application of 7.5% K sap along with 100% recommended dose of fertilizer proved to be more productive and economically viable for soybean cultivation in rainfed areas of Jharkhand.

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Impact of broad bed furrows and nutrient management on productivity of high density planting in cotton

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Australia, Brazil, China USA and Uzbekistan continue to harvest high cotton yields through straight varieties adopting HDPS using dwarf, compact sympodial varieties with 1 lakh to 2.5 lakh plant populations per hectare under mechanization. A system of high density planting with better genotype is one of the option to break the current trend of stagnating yield of Bt cotton and related problems under rainfed ecosystem of Vidarbha region of Maharashtra, where 90% of cotton is under rainfed. Practices of making ridge by opening furrow may have an advantage in concentration of more rain water on the

Table 1. Pooled SCY and economics as influenced by MCT and nutrient management under HDPS.

Treatment	SCY(kg/ha)				Gross returns	Net returns (Rs /ha)	B:C	RWUE (Kg/ha-mm)
	2013-14	2014-15	2015-16	Pooled				
Moisture Conservation Technique								
M_1 - Flat Sowing (Control)	2843	1485	2521	2283	89039	53078	2.47	3.82
M_2 - Furrow opening at 40-60 DAS	2890	1603	2709	2401	93642	56092	2.49	4.02
M_3 - Broad Bed Furrow (BBF)	3125	1842	2934	2633	102716	64006	2.65	4.41
CD (P=0.05)	NS	157	213	89	3492	3017	-	
Nutrient management								
F_1 - RDF (60:30:30 NPK kg /ha)	2604	1447	2428	2159	84238	49091	2.39	3.62
F_2 - RDF + 2.5 kg Zn /ha)	2845	1633	2623	2367	92325	55180	2.48	3.96
F_3 - 125 % RDF (75:37.5:37.5 NPK kg /ha)	3127	1706	2798	2544	99225	61317	2.61	4.26
F_4-125 % RDF (75:37.5:37.5 NPK) + 2.5 Zn kg /ha	3235	1786	3035	2685	104743	65316	2.65	4.50
CD (P=0.05)	280	147	218	88	3446	2800	-	

bed which enrich soil moisture content (Gidda and Morey, 1981). With this view the study was conducted to find out optimum nutrient management and moisture conservation practices for HDPS cotton.

METHODOLOGY

The soil was medium deep clayey and having organic carbon 4.20 g/kg, pH 7.9, EC 0.30 dS/m, available N, P and K 180, 14.4 and 401kg/harespectively. Three moisture conservation techniques viz flat bed, furrow opening in between two rows of cotton at 40 days after sowing and cotton was sown with broad bed furrow system with tractor and Nutrient management levelswith 100% RDF (60:30:30 NPK kg/ha), 100% RDF + 2.5 KgZn, 125% RDF (75: 45: NPK kg/ha), and 125% RDF + Zn were tested in Split plot design with three replication under TMC Project 1.4. A common foliar spray of 1% urea and 1% magnesium sulphate at boll development stage was taken and Flubendamide and Spinosad sprayed for control of bollworms.The crop was sown at 60 cm x 10 cm spacing (1.66 lac plant population) and cotton was sown on 26th june 2013, 18th july 2014 and 18th June 2015 with cotton variety AKH-081 is dwarf, tolerant to sucking pest and early maturing (140-160 days) is suitable for high density planting under rainfed condition of Vidarbha region of Maharashtra. The rainfall of the three season were 908,593 and 645 mmand rainy days 49, 29 and 28 respectively. Seed cotton yield and economics and rainfall use efficiency was worked out.

RESULTS

Seed cotton yield per hectare was significantly influenced due to moisture conservation techniques. Significantly highest SCY (2934Kg/ha) was recorded by tractor drawn BBF (3 rows at 60x10cm) followed by opening of furrows at 40 DAS over flat sowing. Significantly highest Seed Cotton Yield (3035Kg/ha) was recorded with 125% RDF (75:37.5: 37.5 NPK+ 2.5 Zn Kg/ha) over RDF (2428 Kg/ha) with foliar spray of 1% urea and 1% magnesium sulphate at boll development stage. The highest Gross and Net monetary returns with 125 % RDF + Zn which was at par with 125 % RDF with foliar spray of 1% urea and 1% magnesium sulphate at boll development stage, which is the need of higher plant density. Benefit cost ratio was highest with the maximum rain water use efficiency with moisture conservation practice with BBF (4.41 Kg /ha mm) and nutrient management with 125 % RDF + Zn and foliar spray of 1% urea and 1% magnesium sulphate at boll development stage (4.50 Kg /ha mm). Moisture content was improved under BBF practices. Sowing of high density planting at 1.66 lakh per hectare (60 × 10 cm) on BBF is recommended with 125% RDF(75:37.5: 37.5 NPK+ 2.5 Zn Kg/ha) with foliar spray of 1% urea and 1% magnesium sulphate at boll development stage for higher seed cotton yield economic returns and conservation of moisture.

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Effect of static magnetic field on growth characteristics of tomato (*Solanum lycopersicum*)

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The performance of crop growth, yield and quality of produce are determined by the seed quality. However, certain physical and chemical pre-sowing treatments are found to improve the seed quality. Physical methods are not only cost effective but also significantly improved the yield without any adverse affect on environment. The effect of magnetic field on germination of seed and growth of the plant had been the object of numerous researches. De Souza *et al.* (2006) observed in their experiments that pre-sowing magnetic treatments would enhance the growth and yield of tomato crop. Vashisth and Nagarajan (2008, 2010) reported significant enhancement in shoot and root length of one month old plant of chickpea and sunflower with seeds exposed to different combinations of magnetic field and time duration. Efforts have been made by different researchers to establish the relationship between the magnetic field dose and seedling/yield expressions in different crops. Our work is aimed to standardize the magnetic field for maximum enhancement in seedling growth and to evaluate the effect of magnetic treatment on growth and yield of tomato (Pusa Rohini) under field conditions.

METHODOLOGY

Field experiments were conducted during *Rabi* 2015-16 seasons at research farm of IARI, New Delhi, India. Tomato seeds were exposed to a magnetic field of 50 mT, 100mT and 120mT for 5, 10, 15, 20, 25 and 30 minute in a cylindrical shaped sample holder, made of non-magnetic thin transparent plastic sheet. The required strength of the magnetic field was obtained by regulating the current in the coils of the electromagnet. Gauss meter was used to measure the strength of the magnetic field between the poles. The germination test was carried out following the method of ISTA (1985). Based on experimental data 100 mT for 30 minutes were adjudged to be the best for improving germination and vigour. Therefore the same were evaluated in the field for growth and yield. Seedlings produced by seeds exposed to 100 mT static magnetic field for 30 minute were transplanted in the research farm along with untreated seeds. Irrigation was provided as and when required. All growth parameters like dry weight of root, shoot and leaves, length of shoot and roots, number of leaves, branches, fruits and fruits weight were measured at different growth stages. Radiation interception, soil moisture and soil temperature were also recorded at different growth stages.

RESULTS

Exposure of tomato seeds to different magnetic field intensities increased significantly all of its germination related characters, such as, germination percentage, shoot and root length, seedling dry weight and calculated vigour indices (Table 1). The improvement in germination percentage was 2-16%, the shoot length was 0-16%, the root length was 2 to 33%, the total seedling length was 6-19% and the seedling dry weight was 0-17% in different treatment of magnetic field as compared to untreated control. The calculated vigour indices I and vigour indices II was also increased by 12-39% and 4-32% respectively in different treatment of magnetic field as compared to untreated control. Among the opted magnetic treatments 100 mT for 30 minutes was found most effective in

Table 1. Effect of pre-germination exposure of tomato seeds to magnetic field on growth at 60 days after transplanting

Treatment	Root dry weight (g/plant)	Shoot dry weight (g/plant)	Leave dry weight (g/plant)	Total biomass (g/plant)	Root Length (cm)	Shoot Length (cm)	Number of leaves	Number of branches
Magnetic field (100mT, 30 min)	14.9**	60.1**	94.8**	169.8**	23.5**	38.3 NS	14 NS	4 NS
Control	11.5	53.8	77.6	142.8	17.8	35.7	10.7	3.7
LSD (P=0.05)	1.33	2.93	2.51	6.1	5.03	4.19	8.29	0.74

** Significant at 1% level of probability, NS: Not significant at 5% level of probability.

increasing most of the seedling parameters. In case of plant raised from magnetically treated seeds the percentage increase in biomass, plant length and root length was 18%, 7% and 22% respectively as compared to untreated control.

CONCLUSION

The exposure of tomato seed to static magnetic field increased germination, seedling length and dry weights significantly under laboratory conditions compared to unexposed control. Among the opted combinations of field strength and duration 100 mT for half hour exposure gave best results. Plants raised from the seeds exposed to 100 mT for 30 minutes showed increased growth parameters in terms of shoot/ root length number of fruits and fruits weight.

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Performance evaluation of head feed combine in scented and non-scented paddy varieties

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Paddy is one of the most important crops for food security in India, contributing significantly towards providing food and livelihood for 130 million people. The area under paddy cultivation in India is around 44 million ha with production of 105 mt in 2014.Combine harvesters are mainly used for harvesting of wheat and rice in India. In head feed combine only the head parts are involved in the threshing device. The head feed combine also overcomes the problem of straw. **It** can process paddy straw in different ways, windrow them in an orderly manner or in bundles or cut them in even length and spread them uniformly on ground which will work as a mulch for succeeding crop.The performance of modern combines depends critically on straw throughput and grain losses. The threshing effectiveness and losses of combine harvester are greatly influenced by machine parameters *viz.* cylinder type, cylinder speed, number of crop rotation, feed rate, method of feeding and forward speed of operation. Crop parameters *viz.* moisture content of grain and straw, grain-straw ratio. Thus, a need to test and evaluate the head feed combine for efficient harvesting is initiated for its performance and economic feasibility in scented and non-scented paddy varieties.

METHODOLOGY

The head feed combine (DSM 72) having loop type threshing mechanism was tested for its performance and economic feasibility in scented paddy varieties Pusa – 1121 and CSR – 30 at optimum conditions of 18.1 %grain moisture content, forward speed of 4.0 km/h and cylinder speed of 15.53 m/ sand non-scented paddy varieties HKR – 47 and HKR - 127 at optimum conditions of 18.1 % grain moisture content, forward speed of 4.5 km/h and cylinder speed of 16.64 m/ sfarmers field in Tohana, Fatehabad, Haryana. Soil moisture content varied from 15.2 to 15.5 % whereas grain moisture content varied from 18.1 to 22.4 % in both scented and non-scented varieties. Bulk density of the paddy fields varied from 1.48 to 1.50 g/cm. Straw moisture content varied from 52.2 to 53.1 % in scented and non-scented varieties. Straw grain ratio was in the range of 1.26 to 1.45 and 1.21 to 1.22 % in scented andnon-scented paddy varieties.The combine was tested for its performance in reference to field capacity, field efficiency, fuel consumption, grain throughput, straw throughput,threshing efficiency, cleaning efficiency and total grain losses. The combine was tested for economic feasibility in scented and non-scented varieties in reference to cost of operation, Break-even Point (BEP), Pay-back period (PBP) and Benefit cost ratio.

RESULTS

The field capacity of head feed paddy combine was 0.45 and 0.50ha/hr with efficiency of 75 % in scented and non-scented paddy varieties. The results are in conformity with Kumar and Rani (2016). The average threshing efficiency varied from 99.76 to 99.81 and 99.62 to 99.72 %, whereas cleaning efficiency varied from 99.14 to 99.16 and 98.95 to 99.14 % in scented and non-scented paddy varieties, respectively.Manes *et al*. (2015) also found similar results in axial flow threshing system. The total losses varied from 1.43 to 1.64 and 1.34 to 1.45 % in scented and non-scentedpaddy varieties which was very less as compared to traditional axial flow combines. Manes *et al.* (2015) found total grain losses of 5.79 to 6.46 % in scented paddy varieties in axial flow threshing system. Grain throughput varied from 1603 to 2288 and 3955 to 4063 kg/hwhereas, crop throughput varied from 3927 to 5095 and 8741 to 9020 kg/h in scented and non-scented paddy varieties.The cost of operation was Rs 2772/ha and Rs 2625/ha in scented and non-scented paddy varieties, respectively. The break-even point was 340 and 603 hoursin scented and non-scented paddy varieties, respectively, which was 43 and 57 % of the annual utility in scented and non-scented paddy varieties.The payback period of the head feed combine was 3.22 and 5.71 years.Benefit cost ratio was 1.62 and 1.33 in scented and non-scented paddy varieties, respectively. The result of B: C ratios of more than unity indicate that investment in machine is economically viable. The results are in conformity with Hossain *et al.* (2015) and Kumar and Rani (2016).

CONCLUSION

The head feed paddy combine harvester having loop type threshing mechanism was found economical and viable in scented paddy varieties. It was because of negligible breakage losses and less break- even point, resulted in more beneficial for rice millers and farmers, hence recommended for use in scented varieties.

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Assessment of genetic purity of maize hybrid seeds using microsatellite markers

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Genetic purity of hybrid is an essential criterion for high commercial value (Daniel *et al*. 2012). A high level of genetic purity in crop hybrids must be achieved and maintained to ensure that the improvements in productivity and quality imparted by breeders are delivered to the farmers and ultimately to the consumers. DNA fingerprinting approaches, relying on various types of molecular markers and involving the comparison of samples with true-to-type control and its parental lines, have greatly replaced the earlier method of grow-out test for assessing genetic purity by obtaining a specific pattern for each hybrid (Sharma *et al*. 2014). Among the molecular markers, microsatellite markers have been the markers of choice for genetic purity assays (Sserumagal *et al*. 2014). During the present study, a random sample of seeds of hybrid V6042 representing the commercial seed lot produced by the private seed company, Dhanya Seeds Limited, Bangalore was used for testing the genetic purity using the diagnostic markers for the hybrid, namely, phi 423796, phi 96100, umc 1128 and bnlg 1017. The pattern was also verified by comparing with the DNA fingerprint reference library of V6042 developed and maintained earlier.

METHODOLOGY

The study was conducted at the Department of Seed Science and Technology, CSK HPKV, Palampur during 2015-16. A random sample of 20 seeds of V6042 representing the commercial seed lot produced by the private seed company, Dhanya Seeds Limited, Bangalore was used for testing genetic purity. Each seed was grown under controlled conditions until 3-4 leaf stage. The genomic DNA was isolated from the fresh young leaves of each seedling using cetyl trimethyl ammonium bromide (CTAB) method. The purity of isolated DNA was ascertained by measuring the ratio A_{260}/A_{280} using nanophotometer (Implen). The extracted DNA was quantified using nanophotometer and diluted to a concentration of 15 ng./ml before being used for DNA fingerprinting. Four diagnostic microsatellite markers for the hybrid V6042, namely, phi 423796 (T_m 55.1), phi 96100 (T_m 53.8), umc 1128 (T_m 52.2) and bnlg 1017 (T_m 54.2) were used for carrying out polymerase chain reaction (PCR). PCR was also carried out in quadruplicate for the DNA sample of hybrid seeds of V6042 procured directly from the company and used for developing the reference library. PCR reaction mixture consisted of 30 ng DNA, 1X PCR buffer, 2 mM $MgCl_2$, 0.2 mM dNTP mix, 0.2 mM of each primer pair (Integrated DNA Technologies, USA) and 1 Unit Taq Polymerase (Promega, Wisconsin, USA). The amplifications were performed in a thermal cycler (TC-PRO BOECO, Germany) with an initial denaturation step of 94°C for 5 minutes, followed by 39 cycles of denaturation, annealing and extension steps (94°C for 30 seconds, X°C for 30 seconds and 72°C for 1 minute, respectively) with a final extension of 5 minutes at 72°C and a final hold at 4°C. X°C refers to the annealing temperature (T_m) which is specific for each primer pair. The amplified PCR products were electrophoretically resolved on 2.5 per cent (w/v) agarose gel (Ultra-resolution, Hi-Media, India) stained with ethidium bromide. After the completion of the electrophoretic run, the gel was visualized under UV light using a gel documentation system (Enduro™ GDS, Labnet International, Inc.). Gel photographs were scored manually following the conventional binary method. The size of each allele was determined by running simultaneously a 50-1000 base pair (bp) DNA ladder.

RESULTS

The production potential of any crop hybrid depends upon its genetic make-up or background. However, during the process of seed production or multiplication, there is deterioration of valuable hybrids due to natural pollination behaviour of the crops and the mismanagement of the produce at different stages of growth and harvesting, threshing, processing and storage (Sharma *et al.* 2014). The impure seeds generally result in poor yields at the farmers fields and show increased susceptibility to many diseases. The problem is becoming more conspicuous in the cross-pollinated crops like maize where the chances of the deterioration of the hybrids are more due to open pollination. The loss in yields caused due to impure seed can be overcome if the pure seed is supplied to the farming community. DNA fingerprinting using a set of highly informative molecular markers confers significant advantages over morphological and biochemical markers in the assessment of genetic purity (Sharma *et al.* 2014). During the present study, a random sample of 20 seeds of V6042 representing the commercial seed lot produced by the private seed company, Dhanya Seeds Limited, Bangalore was used for testing genetic purity using the diagnostic microsatellite markers for the hybrid, namely, bnlg 1017 (A), phi 423796 (B), phi 96100 (C) and umc 1128 (D). Simultaneously, the DNA fingerprinting was also carried out for the pure DNA sample of the hybrid seeds used for developing reference library. According to the DNA fingerprinting library developed earlier, the genotype formula for the hybrid seeds was $A_{165}A_{180}A_{520}B_{130}B_{145}C_{290}C_{300}D_{155}D_{170}$. The experiment was repeated twice from fresh genomic DNA samples of the same seedlings to confirm the results. The DNA fingerprinting profiles developed clearly indicated that in a random sample of 20 seeds, the four diagnostic markers identified 2 seeds (lanes 1 and 16) which were not pure (Fig. 1). This amounts to 10% off-types in the seeds produced for the hybrid V6042.

CONCLUSION

The success of maize hybrids depends upon the production and timely supply of genetically pure seeds to the farmer community. DNA fingerprinting using microsatellite markers is a

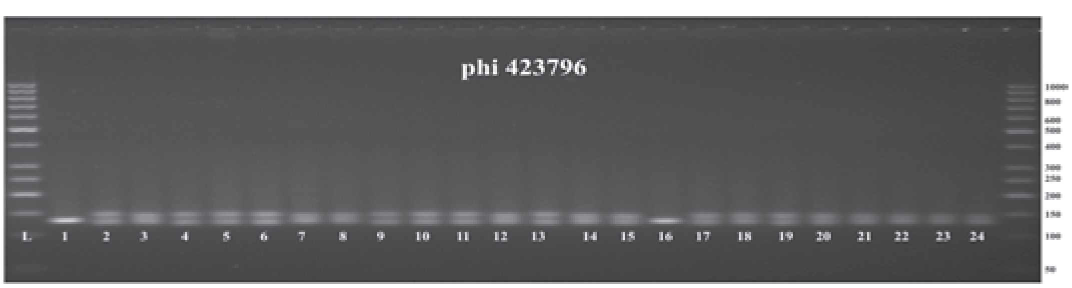

Fig. 1. Assessment of genetic purity of hybrid seed of V6042 using diagnostic SSR markers, phi 423796. L, 50-1000 bp DNA ladder; lane 1-20, DNA samples from individual seedlings representing a random sample from seed lot of hybrid V6042; lane 21-24, standard DNA sample from control hybrid seeds used for generating DNA fingerprint profile library; lanes 1 and 16, impure seeds

successful and less time consuming approach to ascertain genetic purity. This technique will potentially raise genetic purity standards of the crop and enable farmers and consumers to benefit from increasingly productive hybrids.

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Pre-sowing seed treatment with static magnetic field (SMF) improves seed yield in chickpea

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Crop yields can be maximized by establishment of an adequate and uniform plant population for which good quality seed is a prerequisite. The benefits of agronomic inputs are not completely realized if the seed is of poor quality resulting in a poor stand. Stimulation of seeds with magnetic field is an effective way to increase their quality of germination. Static Magnetic Field (SMF) at recommended dose is known to affect germination, seedling vigor and subsequent growth and yield of many crop plants (Shine *et al.*, 2011; Bhardwaj *et al.*, 2012). Chickpea, being a very important pulse grown during *rabi* season in India, is generally grown on residual soil moisture after harvest of *kharif* crops, facing water stress at germination and later growth stages. There is a possibility to improve the crop establishment of chickpea by physical seed treatment with SMF. However, the information on this aspect was not available.

METHODOLOGY

A field experiment was conducted for two years (*rabi*2012-13 and 2013-14) at the ICAR-Indian Agricultural Research Institute, New Delhi to study the impact of static magnetic field -treated seeds on seed yield and its attributes in desi and kabuli chickpea varieties. The experiment was laid out in a factorial randomized complete block design with 8

Table 1. Effect of static magnetic field (SMF)- treated seed on yield and yield attributes of chickpea

Treatment	Grain yield (t/ha)		Pod no./ plant		Grain weight (g)/ plant		1000-seed weight (g)	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Variety								
'Pusa 256' (Desi)	2.30^{A}	2.51^{A}	47.5^{A}	38.0^{A}	12.7^{A}	11.2^{A}	201.8^{B}	211.4^{B}
'Pusa 1003' (Kabuli)	2.01^{B}	2.30^{B}	38.4^{B}	37.9^{A}	8.9^{B}	10.0^{B}	213.0^{A}	219.5^{A}
SMF treated seed								
Untreated seed	2.02^{B}	2.25^{B}	39.8^{B}	38.2^{A}	9.07^{B}	10.3^{B}	202.6^{B}	213.8^{B}
Treated seed	2.29^{A}	2.57^{A}	46.1^{A}	37.8^{A}	12.6^{A}	10.9^{A}	212.2^{A}	217.0^{A}

Means within a column followed by the same letter or letters do not differ significantly at $P \leq 0.05$ by Duncan's multiple range test.

replications. Treatments (4) comprised of combination of 2 chickpea varieties, i.e., 'Pusa 256' (desi type) and 'Pusa 1003' (Kabuli type) and 2 SMF -treated seeds (untreated control and SMF –treated seed).

RESULTS

Significant differences in different yield attributes and seed yield of two varieties were recorded in the present study (Table 1). Variety 'Pusa 256' produced significantly higher seed yield as compared to 'Pusa 1003'. Averaged across two year variety 'Pusa 256' produced 11.7% higher seed yield over 'Pusa 1003'. Significantly differences in yield attributes, especially pod number/plant and grain weight/ plant contributed to the yield differences observed in two varieties. Irrespective of the variety, SMF -treated seeds resulted significantly in higher seed yield over untreated seeds of chickpea. The seed yield of chickpea, on an average, increased by 13.8% due to use of SMF-treatment. Significant improvement in yield attributes, viz. pod number /plant, grain weight/plant and 1000-seed weight, caused the significant increase in seed yield of chickpea under SMF-treated seed.

CONCLUSION

Variety 'Pusa 256' produced significantly higher seed than 'Pusa 1003'. Pre-sowing SMF-treatment can be recommended for improving seed yield of chickpea under rainfed condition.

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Growth and yield of pearlmillet as a influenced by varieties and bio-regulators

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Pearlmillet is one of the most important *kharif* cereals of arid and semi-arid environment. Under adverse growing conditions, selection of high yielding cultivars with appropriate maturity duration attains paramount importance.There is an urgent need to replace old varieties/hybrids with newly developed high potential cultivars for better production and profitability. Economic analysis indicates that in general, hybrid cultivation is more profitable than OPVs in arid Rajasthan. Foliar application of thiourea (TU), a novel bioregulator significantly improved growth and yield of several crops (Garg *et al*., 2006). Further, use of thiol including thiourea (TU) and thioglycolic acid (TGA) have shown positive effect in improving growth and yield of pearl millet, wheat and mustard. They further reported that thiourea and bio-regulators has potential for increasing crop productivity under environmental stresses, which are now on the increase in the wake of changing climate and global warming. Salicylic acid is a naturally occurring plant hormone acting as an important signaling molecule which adds to tolerance against abiotic stresses such as drought, chilling, heavy metal toxicity, heat and osmotic stress. Therefore, keeping the above facts in view present investigation was carried out to observe the effect of different bio-regulators on pearlmillet for increasing crop productivity under environmental stresses.

METHODOLOGY

The experiment was conducted at the Agronomy farm, Sri Karan Narendra Agriculture University, Jobner ($26^0$05' N, $75^0$28' E), Rajasthan. The soil was loamy sand in texture, alkaline in reaction (pH 8.2), poor in organic carbon (0.14%) with low available nitrogen (130 kg/ha) and medium in phosphorus and potassium content 18.9 and 175.6 kg/ha respectively. Three hybrids RHB-121, RHB-173 and RHB-177 and one composite Raj-171of pearlmillet were tested. Foliar sprays of bio-regulators viz. 500 ppm thiourea (TU), 100 ppm thioglycolic acid (TGA) and 100 ppm salicylic acid (SA) were done at 25 and 50 DAS. 1/3 dose of nitrogen was drilled as basal at the time of sowing and remaining dose of nitrogen was top dressed in 2 splits. Harvesting of pearlmillet was done from each net plot when ears were dry.

RESULTS

The variety Raj-171 recorded the tallest plants which were significantly taller over RHB-121 and RHB-177 and remained at par with RHB-173. The increase in plant height due to Raj-171 was to the magnitude 9.37 and 9.53%, respectively over RHB-121 and RHB-177. The hybrid RHB-173 produced the significantly higher dry matter over RHB-121 and RHB-177 but remained at par with Raj-171. Variety RHB-173 surpassed all the varieties in terms of total number of tillers. However varieties could not bring significant difference in and LAI of pearlmillet but application of bio-regulators increases the LAI over control (Table 1). Further, the differential behavior among the varieties could be explained solely by the variation in their genetic makeup under existing climatic conditions. The yield components i.e. number of effective tillers per plant, ear length and number of grains per ear was significantly higher in RHB-173 as compared to other varieties (Table 2). Further, hybrid RHB-173 produced significantly higher grain yield over RHB-121, RHB-177 and Raj-171 and higher stover yield over RHB121 and RHB-177. Hybrid varieties recorded significantly higher harvest index over Raj-171 (Table 2). The marked increase in yield attributes under RHB-173 might be due to its genetic potential. RHB-173 also proved most efficient in realizing highest net returns and benefit:cost ratio, which were significantly higher over rest of the varieties. The foliar application of bio-regulators (Thiourea, TGA and SA) significantly increased the growth parameters viz., plant height, dry matter accumulation and total number of tillers per plant over control (Table 1). Foliar spray of 500 ppm thiourea significantly increased dry matter accumulation and total number of tillers per plant over salicylic acid and control but remained at par with TGA. The maximum grain yield, stover yield and biological yield recorded with thiourea was significantly higher over salicylic acid and control while it remained at par with TGA (Table 3). Foliar spray of bio-regulators resulted in stimulatory action in various physiological processes of plant. It is concluded that variety RHB-173 out yielded over all the varieties of pearl millet and responded equally to the foliar spray of bio-regulators. Application of

Table 1. Growth parameters of pearlmillet as influenced by varieties and bio-regulators

Treatment	Dry matter accumulation/ plant (g) at harvest	Total number of tillers/ plant	LAI
Variety			
RHB-121	46.50	3.65	3.82
RHB-173	52.50	3.93	3.83
RHB-177	46.18	3.40	3.80
Raj-171	50.00	3.38	3.90
SEm±	1.27	0.09	0.09
CD (P=0.05)	3.69	0.27	NS
Bio-regulator			
Control	42.13	3.27	3.60
Thiourea (500 ppm)	54.10	3.89	4.03
TGA (100 ppm)	50.95	3.66	3.90
Salicylic acid (100 ppm)	48.00	3.54	3.86
SEm±	1.27	0.09	0.09
CD (P=0.05)	3.69	0.27	0.24

Table 2. Yield attributes and yield parameters as influenced by varieties and bio-regulators

Treatment	Effective tillers/ plant	Ear length (cm)	Number of grains/ ear	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Variety								
RHB-121	2.45	25.86	1359	1968	4749	6718	21509	0.88
RHB-173	2.73	28.25	1480	2175	5173	7348	25951	1.06
RHB-177	2.25	24.25	1254	1816	4697	6514	19535	0.80
Raj-171	2.21	22.60	1234	1724	5106	6831	20712	0.85
SEm±	0.08	0.66	37.69	53	125	177	679	0.03
CD (P=0.05)	0.24	1.93	109	153	361	511	1960	0.08
Bio-regulator								
Control	2.07	23.13	1216	1639	4356	5996	16066	0.66
Thiourea (500 ppm)	2.70	27.24	1445	2162	5439	7601	26959	1.09
TGA (100 ppm)	2.49	25.35	1337	2010	5082	7092	23611	0.96
Salicylic acid (100 ppm)	2.39	25.25	1328	1871	4850	6721	21071	0.87
SEm±	0.08	0.66	37.65	53	125	177	679	0.03
CD (P=0.05)	0.24	1.93	109	153	361	511	1960	0.08

either 500 ppm thiourea or 100 ppm TGA sprayed at 25 and 50 DAS significantly enhanced the grain yield of pearlmillet.

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Effects of planting geometries and depths of planting on yield attributes and yield of improved varieties of rice under in system of rice intensification

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Rice is the most important cereal food crop of the developing world and the staple food of more than 3 billion people or more than half of the world's population. One-fifth of the world's population more than a billion people depend on rice cultivation for their livelihoods. Asia, where about 90% of rice is grown, has more than 200 million rice farms. India is considered to be one of the original centers of rice cultivation covering 44.6 million hectares, producing 132 MT of rice with an average productivity of 2.96 t/ha (Pandian, 2009). Around 65% of the total populations in India eat rice and it accounts for 40% of their food production India is the world's second largest producer of white rice, accounting for 20% of all world rice production. World production of rice has risen steadily from about 200 million tonnes of paddy rice in 1960 to over 678 million tonnes in 2009. Rice-based production systems provide the main source of income and employment for more than 50 million households (IRRI, 2008 data). World production of rice has risen steadily from about 200 million tonnes of paddy rice in 1960 to over 678 million tonnes in 2009, Rice production in India is an important part of the national economy. Among the different agronomic practices, planting geometry and depth of planting play a vital role in achieving higher yield levels of improved varieties of rice. It is because the proper distributions of crop plant per unit area and efficient utilization of available nutrient and other resources as well as environment. Therefore present experiment was conducted for studying the optimum planting geometries, improved varieties under depths of planting for getting maximum yield and economic returns in rice.

METHODOLOGY

The experiment was conducted at research farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during *kharif* season of 2010 and 2011 under edaphic and climatic conditions of Jabalpur (M.P.). The three different planting geometries i.e., 20 x 20 cm^2, 25 x 25 cm^2 and 30 x 30 cm^2 between hills and rows were kept for growing the crop and to identify their effect on grain yield parameters. Three varieties of rice i.e. MR-219, WGL-32100 and PS-3 and two depths of planting shallow (2.5 cm) and normal (5.0 cm). The layout of the trial was split-split plot design with three replications having planting geometry as main plots, varieties as sub plot treatments and depths of planting shallow (2.5 cm) and normal (5.0 cm) as sub-sub plot treatments. The area of each plot was 3 x 7 m^2. Seedlings were transplanted with an average of one seedling/hill in the SRI method of planting. Application of 10 t FYM/ha was given uniformly to all the plots before final puddling and leveling. Fertilizer with a uniform dose of 120: 60: 40 kg/ha N, P and K through urea, DAP and MOP was applied in all the plots.

RESULTS

Results showed that the 30 × 30 cm planting geometry had superiority in various yield attributing characters compared to closer spacing of 20 × 20 cm and 25 × 25 cm (Table 1). Rice MR-219 variety was markedly superior in various yield attributing characters *viz*; effective tillers/m^2, healthy grains/panicle, less chaffy grains/panicle and sterility percent over

Table 1. Yield attributes, yield and economics of rice as influenced by planting geometries, varieties and depth of planting.

Treatment	Effective tillers/m^2	Healthy grains/ panicle	Sterility (%)	1000-grains weight (g)	Grain yield (t/ha)	Net returns (Rs/ha)	B C ratio
Planting geometry							
S_1 - 20 cm x 20 cm	427.81	218.2	6.8	19.4	6.43	57607	2.52
S_2 - 25 cm x 25 cm	475.36	249.3	5.3	21.6	6.93	67019	2.89
S_3 - 30 cm x 30 cm	280.50	257.4	5.4	23.3	5.92	55558	2.69
SEm ±	6.62	2	0.3	0.6	0.09	1371	0.04
CD (P=0.05)	18.38	5.7	0.9	1.8	0.37	5381	0.15
Variety							
V_1 - MR-219	425.39	251.6	5	23.7	6.94	74730	3.12
V_2 - WGL-32100	388.64	251.4	5.7	19.7	6.31	45570	2.29
V_3 - PS-3	369.64	221.9	6.8	21	6.02	59885	2.69
SEm ±	4.42	3.9	0.2	0.6	0.08	1143	0.03
CD (P=0.05)	9.62	8.4	0.4	1.3	0.26	3520	0.1
Depth of planting							
D_1 - Shallow Depth (2.5 cm)	405.72	250.5	5.9	22.1	6.58	62470	2.77
D_2 - Normal Depth (5 cm)	383.39	232.8	5.8	20.8	6.27	57653	2.63
SEm ±	4.33	3	0.2	0.4	0.08	1089	0.03
CD (P=0.05)	9.10	6.3	0.4	0.7	0.24	3235	0.09

WGL-32100 and PS-3. The growth parameters and yield attributes significantly greater under shallow depth of planting than deeper planting depth, except effective tillers/m^2 was slightly lower under shallow depth of planting. The grain yield was significantly influenced by planting geometries at harvest during both the years. The 25 x 25 cm planting geometries produced significantly higher grain yield in comparison to 20 x 20 cm and 30 x 30 cm planting geometries. The rice MR-219 gave 9.94 % more grain yield over WGL-32100 and 15.37% over PS-3, during pooled average analysis. Significantly higher grain yield of rice was obtained under shallow depth of planting in compared to normal depth of planting. The shallow depth of planting showed higher NMR (62470 Rs/ha) in comparison to normal depth of planting during pooled mean analysis, respectively. The higher NMR were obtained under shallow depth of planting (2.5 cm) than normal depth of planting (5.0 cm). Thus, the former planting depth was more remunerative with B: C ratio of 2.77 than the normal depth of planting with B: C ratio of 2.63. The overall view of economic analysis revealed that variety MR-219 with shallow depth of planting under 25 cm × 25 cm plant geometry was more remunerative and fetching higher GMR and NMR returns.

CONCLUSION

Therefore, it can be concluded that growing of MR-219 with shallow depth of planting at 25 cm × 25 cm produced the highest grain yield and net monetary returns and benefit cost ratio.

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FLDs to enhance yield and economics of pulse crops in zone-V of Rajasthan

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The front line demonstrations (FLDs) are the key tool for the effective and quick transmission of latest technology among the farming community. Therefore, for achieving above purpose the FLDs on the pulse crops in both the seasons (*kharif* and *rabi*) during 2006-07 to 2008-09 was conducted at farmers field selected from the adopted villages by the KVK, Jhalawar. The number of the demonstration was 49 under urdbean (*Vigna mungo*) and 60 under chickpea (*Cicer arietinum*) in three consecutive years. The objective of the present study was to find out the yield and economic impact of the pulses FLDs.

METHODOLOGY

The farmers were purposively selected from the adopted area of the KVK, Jhalawar through PRA, Extension personal contact, group discussion, etc. After selection of the farmers, first they trained about the latest packages of practices of concerned crops at Krishi Vigyan Kendra, Jhalawar before implementing the FLDs. The size of the plot was 0.40 ha for FLDs as well as the local check. The visits, field days, extension activities, etc. were conducted during crop durations. After harvesting the FLDs the data were collected and analyzed for the impact on yield and economics.

RESULTS

The data (Table 1) showed that the pooled average yield of urdbean and chickpea was found 820 and 1128 kg/ha which was 19.59 and 17.06% higher over local checks, respectively. Further, the data showed the extension gap kg/ha (133 and 175), technology gap kg/ha (280 and 872) and technology index % (25.45 and 43.58) in both the season over local practices were recorded. The data indicate that the positive response of front line demonstration over the existing local practices towards enhancement in the yield of urdbean during *kharif* and chickpea during *rabi* in Jhalawar district of Rajasthan province. The economic data presented in Table 1 further indicated that the average B:C ratio (1.36 and 1.35), gross return Rs/ha (15750 and 30883) and net return Rs/ha (4083 and 8050) in both the crops which found higher under FLDs in comparison to local checks.

Table 1. Yield and economic returns of the pulses FLDs during 2006-07 to 2008-09

Particular	Pooled data of three years (2006-07 to 2008-09)			
	Kharif		*Rabi*	
	FLDs	Local Checks	FLDs	Local Checks
Crop	Urdbean	Urdbean	Chickpea	Chickpea
Variety	PU-19	Local	GNG-469	Kantedar
Area (ha)	20.00	20.00	25.00	25.00
Number of demonstrations	49.00	49.00	60.00	60.00
Average Yield (kg/ha)	0820	0687	1128	0953
Percent Increase over Local Checks	19.59	-	17.06	-
Extension gap (kg/ha)	0133	-	0175	-
Technology gap (kg/ha)	0280	-	0872	-
Technology index (%)	25.45	-	43.58	-
Total cost of cultivation (Rs/.ha)	11667	10350	22833	18650
Gross return (Rs/ha)	15750	12092	30883	25243
Net return (Rs/ha)	4083	1742	8050	6593
Benefit : Cost ratio	1.36	1.17	1.35	1.35

CONCLUSION

It can be concluded that by the use of improved practices of cultivation for pulses the yield and economic benefits in both the crops during study period can be enhanced. So, the number of FLDs on the pulses may be enhanced for the fulfillment of pulse requirement in the country.

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Effect of day time application of mesosulfuron-methyl on *Azotobacter* population of wheat rhizosphere

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Wheat is one of the most important crops among cereals. Many factors are responsible for low yields of wheat, but weed infestation may be cause yield losses upto 25-35 per cent which is more than the combined loss by insects, pests and disease (Dangwal *et al.,* 2010). Indiscriminate and over-application of herbicides to achieve higher weed control efficacy may have ill effects on public health and environment. They not only control target organisms, but may also leave potential residual effect in soil and cause various negative impacts, such as the killing of beneficial non-target organisms involved in nutrient retention and recycling, and impoverishment of the nutrient pool, leading to decreased soil fertility. Mesosulfuron-methyl a broad spectrum herbicide which mostly applied as post-emergence to get rid of weed notoriety in wheat but information on day time effect of mesosulfuron-methyl on soil microorganisms is not available in literature. Therefore a comprehensive study has done to see effect of day time application of mesosulfuron-methyl on *Azotobacter* population of wheat rhizosphere.

METHODOLOGY

A field experiment was conducted during *Rabi* seasons of 2014-15 and 2015-16 at Product Testing Unit, Department of Agronomy, JNKVV, Jabalpur (M.P.) to see the effect of day time application of mesosulfuron-methyl on Azotobacter population of wheat rhizosphere. The soil of the experimental field was sandy clay loam in texture, neutral in reaction (*pH* 7.0), Electrical conductivity (0.33dS/m), medium in organic carbon (0.62%), available N (393 kg/ha) and available P (17.44 kg/ha) but high in available K (296 kg/ha). Fifteen treatments comprising of three doses of mesosulfuron-methyl (10, 11.5 and 12 g/ha) including one hand weeding (30 DAS) and unweeded check as a main plots treatments and were superimposed with three day times of herbicide application (8 am, 12 noon and 6 pm) as a sub plot treatments and laid out in a split plot design with four replications. Wheat variety GW 273 was sown in the experimental field with recommended package of practices. Major plant nutrients (120 kg N, 60 kg P_2O_5, 40 kg K_2O /ha) were applied through urea, single super phosphate and muriate of potash. The herbicides was sprayed as post emergence at 40 days after sowing (DAS) using a spray volume of 500 L/ha with a knapsack sprayer fitted with flat fan nozzle. Soil sample were collected from 0-15 cm surface soil in all the plots at the time of 0, 10, 30 days after herbicide application and at harvest during both years. The soil samples were soaked into 90 ml deionized water at the rate of 10 g, later this mixture was shaken for 10 minute and kept for 5 minute. Thereafter, 1 ml of the supernatant was diluted twice and inocubated in the diluted water at hte constant temperature of 30^0C. The viable microbial counts were analyzed by the standard technique of serial dilution and pour plating. Enumeration of *Azotobacter* was carried out in soil extract by Ashbys Mannitol Azotobacter Agar medium. After allowing for development of discrete microbial colonies during incubations under suitable conditions, the colonies were counted and the number of viable *Azotobacter* [expressed as colony forming units (cfu)] per gram dry weight of soil was estimated by taking into account the soil dilutions.

RESULTS

The reaction of *Azotobacter*, an asymbiotic nitrogen fixer, toward the mesosulfuron-methyl doses was highly variable (Table 1). Unweeded check recorded the highest population of *Azotobacter* over doses of mesosulfuron-methyl applica-

Table 1. Effect of day time application of mesosulfuron-methyl on *Azotobacter* population (two seasons pooled data)

Treatment	*Azotobacter* (10^4 cfu/g dry weight of soil)			
	5 DAA	10 DAA	30 DAA	Harvest
Main plot (Herbicide dose)				
Mesosulfuron-methyl 10 g/ha	10.50	12.00	13.17	11.67
Mesosulfuron-methyl 11.5 g/ha	10.25	11.83	13.25	11.17
Mesosulfuron-methyl 12 g/ha	10.00	10.58	12.83	10.75
Hand weeding (30 DAS)	11.17	13.33	19.50	18.33
Unweeded check	11.92	14.92	21.00	19.50
LSD (P=0.05)	NS	NS	1.61	1.56
Sub-plot (day time of spray)				
Morning (8am)	10.55	12.20	15.90	14.20
Noon (12pm)	10.85	12.60	15.70	14.35
Evening (6pm)	10.80	12.80	16.25	14.30
LSD (P=0.05)	NS	NS	NS	NS

DAA- Days after application

tion being at par to hand weeding. It is evident that with the increment in herbicide doses, *Azotobacter population* was numerically same under all the treatments at 5 and 10 DAA but gradually increased at 30 DAA. However, the population was more under weedy check and hand weeded plots but significant difference did not touch to the level of significant between latter treatments. The population was reduced significantly at harvest during both years being lower when mesosulfuron was applied at 12 and 11.5 g/ha compared to the lowest dose (10 g/ha and proved inferior to weedy check and hand weeded plots which had more population of *Azotobacter*. Suggesting that there was antagonistic inhibition between the herbicide degradation bacteria and those which could not utilize herbicide as carbon or nitrogen source for their growth. So above result might be considered that during the earlier period after mesosulfuron-methyl application, other microorganisms could not grow vigorously because of the inhibition, but aerobic *Azotobacter* was not affected by the formidable edaphic condition and there was rapid increase in population. Day time application of mesosulfuron-methyl had no significant effect on microbial population.

CONCLUSION

It is concluded that post-emergence application mesosulfuron-methyl at 10 g/ha is safe as it did not affect adversely the *Azotobacter* population to that of nonherbicidal treatments (hand weeding and weedy check plots). Day time application of mesosulfuron-methyl at different rates did not affect the population of *Azotobacter*.

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Standardization of vegetative propagation techniques through budding and grafting of Bahera (*Terminalia bellerica*)

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Bahera (*Terminalia bellerica*) belonging to family Combretaceae is native of India. The fruits have multiple medicinal and industrial usage. Due to narrow canopy, the species has potential under agroforestry system. Sizeable variability with respect to fruit yield, fruit size and bearing habit has been reported (Anon, 1989). There is ample scope to select elite genotype and perpetuate it true to the type through vegetative means. Further, the spp. exhibit long juvenile phase. Vegetative propagation techniques are known to reduce gestation period. Budding and grafting are important methods of vegetative propagation wherein plants are perpetuated on the roots of others. The special advantages of the method lies in the exploitation of specific abilities of rootstock (stionic influence).The information available on vegetative propagation of Bahera is scanty. Therefore present study was planned.

METHODOLOGY

The experiment consisted of two methods of budding and two methods of grafting. The operation was performed in July and August. The experiment was carried out in 2005 and 2006 with 8 treatment combinations replicated thrice in completely randomized design. Twenty grafts/ buds per replication constituted unit and observed upto one year. The treatments consisted of four methods of propagation i.e. Patch budding, Chip budding, Cleft grafting and Veneer grafting and two time operation i.e. July and August. Data on bud/ graft take, days taken to initiate and complete sprouting, per cent success of bud /graft, of ultimate plant were recorded and subjected to statistical analysis as suggested by Panse and Sukhatme (1995).

RESULTS

Data reveals that bud/ graft take after one week of the treatment ranged between 71.7% to 98.3% in 2005 and 2006. Maximum (65-75%) bud/ graft take was recorded in cleft method of grafting in both the years while minimum (25%) for veneer grafting in July 2005. It is apparent from the data days taken to initiate sprouting ranged between 16-23 days. Sprouting was completed within 26.3 to 35.3 days in different treatments in both the years (2005 and 2006). Maximum

Table 1. Graft take percent, days taken to initiate and complete sprout and graft success percent as influenced by time and methods of budding/grafting.

Time	Method	Graft take (%)		Days taken to initiate sprout		Days taken to complete sprout		Graft success (%)	
		2005	2006	2005	2006	2005	2006	2005	2006
July	Patch	88.3	71.7	17.7	17.3	35.3	29.0	36.7	35.0
	Chip	86.7	86.7	18.7	18.7	38.0	26.3	28.3	30.0
	Cleft	78.3	86.7	17.3	17.7	32.7	29.0	65.0	65.0
	Veneer	73.3	90.0	21.7	21.0	32.7	33.7	25.0	30.0
Aug	Patch	81.7	88.3	16.3	17.7	34.7	30.3	36.7	33.3
	Chip	85.0	83.3	18.7	19.3	32.0	32.7	31.7	31.7
	Cleft	98.3	93.3	16.0	16.7	31.3	35.0	70.0	75.0
	Veneer	83.3	96.6	23.0	21.7	30.7	30.3	30.0	26.7
CD (P=0.05)									
Time		NS	NS	NS	NS	NS	NS	NS	NS
Method		NS	NS	3.3	NS	NS	NS	10.2	14.8
Time xMethod		NS	NS	NS	NS	NS	NS	NS	NS

(75%) success was obtained in cleft grafting in the month of August closely followed by that in July (65.0%). Minimum (25%) success was recorded in veneer grafting. Plant height was recorded higher (48.5) chip budded plants in August. Grafted plants recorded higher canopy than budded plants. This is obviously due to more number of leaves in grafted plants, cleft grafted plants recorded higher canopy spread in both the years. In general, grafted plants recorded higher number of leaves than budded plants throughout the study period.

CONCLUSION

From the present study it may be concluded that cleft grafting in the month of July and August gave maximum (65-70% and 65-75%) success in Bahera under semi-arid conditions of Jhansi. Bud take observations after 2 week of budding/ grafting give correct picture of budding / grafting success in Bahera. Growth of ultimate plant is initially influenced by time and method of budding/ grafting in Bahera.

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Harnessing chickpea yield through multi-location demonstration in Uttar Pradesh

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The Pulses Production (17.2 million tons) is stagnating and acreage remained more or less stagnant (23.82 million ha) since last two decades. A drastic reduction in per capita availability from 65 g/day in 1961 to 39.4g/day in 2011 of pulses noticed during the last five decades from 1961 to 2011. The low production of pulses 785 kg/ha during 2013-14 has not witnessed significant improvement. In Rabi season, the chickpea crop has attained highest acreage 9.93mha and productivity of 960 kg/ha in India. Whereas, in Uttar Pradesh the crop covered 5.77 lakh ha area with the productivity of 824 kg/ha. The low productivity is mainly attributed to the poor production potential of the varieties, relatively low economic viability of the crops and crop sequence besides poor cropping management. Farmers generally grow pulse crops as a mixed or intercrop in rainfed situation on marginal lands. No processing and marketing at village level thus, the crop always suffers from input starvation in terms of nutrition, plant protection and poor management. The continuous efforts have been made to increase productivity in a sustainable manner by evolving new varieties and low cost production technologies by different research institutions.To achieve target production, the scheme called National Pulse Development Project (NPDP) was launched by Ministry of Agriculture and Cooperation, GOI During 1989 to 1990 with the main objective of enhancing the pulse productivity through adoption of improved location specific production technologies (Anonymous, 1994-95).

METHODOLOGY

The KVKs under Zonal Project Directorate, Kanpur have conducted 1950 demonstrations in an area of 453.5 ha of chickpea. These demonstrations were organized on packages of practices such as high yielding varieties with Sulphur (20-25kg/ha), PSB (250g/10kg seed), Rhizobium culture (250g/10kg seed) & Resource conservation technologies (raised bed, seed drill and line sowing) with weed management practices such as pendimethalin @ 3.33kg/ha. The demonstration were laid out under irrigated/rainfed conditions of 32 KVKs under 9 Agro Climatic Zones (Central Plain, Western Plain, Mid-Western Plain, South-Western Semi-Arid, North Eastern Plain, Bundelkhand, Eastern Plain, Bhabar & Tarai and Vindhyan) of Uttar Pradesh these on various types of soils and

Table 1. Mean grain yield of chickpea under different thematic areas & yield gap analysis Pooled data (2011-2015)

Thematic Area	Demo. Area (ha.)	Number of Demo.	Demo yield (kg/ha)	Check yield (kg/ha)	Percentage yield Increase	Yield Gap (kg/ha) over local check
ICM	86.60	376	1380	997	38.34	382
INM	36.92	184	2040	1638	24.54	402
IPM	35.55	190	1670	1285	29.96	385
IWM	37.00	144	1870	1324	41.15	546
RCT	10.40	33	1110	993	11.78	117
IDM	03.00	13	2040	1380	47.82	660

varied rainfall distribution under rainfed conditions. These demonstrations were conducted at farmers' fields in selected villages in the periphery of respective KVKs on cluster basis during rabi season. The KVK wise eleven varieties demonstrated in descending order as Awrodhi (18), Radhey (10), Pusa 267. K 850, Udai, BG 256, K-4, KPG 59 during *rabi* season. The seed and fertilizers were made available as critical inputs to the farmers along with technical knowledge through training programme before conducting demonstration. The KVKs and Zonal Project Directorate scientists had monitored FLDs from sowing to harvesting. The other agronomic practices were followed as per the recommendation of chickpea crop i.e. seed rate appropriate time of sowing second to third week of October (Kumar *et al.,* 2003), Rhizobium culture (20g/kg seed). NPK application (25:40:30 kg/ha). The data were collected and analyzed by using simple statistical methods like weighted of yield increase and yield gap over local check mean, percentage.

RESULTS

The improved technologies provided highest grain yield (2040kg/ha) of chickpea under Nutrient management and disease management followed by integrated weed management (1870 kg/ha) as compared to their local checks 16.38q/ha under Integrated Nutrient Management and in Integrated Disease Management & same in case of weed management (1380kg/ha). The yield increased was ranged between 11.78% to 47.82% across the different thematic area demonstrated. However, Integrated Nutrient management resulted additional yield of 400kg/ha and disease management given an additional yield advantage of 660 kg/ha is a key thematic areas followed by integrated weed management additional yield advantage of 546kg/ha& integrated pest management 385kg/ha. The yield gap of 330kg/ha was observed between demonstrated technologies as compared to local check (NikulsinhM. Chauhan2012) and (Tiwari and Tripathi, 2014). The overall percentage increase was recorded 28 percent.

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Effect of different sowing dates on quality and yield of rapeseed-mustard varieties

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India is the fourth largest oilseed economy in the world and rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm (*Elaeis guineensis* Jacq.) oil. It is the second most important edible oilseed after soybean sharing 41% in India's total oilseed production (Anonymous, 2012). Sowing time is the most vital non-monetary input to achieve target yields in rapeseed-mustard. Production efficiency of different genotypes greatly var-

Table 1. Effect of different treatments on quality parameters and yield (kg/ha) of rapeseed-mustard

Treatment	Oil content (%)	Protein content (%)	Seed yield (kg/ha)	Straw yield (kg/ha)
Date of sowing				
5th October	41.7	17.6	1426	5514
15th October	40.6	18.9	1215	4805
25th October	39.5	19.7	1326	5110
4th November	38.8	19.9	1326	4926
LSD (P=0.05)	0.77	0.80	NS	426
Variety				
KBS-3	42.0	17.2	1037	4337
Neelam	41.2	19.2	1481	5614
RCC-4	38.3	21.5	1060	4535
Jayanti	39.3	18.1	1583	6091
ONK-1	39.9	19.1	1454	4866
LSD (P=0.05)	1.1	0.9	113	256

ies under different planting dates. Sowing time influences phenological development of crop plants through variations observed in light and temperature. Sowing at optimum time gives higher yields due to suitable environment that prevails at all the growth stages. The growth phase of the crop should synchronize with optimum environmental conditions for better expression of growth and yield.

METHODOLOGY

The field experiment was conducted in *Rabi* 2011-12 at Shivalik Agricultural Research and Extension Centre, Kangra of Chaudhary Sarwan Kumar Himachal Pradesh Krishi *Vishvavidyalaya*, Palampur. The treatments consisting of five varieties (KBS-3, Neelam, RCC-4, Jayanti and ONK-1) in main plots and four dates of sowing (5th October, 15th October, 25th October and 4th November) in sub plots which were laid out in split plot design with three replications. Protein content in grains by Kjeldahl's method and oil content by Soxhlet method were determined.

RESULTS

The data pertaining to the oil content (Table 1) revealed its gradual and significant decrease with delay in sowing dates. The maximum (41.7%) oil content was found in 5th October sown crop followed by 15th October, 25th October and 4th November sowing. Among varieties, KBS-3 being at par with variety Neelam produced significantly higher oil content (42%). Similar observations were reported earlier by Bala *et al*. (2011). The significantly higher protein content was recorded at in 4th November and 25th October sowings, whereas first date of sowing (5th October) and second date of sowing (15th October) recorded significantly lower protein content. Among varieties, RCC-4 produced significantly higher protein content (21.5%) followed by Neelam (19.2%). The effect of sowing date on seed yield was observed non-significant. However among varieties, Jayanti produced significantly higher seed yield followed by Neelam and ONK-1. Among different sowing dates, 5th October sown crop produced significantly highest straw yield as compared to other dates of sowing. The higher straw yield in first date of sowing may be due to prolonged growth period which resulted in higher number of leaves/plant and leaf area, and consequently more dry matter accumulation. Among varieties, Jayanti produced significantly more straw yield followed by Neelam and ONK-1. Higher straw yield in variety Jayanti might be due to more plant height and biomass.

CONCLUSION

The study conclusively indicated that the 5th October sown crop produced significantly higher oil content and more straw yield as compared to other dates of sowing. However, maximum protein content was recorded in the 4th November sowing. The effect of sowing dates on seed yield was observed to be non-significant. Among varieties, oil content was observed significantly higher in KBS-3 whereas protein content was recorded higher in RCC-4. Jayanti produced significantly higher seed yield followed by Neelam and ONK-1. Neelam produced significantly higher straw yield followed by ONK-1 and RCC-4.

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An intercropping of sesame with pulses: A step for increasing crop yield and farm profit

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As Indian agriculture highly depends on south-west monsoon, a triple cropping or quadruple cropping is not possible in Rainfed farming region. As around half of our cultivable land is under dryland region, it is not possible to go for any exhaustive crop cultivation in *pre kharif* season. But Sesame, Black gram & Green gram can be cultivated in this season as they are resistive enough towards high temperature & low moisture stress condition. Chaniyara *et al.* (2008) found that intercropping enhances chlorophyll content in component crops. The objective of this experiment was to study whether the intercropping of Sesame with Black gram & Green gram is beneficial or not in *pre-kharif* season in the Red and Lateritic belt of West Bengal.

METHODOLOGY

The experiment was conducted in the farm of Palli Siksha Bhavana in the *pre-kharif* season of 2015 in randomised block design with twelve treatments which consisted of four numbers of sole sesame (at the spacing of 30 cm, 40 cm, 20/60 cm & 20/100 cm), sole black gram(15 cm x 10cm), sole green gram (40 cm x 10cm) & six numbers of intercropping of sesame with both black gram and green gram in 1:1 ratio, 2:2 ratio and 4:4 ratio. The varieties used were Savitri (SWB-32-10-1), WBU-108 & Samrat (PDM-84-139) for Sesame, Black gram & Green gram respectively. Standard package & practices were followed.

RESULTS

From the above experiment, it was found that plant height was highest in sole crop treatments in both Sesame and pulses throughout the crop growth period (Table 1 and 2). In case of sesame, the CGR was highest in intercropping treatments but in pulses it was irrespective of treatments throughout the crop growth period. In both the crops, the total chlorophyll was highest in intercropping treatments. The grain yield of sesame was highest in 30 cm row spacing and it was at par with sesame: Black gram 2:2 ratio. In pulses, the yield of intercropping treatments was proportional to the plant population. The oil yield was highest in intercropping treatments. Protein content was highest in sole crop treatments. In many parameters, intercropping gave better results.

CONCLUSION

It was concluded that intercropping of Sesame with Black

Table 1. Effect of intercropping on plant height, CGR, total chlorophyll, seed yield and oil percentage of sesame

Treatment of sesame	Plant height at 45 DAS (cm)	Total chlorophyll (mg/g)	Seed yield (kg/ha)	Oil(%)
Sole sesame 30 cm row spacing	85.63	0.89	1.34	44.77
Sole sesame 40 cm row spacing	80.83	1.74	1.11	44.40
Sole sesame paired row	82.29	1.87	1.10	45.44
Sole sesame four row	81.46	1.06	1.05	44.05
SM:BG::1:1	76.67	1.70	0.84	46.09
SM:GG::1:1	80.63	1.90	0.75	47.25
SM:BG::2:2	75.83	1.59	1.24	47.74
SM:GG::2:2	83.13	1.86	1.12	47.97
SM:BG::4:4	74.38	1.47	0.68	48.31
SM:GG::4:4	77.71	1.55	0.93	48.26
SEm(±)	3.55	0.14	0.05	0.46
CD (P=0.05)	10.55	0.42	0.14	1.38

Table 2. Effect of intercropping on plant height, CGR, total chlorophyll, grain yield, protein percentage of pulses

Treatment of Pulses	Plant height at 45 DAS (cm)	Total chlorophyll (mg/g)	Grain yield (kg/ha)	Protein (%)
Sole black gram	32.50	2.04	1.31	25.42
Sole green gram	30.42	1.06	1.25	24.35
SM:BG::1:1	30.21	2.37	0.38	21.04
SM:GG::1:1	31.67	2.37	0.65	23.23
SM:BG::2:2	31.67	3.40	0.46	22.17
SM:GG::2:2	31.04	1.62	0.57	21.77
SM:BG::4:4	32.29	2.25	0.37	20.56
SM:GG::4:4	28.75	1.49	0.59	22.17
SEm(±)	1.80	0.24	0.05	0.18
CD (P=0.05)	5.45	0.72	0.14	0.53

gram & green gram gave higher chlorophyll & oil percentage, while plant height, CGR and protein percentage of pulses were highest in sole crop treatments. So, intercropping of Sesame with Black gram and Green gram in different row ratios especially in 2: 2 ratio may be beneficial for improved productivity.

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Performance of lentil varieties as affected by different seed rates under rice *utera* conditions

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In Assam, winter rice (*Oryza sativa* L.) is the main crop occupying about 19 lakh ha (2014-15). Out of it, 50% area is medium land, 35% is low land and 15% is very low land. The medium and low land situations have both medium and heavy textured soil while very low lands are mostly heavy textured soil. In medium and low land situations, about 10 lakh ha have medium textured soil which are suitable for *Rabi* pulses. Out of this 10 lakh ha, about 6.5 lakh ha remain fallow during *Rabi* season. At the same time, the domestic pulse production can meet only 32% of the pulse requirement (3.78 lakh t) of the state. Therefore, horizontal expansion is one of the viable strategies for increasing pulse production. As the Assamese people consume maximum of lentil (*Lens culinaris* Medik.), the state has to put emphasis on its production. This crop is a viable option for cultivation in medium textured medium rice-fallows. Gupta & Bhowmick (2005) from west Bengal, India and Islam *et. al*. (2015) from Bangladesh reported lentil's suitability and scope for growing in rice-fallows both under sequential cropping and *utera* cultivation. Lentil varieties show wide variation with respect to their productivity and adaptability under rice *utera* conditions. In such situation, another important factor governing success of a relay crop is plant stand per unit area. So, the present investigation was planned and executed to find out suitable lentil variety with optimum seed rate for rice relay cropping system.

METHODOLOGY

The field trial was conducted at Shillongani, Assam during *Rabi* 2012-13, 2013-14 and 2014-15. The rice variety 'Ranjit' was transplanted in second week of the July and harvested (at

30 cm above ground level) in fourth week of November. There were 3 varieties of lentil *viz*. 'HUL57', 'KLS 218' and 'PL 406' and two seed rates (37.5 and 45 kg/ha). For a pure crop of lentil, the state recommendation of seed rate is 30 kg/ha. The combination of variety and seed rate were tested in a randomized block design with 4 replications. The *Rhizobium* and PSB (each @ 50 g/kg seed) inoculated seeds were broadcast 12-17 days after 50% flowering of rice crop (in second week of November) when soil was in moist conditions (at or just above field capacity; field capacity of the concerned soil was 23.60%). Plant stand was recorded at 30 days after sowing (DAS), soil moisture at 30, 60 and 90 DAS and soil microbial population (fungi & bacteria) was determined at lentil sowing and harvest. The generated technology then tested in farmer's fields through Krishi Vegan Kendra (KVK) in 4 districts (Nagaon, Jorhat, Darrang and Chirrang) of Assam against farmer's practice during *Rabi* 2015-16.

RESULTS

Pooled analysis showed that the highest grain yield was recorded under lentil variety 'HUL 57' (Table1). This might be attributed to better adaptability of this variety in rice-*utera* conditions as reflected by considerably higher plant stand in comparison to the other two varieties. This finding corroborates the results of DAC-ICARDA-ICAR (2012-13). The seed rate of 45 kg/ha (805.44 kg/ha) accrued in significantly higher grain yield than 37.5 kg/ha (587.62 kg/ha). The variety 'HUL 57' when sown using a seed rate of 45 kg/ha (897.57 kg/ha)

Table 1. Grain yield (kg/ha) (pooled data of 3 years)

Variety	Seed rate (kg/ha)	Mean 37.5	45.0
PL 406	512.64	731.39	622.01
HUL 57	659.03	897.57	778.30
KLS 218	591.18	787.36	689.27
Mean	587.62	805.44	
CD (P=0.05)	Variety Seed	31.30	
	rate Interaction	25.56	CV (%) = 7.94
		44.27	

Table 2. Economics of different treatment combinations

Treatment	GR (Rs)	Cost (Rs)	NR (Rs)	B:C
PL 406 (37.5)	33322	14237	19085	1.34
PL 406(45)	45540	15062	30478	2.02
HUL 57 (37.5)	42837	14237	26600	2.00
HUL 57 (45)	58342	15062	43280	2.87
KLS 218 (37.5)	38427	14237	24190	1.69
KLS 218 (45)	51178	15062	36116	2.39

Figures in parentheses alongside variety represent seed rate

significantly out yielded all other treatment combinations. In all the years, soil moisture conservation was better under 'HUL 57' grown with 45 kg/ha seed rate. Higher plant stand and better soil moisture conservation under this treatment combination led to considerable increase in soil microbial (both fungi and bacteria) population at harvest. The highest net return (Rs. 43,280) and benefit:cost ratio (2.87) were also recorded under this combination. This technology under on-farm testing through KVK resulted in 40-50% yield increase over farmer's practice (local variety with 30 kg/ha seed rate).

CONCLUSION

There is a vast scope for lentil cultivation in medium textured winter rice lands of Assam. The lentil variety 'HUL 57' with 45 kg/ha seed rate maintains or improves soil environment and at the same time ensures higher productivity showing its better adaptability under rice-*utera* conditions along with positioning itself in an economically advantageous state.

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Performance of clusterbean (*Cyamopsis tetragonoloba*) genotypes as influenced by crop geometry in scarce rainfall zone of Andhra Pradesh

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Clusterbean, popularly known as guar is very drought tolerant, summer legume and sun-loving, but susceptible to frost that requires only 300-400 mm annual rainfall. Clusterbean is a main *Kharif* legume crop, recently classified in arid legume group and is grown for vegetable, green fodder, green manure and for grain. Clusterbean tolerates high temperatures and dry conditions and is adapted to arid and semi-arid climates (Pathak *et al*., 2009). Clusterbean basically grown under arid rainfed conditions, deep penetrating root system enables the plant to utilize available moisture more efficiently and thus offers better scope for its rainfed cropping. Ananthapuramu district is the second most drought - affected district of India. Rainfed agriculture in Ananthapuramu district is greatly influenced by water shortage caused by low, highly variable and erratic rainfall. Due to moisture scarcity, the soil organic matter turnover and fertilizer use efficiency is very low.In clusterbean information on spacings and nutrient management is meagre for scarce rainfall zone of Andhra Pradesh and hence present study was initiated.

METHODOLOGY

A field experiment was conducted to study the influence of spacing on clusterbean varieties in alfisols of Agricultural Research Station, Ananthapuramu of Andhra Pradesh in scarce rainfall zone under rainfed conditions for three years during *kharif*, 2013-14 to 2015-16.The soil of the experimental site was red sandy loam with shallow depth, low in organic carbon (0.38%) and low in available nitrogen (138 kg/ha), medium in available phosphorous (28 kg/ha) and potassium (215 kg/ha). The experiment was laid out in split plot design with three replications. The treatments consisted of two varieties *viz.*, B_1: Branched (RGC 936) and B_2: Unbranched (RGC 1066) allotted to main plots and spacings *viz.*, S_1: 22.5x7.5 cm S_2:22.5x10 cm, S_3:30x7.5 cm, S_4: 30x10 cm, S_5:45x7.5 cm and S_6: 45x10 cm allocated to sub plots. Sowing was taken up as per the treatments. Thinning was done at 15 DAS retaining one healthy seedling/hill. The recommended dose of N, P_2O_5 and K_2O kg/ha was applied at the time of sowing through urea, single super phosphate and muriate of potash respectively.

Table 1. Test weight, seed and haulm yield of clusterbean as influenced by genotypes and crop geometry in rainfed alfisols

Treatment	Test weight (g)				Seed yield (kg/ha)				Haulm yield (kg/ha)			
	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean
Genotype												
B1: Branched	34.9	30.8	32.0	32.6	351	496	495	447	1033	819	991	948
B2: Unbranched	34.1	30.1	31.6	31.9	372	495	469	445	1242	891	983	1036
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Crop geometry												
S1: 22.5 x 7.5 cm	29.3	24.6	28.2	27.4	279	514	509	399	1014	786	876	833
S2: 22.5 x 10 cm	36.1	32.5	36.1	34.2	395	584	536	512	1109	976	1025	1038
S3: 30 x 7.5 cm	32.0	30.8	30.1	32.1	445	522	473	467	1320	798	942	1061
S4: 30 x 10 cm	38.8	31.8	32.4	33.7	355	450	547	489	1148	758	1036	1002
S5: 45 x 7.5 cm	31.6	32.5	30.5	32.3	378	523	445	417	1244	1050	1043	1067
S6: 45 x 10 cm	39.2	30.5	33.6	33.8	315	380	382	393	990	762	997	949
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

RESULTS

During the crop season an amount of 328.4, 160.6, 212.6 mm of rainfall was received in11, 10, 14 rainy days during 2013-14 to 2015-16 respectively. Pooled analysis of three years data revealed that plant height, pods/plant, seeds/pod, test weight, seed and haulm yield (Table 1) of clusterbean was not significantly influenced by genotypes and crop geometry. Pooled data revealed that higher yield was recorded with branched varieties (447 kg/ha) than unbranched varieties (445 kg/ha). Among crop geometry 22.5 X 10 cm recorded higher seed yield (512 kg/ha) and lowest seed yield of 393 kg/ha obtained with 45X10 cm. Unbranched variety produced higher haulm yield. Among crop geometry tested, higher haulm yield was registered with 45x7.5cm and 22.5x7.5cm spacing resulted lowest haulm yield.

CONCLUSION

As the results indicated that there was no significant difference among different spacing, considering the economics and large scale availability of seed drills and planters with farmers sowing of cluster bean either branched or unbranched genotypes with 30 X 7.5 or 10 cm spacing was found optimum.

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Study on economic life span of large cardamom (*Amomum subulatum*) *Sawney* cultivar at Sikkim, India

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A field experiment was conducted during 1995 - 2014 at Pangthang Research farm (1952 m AMSL) of Indian Cardamom Research Institute, Regional Research Station, Spices Board, East Sikkim to find out the economic life span of large cardamom. The popular cultivar *Sawney* was selected for this study since it is suitable variety in this location. The experiment was laid out in randomized block design (RBD) with six treatments and four replications. The treatment details are *viz*., $T_{1:}$ Control, $T_{2:}$ Full dose in April (40:60:40 kg N, P_2O_5 & K_2O/ha), T_3: Two equal splits in April and September, T_4: Two splits: half N & K and full P in April & half N & K in September, T_5: Three equal splits in April, June and September and T_6: Three splits: full P in April and 1/3 of N & K in April, June and September. It is observed that no significant difference in yield was recorded in the plants imposed with single, double and three split application of fertilizers. The growth parameters were recorded up to seventeen years after planting. The yield of large cardamom was recorded after third year of planting onwards. The observation on yield (kg/ha) showed for the years 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2005, 2006, 2007, 2008, 2009 and 2010 was 11.70, 128.30, 199.60, 817.40, 566.20, 576.20, 648.10, 267.60, 321.80, 350.00, 391.00, 170.80 and 535.20 respectively. The highest growth and yield were recorded in sixth year (2000) after planting (817.40 kg/ha). The stability in growth and yield were observed up to fifteen years after planting (535.20 kg/ha). The observations were not recorded during the years 2004 and 2011 due to severe crop damage by hailstorm and observed declining in growth and yield from 2012-13 compared to previous years and 95.83 per cent plants were died in the year 2013-14. Based on the study it is concluded that the economic life span of *Sawney* cultivar of large cardamom was fifteen years after planting by adopting improved agro-techniques.

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Effect of land configurations and varieties in summer groundnut

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India share 23% of the world's groundnut area and production. In India, it is grown in area of 4.77 M ha with total production 4.75 MT. Above 80% of the area under groundnut is concentrated in five states *viz.* Gujarat, Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka. Gujarat occupies the first place in regard to area and production. The average yield of groundnut in India is 999 kg/ha, which is less than the average yield of groundnut in world has 1600 kg/ha. Maharashtra is one of the important groundnut growing states in India. The total area under groundnut in Maharashtra is 3.57 lakhs ha out of which 2.57 in *kharif* and 0.87 summer with total production of 4.44 lakh tonnes with an average yield of 1150 kg/ha.The amount of summer rainfall is increasing during last five years and due to the unseasonal heavy rainfall as well as hail storms during summer season the crop is suffering from waterlogging. Broad bed and furrow system (BBF) is one of the most efficient land management practices for in situ moisture conservation in deep black soils as well as the furrows will acts as drainage channels during heavy rainfall.Effect of land configuration and varieties in groundnut was reported by Baskaran *et al.* (2003) and Patil *et al.* (2007).The experiment was conducted with an objective to study the effect of land configurations on growth and yield of summer groundnut and to identify the suitable variety in summer season.

METHODOLOGY

The experimental field well leveled and drained. The soil was clay in texture, low in nitrogen (212 kg/ha), medium in phosphorous (15 kg/ha), medium in potash (578 kg/ha) and alkaline in reaction(pH 8.7).The experiment was laid out in a split-plot design with 12 treatment combinations, which comprised of four land configurations and three varieties. The main plots treatments were L_1-Ridges and furrows, L_2-Broad Bed Furrows, L_3-Sara method and L_4-Flat beds and three varieties i.e. LGN-1, TAG-24 and SB-XI were assigned as sub plot treatments. Each experimental unit was replicated thrice. The net plot size was 4.8 m x 3.8 m. Sowing was done by dibbling on 26 February at spacing of 30 cm x 10 cm. The recommended cultural practices and plant protection measure were undertaken. The recommended dose of fertilizer (25:50:00 NPKkg/ha) was applied at the time of sowing through urea and DAP.

Table 1. Dry pod, haulm, biological yield and net monetary returns of groundnut as influenced by various treatments

Treatments	Dry pod yield (kg/ha)	Haulm yield (kg/ha)	Biological yield (kg/ha)	Grossmonetary returns (Rs/ha)	Net monetary returns (Rs/ha)
Land configurations					
L_1 : Ridges andFurrows	1835	2688	4523	80125	54645
L_2 : BBF	1939	2756	4729	84469	59188
L_3 : Sara method	1642	2480	4089	71885	48105
L_4 : Flat bed	1553	2396	3950	68134	45464
SEm±	26.16	23.02	39.62	1065	788
CD (P=0.05)	90.55	79.68	137.12	3686	2729
Varieties					
V_1 :TAG-24	1999	2820	4820	87047	62450
V_2 : SB-XI	1678	2516	4195	73437	50040
V_3 : LGN-1	1549	2405	3954	67976	43062
SEm±	13.75	19.82	40.93	602	466
CD (P=0.05)	41.23	59.44	122.71	805	1397
Interactions (L X V)					
SEm±	55.94	79.13	163.71	2409	1865
CD (P=0.05)	NS	NS	NS	NS	NS

RESULTS

Amongst the land configurations, broad bed furrows recorded significantly higher dry pod, haulm and biological yield (Table 1). The highest GMR and NMR were recorded with broad bed furrows followed by ridges and furrows. Among the varieties,TAG-24recorded significantly higher values of all above parameters and GMR and NMR as compared to the varieties SB-XI and LGN-1.The higher yields with broad bed furrows might be due to optimum moisture conditions, higher availability of nutrients and also more surface area for peg penetration.

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Agronomic modifications under anaerobic condition during germination can enhance the productivity and profitability of rice in flood-prone areas

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Poor seedling emergence and establishment is a major deterrent in adopting direct seeding of rice especially under rainfed lowlands where flood occurs immediately after sowing, creating anaerobic conditions for germinating seeds. In areas where direct seeding is practiced, farmers may encounter flooding or waterlogging when it rains immediately after seeding and this leads to severe reduction in or complete failure of crop establishment because of the high sensitivity of rice to low oxygen stress caused by flooding during germination. The problem of poor crop emergence and establishment is further compounded by the invasion of weeds, especially weedy rice and red rice, as the young rice plants grow under direct seeded condition. Varieties that can germinate in flooded soils could be beneficial for direct-seeded systems in these areas and even for intensive irrigated systems, where early flooding can suppress weeds (Ismail *et al.,* 2009) apart from improving crop establishment. This will consequently result in enormous savings in production costs compared with when rice is transplanted. It can also reduce the cost of manual or mechanical weeding and the use of hazardous chemicals for weed control. Therefore, the study was conducted using IR64-AG NILs (tolerant to AG but intolerant to submergence),IR64-Sub1 (tolerant to submergence but intolerant to AG), and IR64 (intolerant to submergence and AG) with the objectives: (i) to evaluate the germination and growth attributes of IR64-AG NILs with IR64 and IR64-Sub1 under controlled submerged conditions; (ii) to compare the performance of IR64-AG NILs with IR64 and IR64-Sub1 under submerged condition starting from 0- to- 21- day after sowing (DAS) using different establishment methods; (iii) to evaluate the different agronomic manipulations in relation to productivity of IR64-AG NILs with IR64 and IR64-Sub1 under submerged condition starting from 0- to- 21-DAS.

METHODOLOGY

The experiments were carried out at the Indian Council of Agricultural Research-National Rice Research Institute (ICAR-NRRI), Cuttack (20° 45′ N, 85° 93′ E; elevation 24 m above mean sea level) during 2013-15. The experiments were conducted to evaluate the performance of IR64, IR64-Sub1, and two Anaerobic Germination near isogenic lines (AG NILs); IR64-AG131 (IR 93312-30-101-20-3-66-6) and IR64-AG132 (IR93312-30-101-20-13-64-21) in varying flooding stress; and impact of genotypes, crop establishment methods and nutrient management practices on yield attributes and yield of these genotypes/varieties. The experiment was laid out in a split-plot design with 35 m^2 plots, in 3 replications. Three crop establishment methods were used in main plot, (i) direct dry seeding in unpuddled soil; (ii)wet seeding by drum seeder in puddled soil and (iii) Broad casting in puddled soils (Farmers' practice in lowland condition) and genotypes in sub plots. For direct dry seeding in unpuddled condition, a fine seed bed was prepared with 2-3 cultivations and planking after one irrigation before sowing.

RESULTS

Percentage germination was highest in control and lowest in 21-d flooding treatment. The anaerobic tolerant lines showed higher germination during all flooding durations, which was 92% after 5-d flooding and 75% after flooding for more than10-d. The lowest germination was observed in IR64 which was around; 17% after 10-d of flooding. Our results suggest that the increased availability of soluble sugars translocated from the rice endosperm to the coleoptiles was due to stimulated coleoptile elongation in the seeds of IR64-AG under anoxia. Plant population was higher during 2014 as compared 2013. Among the establishment methods, plant population was highest in broadcasting followed by drum seeding. IR64-AG had the significantly highest plant population, which was 81.1 and 217.5% higher over IR64-Sub1 and IR64, respectively, irrespective of the establishment methods. The anaerobic condition soon after sowing restricted the emergence of rice seedlings in intolerant cultivars. Better yield attributing characters was recorded during 2014. IR64-AG significantly outperformed the other two cultivars in terms of effective tillers, panicles, grains per panicle and spikelet fertility per cent. Among the establishment methods, Drum seeding recorded significantly highest, whereas, dry–DSR had the lowest values of all the yield attributing characters. Less number of tillers/m^2 and panicles/plant resulted in lower grain yield during 2013; drum seeding had the significantly highest grain yield during both the years followed by broadcasting. Grain yield in drum seeding was 11.3 and 5.5% higher during 2013, 12.1 and 4.8% higher during 2014 over dry–DSR and broadcasting, respectively (Table 2). Among the cultivars, IR64-AG proved its superiority in higher grain yield over other two cultivars; it was 36.3 and 15.2% higher in 2013, 51.9 and 22.4% higher in 2014 over IR64 and IR64-Sub1, respectively, irrespective of the establishment methods. Grain yield in drum seeding was 11.3 and 5.5% higher during 2013, 12.1 and 4.8% higher during 2014 over dry-DSR and broadcasting, respectively. In a study, Santhi *et al.* (1999) observed that drum seeder gave the highest yield even though there was no marked difference between establishment methods and significantly more number of panicles m^{-2} than transplanted rice.

CONCLUSION

It can be concluded that irrespective of the flooding duration, IR64-AG recorded higher germination than intolerant IR64 and IR64-Sub1, mainly due to fast depletion of starch and higher maintenance of sugar in IR64 AG 131 and 132. Among the establishment methods, plant population was highest in broadcasting followed by drum seeding. Highest grain yield was recorded in drum seeding and IR64-AG followed by IR64-Sub1. Additional 20% P application along with N-P_2O_5-K_2O proved its superiority in higher grain yield (19.8 and 10.1%) over control and N-P_2O_5-K_2Otreatments, irrespective of the seed rate and cultivars. Small investment with higher seed rate and nutrient application may lead to better crop establishment and productivity of rice under stress environment.

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Performance of late sown toria in rice-fallow situation under different crop management practices

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Rapeseed-mustard (*Brassica* spp.) is the third largest vegetable oilseed crop in the world after soybean (*Glycine max*) and palm oil (*Elaeis guineensis*).In Assam, *tori* is the only popular and predominant oilseed crop because of the prevailing climatic conditions and early duration of the crop, which enable the farmers to go for the summer crop after harvest of *toria.* However, the productivity of the crop is much lower than national average productivity. This low productivity is accounted for various factors like lack of moisture during crop growth period, untimely and unscientific method of sowing and poor crop husbandry resulted from inadequate or excess seed rate. About 90% of the crop is cultivated under rainfed condition so its performance depends upon the amount and distribution pattern of rainfall during the crop season. Sowing time, seed rate and method of sowing are the most important non-monetary input which influence to great extent on both the productivity of seed and oil. Rapeseed-mustard is considerably sensitive to weather as evidenced by the variable response to different date of sowing (Kumar *et al*., 2007). Optimum sowing time, seed rate and method of sowing play an important role to fully exploit the genetic potential of variety as it provides optimum growth conditions such as temperature, light, humidity and rainfall etc. Processes of yield formation are highly variable and depend on genetic, environmental and agronomic factors as well as interactions between them (Sidlauskas and Bernotas, 2003).The optimum sowing time of rapeseed-mustard in Assam condition is middle of October to middle of November. But due to delayed monsoon rain or delayed harvesting of *kharif* rice it may extend up to December. JT-90-1(Jeuti) is a newly developed rapeseed variety of Assam Agricultural University especially for late sown rice-fallow condition whose performance at different date of sowing, seed rate and method of sowing is yet to be studied under late sown rice-fallow situation. Hence the present study was conducted to find out the optimum sowing date, seed rate and best method of sowing under late sown rice-fallow condition.

METHODOLOGY

A field experiment was conducted during *rabi* season of the year 2014-2015 and 2015-2016 at the Instructional-cum-research farm of the Assam Agricultural University. This field experiment had 4 different dates of sowing i.e. D_1 - 1st December, D_2 - 8th December, D_3- 15th December and D_4 - 22nd December; 3 different seed rates i.e. S_1 - 6 kg/ha, S_2 - 8 kg/ha, S_3 - 10 kg/ha and 2 methods of sowing i.e. M_1 - line sowing and M_2- broadcasting and laid-out in a split plot design with 3 replications. All plots received 40 kg N/ha, 35 kg P_2O_5/ha and 15 kg K_2O/ha in the form of urea, single super phosphate (SSP), muriate of potash (MOP) and compost @ 2 t/ha. In this experiment recently developed late sown *toria* var. 'JT-90-1'(Jeuti) was used. The crop was sown in two methods one by placing the seeds in the furrows of 3-4 cm depth opened at 25 cm apart and other by broadcasting and was covered with thin layer of soil. The seeds were weighted out separately for each plot according to different seed rates. All the necessary observations were recorded as per the established norms.

RESULTS

Experimental findings revealed that for every 7 days delay in sowing of the crop from 1st December lead to a significant reduction in the growth and yield attributing characters that consequently lead to yield reduction. The highest seed yield of 724.33 kg/ha and 742.06 kg/ha, stover yield of 2268.41 kg/ha and 2296.45 kg/ha and seed oil content of 35.13% and 35.17% were recorded in 1st December sown crop which were significantly higher over other dates of sowing in first and second year, respectively. The extent of decrease in seed yield was 9.20% to 34.56% and 6.82% to 32.63% for 7 and 21 days delay in sowing from 1st December (D_1) in first and second year, respectively. In case of stover yield the extent of reduction was 8.16% to 24.02% and 6.42% to 23.93%, respectively. The pooled mean of two years in respect of seed yield was also found to be higher in 1st December (D_1) sowing crop. The seed rate of 10 kg/ha (S_3) recorded significantly higher yield of seed, stover, seed oil content over that of 6 and 8 kg/ha. In case of sowing method line sowing was found to be better than broadcasting in all growth and yield attributing characters. Seed yield reduced 10.86% and 10.29%, and stover yield reduced 9.62% and 8.51% in broadcasting method than that of line sowing in first and second year, respectively.

The pooled mean of two years in respect of seed and stover yield were also found to be higher in line sowing. The crop recorded highest gross return (50223.35 ₹/ha), net return (33013.35 /ha) and benefit-cost ratio (2.92) when sown on 1st December with seed rate of 10 kg/ha in lines made at 25 cm apart.

CONCLUSION

From this field investigation, it could be concluded that there was a significant reduction in seed and stover yield and oil content of late sown *toria* due to delay in sowing from 1st December to 22nd December. Higher seed rate (10 kg/ha) and line sowing produced significantly higher seed, stover and oil yields of *toria* under late sown rice–fallow condition of Assam.

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Relay cropping of wheat in cotton by different methods of sowing

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Cotton– wheat is the second most important cropping system after rice–wheat in the north-western plains of the Indian sub-continent and adjoining areas of Punjab and Sindh provinces of Pakistan and is practiced on about 4.5 M ha (Das *et al.*, 2014). At present very low yield of wheat crop is the main cause of poor productivity of cotton-wheat based cropping systems in these regions because wheat planting after cotton harvest is generally delayed by about one month due to late pickings of cotton and subsequent tillage and field operations prior to wheat planting. Relay cropping technology for wheat could be a sound way to tackle this problem in the areas where wheat can be sown in standing cotton crop by broadcasting or drilling the seed. Buttar *et al.* (2013) also reported that relay planting of wheat with relay seeder produced 24.9% higher grain yield compared to conventional planting Khan and Khaliq (2005) reported 69.4% higher grain yield from relay planting of wheat by surface seeding compared with conventional sown wheat after cotton harvest. However, methods and time of relay cropping of wheat in standing cotton will decide the success rate of this new technology. So, the present experiment was conducted to explore the possibilities of suitable time and methods of sowing for relay cropping of wheat in cotton.

METHODOLOGY

A field experiment was conducted at Research Farm of CCS Haryana Agricultural University, Hisar, India (29°10'N latitude, 75°46'E longitude and 215.2 M altitude) during *rabi* season of 2013-14. The experiment was laid out in split plot design with six methods of sowing in main plot and four genotypes in sub plots and replicated thrice (Table 1). Cotton crop was sown conventionally with recommended package and practices. Wheat as relay crop was sown by different methods *i.e.* broadcasting and line sowing with drill attached with power tiller for sowing between two rows of cotton crop under timely (November) and late (December) sown conditions. Under broadcasting method of sowing irrigation was applied to cotton crop and wheat seed was broadcasted in standing water to achieve good germination while for drill sowing and conventional sowing irrigation was applied in standing cotton crop and at *batter* condition wheat sowing was done. The cotton crop was allowed to grow to attain maximum seed-cotton yield from late maturing bolls. When satisfactory seed-cotton yield was achieved (up to 15th January) then cotton sticks were harvested and removed from the field. One-third recommended doses of nitrogen and full dose of phosphorus

Table 1. Effect of different relay sowing methods on grain yield and yield attributes of wheat varieties.

Treatment	Effective Tillers/m^2	Grains/ ear head	Test Weight (g)	Grain yield (t/ha)
Method of Sowing				
Conventional sowing in November (11th Nov.)	441	50.62	41.84	6.02
Conventional sowing in December (20th Dec.)	381	47.62	39.75	4.71
Relay sowing by broadcasting in November (11th Nov.)	423	48.49	41.14	5.23
Relay sowing by broadcasting in December (3rd Dec.)	364	49.53	39.01	4.51
Relay line sowing by drill in November (11th Nov.)	395	47.28	41.68	4.76
Relay line sowing by drill in December (3rd Dec.)	399	47.27	39.01	4.83
SEm ±	6	0.66	0.41	0.13
LSD (P= 0.05)	20	2.08	1.30	0.42
Genotype				
WH 1105	402	51.98	40.90	5.23
HD 2967	405	49.43	40.29	5.11
DPW 621-50	408	45.89	39.05	4.92
PBW 550	386	46.58	41.38	4.79
SEm±	5	0.33	0.38	0.10
LSD (P=0.05)	15	0.95	1.09	0.29

fertilizers was applied at wheat sowing and remaining one-third dose of nitrogen was applied at first irrigation and one-third dose of nitrogen was applied at second irrigation. The other agronomical practices followed for wheat crop were same as recommended by CCSHAU, Hisar.

RESULTS

The perusal of data revealed that timely and conventional sown wheat after cotton harvest produced significantly higher grain yield (6.02 t/ha) compared to all other sowing methods (Table 1). Conventional sown wheat during December produced grain yield of 4.71 t/ha with a significant yield reduction of 21.7% as compared to November sown conventional wheat. Among different relay cropping methods highest grain yield (5.23 t/ha) was recorded with wheat sown by broadcasting method in November which was significantly higher than all other relay sowing methods except relay sowing by drill under late sown condition (December) and it was 11.0% higher than conventionally sown wheat in December. Among the varieties, WH 1105 produced highest grain yield, which was significantly superior to PBW 550 and DPW 621-50 and numerically better than HD 2967 with a yield gain of 8.47, 5.96 and 2.27%, respectively.

CONCLUSION

The wheat sown with conventional method after cotton harvest in November yielded significantly more as compared to other methods. However, relay planting of wheat by broadcasting method during November was found profitable compared to conventional sown wheat in December. WH 1105 was found most suitable for relay planting in cotton with highest grain yield among varieties tested.

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Effect of seaweed sap in sustainable crop production under rice- potato-greengram cropping system

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Indian agriculture during the last seven post-independence decades, exhibited several success stories transforming our country from the image with 'begging bowl' to not only that of a self-sufficient nation in food grains but also to be a leading exporter of some agricultural produces in the global market.Despite the glorious progress during the last few decades we can't ignore the grim part of the story as well. Planners, agricultural scientists and agricultural economists are really worried about the slow growth rate of agricultural production in the recent years. To feed the mammoth population of India the total productivity of the agricultural land must be escalated. Decelerated factor of productivity vis-à-vis input use efficiency, resource degradation, environmental pollution etc. floated up across the country are the burning issues of the post green revolution era. If we want to get rid of such multifarious difficulties we have to adopt some strategies in a systematic way. Any improvement in agricultural system resulting higher production should reduce the negative environmental impact to enhance the sustainability of the system. One such approach is the use of bio-stimulants, which can enhance the effectiveness of conventional mineral fertilizers (Zodape*et al*., 2010).Keeping all these in background a field experiment was conducted with the objectives to study the effect of seaweed sap on productivity of different crops in sequence and to access the input use efficiency by using this sap.

METHODOLOGY

The field experiment was conducted during 2012-13 and 2013-14 at Uttar Chandamari village, Nadia, West Bengal, India (22°57'N, 88°20'E and altitude is 7.8 m above MSL). The soil of the site was sandy clay loam (pH-6.90, OC-0.57%, total N-0.055%, available P_2O_5 and K_2O-26.29 and 188.67 kg/ha, respectively). The experiment was laid out in a factorial randomized block design having two factors *viz.* chemical fertilizer and *Kappaphycus*- sap ~K-sap (seaweed sap). The total numbers of treatments were twelve (T_1- 2.5% K-sap+ 100%RDF; T_2- 2.5% K-sap+ 75%RDF; T_3- 2.5% K-sap+ 50%RDF; T_4- 5% K-sap+ 100%RDF; T_5- 5% K-sap+ 75%RDF; T_6- 5% K-sap+ 50%RDF; T_7- 7.5% K-sap+ 100%RDF; T_8- 7.5% K-sap+ 75%RDF; T_9- 7.5% K-sap+ 50%RDF; T_{10}- 0.0% K-sap+100%RDF; T_{11}- 0.0% K-sap+75%RDF and T_{12}- 0.0% K-sap+50%RDF) replicated thrice. Size of each plot was of 5 m × 4 m size. Variety used for rice, potato and greengram were *Shatabdi, Samrat* and *Kufri-Jyoti* respectively. Seaweed sap was applied as foliar spray thrice in both rice and potato and twice in greengram. The agronomic efficiency (AE= kg grain/kg nutrient added) and recovery fraction (RF= kg nutrient absorbed/ kg nutrient added) were calculated.

RESULTS

The pooled data of two consecutive years of investigation as illustrated in table 1, showed that the yield of rice, potato and greengram differed significantly with the diversification in percentages of chemical fertilizer and sap. The highest grain yield of rice, potato and greengram was documented with the use of 100% RDF and 7.5% K-sap. In case of interaction effects of chemical fertilizer and K-sap on yield, it was found that the application of 100% RDF+7.5% K-sap resulted in the best result. Use of 7.5% K-sap along with 75% RDF also exhibited promising yield. This might be due to the fact that being a wealthy source of macro vis-à-vis micro-elements and plant growth regulators especially cytokinins, the liquid K- sap is responsible for betterment of different yield attributing characters and yield of the crops. These findings are in agreement with those recorded by Zodape *et al*. (2010) and Pramanick *et al*. (2014). The agronomic efficiency of the cropping sequence was the maximum and minimum under 7.5% K-sap+50% RDF and 0% K-sap+100% RDF respectively. The plots treated with the higher percentages of K- sap i.e. 5% and 7.5% along with the lower doses of chemical fertilizer i.e. 50% or 75%RDF, exhibited the superior results over the plots treated with lower percentages of K-sap i.e. 0% or 2.5% in combination with any dosages of RDF. So, K- sap has strong influence in governing the agronomic efficiency of the system. The highest recovery fraction (1.35) was obtained in the treatment T_7 being closely followed by the treatment T_4 and T_8. So, it is clear that the plots receiving higher dosages of K- sap along with 100% RDF exhibited higher recovery of

Table 1. Effect of different treatments on productivity and efficiencies of the system (pooled data)

Treatment	Grain yield of rice (kg/ha)	Tuber yield of potato (kg/ha)	Seed yield of greengram (kg/ha)	AE	Recovery fraction
100% RDF	4480	26900	1270	-	-
75% RDF	3250	20900	1030	-	-
50% RDF	2030	14680	780	-	-
CD (P=0.05)	90	490	31	-	-
7.5% K- sap	3790	23900	1150	-	-
5.0% K- sap	3410	21990	1090	-	-
2.5% K- sap	3100	20160	980	-	-
0.0% K- sap	2720	17250	880	-	-
CD (P=0.05)	110	560	30	-	-
T_1- 2.5% K-sap+100% RDF	4330	26830	1200	30.61	1.02
T_2- 2.5% K-sap+75% RDF	2960	19630	980	30.16	0.77
T_3- 2.5% K-sap+50% RDF	2000	14030	760	32.52	0.44
T_4- 5% K-sap+100% RDF	4730	28350	1380	33.12	1.20
T_5- 5% K-sap+75% RDF	3360	21420	1070	33.12	0.94
T_6- 5% K-sap+50% RDF	2130	16210	810	36.37	0.61
T_7- 7.5% K-sap+100% RDF	5040	30170	1450	35.13	1.35
T_8-7.5% K-sap+75% RDF	4020	24430	1140	37.52	1.20
T_9-7.5% K-sap+50% RDF	2300	17100	870	38.63	0.75
T_{10}-0.0% K-sap+100% RDF	3830	22250	1050	25.98	0.78
T_{11}-0.0% K-sap+75% RDF	2650	18140	920	27.78	0.58
T_{12}-0.0% K-sap+50% RDF	1680	11380	680	27.26	0.30
CD (P=0.05)	180	970	60	-	-

the system than that exhibited under 0% K- sap along with lower doses of RDF.

CONCLUSION

From the experimental findings it may be concluded that use seaweed sapin addition to judicious amount of chemical fertilizers can increase the productivity and input use efficiency thus making the system sustainable.

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Boron and TIBA induced anatomical changes vis-a-vis productivity of staggered sown *spring* sunflower (*Helianthus annuus* L.)

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Within the genetic potential, higher plant growth and yield can be realized under favorable environmental conditions as yield is a result of complex interactions between genetic, environmental and agronomic factors (Sheoran *et al.*, 2014). Prevalence of sub-optimal environmental conditions at any growth stage of a crop impairs its growth and development, consequently yield. Several physiological, genetic and agronomic management factors are also responsible for poor seed setting and filling in sunflower. Application of growth regulators may increase the remobilization of metabolites from stalk, which is otherwise less than 25%, during the leaf senescence and thereby, increase productivity. A higher proportion of empty achenes (up to 60%), especially in the centre of capitulum results from limited assimilate supply to the developing sink due to poor vascularisation in the centre of capitulum and several unrelated factors including boron (B) deciency (Ram and Davari, 2011). Hence, studies were conducted to determine the role of boron and TIBA in improving seed setting and yield of staggered sown sunflower.

METHODOLOGY

A field experiment was conducted for two seasons (*Spring* 2014 and 2015) at Punjab Agricultural University, Ludhiana, India. The field experiment was laid out in split–plot design with three replications. The main–factor consisted of three sowing dates i.e. January 20 – D_1, February 10 –D_2 and March 2 – D_3, and sub factor were eight foliar spray treatments (control, water spray, boron @ 110, 220, 440 ppm, TIBA @ 100, 200, 400 ppm). Foliar sprays were done at ray floret opening stage using 400 liters of water/ha. Pollen viability and load/count were determined in three capitulum sectors-peripheral, middle and central. Thin transverse sections of pedicel stained with toluidine-o- blue were examined for studying anatomical changes. The seed and biological yields were recorded from net plot area of each experimental unit. The yield was adjusted to 9% moisture and expressed as kg/ha.

RESULTS

Data in Table 1 indicate a progressive reduction in pollen viability due to delay in sowing. Among the foliar application treatments, the highest pollen viability was registered with boron 440 ppm, which was statistically at par with all other boron concentrations. The control treatment recorded the least pollen viability, which was on par with water spray and all TIBA treatments. Pollen load (number of pollen grains per floret) also decreased due to delayed sowing. However, pollen load did not vary due to foliar spray treatments. Length and width of vascular bundles decreased as the sowing was delayed. The highest length and width of vascular bundles was registered with TIBA @ 200 and 400 ppm, respectively. When averaged over all the sowing dates and concentrations of foliar sprays, application of boron caused 19.1 and 29.4 % increase, whereas TIBA caused 39.5 and 39.8 % increase in length and width of vascular bundles over control. Delayed sowing also resulted in a significant and progressive reduction in biological and seed yield with a concomitant reduction in harvest index of the crop. The highest biological yield produced by January 20 sown crop was 9.9% higher over February 10 and 19.4% over March 2 sowing date. Similarly, the highest seed yield obtained with January 20 sowing date (2010 kg/ha) was 10.5 and 35.2% higher than D_2 and D_3. The least biological yield obtained under control was statistically at par with water spray. Significantly the highest biological yield obtained with a spray of TIBA @ 200 ppm was statistically at par with all other treatments except water spray and control. Data further reveal that the seed yield varied significantly due to different foliar applications. The highest seed yield obtained with foliar application of TIBA @ 200 ppm, was statistically at par with foliar application of boron and TIBA at any concentration but significantly better than control and water spray as well as boron 110 ppm. However, TIBA 400 ppm and boron 110 ppm also out yielded control and water spray treatments.

CONCLUSION

Early sown crop gave higher seed yield due to improved pollen viability, pollen load and vascularisation. The higher pollen viability and improved vascularisation also contributed towards a better yield of sunflower under boron and TIBA treatments.

Table 1. Effect of sowing dates and foliar application of boron and TIBA on reproductive physiology and productivity of sunflower

Treatment	Pollen viability			Pollen load (number x 10^2)			Seed yield (kg/ha)
	Sectors of head			Sectors of head			
	Peripheral	Peripheral	Middle	Peripheral	Peripheral	Middle	
Sowing date							
Jan., 20	88.3	88.1	88.8	296	325	347	2010
Feb.,10	84.2	83.3	84.6	284	315	333	1819
March, 2	76.5	77.3	79.0	217	221	242	1487
CD (P= 0.05)	3.8	2.1	4.0	15	14	42	79
Foliar spray (ppm)							
Control	80.0	79.4	80.0	264	285	306	1578
Water spray	80.0	80.0	80.0	267	286	307	1603
Boron 110	85.0	87.2	87.8	260	289	311	1754
Boron 220	86.7	86.7	89.4	272	292	302	1823
Boron 440	87.2	89.4	91.1	259	280	305	1832
TIBA 100	82.8	80.6	81.7	268	285	310	1875
TIBA 200	80.6	80.0	81.7	266	291	310	1917
TIBA 400	81.7	80.0	81.1	268	287	308	1796
CD (P= 0.05)	3.2	3.8	3.9	NS	NS	NS	130

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Studies on the yield maximization of different rice-based cropping sequence in northern coastal Cauvery deltaic areas

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Field investigations were conducted to study the yield maximization techniques and identify a suitable rice based cropping sequence i.e., Rice + blackgram, Rice + greengram, Rice + sunflower and Rice + sesame based on the availability of water for the lowlands of Northern Cauvery delta in Tamil Nadu. Two field experiments were conducted during August2013-May2015, to find out the yield maximization techniques, nutrient balance, and to identify a sustainable cropping sequence through integrated application of organic, inorganic and biofertilizers

METHODOLOGY

The rice was grown during *Thaladi* seasons (Sep. – Jan.) of 2013 and 2014, followed by pulses (blackgram and greengram) as fallow crop in January-April 2014 and 2015 and oilseeds (sunflower and sesame) as irrigated crop in February-May 2014 and 2015. The experiments were conducted in split-plot design replicated thrice in a permanent fixed layout with main plots of different doses of inorganic fertilizers *viz*., Control (M_1), 100% Recommended dose of fertilizers (M_2), 75% Recommended dose of fertilizers (M_3). Organic manures and bio-fertilizer treatments as the sub plot *viz.*, S_1 - FYM @ 12.5 t/ha + *Azospirillum* @ 2 kg/ha, S_2 – Vermicompost @ 5 t/ha + *Azospirillum* @ 2 kg/ha, S_3 – EFYM @ 12.5 t /ha + *Azospirillum* @ 2 kg/ha, S_4 – Neem cake @ 500 kg/ha + *Azospirillum*@ 2 kg/ha, S_5 – Pressmud @

12.5 t/ha + *Azospirillum* @ 2 kg/ha, S_6 – Crop residues for rice crop. The sequence followed with pulse crops (blackgram and greengram) were experimented with main plots of different foliar application *viz*., M_1 - Control, M_2 - 2% DAP and M_3 -40 ppm NAA and sub plot treatments *viz*., S_1 to S_6 - the residual management + application of biofertilizers (*Rhizobium* + Phosphobacteria) as seed treatment. The sequence followed for the irrigated oilseed crops (sunflower and sesame) were experimented with main plots *viz*., Control (M_1), 100% Recommended dose of fertilizers (M_2), 75% Recommended dose of fertilizers (M_3) and sub plots *viz*., S_1 to S_6 – the residual management + application of *Azospirillum* (seed treatment).

RESULTS

The results revealed that the treatment M_1S_2 recorded an increased growth, yield attributes, yield, nutrient uptake and available soil nutrients status. The integrated application of organic manures, inorganic fertilizers and biofertilizer followed in the first crop of rice showed a significant residual effect thereby increasing the yield of the following crops *viz*., blackgram, greengram, sunflower and sesame. The treatment M_1S_2 recorded the highest grain yield of rice was 7107 and 8271 kg/ha during *Thaladi season* of 2013 and 2014, respectively. In both blackgram and green gram crop, the residual effect of inorganic fertilizers, organic manures and application of 2 per cent of DAP along with *Rhizobium* + Phosphobacteria (seed treatment) recorded the highest seed yield of 1564 and 1799 kg and 1082 and 1119 kg/ha during January-April 2014 and 2015, respectively. In sunflower crop, application of 100 per cent recommended dose of fertilizers + seed treatment with *Azospirillum* along with the residual effect of M_1S_2 recorded the highest seed yield of 2157 kg/ha and 2265 kg/ha during 2014 and 2015, respectively and the same trend was noticed in sesame crop.

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Influence of different planting techniques on performance of improved wheat (*Triticum aestivum*) varieties in north-eastern plain zone of India

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Wheat is an important crop of India and grown on an area of 31.19 million hectares with total production of 95.91 million tones and productivity of 3075 kg/ha (Agricultural Statistics at a glance, 2014). As a result of green revolution and technological innovations, the wheat production of the country was only 5.6 million tones at the time of independence (1947-48), is now producing seventeen-fold more grain yield. This increase in wheat production is by and large attributed to adoption of high-yielding varieties and improved package and practices.Farmers of Bihar are facing multiple constraints of water supply, declining soil quality, and rising costs of agro-inputs. The impact of these factors is compounded by the pressures and hazards of climate change. Under these conditions, alternative crop establishment methods, high yielding varieties and their management that could cope with these conditions giving higher yield at less cost, with less water requirements.

METHODOLOGY

The field experiment was conducted during 2013-14 and 2014-15 at Indian Agricultural Research Institute, Regional Station, Pusa Bihar.The experiment was conducted in Split-Plot Design allocated four crop establishment methods (FIRB, Bed Planting, SWI and Conventional) in main plot and four wheat varieties (HD 2733, HD 2967, DBW 39 and Raj 4229) in sub plots and replicated thrice. In SWI method, seeds of wheat were sown at square marked distance as per treatments. Conventional wheat sowing was done in line at 22.5 cm.The gap filling was done in wheat immediately after the germination wherever it was necessary in order to maintain optimum

Table 1. Effect of various planting techniques and wheat varieties on growth, yield attributes and yield of wheat (pooled mean of 2 years data)

Treatment	Plant height (cm) at maturity	Grains/ spike	Test weight (g)	Grain yield (t/ha)	HI (%)
Planting technique					
FIRB	94.72	50.6	41.19	5.26	42
BP	92.73	48.7	39.74	4.8	41.8
SWI	97.12	54	42.32	5.8	43
CONV	89.83	45.3	38.47	4.1	39.6
SEm±	0.9	0.5	0.53	0.2	1.8
CD (P=0.05)	3.11	1.8	1.84	0.7	NS
Variety					
HD 2733	93.92	49.8	40.59	5.13	42.4
HD 2967	94.9	50.7	40.93	5.25	42.89
DBW 39	93.13	49.4	40.43	4.89	40.8
RAJ 4229	92.45	48.7	39.77	4.67	40.4
SEm±	0.97	0.4	0.38	0.11	1.4
CD (P=0.05)	NS	1.2	NS	0.33	NS
Interaction					
SEm±	1.94	0.8	0.77	0.22	2.8
CD (P=0.05)	NS	NS	NS	NS	NS

plant population. Wheat was irrigated four times in both the years at critical stages of crop growth. Grains were cleaned and weighed for each net plot and yield was expressed in t/ha. The weight of straw was calculated by substracting grain weight from bundle weight.

RESULTS

Growth, yield attributes and yields were significantly affected with the different method of planting. However, harvest index did not show any significant difference among all planting methods. Planting techniques significantly influenced the characters specially plant height at maturity and effective tillers per m^2. Growth, yield attributes and yields were higher in SWI method than conventional method and bed planting methods.Management methods signicantly inuenced yield components, viz. number of ear length, grains per spike and 1000-grain weight.The wheat variety HD 2967 recorded higher growth, yield attributes and grainyield over DBW 39 and Raj 4229 varieties followed by HD 2733 (Table 1). Similarly, HD 2733 produced significantly higher grain yield than Raj 4229 but at par with HD 2967 and DBW 39. HD 2967 out-yielded other varieties and produced 12.41%, 7.36% and 2.34% higher grain yield than Raj 4229, DBW 39 and HD 2733, respectively. Akhtar *et al.,* (2002) also recorded similar trend among different varieties of wheat.

CONCLUSION

It was concluded that System of Wheat Intensification (SWI) and wheat variety HD 2967 could be recommended to obtain higher productivity of wheat in North Eastern Plain Zone (NEPZ) of India.

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Effect of origin and storage conditions on seed potato quality and field performance

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Potato ranks fourth among the major food crops of the world. India ranked 3rd in area (2.18 million ha) and 2nd in production (48.04 million tonne) in the world during 2014-15. In Punjab, it occupied an area of 90 thousand ha with a production of 2.26 million tonne during 2014-15 (FAO, 2016). About 60 per cent of the total area under potato cultivation in Punjab is under seed potato. Eighty five per cent seed requirement of the country is met by Punjab state (Bhardwaj, 2014). There is a great potential to enhance the production and productivity of seed potatoes in the state owing to geographic advantage and absence of virus transmitting vectors from mid October to end of January. The production and productivity of the crop have significantly been increased during past by a number of technological interventions viz., improved varieties coupled with matching production techniques and effective insect-pest and disease management technologies. However, non-adoption of recommended production and protection technologies and faulty post-harvest storage affect the quality of seed tubers and productivity of subsequent crop raised from these tubers. The major objectives of the study were to explore the variation in quality of seed tubers produced by seed potato growers and stored under different cold storage conditions and evaluate performance of these seed tubers under field conditions.

METHODOLOGY

Laboratory and field studies were conducted at Punjab Agricultural University, Ludhiana in collaboration with Wageningen University and Research Centre, The Netherlands during 2013-14. Fifty seed potato lots, from member farmers of POSCON (an association of seed potato growers in Punjab) of variety *Kufri Pukhraj* were collected at random for the studies. The seed-lots were evaluated for origin and seed quality of tubers before planting them in the field. The field experiment was conducted by taking all the fifty seed-lots as treatments and replicated thrice in randomized block design. The soil of experiment site had a pH of 7.5, organic carbon 0.41% and 120.8, 51.2 and 132.6 kg/ha available (alkaline permanganate oxidisable) nitrogen, phosphorus (0.5 M $NaHCO_3$ extractable) and potassium (1 M ammonium acetate exchangeable), respectively. The experimental field was applied with 50 tonnes of farmyard manure on fresh weight basis along with 187.5 kg N, 62.5 kg P_2O_5 and 62.5 kg K_2O/ ha. The planting of tubers was done on Oct 14, 2013 at a row to row spacing of 60 cm and tuber to tuber spacing of 20 cm. The extremely rotten tubers were discarded and not planted. Seed tubers were treated by spraying Monceren 250 SC for control of black scurf caused by *Rhizoctonia solani* before planting. The haulms of crop were cut on 28 January, 2014 and tubers were harvested on 15th of January, 2014 from a net plot of three rows with 10 plants each. The data on seed-lots were analysed as such and also by categorizing seed-lots into different groups based on their storage conditions.

RESULTS

Origin and quality of seed tubers

The highest number of seed-lots (44%) was from the fields of farmers who had cut the haulms during 2nd fortnight of December and harvested the crop during 2nd fortnight of February. The days between haulm cutting to harvest varied from 10-30 and harvest to loading for storage varied from 4.0-53 among the seed-lots. The seed-lots had seed size grades of 46–55mm (32%), 56–65mm (26%), 66–75mm (14%), 35–45mm (10%), 86–95mm (8%), 76–85mm and 96–105mm (4% each) and >106 mm (2%). The storage systems of tubers included banker (56%), cooling coil (18%), cooling unit (8%), diffuser and frick (2% each). General impression of the seed-lots varied from 2-9 and average weight of seed tubers of different seed-lots varied from 38.8-116.4 g/tuber. Incidence of black scurf on tubers of different seed-lots varied from 0-23.3%, silver scurf 0-3.3%, scab 0-6.7%, wet rot from 0-30% and *Fusarium* dry rot 0-90%. Average number of sprouts/tuber varied from 3.6-9.4 and average length of sprouts was from 2-9 mm in different seed-lots. There was inconsistency among the seed growers in respect of time of haulm cutting, harvesting and days to loading for storage. A great variation among the seed-lots was observed in respect of general impression, seed size, incidence of diseases and sprouting of tubers thus, indicating differences in their production, protection and post harvest handling management technologies.

Field experiment

There was no significant relationship between the incidence of *Rhizoctonia*, *Fusarium* dry rot and wet rot on the seed-lot tubers and the number of stems/plant or number of plants/plot (r = 0.3 or lower) in the field plots planted with these tubers. Application of Monceren to tubers before planting and exclusion of extremely rotten tubers from planting might have disturbed this relation. The number of plants/net plot and number of stems/net plot varied from 14.7-30 and 56.3-194.3, respectively. The significantly lowest number of plants and stems/net plot were in seed-lot numbered 44 than all the other seed-lots. The data showed relationship between tuber size and number of stems per plant (r = 0.68). The total tuber yield among the seed-lots varied from 35.3-58.2 t/ha. The highest tuber yield was recorded in seed-lot number 32 (58.2 t/ha) and the lowest in seed-lot number 44 (35.3 t/ha). Tuber yield was fairly correlated with the number of plants per plot (r = 0.61). There was no significant correlation between storage conditions of seed-lots and the quality of the stored seed tubers or on the crop growth and yield in the field experiment.

CONCLUSION

From the present study, no clear relationship was found between storage conditions and quality of stored seed tubers. However, there was large variation in origin and quality of tubers among the seed-lots. So, there is need to bring uniformity in seed tubers produced by different seed growers in the state for establishing the state as a quality seed potato hub for the national and international market.

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High density planting system for increased cotton productivity

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India is the leading country in terms of area under cotton in the world for decades. However, India's average cotton productivity is 494 kg lint yield /ha and this is low compared to other countries like Australia (1,910 kg/ha), China (1,524 kg lint/ha), Brazil (1,536 kg/ha), U.S. (864 kg/ha) as well as the world average yield of 705 kg/ha (AICRP on Cotton, 2016). The manipulation of row spacing, plant density and the spatial arrangements of cotton plants, for obtaining higher yield have been attempted by agronomists for several decades in many countries. The concept on high density cotton planting, more popularly called Ultra Narrow Row (UNR) cotton was initiated by Briggs *et. al.* (1967). Several leading cotton producing countries like USA, Australia, Brazil, Uzbekistan and China have developed suitable plant types to accumulate plant densities varying from 1 lakh to 2.5 lakh plants/ha with using narrow and ultra narrow row spacing. However in India, the recommended plant density for cotton seldom exceeded 55000 plants/ha. Hence, an experiment was conducted to evaluate two pre release cotton cultures at three plant densities and three fertilizer levels with the objective of getting higher productivity.

METHODOLOGY

The experimental crop was raised during winter, 2015 under irrigated condition at Cotton Research Station, Srivilliputtur. The experiment consisted of three factors *viz.*, two pre- released cotton cultures, LH 2298 & TCH 1705; three spacing, 45 x10 cm, 60 x10 cm and 75 x 10 cm and three fertilizer levels , 100 % RDF, 125 % RDF 150% RDF laid out in FRBD with three replications.

RESULTS

The final plant population/ net plot varied from 116 to 216. Different treatments *viz.*, varieties and fertilizer levels had no

Table 1. Effect of compact cultures, spacing and fertilizer levels on growth & yield attributes and seed cotton yield under HDPS

Treatments	Final plant population (no./net plot)*	No.of Monopodia	No.of Sympodia	Bolls/m²**	Seed cotton yield(kg/ha)
Cultures					
V_1–LH 2298	164 (12.9)	1.0	20.3	104 (18.3)	2218
V_2– TCH 170	162 (12.7)	1.0	19.0	109 (22.6)	2215
Spacing					
S –60 x 10cm	216 (15.8)	0.7	21.0	116 (23.0)	2304
S_2–75 x 10cm	157 (12.5)	0.9	20.5	108 (18.7)	2299
S_3–90 x 10cm	116 (10.1)	1.4	17.3	95 (19.7)	2048
Fertilizer levels					
F_1 100%RDF	166 (12.9)	0.9	21.2	105 (19.1)	2254
F_2 125%RDF	163 (12.7)	0.9	20.3	110 (22.2)	2280
F_3 150%RDF	161 (12.8)	1.3	17.4	104 (20.1)	2116

	S.Ed.	CD P=0.05	S.Ed.	CD P=0.05	S.Ed.	CD P=0.05	S.Ed.	CD P=0.05	S.Ed.	CD P=0.05
V	1.8	NS	0.07	NS	0.54	1.10	3.48	NS	70	NS
S	2.2	4.5	0.08	0.17	0.66	1.35	4.26	8.67	86	175
F	2.2	NS	0.08	0.17	0.67	1.36	4.26	NS	86	NS
V at S	3.1	NS	0.12	NS	0.94	1.92	6.02	NS	122	247
V at F	3.1	NS	0.15	NS	0.94	1.92	6.04	NS	122	NS
F at S	3.8	NS	0.12	NS	1.15	2.31	7.38	NS	149	NS
V S F	5.4	NS	0.21	NS	1.63	3.32	10.44	NS	211	NS

*- Figures in parenthesis indicate plant population/ m²
** - Figures in parenthesis indicate number of bolls / plant

significant influence on final plant population/ net plot, while spacing has significant effect. Significantly higher plant population was observed in closer spacing S_1 (60 x10 cm), which was followed by S_2 (75 x10 cm) and S_3 (90 x10 cm).

As regards, no. of monopodia / plant, spacing and fertilizer levels had significant influence, while varieties had no significant effect. Wider spacing, S_3 (90 x10 cm) had produced significantly higher number of monopodia / plant, which was followed by S_2 (75 x10 cm) and S_1 (60 x10 cm). Among the fertilizer levels, 150% RDF has recorded significantly higher number of monopodia / plant, which was followed by the comparable performance of 100 % RDF and 125 % RDF.

Among the varieties, LH 2298 produced significantly higher number of sympodia than TCH 1705. Among the spacing treatments, S_1 (60 x10 cm) (21) and S_2 (75 x10 cm) (20.5) had comparable number of sympodia which was followed by wider spacing, S_3 (90 x10 cm) (17.3). As regards fertilizer levels, 100 % RDF (21.2) and 125 % RDF (20.3) had produced comparable number of sympodia, which was followed by 150 % RDF (17.4).

Number of bolls/m² was not significantly influenced by varieties and fertilizer levels. However, spacing has significant influence on the above said characters. Closer spacing S_1 (60 x10 cm) and medium spacing, S_2 (75 x10 cm) had comparable number of bolls/m² which was followed by wider spacing, S_3 (90 x10 cm). This may be due to the fact that the cotton plants under HDPS produce fewer bolls than conventionally planted cotton but retain a higher percentage of the total bolls in the first sympodial position and a lower percentage in the second position as reported by Vories and Glover, 2006.

The factors *viz.*, varieties and fertilizer levels had no significant influence on seed cotton yield. With regard to spacing, S_1 (60 x10 cm) (2304 kg/ha) and S_2 (75 x10 cm) (2299 kg/ha) had registered comparable seed cotton yield and was followed by S_3 (90 x10 cm) (2048 kg/ha). The results are in line with the findings of Venugopalan *et al.,* 2011

CONCLUSION

The varieties, LH 2298 (2315 kg/ha) and TCH 1705 (2293 kg/ha) have registered comparable and significant seed cotton yield under closer spacing of S_1 (60 x10 cm).

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Response of pigeonpea to different managemental production factors in *Tarai* region of Uttarakhand

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Requirement of pulses is increasing continuously and there is need to increase pulses production in the country. Higher pigeonpea production can contribute in total pulses production considerably. Pigeonpea also known as red gram or *arhar*, is second important pulse crop after chickpea in the country. It is perennial in nature and has an indeterminate growth habit which means growth cycle continues upto the harvest. The crop is mainly grown in June-July and harvested as per maturity duration. It is a cheap source of protein as compared to animal protein. The grains of pigeonpea contain about 22% protein which forms an important part of vegetarian diet. India being major pigeonpea producing country contributes almost 80% of total production and area in the world. In India pigeonpea is grown in all parts of the country including northern, southern, eastern and western zones. Area, production and productivity under this crop during 2014-15 was 3.55 m ha, 2.78 mt and 783 kg/ha, respectively (Project Director's report 2015-16). Different biotic and abiotic stresses affect yield of crop.

Development of disease and insect resistant varieties and adoption of suitable management production factors have been proved to achieve higher yield. Considering the importance of crop an experiment was carried out to optimise the better managemental production factors for higher pigeonpea production in *Tarai* region.

METHODOLOGY

An experiment was carried out during 2013-2015 in *kharif* seasons at N. E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture & Technology Pantnagar. The soil of experimental site was clay loam in texture with neutral in reaction (pH 6.7) having high organic carbon (1.18%), medium available phosphorus (10.5 kg P/ha) and available potassium (162.0 kg K/ha) contents. Eight treatments viz. INM (RDF+5t FYM/ha+ seed treatment with *rhizobium* and PSB), IWM (pendimethalin 1 kg/ha PE + imazethapyr 100g/ha at 20 DAS+ One hand weeding at 50 DAS), IPM (Spray of contact insecticides at the time of flower bud formation followed by spray of systemic insecticides 15 days after first spray, INM+IWM, INM+IPM, IWM+IPM and INM+IWM+ IPM along with farmer's practice were laid out in randomised block design with 3 replications. The sowing of crop was done in the last week of June and harvested in the month of January in all the years of experimentation. The variety UPAS-120 was sown 90 cm row apart on raised beds. Other practices were same for all the treatments.

Table 1. Grain yield and economics of pigeonpea as influence by managemental production factors

Treatments	Grain yield (kg/ha)		Mean	Benefit: cost ratio
	2014	2015		
INM (FYM @ 5 t/ha + RDF i.e. 18 kg N, 48 kg P_2O_5 and 24 kg K_2O/ha,S+ seed treatment with *Rhizobium* and PSB)	798	770	784	3.4
IWM (Pendimethalin 0.75 kg/ha on 3 DAS + Imazethapyr @ 100 g ai/ha on 10-15 DAE of weeds +1 HW on 50 DAS/1 inter cultivation on 50 DAS)	832	875	853	3.9
IPM (Indoxacarb 15.8% EC at the time of flowering @ 375 ml/ha + one systemic insecticide spray 15 days after 1st spray)	628	666	647	3.7
INM+IWM	1120	916	1018	2.95
INM +IPM	747	749	748	2.4
IWM+IPM	917	729	823	2.8
INM+IWM+IPM	1290	1082	1186	3.0
Control (One hand weeding at 45 DAS i.e. farmers' practice)	730	707	718	3.0
CD (P=0.05)	158	235		-

RESULTS

Different management factors influenced the pigeonpea grain yield significantly in both the years Table 1. In first year, combined application of INM+IWM+IPM recorded significantly higher grain yield than other treatments. INM, IWM and IPM when applied alone, IWM remained at pat with INM and yielded significantly higher than that of IPM. In second year, INM+IWM+IPM remained at par with IWM and INM+IWM and yielded significantly higher than other treatments. Among the application of INM, IWM and IPM alone, IWM again recorded higher grain yield than INM and IPM thought the difference was at par among them. This showed that weeds are major yield limiting factor in pigeonpea. Adoption of IWM i.e. application of pendimethalin 1 kg/ha PE + imazethapyr 100 g/ha at 20 DAS+ One hand weeding at 50 DAS performed better and produced higher grain yield alone or in combination of other practices. This finding is in corroboration of Bhengra *et al*. (2010) and Singh and Sekhon (2013). In terms of economics, IWM proved more economical that INM and IPM because of more response on yield than others. Combined application of IWM, IPM and INM decreased the B:C ratio because of lower response of INM and IPM. Furthermore the soil of experimental area was good in fertility and hot and humid conditions prevailed during crop seasons attracted more insect which reduces the response of INM & IPM.

CONCLUSION

On the basis of above study it may be concluded that adoption of IWM managemental production factor is more important and can be recommended for producing economically higher yield of pigeonpea in *tarai* region.

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Effect of different dates of sowing, varieties, temperature and relative humidity on mustard

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In India mustard occupies second position after groundnut, and its contribution in the worlds mustard production is highest than any other country but its position in respect of average yield/ha is not satisfactory. Since the rate of development of crop and oil in seed is greatly influenced by the variation in temperature, humidity and other biotic factors. Sowing either too early or too late has been reported to be harmful. Not only dates of sowing but varieties or cultivars grown also have major contribution in increasing the yield potential in mustard. Adoption of improved variety and suitable crop management practices are important factor for improving crop productivity. Sowing time plays important role in crop husbandry and remains to be the prominent factors in deciding seed as well as oil yield. Optimum sowing time is an important nonmonetary input and if managed properly, it helps to enhance seed yield. Sowing of mustard at inappropriate time reduce seed yield and yield attributes. The study of efficient utilization of the weather parameters is also necessary. With these contest the present study was carried out.

METHODLOGY

The soil samples were drawn for studying the soil properties and then the experiment was laid out at Agronomy Section Farm of College of Agriculture, Nagpur during the year *rabi* season of 2012-2013 in split plot design with ten treatment combinations with three replications consisting five sowing dates *i.e.* D_1 (42nd MW), D_2 (43rd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) with two sub-treatments of varieties *viz.*, V_1 (Pusa bold) and V_2 (ACN-9). The distance between two replications was 1.35 m and 0.5 m between two

Table 1. Influence of various treatments on different traits, temperatures (^0C) and relative humidity (%) requirement for mustard.

Treatments	Number of branches/plant				No. of siliquae/ plant	Seed yield/ plant (g)	Straw yield/ plant (g)	B:C ratio	Temp requirement (^oC)	RH (%)
	30 DAS	60 DAS	90 DAS	At harvest						
Sowing Date										
D_1 – 42[nd] MW	2.96	5.95	8.96	9.85	136.25	7.90	20.84	2.00	17.01	60.41
D_1 – 42[nd] MW	2.96	5.95	8.96	9.85	136.25	7.90	20.84	2.00	17.01	60.41
D_2 – 43[rd] MW	3.18	6.10	9.87	10.30	142.30	8.60	22.54	2.11	16.87	60.23
D_3 – 44[th] MW	2.54	5.83	8.50	9.60	128.65	7.80	17.85	1.78	16.25	60.12
D_4 – 45[th] MW	2.34	5.65	8.26	9.51	120.60	7.30	15.20	1.36	16.23	59.90
D_5 – 46[th] MW	2.10	5.44	7.86	9.05	112.40	6.88	13.15	1.15	16.36	59.87
CD (P=0.05)	1.48	1.28	0.95	0.76	17.90	0.68	1.60	-	-	-
Variety										
V_1 –Pusabold	2.87	5.86	9.20	10.30	132.25	8.25	19.80	1.89	16.40	60.15
V_2 – ACN-9	2.37	5.30	8.07	9.18	123.83	7.13	17.75	1.69	16.23	59.95
CD at 5%	0.46	0.27	0.76	0.61	15.88	1.58	2.20	-	-	-
Interaction										-
CD (P=0.05)	-	-	-	-	-	-	-	-	-	-

plots. The gross and net plot size were 3.6 m × 4.8 m and 2.7 m × 4.2 m respectively. The data were recorded and statistically analysed as per Panse and Sukhatme (1971).

RESULTS

Different dates of sowing significantly influenced the growth characteristics and yield components of the varieties used in the experiment i.e. number of branches/plant, number of siliquae/plant, seed yield/plant and straw yield/plant. Among the five dates of sowing D_2 (43[rd] MW) showed significant superiority over other dates of sowing for the traits studied at all the stages of observation. Among sowing dates, D_2 (43[rd] MW) recorded higher benefit: cost ratio of 2.11 and lowest benefit: cost ratio 1.15 was recorded by sowing date on D_5 (46[th] MW). There was significant difference among the varieties with respect to their performance in the field for all the characters studied. The variety V1 (Pusa Bold) recorded significant superiority for all the characters studied over V2 (ACN-9). Among two varieties, variety V_1 (Pusa bold) recorded higher benefit: cost ratio of 1.89 and was followed by V_2 (ACN-9) with benefit: cost ratio of 1.69. The interaction effect between dates of sowing x varieties was non-significant for all the traits studied. The temperature requirement (GDD) and relative humidity requirement varied with the sowing time and also with varieties. The mustard sown on D_1 (42[nd] MW) showed maximum GDD (17.01 thermal units) and relative humidity requirement (60.41). Variety V_1 (Pusa bold) recorded higher thermal (16.40 thermal unit) and relative humidity requirement (60.15) as compared to V_2 (ACN-9).

CONCLUSION

It is concluded from this study that early sowing gives better results due to good plant vigour as favourable climatic conditions prevail throughout crop life cycle. Sowing of mustard crop on D_2 (43[rd] MW) would be suitable and variety V_1 (Pusa bold) would be better than V_2 (ACN-9) which also is likely to give maximum benefit: cost ratio.

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Response of summer sesamum (*Sesamum indicum*) to nipping and spacings

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The present investigation was conducted at College of Agriculture, Pune during summer season 2011. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with nine treatments in three replications. The treatments comprised three nippings *viz.,* 20 DAS, 30 DAS and 40 DAS with three spacings i.e. 30 cm X 15 cm, 45 cm X 10 cm and 60 cm X 7.5 cm with same plant density maintained in net plot. The results indicated that nipping done at 30 DAS showed higher number of capsules/plant, dry matter/plant and the yield parameters such as weight of capsules/plant (28.86 g), number of capsules/plant (95.45), seed weight/plant (15.66 g) and test weight (3.33 g) resulting in higher seed yield (1216.02 kg/ha) and straw yield (2249.65 kg/ha). Spacing showed significant effect on sesamum in respect of number of capsules/plant, dry matter/plant and the yield parameters such as weight of capsules/plant (27.52 g), number of capsules/plant (94.80), seed weight/plant (14.63 g) and test weight (3.1 g) resulting in higher seed yield (1108.35 kg/ha) and straw yield (1957.01 kg/ha). The combined effect of nipping at 30 DAS with 45 cm x 10 cm spacing were found significant which ultimately gave higher income as compared to the other treatment combinations. This treatment combination showed following higher characters like number of branches/plant, number of capsules/plant, dry matter/plant. and the yield parameters such as weight of capsules/plant (29.47 g), number of capsules/plant (101.53) and seed weight/plant (15.88 g) resulting in higher seed yield (1224.84 kg /ha) and straw yield (2265.95 kg/ha). It also registered higher gross monetary returns (73490.40 Rs /ha), net monetary returns (39620.4 Rs / ha). Therefore, from the above experiment, it can be concluded that nipping at 30 DAS with the 45 cm x 10 cm spacing gave higher productivity of summer sesamum.

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Evaluation of exotic and indigenous beet (*Beta vulgaris*) varieties for fodder yield and nutrient uptake potential

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The beet (*Beta vulgaris* L.) belongs to family amaranthaceae, is a biennial crop grown primarily for edible taproots. Different type of beet's are grown in India during winter season from October to May for sugar, fodder and vegetable purpose and commonly known as sugar beet, fodder beet & beet root, respectively. All kind of beet with root & leaves (shoot portion) have been found suitable for animal feeding and it has emerged as a new nutritious green fodder crop for Indian dairy farmers. Basically, beet is suitable for cultivation in temperate regions but in recent years,several public sector agricultural research institutes and private sector companies have indigenously developed and also introduced many exotic new varieties of beet crop suitable to grow in tropical and sub-tropical conditions in India (Kapur and

Table 1. Yield and primary nutrients uptake by beet crop as affected by varieties (Pooled data of 2 years)

Treatment (Varieties)	Yield (t/ha)			Primary nutrients uptake (kg/ha)		
	Green Fodder	Dry Matter	Crude Protein	N	P_2O_5	K_2O
Fodder Beet						
Cagnote	53.25	10.20	1.16	194.63	55.27	162.08
Jamon	72.71	10.49	1.39	232.82	69.64	168.21
Monro	57.75	7.15	1.13	182.33	45.81	130.81
Brigadier	56.82	9.18	1.30	207.64	56.2	161.24
Bangor	50.56	7.73	1.07	174.59	54.58	117.4
Energarci	59.11	9.59	1.09	185.08	59.31	140.88
Enermax	61.86	10.71	1.24	213.82	61.3	165.84
Kyros	61.29	9.33	1.26	208.98	59.67	174.42
Magnum	59.61	10.19	1.16	201.57	56.51	179.15
Mean	59.22	9.40	1.20	200.16	57.59	155.56
Sugar Beet						
Calixta	70.46	14.86	1.60	270.5	81.24	186.52
Magnolia	63.52	13.77	1.25	223.41	61.65	145.38
LS 6	66.63	13.51	1.43	256.48	87.2	210.76
Mean	66.87	14.05	1.43	250.13	76.7	180.89
Vegetable Beet Indam Ruby Queen	36.17	7.28	1.16	183.68	51	112.36
CD (P=0.05)	16.97	2.68	NS	56.01	16.17	NS

Kanwar, 1990). The study was conducted to find out the yield and nutrient uptake potential of different beet varieties available in India.

METHODOLOGY

The experiment was laid out in a randomized block design (RBD) with three replications consisting of thirteen beet varieties belonging to fodder beet, sugar beet and vegetable beet type fodder demonstration unit (FDU) of National Dairy Development Board, Anand (Gujarat) during 2013-14 and 2014-15. The soil of the experimental site was sandy loam type with EC- 0.40, pH- 7.9, total nitrogen (806.7 kg/ha), available P_2O_5 (56.72 kg/ha) and available K_2O (233.29 kg/ha). The crop was sown manually in the last week of December. Three seed per hill were sown at 3 cm depth with 0.50 m X 0.20m spacing. The crop was fertilized with 120:60:60 kg NPK/ha. Half of N and the entire quantity of P & K was given as basal dose and remaining N was applied as top-dressing at 60 days stage. Total 8 irrigations were applied during the crop growing period. The crop was harvested in mid-April during both the years at around 105 day's stage.

RESULTS

Two years pooled result showed that sugar beet variety Jamon produced significantly the highest green fodder yield (72.71 t/ha) as compared to fodder beet varieties Cagnote, Bangor and vegetable beet variety Indam Ruby Queen (Table 1). Sugar beet variety Calixta at par with other sugar beet varieties recorded significantly the highest dry matter yield (14.86 t/ha) in comparison to remaining fodder beet and vegetable beet varieties. All the sugar beet varieties at par amongst themselves significantly produced better dry matter yield than remaining beet varieties. Statistical differences were found to be non-significant for crude protein yield among beet varieties, however, higher crude protein yield (1.60 t/ha) was recorded in sugar beet variety Calixta. Overall sugar beet varieties showed superiority in green fodder, dry matter and crude protein yields in comparison to fodder beet and vegetable beet varieties. The differences among beet varieties under study could be due to the difference in the genetic makeup and their response to the environmental conditions. Significant differences were observed for nitrogen (N) and phosphorus (P_2O_5) uptake between beet varieties (Table 1). Sugarbeet varieties Calixta at par with Jamon, Magnolia and LS 6 significantly recorded the highest N uptake (270.5 kg/ha) than remaining beet varieties. LS 6 variety at par with Calixta recorded significantly greater P_2O_5 uptake (87.20 kg/ha) in comparison to remaining beet varieties. Non-significant differences were found for potassium uptake among beet varieties.Overall mean data showed slightly better nutrients uptake by sugar beet varieties as compared to fodder and vegetable beet varieties (Table 1).

CONCLUSION

The fodder beet varieties Cagnote, Jamon, Enermax and Magnum along with sugar beet varieties Calixta, Magnolia and LS 6 yielded over 10 t/ha dry matter yield. Hence, these fodder beet and sugar beet crop varieties can be recommended for green fodder cultivation.

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Effect of different planting methods on flower and corm yield of saffron (*Crocus sativus*) in temperate conditions of Kashmir valley

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Saffron a low volume high value spice crop is under cultivation in four districts of Jammu and Kashmir with major portion in Heritage Site of Pampore Kashmir. Crop gives livelihood security to more than 16000 farm families with an earning of Rs 225 crores. J & K state has a unique distinction in India because temperate climatic conditions of state meet the chilling requirement that is received by crop during recapitulation stage (December to March). Moderate temperatures during activation stage with low summer precipitation helps in emergence of floral primordia leading to saffron flowering in October/November. Fluctuations in weather parameters *viz*; precipitation, day/night temperatures and relative humidity observed in the last couple of years in saffron districts of J&K warranted to study performance of saffron under different planting methods.

METHODOLOGY

A field experiment was conducted at Saffron Research Station, Konibal (33^{o} 98'N Latitude, 74^{o}80'E Longitude and 1294 m above msl) of Sheri Kashmir University of Agricultural Sciences & Technologies, Shalimar Srinagar during *kharif* 2011-14.The soil was silt clay in texture. The experiment was laid in randomized block design with three replications. Three planting methods of included raised bed, ridge and flat bed. Under raised bed drainage channels were created all around the beds for efficient drainage. Saffron corms were planted with a plant geometry of 20 x10 cm accommodation 5 lac corms/ha. Whereas under Ridge plantation 25 cm raised ridges were created with a distance of 60 cm accommodating 5 lac corms/ha (3 corms/hill) with a distance of 60x10 cm. In flat sowing corms were planted on flat beds with geometry of 20x10 cm and no drainage channels were created.

RESULTS

Evaluation over 4 years confirmed distinct superiority of raised bed plantation over ridge plantation for flower and corm yield to the extent of 12 % and corm yield by 16%. Flat bed plantation was not observed to be feasible for saffron cultivation under temperate conditions of Kashmir as accumulation of water during spring lead to corm loss by 35% in Ist year, 45 % in the 2nd year and 20% in the 3rd Year.

CONCLUSION

Raised bed plantation significantly increased flower and corm yield of saffron over ridge plantation. Flat bed plantation was not feasible for saffron as water accumulation lead to corm loss by 35% from Ist year and subsequent reduction in flower yield by a margin of 40 to 55%

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Growth and seed yield of pea (*pisum sativum* as influenced by spacing and nipping

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In India, pea is commercially grown in an area of 422 thousand ha producing 3,867 thousand metric tonnes with productivity of 9.6 metric tonnes/ha and shares 2.4% production among the major vegetable crop. Among different pulses in the country, pea ranked the seventh position occupying an area of 0.76 million ha producing 0.67 million tonnes (Anon, 2012).The share of pulses in protein supply of the country is 6.90 g/capita/day as against 3.50 g/capita/day and 3.10 g/capita/day of the world and Asia, respectively (Chaturvedi and Masood, 2002). Peas are highly nutritive and contain high content of digestible protein (7.2 g/100g), Carbohydrate (15.8 g), Vitamin-C (9 mg), Phosphorus (139 mg) and minerals. The field pea is generally grown for dry seeds while garden peas are harvested in an immature condition and cooked as fresh or canned for subsequent uses. Nipping of pea shoots is a traditional practice in the state of Manipur where the nipped shoots are consumed as salad item and has the potential for generation of additional income for the farmers.

METHODOLOGY

A field experiment was conducted at the College of Agriculture, Central Agricultural University, Imphal situated at 24°46' N latitude and 93°54' E longitude and an altitude of about 790 metres above Mean Sea Level, during the *rabi* season of 2014–15. The materials used and the methodology adopted for the researches are detailed below.

Table 1. Influence of spacing and nipping on plant height, no. of branches, days to 100% flowering and seed yield of pea cultivar *Makhyatmubi*:

Treatment	Plant height at harvest (cm)	Number of branches (at 90 DAS)	Days to 100% flowering (days)	Seed yield (q/ha)
Spacing				
S_1 (20×15 cm)	76.72	1.80	81.33	10.05
S_2 (20×20 cm)	71.41	2.17	80.83	11.19
S_3 (30×10 cm)	70.00	2.45	81.67	11.96
S_4 (30×15 cm)	66.00	2.80	83.27	15.03
SEm±	0.66	0.08	0.72	0.17
CD (P=0.05)	1.99	0.17	NS	0.36
Nipping				
N_1 (Non-nipped)	77.53	1.83	79.03	10.96
N_2 (Nipped)	64.53	2.78	84.52	13.16
SEm±	0.46	0.04	0.51	0.12
CD (P=0.05)	1.41	0.12	1.09	0.25
Treatment Combinations				
S_1N_1	85.63	1.17	78.33	9.04
S_1N_2	67.80	2.43	84.33	11.05
S_2N_1	77.69	1.60	78.67	10.44
S_2N_2	65.13	2.73	83.00	11.93
S_3N_1	74.67	2.13	79.00	10.29
S_3N_2	65.32	2.77	84.33	13.63
S_4N_1	72.13	2.40	80.12	14.04
S_4N_2	59.86	3.20	86.41	16.02
SEm± S×N	0.93	0.08	1.02	0.23
CD (P=0.05) S×N	2.81	0.17	2.18	0.50

The soil chosen for experiment was under the category of clayey soil having pH 5.4 and organic carbon percentage of 0.58. The available nitrogen is 280.53 kg/ha, phosphorus 18.45 kg/ha and potassium 225.06 kg/ha. The experiment was laid out in Factorial randomized block design with three replications consisting two nipping treatment (N_1: No-nipping and N_2: Nipping) and four spacing treatments (S_1, 20 × 15 cm; S_2, 20 × 20 cm; S_3, 30 × 10 cm and S_4, 30 × 15 cm). Eight treatment combinations were S_1N_1; S_1N_2; S_2N_1; S_2N_2; S_3N_1; S_3N_2; S_4N_1; S_4N_2. Four irrigations were given during the crop period. Firstly, a light irrigation was given 4 days after sowing to enhance seed germination and the rest were given at flowering, fruit set and grain filling periods. Data on plant height (at harvest), number of branches/plant (at harvest), days to 100% floweringand yield were recorded.

RESULTS

The maximum plant height of 85.63 cm was recorded at the treatment combination of spacing 20 x 15 cm without nipping (S_1N_1) and reduces with increased in spacing and with nipping. The variation in plant height may be attributed to degree of competition. The number of branches per plant at 90 DAS due to interaction of spacing and nipping is maximum with i.e. 3.20 branches recorded at the treatment combination of spacing 30 cm × 15 cm with nipping (S_4N_2) while the minimum number 1.17 in the treatment combination of spacing 20 cm × 15 cm without nipping (S_1N_1). This was the main reason behind shorter plant height in wider row spacing and producing more branches as compared to taller plants in closer row spacing was with less number of branches per plants (Sajid *et al.,* 2012).

The minimum number of days to 100% flowering i.e. 78.33 was observed with the spacing 20 cm × 15 cm without nipping treatment (S_1N_1) while the maximum number of days taken to100% flowering i.e. 86.41was observed in spacing 30 cm × 15 cm under nipping (S_4N_2). Nipping of the apical bud causes delayed in flowering due to the temporary cessation of the meristematic cell division of the growing tip. The treatment combination of spacing 30 cm × 15 cm with nipping (S_4N_2) gives the highest seed yield of 16.02 q/ha and the lowest of 9.04 q/ha was recorded with the spacing of 20 cm × 15 cm without nipping (S_1N_1). The higher values of yield noticed under wider spacing and nippingis attributed to better growth anddevelopment of plants under less plant population and production of more number of branches providing better yield attributes.

CONCLUSION

It was concluded that the treatment combination S_4N_2 (30 cm × 15 cm spacing with nipping) gives most promising yield with lesser seed requirement owing to wider spacing amongst all the treatment combinations of the study.

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Optimization of safflower sowing time in northern Karnataka

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Safflower (*Carthamus tinctorius* L.) is a traditional oil seed crop cultivated on medium to deep black soils of Deccan plateau during post-rainy season under receding moisture conditions. Therefore, average productivity (627 kg/ha) is very low in India (Tiwari *et al*. 2002). Safflower is a cool (*rabi*) season crop, although there is no winter in south India. The optimum temperature for germination is about 15.5^o C and day temperature in the range 24-32^o C at flowering are congenial for higher yields. In contrast, as the crop get exposed to hot and dry climate during post-sown period in semi-arid regions of India sowing the crop at optimum time (preferably early) to make the best use of stored soil moisture for early growth and biomass accumulation, and to escape pest load as well is very critical (Strasil and Vorlicek, 2002). Therefore, three safflower genotypes (A-1, NARI-6 and NARI-57) were tested across three sowing times (1 to 30, Oct.) at fortnight interval during 2014-15 and 2015-16 with an objective to find out the best sowing time for safflower crop and best performing variety in northern dry zone of Karnataka.

METHODOLOGY

A field experiment was conducted at Agriculture Research Station, Annigeri ($15^0 8''$ N, $75^0 7''$ E and 624.8 m amsl), University of Agricultural Sciences, Dharwad as part of All-India Coordinated Research Project on Safflower during *rabi* seasons of 2014-15 and 2015-16 under rainfed condition. The soil is clayey in texture (Vertisol) with pH of 7.95, bulk density of 1.27 dS/m, and available N:P:K of 224, 21 and 342 kg/ha. The experiment included two factors; three varieties and three sowing periods laid out in split-plot design with three replications. During 2014-15 first sowing was done on 15, Oct. 2015 where as during 2015-16 on 1, Oct. 2015, but second and third sowing were taken up at 15 days interval after first and second sowing, respectively.

RESULTS

As 2014-15 (normal) and 2015-16 (drought) were quite contrast in weather, thus instead of pooled analysis each year analysis was done separately and discussed. Irrespective of the sowing dates and varieties crop growth and yield were much better during 2014-15 than in 2015-16 (Table 1). Among the date of sowings, however, the crop sown during first fortnight of October (1-15 Oct.) recorded significantly higher seed yield (1572 and 937 kg/ha, respectively during 2014-15 and 2015-16) compared with latter sowing dates. Among the safflower cultivars, significantly the highest seed yield was recorded with A-1 (1718 and 1033 kg/ha, respectively during 2014-15 and 2015-16) compared with the yield of NARI-6 and NARI-57. The newly released genotypes (NARI-6 and NARI-57) did not perform as well as age old and locally very popular cultivar (A-1) under dryland ecosystem of northern Karnataka. Although interactions between planting date and genotypes were non-significant early sowing (1-15 of October) with A-1 variety recorded higher seed yield of 1772 and 1127 kg/ha, respectively during 2014-15 and 2015-16 than other combinations. Further, late sowing not only exposed the crop to warmer temperature, especially dur-

Table 1. Growth and yield of safflower varieties across sowing periods (pooled data of two years)

Treatment	Plant height (cm)		100 seed weight (g)		Seed yield (t/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Sowing time						
D_1	80.80	66.17	4.56	4.00	1.57	0.94
D_2	77.30	62.67	4.04	3.90	1.36	0.93
D_3	66.60	60.92	4.21	3.90	1.25	0.78
SEm±	2.30	1.85	0.1	0.1	0.060	0.038
CD (P=0.05)	8.00	NS	NS	NS	0.207	0.131
Varieties						
V_1 (A-1)	71.50	61.03	5.29	4.60	1.72	1.03
V_2 (NARI-6)	84.90	66.97	3.82	3.30	1.19	0.80
V_3 (NARI-57)	68.30	61.75	3.69	3.90	1.29	0.83
SEm±	1.80	1,95	0.14	0.10	0.042	0.029
CD (P=0.05)	5.20	NS	0.41	0.40	0.124	0.087
Sowing time x Varieties						
D_1V_1	82.00	64.30	5.87	4.30	1.77	1.13
D_1V_2	87.50	67.95	3.99	3.40	1.43	0.90
D_1V_3	73.10	66.25	3.81	4.30	1.52	0.82
D_2V_1	72.40	59.50	4.65	4.80	1.70	1.02
D_2V_2	87.60	66.50	3.82	3.10	1.17	0.79
D_2V_3	71.90	62.00	3.65	3.80	1.23	0.97
D_3V_1	60.30	59.30	5.36	4.60	1.69	0.96
D_3V_2	79.70	66.45	3.65	3.40	0.94	0.71
D_3V_3	59.90	57.00	3.61	3.70	1.12	0.68
SEm±	3.40	3.32	0.22	0.20	0.084	0.056
CD (P=0.05)	NS	NS	NS	NS	NS	NS

D_1= 1-15, October, D_2= 15-30, October, and D_3=30, October to 15, November.

ing second year all through the growing period until maturity but also exhausted residual soil moisture much faster for the crop to experience soil moisture, thus affected seed yield.

CONCLUSION

During the two years of study, irrespective of initial stored soil moisture and rains during post-rainy season, early sowing (1-1, Oct.) has been found to be optimum to realize higher yields and among the three varieties tested the good old A-1 variety seems to be more adapted to extremes of northern dry zone and performed much better than NARI-6 and NARI-57.

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Land configuration for higher yields in rainfed cotton

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Cotton (*Gossypium hirsutum* L.) is important commercial crop cultivated over 12.9 m ha in India, representing about a quarter of the global area of 33 mha (www.indiastat.com) more than 70% of which is cultivated under rainfed situation. Rainfed cotton suffers from moisture stress due to erratic and uneven distribution of rainfall during post monsoon season which coincides with flowering and boll development stages adversely affects the growth and later the shedding of reproductive parts resulting in crop yield. Land configuration is mechanical measure for better *in situ* moisture conservation as the soil profile act as reservoir for moisture storage and the facility need to exploit to the maximum extent. In the experimental state (Telangana), the crop is mostly cultivated under shallow soils (<25 cm depth) with heavy investments. The failure of the crop due to biotic or abiotic constraints often leading to tragedy end to the farming community.

METHODOLOGY

The experiment was conducted at the Regional Agricultural Research Station, Warangal, Telangana State to study the effect of land configuration on growth, yield and moisture content in the soil during *kharif* 2014 and 2015. The experimental site is geographically located at $18^{o}03^{\hat{}}$ N latitude and $79^{o}22^{\hat{}}$ E longitude at an altitude of 270 m above the mean sea level. The experimental soil was sandy loam, alkaline in reaction (pH 7.8), low in organic carbon (0.38%), low in available N (259 kg/ha), medium in available P (13.1 kg/ha) and available K (435 kg/ha). The treatments land configuration of consists of five methods of cotton sowings *viz.,* ridge and furrow (RF), broad bed furrow (BBF), dust mulching with blade harrow (with appearing hair line soil cracks), deep furrow opening near to crop row at 30 DAS and flat bed (farmers practices). The land configuration layout prepared manually at predetermined spacing (90 x 60 cm). The experiment was laid out in randomized block design with four replications. Cotton hybrid seeds Jaadoo of Kavery hybrid BG-II was sown by dibbling on 22nd June in 2014 and on 29th June in 2015. Crop was harvested in two picking up to last week of November. The recommended dose of 120-60- 40 NPK kg/ha was applied to crop. The total rainfall received during crop growth period was 334 mm in 2014 and 553 mm in 2015 over normal rainfall (deficit 45.3 and 16.5%) respectively. For the determination of moisture content in the soil samples were taken to a depth 0-30 cm with the help of screw auger. The soil moisture was estimated at flower initiation and boll development stage of the crop.

RESULTS

Land configuration had significant effects on yield attributes and yield of cotton. Sowing on ridge and furrow improved seed cotton and stalk yield of cotton by 36.7 and 22.7% respectively as compared to conventional sowing flat

Table 1. Effect of land configuration on yield attributes, yield and harvesting index of rainfed cotton (pooled data of two years)

Treatments	Fruiting branches at maturity	Open bolls/ plant	Boll weight (g)	Yield (t/ha) Seed cotton	Yield (t/ha) Stalk	Harvesting index (%)
Ridge and furrow	16.9	29.4	2.7	1.208	2.70	44.5
Broad bed furrow	15.7	24.3	2.9	1.101	2.61	42.4
Deep furrow opening near to crop row at 30 DAS	14.5	23.5	2.7	1.050	2.45	42.8
Dust mulching with blade harrow	14.2	20.0	2.6	0.947	2.33	41.1
Flat bed sowing /Farmer practice	12.9	19.4	2.5	0.884	2.20	40.1
SEm±	0.3	0.4	0.1	0.025	0.029	0.8
CD (P=0.05)	0.9	1.2	0.2	0.076	0.089	2.5
CV (%)	6.4	8.2	4.2	15.0	12.0	9.7

Table 2. Effect of land configuration on soil moisture content, moisture use efficiency and N, P and K total plant uptake of cotton (pooled data of two years)

Treatments	Soil moisture content (%) at 30 cm depth		Moisture use efficiency (kg/ha-mm)	Total plant nutrients uptake at maturity (kg/ha)		
	At flowering	At boll development		N	P	K
Ridge and furrow	18.8	21.7	3.6	168	52	245
Broad bed furrow	17.4	20.5	3.2	147	45	222
Deep furrow opening near to crop row at 30 DAS	16.7	18.9	3.1	136	41	213
Dust mulching with blade harrow	15.9	16.5	2.8	118	39	188
Flatbed sowing / Farmers practice	14.5	15.4	2.6	112	36	179
SEm±	0.3	0.4	0.1	1.6	1.0	1.7
CD (P=0.05)	0.7	1.1	0.3	5.0	3.0	5.3

bed in the years of study. This might have been caused by significant improvement in overall yield attributes of cotton due to sowing on ridge and furrow, which led to higher crop yield (Table 1). These results are in conformity with those of Narkhed *et al*. (2015), Jadhav *et al.* (2008) in cotton and Jat *et al*. (2012) in greengram. Moisture content in soil profile was analyzed at flowering and boll development stages at 0-30 cm soil depth. Maximum moisture conservation was observed in the ridge and furrow was significantly higher at flowering and boll development crop stages over other moisture conservation methods (18.8 and 21.7%) respectively. Jadhav *et al.* (2008) revealed the land configuration of ridges and furrow was found most effective and feasible for soil moisture conservation and producing the highest cotton yield on black cotton soil under assured rainfall condition. Moisture use efficiency increased (38.5%) significantly when cotton was sown on ridge and furrow over flat bed sowing (3.6and 2.6 kg/ha/mm) respectively. These results support the finding of Narkhede *et al.* (2015). The uptake of N, P and K by plants was significantly higher under ridge and furrow method of sowing as compared to other land configuration methods. This might be due to better root growth and moisture extraction from deeper layer of soil and consequently higher N, P and K uptake (168.52 and 240 kg/ha) respectively, resulting in higher seed cotton yield. Similar findings have also been reported by Jat *et al.* (2012) in greengram.

CONCLUSION

The land configuration of ridges and furrow was found most effective and feasible for soil moisture conservation and producing the highest cotton yield on sandy loam soil under assured rainfall condition.

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Evaluation of cropping patterns and tillage methods on productivity and profitability of rice based cropping system in rainfed upland ecology

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The eastern states of India, in general have lower cropping intensity and poor productivity than several other states of India largely due to mono-cropping in upland rainfed ecologies. Despite receiving moderate to good rainfalls (800-1200 mm) in monsoon and sufficient soil moisture at the end of the monsoon, farmers are in practice to cultivate single crop (paddy in monsoon) and left their land fallow in post monsoon period resulted into huge unproductive soil evaporation and poor water use efficiency. Adoption of improved cultivars and production technologies in these areas is very slow mainly due to lack of knowledge, about improved cultivars and technologies, poor availability of improved seeds and other required inputs like mechanization and fear to fail the crop.With the availability of new short duration drought tolerant rice varieties like SahbhagiDhan, Abhishek, Saburardjal, SushkSamrat etc. and popularization of zero tillage practices, it has become possible to plant various pulses and oilseeds crops either sole or mixed and low water requiring cereals like barley in time during last week of October or in early November under rainfed situation. Zero-tillage reduces the time for land preparation and planting and saves fuel, water and labour costs in both timely planting and late planting. It also improves the efficiency of fertilizer and reduces wear and tear on the farm machinery. This experiment had been planned to test various low water requiring crops after short duration rice variety SahbhagiDhan using zero tillage and conventional tillage soil configuration options for rainfed drought-prone areas.

METHODOLOGY

A field experiment was conducted in Research Farm of Bihar Agricultural University, Sabour during 2011-12 and 2012-13 and demonstrated on farmers field of Bhagapur and Banka districts in 2013-14 and 2014-15. The experimental sites are rainfed upland and having loam soil type. It is under sub-tropical climatic condition characterized with hot desiccating summer, cold winter and moderate rainfall. The soil type is mainly sandy loam having *p*H 7.1, organic carbon 0.53%, available nitrogen (N) 160.2 kg/ha, phosphorus (P_2O_5) 26.7 kg/ha and potassium (K_2O) 220.6 kg/ha. The experiment was laid out in a split-plot design which included two main plots of soil configuration methods viz. zero tillage and conventional tillage and subplot treatments comprising of eight cropping patterns viz. rice-linseed, rice-chickpea, rice-lentil, rice-mustard, rice-lathyrus, rice-barley, rice-chickpea + mustard and rice-lentil+ mustard were evaluated for their production potential and economics. The experiment comprising of sixteen combinations were replicated three times. The varieties used under study were, Garima (linseed), PG-186 (chickpea), HUL-57 (lentil), Varuna (mustard), Azad (barley) and local (lathyrus) in both the years. Fertilizers were applied as per recommended dose in rice as well as in rabi crops.

RESULTS

Results revealed that all*rabi* crops performed better in terms of growth and yield attributing characters under zero till condition than conventional tillage. The data presented in (Table1) indicated that tillage system had significant effect on lentil equivalent yield, adoption of zero tillage recorded higher lentil equivalent yield (1.46t/ha) as compared to conventional tillage (1.24 t/ha). Among *rabi* crops chickpea after rice recorded significant higher lentil equivalent yield (1.43 t/ha) as compared to other rabi crops. Lentil and mustard attained second and third rank in terms of lentil equivalent yield. Chickpea+mustard intercropping after rice gave more lentil equivalent yield (1.83t/ha) than lentil + mustard intercropping. The same trend was followed in case of rice equivalent yield of these crops. The system productivity was higher in rice-chickpea + mustard system and B-C ratio was also maximum in rice-chickpea + mustard system (3.07) under zero tillage condition. Pala *et al.* (2000) studied that the benefit of legumes including lentil in no-till system because of the extra soil moisture, conserved from leaving standings stubble over the winter, increasing moisture conservation and the improved micro climate during the growing season. Establish-

Table 1. Effect of tillage and cropping patterns on lentil, rice equivalent yield of *rabi* crops and the productivity of the systems

Treatment	Lentil Equivalent yield (t/ha)	Rice Equivalent yield (t/ha)	System Productivity (REY t/ha)	B:C ratio
Tillage				
Zero tillage	1.46	5.11	9.36	2.65
Conventional Tillage	1.24	4.35	8.60.	2.37
SEm ±	0.22	0.79	0.79	0.08
CD(P=0.05)	0.60	2.10	2.10	0.23
Cropping System				
Rice-Linseed	11.20	3.92	8.170	2.26
Rice-Chickpea	1.43	5.01	9.26	2.54
Rice-Lentil	1.40	4.89	9.14	2.44
Rice-Mustard	1.28	4.47	8.72.	2.66
Rice-Lathyrus	1.02	3.57	7.82-	2.23
Rice- Barley	1.01	3.53.	7.78	2.23
Rice-Chickpea+Mustard	1.83	6.39	1.06	2.92
Rice-Lentil+Mustard	1.74	6.08	1.03	2.84
SEm ±	0.25	0.90	0.90	0.11
CD (P=0.05)	0.79	2.76	2.76	0.34

ment of *rabi* crops, oil seeds and pulses (lentil, gram, lathyrus, Linseed, Mustard and Barley) through zero tillage increased the lentil equivalent yield and net return as compared to conventional tillage. The productivity increased due to timely crop establishment, better utilization of underutilized land (rice fallows/lowland, excess moisture areas), more opportunity for system intensification/diversification, saving in external inputs reduction in production cost and increase in input use efficiency. Rice-chickpea + mustard system under zero tillage condition gave promising results as compared to another system. This is because of high intercrop yield of chickpea + mustard under zero till condition. The yield of chickpea was lower as compared to its average expected yield range at the end of experimentation. This may be because of its excessive flower drop due to high rainfall at the flowering stage. No-till lentil holds promise for minimizing soil and crop residue disturbance, controlling soil evaporation, minimizing erosion losses, sequestering carbon and reducing energy needs. Generally, the weed flora observed in lentil is complex including grassy, broadleaf and sometimes sedges. In zero till planting of *rabi* crops significant reduction of weed flora also responsible for higher yield. After taking of rice variety shabhagidhan and no-till planting of *rabi* crops has been demonstrated at farmers field, resulting in adoption by farmers in some regions of Bhagalpur and Banka districts of Bihar.

CONCLUSION

On the basis of two-year experimentation and demonstrations on farmers field revealed that tillage system had significant effect on lentil equivalent yield.Adoption of zero tillage after taking of shabhagidhan under partial puddled field recorded higher lentil equivalent yield (1.46t/ha) as compared to conventional tillage (1.24t/ha). Among the cropping patterns, rice-chickpea + mustard recorded significantly higher lentil equivalent yield (1.83t/ha) as compared to other cropping patterns. The system productivity (1.06t/ha) was higher in rice-chickpea + mustard system and B:C ratio was also maximum in rice-chickpea + mustard system (2.92) and closely followed by the rice-lentil+mustard system (2.84).

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Efficacy of mesotrione on *rabi* maize (*Zea mays*) and its residual effect on black gram (*Vigna mungo*)

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Rabi maize cultivation is practiced in areas where irrigation facility is assured. *Rabi* maize cultivation mainly depends on the assured irrigation and modern inputs. Maize crop is sensitive to weed competition during early growth period due to slow growth in the first 3-4 weeks. Maximum weed competition in maize occurs during the period of 2-6 weeks after sowing. Mesotrione, a tri-ketone herbicide, is the result of chemical optimization of a phytotoxin isolated from the bottlebrush (*Callistemon citrinus*). Its mode of action is to inhibit the enzyme 4-hydroxyphenolpyruvate dioxygenase (HPPD). This enzyme is in the biochemical pathway that converts the amino acid tyrosine to plastoquinone. This leads to a reduction of carotenoids and causes the bleaching symptoms (albinism) that are typical of this mode of action (Mitchell *et al*., 2001).

METHODOLOGY

A field experiment was conducted during *rabi* season of 2014-15 in Agricultural Farm, Palli Siksha Bhavana (Institute of Agriculture) at Visva-Bharati, Sriniketan, India to study the efficacy of mesotrione on *rabi* maize (*Zea mays* L.) and its residual effect on black gram (*Vigna mungo* L. Hepper). The experiment consisted of nine treatments which were laid out in randomized block design with three replications.

RESULTS

The experimental results clearly indicated the different weed management practices to reduce the influence of weeds in *rabi* maize cultivation. The results showed that the application of Mesotrione @ 90 g a.i./ha, Mesotrione @ 100 g a.i./ha and Mesotrione @ 120 g a.i./ha improved productivity of *rabi* maize (Table 1). The highest weed control efficiency was observed with the application of hand weeding at 25 and 45 DAS (T_8) treatment followed by application of Mesotrione 48 EC @ 120 g a.i./ha, Mesotrione 48 EC @ 100 g a.i./ha and Mesotrione 48 EC @ 90 g a.i./ha . The lowest weed index was recorded with the application of Mesotrione 48 EC @ 120 g a.i./ha followed by Mesotrione 48 EC @ 100 g a.i./ha and Mesotrione 48 EC @ 90 g a.i./ha. Similar observations were reported by Elmore *et al.* (2011) using mesotrione, topramazine and tembotrione. Mesotrione 48 EC @ 90 g a.i./ha provided highest return per rupee invested. The study,

Table 1. Effect of weed management on the grain yield, weed control efficiency, weed index, return per rupee invested in *rabi* maize and seed yield of follow-up crop of blackgram

Treatments	Grain yield of maize (t/ha)	WCE at 80 DAS	Weed Index (%)	Return/rupee invested	Seed yield of blackgram (kg/ha)
T_1 : Mesotrione 48 EC @70 g a.i./ha	5.97	78.71		1.26	971
T_2 : Mesotrione 48 EC @ 80 g a.i./ha	6.06	78.81	13.13	1.29	846
T_3 : Mesotrione 48 EC @ 90 g a.i./ha	6.06	79.33	11.83	1.29	829
T_4 : Mesotrione 48 EC @ 100 g a.i./ha	6.14	79.62	11.76	1.32	960
T_5 : Mesotrione 48 EC @ 120 g a.i./ha	6.21	81.01	10.58	1.35	1140
T_6 : Mesotrione 2.27% @ 79.5 g a.i./ha + : Atrazine 22.27% @ 795.2 g a.i./ha	6.09	79.24	9.59	1.06	1070
T_7 : Atrazine 50% WP @ 1000 g a.i./ha	5.99	75.13	11.34	1.22	1150
T_8 : Hand weeding at 25 & 45 DAS	6.87	91.40	12.68	1.03	1179
T_9 : Untreated check	3.27	-	-	0.27	750
SEm±	0.41	-	52.38	0.15	100
CD (P=0.05)	1.24	-	-	0.44	NS

therefore, indicated that the use of Mesotrione 48 EC @ 90 g a.i./ha may be effective for better growth, higher productivity, greater profit of *rabi* maize. There was no harmful effect of the weed management practices on the performance of the residual crop of black gram.

CONCLUSION

The results clearly indicated the need of different weed management practices to reduce the influence of weed in *rabi* maize cultivation. The study recommends the use of Mesotrione 48 EC @ 90 g a.i./ha for better growth, higher productivity and greater profit of *rabi* maize as this treatment is at par with Mesotrione 48 EC @ 120 g a.i./ha and Mesotrione 48 EC @ 100 g a.i./ha .

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Prevalence of bacteriocinogenic *Rhizobium* spp. in mungbean (*Vigna radiata*)

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Bacteriocins are ribosomally coded antimicrobial peptides produced by bacteria. They have a narrow or broadhost range. Bacteriocins play a role in intra-specific and inter-specific competition as they kill or inhibit closely related species or different strains of the same species. Bacteriocin producing *Rhizobium* spp. are highly likely to dominate nodule occupancy compared to non-producers. The present work was planned with the objective of isolation of bacteriocin producing *Rhizobium* spp, characterization of bacteriocin and examining the advantage of dual inoculation of a bacteriocin producerwith a nitrogen fixer strain.

METHODOLOGY

Soil and nodule samples were collected from the fields of Mungbean (*Vigna radiata*). Appropriate dilutions of the samples were plated onto YEMA medium for isolation of *Rhizobium* (Aneja, 2003). Bacteriocin production was detected by disc diffusionassay as per the method of Ambika and co-workers (2014). Cell free supernatant containing partially purified bacteriocin was characterized for thermo-stability by heating it to temperatures-50,60,70,80 and 90p C for 5/10 minutes prior to disc assay. Proteinaceous nature of the bacteriocin was determined by treating it with pepsin and proteinase K. Nodule occupancy in relation to bacteriocin production was recorded in a pot culture study. Intrinsic antibiotic spectrum was used as marker to differentiate between bacteriocin producing *Rhizobium* isolates and the nitrogen fixer *Rhizobium* M1 strain. The isolates were used independently and in combination with nitrogen fixer M1. Chlorophyll content (Witham *et al.,*1971), leghaemologbin content (Wilson and Reisenauer, 1963), number of nodules and their dry weight, shoot and root dry weight and plant height were recorded to observe advantage, if any.

RESULTS

Bacteriocin producing *Rhizobium* isolate (N8) were obtained by plating of soil and nodule samples. Bacteriocin was found to be present in the concentration of 10^4 AU/ml (Arbitrary units/ml). Proteinaceous nature of the bacteriocin was confirmed by treating with pepsin and proteinase K. Bacteriocin activity was retained after heat treatment to 90pC for 5 minutes. A significant increase in number and dry weight of nodules (Table 1) over use of *Rhizobium* M1alone and uninoculated control was observed in pot culture study. Maximum number and dry weight of nodule was recorded with use of *Rhizobium* M1 + N8 (nodule number 24.3 and 23.4 mg/

Table 1. Characters of various *Rhizobium* species present in mungbean

Treatment	Control (uninoculated)	*Rhizobium* M1	*Rhizobium* + N8
No. of nodules/plant	10.3	18.3	24.3
Nodule index	1	1.22	1.33
Nodule dry weight (mg/plant)	92	110	234
Nodule fresh weight (mg/plant)	115	142	252
Shoot fresh weight (gm/plant)	4.82	5.71	10.0
Root fresh weight (gm/plant)	0.35	0.43	0.63
Shoot dry weight (gm/plant)	1.7	2.2	2.6
Root dry weight (gm/plant)	0.17	0.19	0.24
Chlorophyll content (mg/g fresh weight of leaves)	1.02	1.12	1.34
Leghaemoglobin (mg/g fresh weight of leaves)	0.74	1.05	3.43
Plant height	46.7	53.7	60.6

plant) compared to *Rhizobium* M1 alone (nodule number 18.3 and 11.2 mg/plant) and control (nodule number 10.3 and 9.2 mg/plant). Similar trends were recorded in leghaemoglobin and chlorophyll content which was maximum in *Rhizobium* M1 + N8 (3.43 mg/g of nodules and 1.34 mg/g of leaves) compared *Rhizobium* M1 (1.05 mg/g of nodules and 1.12 mg/g of leaves) alone and control (0.74 mg/g of nodules and 1.02 mg/g of leaves). The positive interaction between dual-inoculants was subsequently reflected in increase in grain yield over *Rhizobium* M1 alone and un-inoculated control. Dual inoculation regime significantly enhanced all symbiotic and growth parameter and also affected yield.

CONCLUSION

Dual-inoculation with bacteriocinogenic *Rhizobium* isolatewith a recommended nitrogen fixer *Rhizobium* M1 resulted in increase in growth, symbiotic parameters and grain yield in mungbean (*Vigna radiata*).

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Productivity of kodo millet (*Paspalum scrobiculatum*) as affected by different dates of sowing and plant population under rainfed conditions

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Small millets are a group of small-seeded species of cereal crops, widely grown around the world for food and fodder. Their essential similarities are that they can be grown in difficult production environment such as those at risk of drought and are rainfed. Among the millet crops, Kodo millet (*Paspalum scrobiculatum*) is predominantly grown in the dry tribal tracks of Madhya Pradesh. The state contributes about 50% area and 35% production of total millet in the country.

The state of Madhya Pradesh ranks first among Kodo millet growing states in the country. Kodo millet is having the capability of growing during adverse soil and climatic conditions and several of their varieties are of short duration. Production about half a tonne of grain/ha which is better than having no crop. Under rainfed conditions early cessation of rains or complete failure of rains is a common feature, as a result of which crop suffers from drought. Drought affects crop growth and recognized as a primary constraint under rainfed upland environment causes a reduction in biomass and component characters resulting poor yields (Thomas, 1992). Hence, identification of proper time of sowing and optimum plant population are the two major non monetary inputs which if managed properly could boost the productivity in terms of quality and quantity both without increasing the cost of cultivation and affecting the soil and environmental health. Hence, an attempt was made through this study to evaluate different dates of sowing and plant population on yield of Kodo millet (*Paspalum scrobiculatum*) under rainfed conditions.

METHODOLOGY

The field experiment was conducted during *Kharif* season successively for three years since 2010 *at* Instructional Farm, College of Agricultural, JNKVV, Rewa, Madhya Pradesh. Rewa is situated in the North eastern part of Madhya Pradesh at 20° 21' North latitude, 81° 15', East longitude and 365.7 meters above sea level. Total annual rainfall is about 980 mm (39 inches) and more than 80% generally occurs during the monsoon season (June-September). The soil of the experimental field was mixed red and black with clay loam in texture and slightly alkaline in reaction with pH 7.67, EC 0.33 Ds/m having organic carbon 0.60 per cent and available nitrogen 267 kg/ha, phosphorus 16.0 kg/ha and potassium 350 kg\ha at 0-15 cm soil depth. The experiment was laid out in Randomized Block Design comprised of six treatments T_1 - Dry sowing based on the probability of receiving dependable rains at 75%, T_2 - Sowing after the receipt of sowing rains, T_3 - Dry sowing based on the probability of receiving dependable rains at 75% (T_1) + with thinning and maintaining 125% of recommended population, T_4 - Dry sowing based on the probability of receiving dependable rains at 75% (T_1) + with thinning and maintaining 150% of recommended population, T_5 - Sowing after the receipt of sowing rain (T_2) + with thinning and maintaining 125% of recommended population and T_6 - Sowing after the receipt of sowing rain (T_2) + with thinning and maintaining 150% of recommended population. The crop was supplied with RDF i.e. 40:20:0 N: P_2O_5: K_2O kg/ha. Among fertilizers, nitrogen was applied through urea in three split doses. Half dose of N and full doses of P was applied as basal just before sowing the crop and remaining half dose of N was applied in two equal splits *i.e.* at active tillering and panicle initiation stage of the crop. The other agronomical cultural practices such as weeding and plant protection measures have been performed as per requisite. The crop was harvested manually at the maturity plot wise and the grain and straw yields were recorded.

RESULTS

Results from the three studies summarized in (Table 1) showed that both the grain and straw yield were significantly affected due to different dates of sowing and plant population. Among all the treatments under study, treatment T_5, Sowing after the receipt of sowing rain along with thinning and maintaining 125% of recommended population gave significantly higher grain yield. The same treatment significantly bolstered the grain yield to the tune of 32% over the lowest yielding treatment T_1. Whereas, significantly higher straw yield was obtained under treatment T_6 where Sowing after the receipt of sowing rain (T_2) along with thinning and maintaining 150% of recommended population was done. This was due chiefly due to higher number of plants per unit area which gave more biomass in terms of straw. Economical gain from the applied treatment is directly related to the success of that particular treatment. The calculation of benefit: cost ratio (rupees per rupee invested) is another way of expressing the economics of the treatments. It is based on the income as against the total expenditure incurred on that particular treatment. In the present study, the highest net income was Rs. 14794/ha in case of T_6 whereas, lowest net income was Rs. 9509/ha in case of T_1. Treatment T_5 registered the highest B:C ratio up to 1.98 and the lowest B:C ratio (1.69) was obtained in case of T_1 treatment. The maximum loss may be due to the fact that the treatment T_1 possessed dry sowing resulting lesser yield attributes and yield.

Table 1. Effect of dates of sowing and plant population on yield and economics of Kodo millet

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Net income (Rs/ha)	B:C ratio
T_1	1.577	3.343	9509	1.69
T_2	2.036	2.285	14522	1.97
T_3	1.795	3.398	13013	1.91
T_4	1.68	2.599	13339	1.89
T_5	2.079	3.261	14329	1.98
T_6	1.969	4.036	14794	1.95
SEm±	0.049	0.108	-	-
CD (P=0.05)	0.16	0.356	-	-

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Identification of suitable varieties of clusterbean for Koshi region of Bihar

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Clusterbean or guar (*Cyamopsis tetragonoloba*) is an important cash crop in rainfed areas, especially in semi-arid and arid regions of India. The qualities of the crop like high adaptation towards erratic rainfall, multiple industrial uses and its Importance in cropping system for factors such as soil enrichment properties, low input requirement, etc have made the guar one of the most significant crops for farmers in arid areas in India. Clusterbean is grown for different purposes, such as vegetables, green fodder, green manure and seed. This crop is mainly grown for production of gum. Clusterbean has a large endosperm that contains galactomannon gum, a substance which forms a gel in water and is known as guar gum having main commercial value. Larger use of guar gum derivatives in drilling and exploration of shale gas created upheaval in volatility of its global prices and future trading after 2011. Among all the agricultural export commodities, guar has become the highest foreign exchange earner of Rs. 212.87 billion followed by Basmati rice in the recent year of 2012-13 (NRAA, 2014). As a result of climate change during past 4-5 years, the amount and distribution of rainfall in Bihar changed drastically. Clusterbean has vast adaptability under diverse climatic conditions. So, in this context it has an immense opportunity to impart sustainability in the production system of the state. By keeping these facts in view the present project has been formulated to introduce this crop in Koshi region of Bihar for imparting sustainability in Rice-Wheat and Rice-Maize cropping systems.

Table 1.Performance of different verities of clusterbean in Koshi region of Bihar

Variety	Dry matter (g/plant)	Test weight (g)	Grain yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Net returns (₹/ha)	B:C ratio
M-83	16.3	35.0	0.862	4.391	19.6	5049	0.20
RGr-12-1	20.7	36.0	2.018	6.596	30.6	45493	1.81
RGC-471	24.3	35.2	1.769	8.178	21.6	36782	1.46
RGC-936	18.9	31.7	1.476	6.107	24.2	26515	1.06
RGC-986	24.9	36.2	1.529	7.778	19.7	28382	1.13
RGC-1002	24.8	36.3	1.840	7.156	25.7	39271	1.56
RGC-1003	22.0	33.4	1.849	6.409	28.9	39582	1.58
RGC-1017	20.3	35.3	1.751	6.676	26.2	36160	1.44
RGC-1031	27.3	35.3	1.938	8.222	23.6	42693	1.70
RGC-1033	24.8	35.2	2.658	8.018	33.1	67893	2.70
RGC-1038	21.3	33.5	1.653	5.902	28.0	32738	1.30
RGC-1055	25.3	34.0	1.991	7.396	26.9	44560	1.77
HG-2-20	26.5	35.1	2.427	8.169	29.7	59804	2.38
HG-365	25.8	34.9	2.382	7.307	32.6	58249	2.32
HG-563	22.4	33.8	2.018	6.898	29.3	45493	1.81
BG-1	28.9	37.8	1.345	8.400	16.0	21942	0.87
BG-2	28.6	35.1	1.564	9.467	16.5	29627	1.18
GG-1	25.5	36.1	1.902	8.373	22.7	41449	1.65
GG-2	21.8	36.8	1.680	6.436	26.1	33671	1.34
SEm±	1.51	0.20	0.150	0.606	0.20	5247	0.209
CD (P=0.05)	4.33	0.58	0.430	1.738	0.58	15048	0.599

#Market price of clusterbean= Rs 35000/t and cost of cultivation= Rs 25129/ha

METHODOLOGY

A field experiment was conducted at Research Farm of Regional Research Sub-Station, Jalalgarh (Bihar) during *kharif*, 2015 under state plan project "Identification of suitable varieties of clusterbean for Koshi region of Bihar". The experiment consisted of nineteen varieties of clusterbean (M-83, RGr-12-1, RGC-471, RGC-936, RGC-986, RGC-1002, RGC-1003, RGC-1017, RGC-1031, RGC-1033, RGC-1038, RGC-1055, HG-2-20, HG-365, HG-563, Bundel Guar-1, Bundel Guar-2, Gujarat Guar-1 and Gujarat Guar-2) from different parts of the country. The experiment was laid out in randomized block design with three replications.A common dose of 20 kg N, 40 kg P_2O_5,40 kg K_2O and 5.0 kg Zn/ha were applied as basal dose at the time of sowing. The crop was sown at 30 x 10 cm spacing using seed rate of 20 kg/ha.

RESULTS

Result revealed that the significantly taller plants were observed under clusterbean variety Bundel Guar-2 (BG-2), whereas, Bundel Guar-2 (BG-2) recorded significantly higher dry matter accumulation (28.9 g/plant). Clusterbean variety Gujarat Guar-2 taken least number of days to maturity (115 days), however, highest number of days to maturity (126 days) was taken by RGC-986 and BG-1. Significantly higher number of pods/plant was observed under RGC-1033 than M-83. HG-365 resulted into significantly higher number of grain per pod (6.64) and BG-1 recorded significantly higher test weight. RGC-1033 being at par with HG-2-20 and HG-365 recorded significantly maximum grain yield of 2.658 t/ha along with harvest index of 33.1 % than other varieties of clusterbean. In terms of total biomass yield BG-2 proved significantly superior. Similarly, RGC-1033 being at par with HG-2-20 and HG-365 and fetched significantly higher net returns (67893/ha) with B:C ratio of 2.70 as compared to rest of the varieties.

CONCLUSION

On the basis of above findings it can be inferred that clusterbean variety RGC-1033 produced significantly higher grain yield of 2.658 t/ha and net returns of 67,893/ha along with B:C ratio of 2.70 followed by HG-2-20 (Grain yield: 2427 kg/ha, Net returns: Rs 59804/ha and B:C ratio: 2.38).

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Yield and yield attributes of maize (*Zea mays*) hybrids under different sowing dates

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In Haryana state, maize is grown over an area of 20,000 ha with productivity of 2610 kg/ha (Anonymous, 2012). The two most important components governing yield of maize cropping systems are plant variety and planting date. Keeping in view the prevailing rainfall and climatic aberrations and availability of high yield potential hybrids, it was realized to undertake research to identify the best hybrids and their optimum sowing time under Haryana conditions.

METHODOLOGY

The experiments were conducted during 2012-13 at Regional Research Station, CCS Haryana Agricultural University, Karnal (29°43''N latitude and 76°58''E longitude) located at an altitude of 245 meters above the mean sea level. The experiment consisted of four dates of sowing (15^{th}June - 10 days before normal date of sowing**,** 25^{th} June -Normal date of sowing, 5^{th} July -10 days after normal date of sowing and

Table 1. Effect of dates of sowing and maize hybrids on yield and yield attributes

Treatments	Cob yield with husk (t/ha)	Cob yield without husk (t/ha)	Grain yield (t/ha)	Shelling (%)
Dates of sowing				
15th June	9.49	8.60	6.45	66.9
25th June	9.38	8.50	6.35	66.4
5th July	9.16	8.30	6.17	65.7
15th July	7.81	7.08	4.87	54.8
SEm±	0.20	0.18	0.13	0.9
CD (P=0.05)	0.67	0.61	0.43	3.0
Hybrids				
HQPM-1	9.26	8.40	6.38	67.8
HM-4	8.23	7.46	5.50	63.6
HM-5	11.88	10.76	7.63	58.5
HM-6	7.78	7.05	5.25	65.1
HM-7	7.66	6.94	5.07	62.3
SEm±	0.18	0.16	0.11	1.2
CD (P=0.05)	0.51	0.47	0.32	3.5

15th July -20 days after normal date of sowing) in main plot and five hybrids of different maturity groups [HQPM-1 Late maturity, HM-5 (Late maturity), HM-4 (Medium maturity), HM-6 (Early maturity), HM-7 (Extra early maturity)] in sub plots and was replicated three times in split plot design. Rests of the inputs were applied as per package and practices of CCSHAU, Hisar.

RESULTS

Dates of sowing and hybrids tested differed significantly in terms of cob yield with husk, cob yield without husk, grain yield (t/ha) and shelling percentage (Table 1). First-three dates of sowing being at par recorded significantly higher cob yield with husk over delayed sowing by 20 days from normal. Lowest cob yield with husk was recorded in last sowing date (15th July). Highest cob yield with husk was recorded HM-5 (11.88 t/ha). Hybrids HM-4 (8.23 t/ha), HM-6 (7.78 t/ha) and HM-7 (7.66 t/ha) being at par recorded significantly lower cob yield with husk as compared to hybrid HQPM-1 (9.26 t/ha). Highest cob yield without husk was recorded HM-5 (10.76 t/ha). Hybrids HM-4 (7.46 t/ha), HM-6 (7.05 t/ha) and HM-7 (6.94 t/ha) being at par recorded significantly lower cob yield without husk as compared to hybrid HQPM-1 (8.40 t/ha). HM-5 (7.63 t/ha) recorded significantly highest grain yield/ha. The hybrids HM-6 (5.25 t/ha) and HM-7 (5.07 t/ha) were found at par with each other in terms of grain yield /ha. Hybrid HM-5 produced 17.5, 37.8, 44.9 and 50.1 % higher grain yield over hybrids HQPM-1, HM-4, HM-6 and HM-7, respectively. Among hybrids, highest shelling percent was recorded in HQPM-1 (67.8 %) followed by HM-6 (65.1 %), HM-4 (63.6 %), HM-7 (62.3 %) and lowest in case of HM-5 (58.5 %). Hybrids HM-4, HM-6 and HM-7 were found at par with each other in term of shelling percent at harvest.

CONCLUSION

Based on one year experiment it is concluded that optimum time of sowing of maize in Haryana was June 15 to July 5 as it utilized prevailing weather conditions especially temperature for *kharif* season. Among the hybrids, HM-7 (extra early), HM-6 (early), HM-4 (medium) and HQPM-1 and HM-5 (long duration) can be grown successfully from June 15 to July 5. HM-5 was found best yielder among all the hybrids under all the dates of sowing.

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Production efficiency of sorghum sudan grass hybrid with cowpea under different sowing methods and varying seed rates

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Livestock plays an important role in rural economy of India by providing employment and supplementing family income, which contribute about 21% of the total agriculture income of the family (Sharma *et al*. 2009). Fodder requirement of livestock is generally met through low-quality crop residues and degraded grasslands, which are not enough for maintenance of animal health and productivity. Feeding of crop residues, cultivated fodder crop and fodder trees are other major fodder resources in Himachal Pradesh. Sorghum sudan grass hybrid and cowpea are the potential *kharif* fodder crops, which can provide good nutrition to livestock with higher fodder yields with better quality, when grown in association with each other. The type of inter/mixed crop and spatial arrangement in inter/mixed cropping have important effects on the balance of competition between the component crops and their productivity. Hence, to get the best results, a rational approach is required for obtaining information on appropriate plant population of inter/mixed crop stand.

METHODOLOGY

A field experiment was conducted during *kharif* seasons of 2012 and 2013 at Fodder Unit, CSKHPKV Palampur under sub tropical climatic conditions. The experiment was laid-out in randomized block design with three replications with 10 treatments. Treatments were comprised of all possible combinations of two sowing methods (line sowing and broadcast sowing) and three seed rates of cowpea (50, 75 and 100% of recommended seed rate) sown with sorghum sudan grass hybrid (SSGH).

RESULTS

Data on effect of treatments on green and dry fodder yields of sorghum sudan grass hybrid and cowpea, sorghum sudan grass hybrid equivalent yield, production efficiency and land equivalent ratio has been presented in Table 1. Broadcast sowing of sorghum sudan grass hybrid and cowpea using 75% of recommended seed rate resulted in higher green fodder yield (36.34 t/ha) and produced 20.77% more green fodder yield than line sowing of sorghum sudan grass hybrid using 50% seed rate of cowpea. Broadcast sowing of sorghum sudan grass hybrid and cowpea using recommended seed rate produced higher dry fodder yield (10.16 t/ha) than other treatments and was at par with broadcast sowing of sorghum sudan grass hybrid and cowpea using 75% recommended seed rate

Table 1. Effect of fertility treatment on green fodder yield (t/ha), dry fodder yield (t/ha), SSGH equivalent yield (t/ha), production efficiency (kg/ha/day) and land equivalent ratio SSGH- Sorghum sudan grass hybrid

Treatments	Green fodder yield	Dry fodder yield	SSGH equivalent yield	Production efficiency	Land Equivalent Ratio
T_1-Line sowing of sorghum sudan grass hybrid + cowpea 50%	28.79	8.71	30.32	315.84	1.35
T_2-Line sowing of sorghum sudan grass hybrid + cowpea 75%	32.02	9.77	34.89	363.46	1.73
T_3-Line sowing of sorghum sudan grass hybrid + cowpea 100%	29.64	8.22	32.78	341.50	1.68
T_4-Broadcast sowing of sorghum sudan grass hybrid + cowpea 50%	30.26	9.94	31.80	331.21	1.35
T_5-Broadcast sowing of sorghum sudan grass hybrid + cowpea 75%	36.34	10.15	38.40	399.97	1.68
T_6-Broadcast sowing of sorghum sudan grass hybrid + cowpea 100%	34.92	10.16	37.75	393.28	1.72
T_7-Line sowing of sorghum sudan grass hybrid	25.84	8.79	25.97	270.52	-
T_8-Broadcast sowing of sorghum sudan grass hybrid	27.75	9.44	28.12	292.86	-
T_9-Line sowing of cowpea	11.01	2.40	14.48	150.81	-
T_{10}-broadcast sowing of cowpea	11.45	2.60	15.06	156.91	-
CD (P=0.05)	2.01	0.59	2.38	24.78	0.16

(10.15 t/ha). Sorghum sudan grass hybrid equivalent yield and production efficiency was better under broadcast sowing of sorghum sudan grass hybrid with cowpea using 75% recommended seed rate (38.40 t/ha). Although line sowing of sorghum sudan grass hybrid with 75% seed rate cowpea has higher value of LER but statistically no much significant difference was observed among different treatments *w.r.t.* LER.

CONCLUSION

The study conclusively indicated that broadcast sowing of sorghum sudan grass hybrid and cowpea using 75% recommended seed rate have resulted in better utilization in comparison to other treatments.

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Effect of chlormequat chloride on growth and yield of soybean

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Soybean has emerged as one of the major oilseed crop and revolutionized rural economy and lifted the socio-economic status of soybean farmers. Excessive vegetative growth resulted in poor yield of soybean. Chlormequat chloride checks vegetative growth and hastens the development of reproductive parts by reducing the plant height, thereby decreasing the distance between the source and sink to effect better translocations of photosynthates into developing pods. Hence present study is undertaken to find out the suitable concentration of Chlormequat Chloride and to find out the effect on growth and yield of soybean.

METHODOLOGY

An investigation was carried out for three years from

Table 1. Plant height, yield attributes, seed yield and B:C ratio of soybean as influenced by chlormequat chloride

Treatment	Plant height (cm)	No. of branches/ plant at harvest	No. of pods/plant at harvest	Seed yield (kg/ha)	B:C ratio
Application of Chlormequat Chloride					
Seed treatment	40.88	3.50	26.40	1302	1.60
Spraying	41.69	3.85	27.72	1463	1.77
CD (P=0.05)	NS	0.12	NS	37.67	-
Concentration of Chlormequat Chloride					
Control	43.48	3.15	22.64	1149	1.42
Water Spray	42.41	3.43	25.31	1327	1.62
500 PPM	41.68	3.60	26.43	1422	1.74
750 PPM	41.58	3.68	27.87	1462	1.78
1000 PPM	39.01	3.98	32.68	1643	1.99
1500 PPM	40.51	3.87	27.48	1355	1.64
2000 PPM	40.31	4.03	27.00	1321	1.59
CD (P=0.05)	2.21	0.24	1.48	77.50	-
SEm±	1.11	0.12	0.74	38.88	-
CD (P=0.05)	NS	NS	2.09	NS	-

2012-13 to 2014-15. The experiment was laid out in Factorial Randomized block design with three replications. There are two levels of application of chlormequat chloride and seven levels of concentration of chlormequat chloride with control. The gross plot size was 5 x 3.6 m^2 and net plot size was 4.8 x 2.7 m^2.

RESULTS

Pooled data over the three years in respect of plant height reveals that foliar application of chlormequat chloride @ 1000 ppm reduces the plant height (39.01 cm) over the control treatment but found at par with the higher dose i.e. 1500 & 2000 ppm. Three years pooled results reveals that significantly highest Number of branches per plant was observed as the concentration of chlormequat chloride increases. Foliar application of chlormequat chloride @ 2000 ppm recorded highest number of branches per plant (4.03) but found at par with 1000 ppm and 1500 ppm. Spraying of chlormequat chloride at different concentration proves significantly superior over seed treatment. Significantly highest number of pods per plant was noticed in treatment of foliar application of chlormequat chloride @ 1000 ppm i.e. 32.68 pods. Foliar application significantly proves better over seed treatment. While among the different concentrations, foliar application of chlormequat chloride @ 1000 ppm showed significantly superior over all rest of the treatments in respect of 1643 kg/ha seed yield and B:C ratio.

CONCLUSION

From three years data it may be concluded that, foliar application significantly proves better over seed treatment. While among the different concentrations, foliar application of chlormequat chloride @ 1000 ppm showed significantly superior over all rest of the treatments in respect of reducing plant height, increasing number of pods and branches per plant, seed yield and B:C ratio.

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Performance of groundnut varieties under different sowing times during *kharif*

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The groundnut is a valuable food and oilseed crop. It is commonly called as the king of vegetable oilseeds crop or poor man's nut. It belongs to family *Leguminaceae*. Groundnut appeared to have originated in South America.The major groundnut growing states of India are Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra. In India, during 2011-12 the area under this crop was 6.10 million ha with its annual production of 7.53 million tonnes and productivity of 1234 kg/ha. However, in Maharashtra area under groundnut was 2.58 lakh ha in *kharif* season (2011-12) and production was 3.47 lakh tonnes with an average productivity of 1344 kg/ha, while in summer season (2011-12) area was 0.82 lakh ha and production was 1.2 lakh tones with an average productivity of 1463 kg/ha (Anonymous 2011). As per the above figures the yield was higher during summer season and this may be due to adequate sunlight, temperature, availability of irrigation and fairly disease and pest free conditions. The major groundnut growing districts in Maharashtra are Dhule, Satara, Kolhapur, Pune, Nashik, Ahmednagar, Parbhani and Jalgaon.The present investigation "Performance of groundnut varieties to sowing times during *kharif*" was undertaken at Post Graduate Farm of Agriculture College Kolhapur, during *kharif* season of 2014.

METHODOLOGY

The field experiment was conducted at post graduate research farm, College of Agriculture, Kolhapur during the *rabi* season of 2014-15. The experiment was laid out in split plot design with twelve treatment combinations *viz.* A) Main Plot treatments in that 3 sowing dates like I.D_1- 24th MW (11June-17 June), II. D_2- 26th MW (25 June- 1 July), III.D_3- 28th MW (9 July- 15 July), B) Sub Plot treatment in that 4 groundnut varieties likeV_1- JL-501, V_2- JL-24, V_3- TG-26, V_4- TAG-24.Gross Plot size 4.50 X 4.00 m^2 and net plot size 3.30 X 3.00 m^2 and had three sowing dates like 1stsowing– 13/06/2014, 2ndsowing– 27/06/2014, 3rdsowing– 11/07/2014.

RESULTS

The number of pods/plant was maximum with 26th MW sowing which was significantly higher than rest dates of sowing. The number of pods was decreased with delayed sowing.

Table 1. Mean number of pods/plant, pod yield/plant, pod yield/plot, pod yield,haulm yield/plot and haulm yield as influenced by different treatments at harvest

Treatments	Pods/plant	Pod yield/ plant (g)	Pod yield/ plot (kg)	Pod yield (t/ha)	Haulm yield/ plot (kg)	Haulm yield (t/ha)
Main Plot (Sowing Dates)						
D_1= 24th MW	28.58	24.75	2.08	2.08	4.33	4.20
D_2= 26th MW	29.69	25.78	2.28	2.29	4.54	4.41
D_3= 28th MW	26.63	23.67	1.73	1.88	3.91	3.98
SEm±	0.35	0.37	0.06	0.04	0.08	0.06
CD (P=0.05)	1.37	1.44	0.22	0.15	0.30	0.24
Sub Plot (Varieties)						
V_1 = JL-501	32.08	29.60	2.32	2.41	4.68	4.50
V_2 = JL-24	29.83	26.68	2.21	2.23	4.56	4.38
V_3 = TG-26	26.56	22.91	1.94	2.01	3.98	4.01
V_4 = TAG-24	24.72	19.73	1.64	1.69	3.82	3.89
SEm±	0.84	0.52	0.05	0.04	0.12	0.07
CD (P=0.05)	2.49	1.56	0.16	0.12	0.36	0.21
Interaction						
SEm±	1.45	0.91	0.09	0.07	0.21	0.12
CD(P=0.05)	NS	NS	N.S	N.S	N.S	N.S
General Mean	28.30	24.73	2.03	2.08	4.26	4.19

However, sowing of 24th MW was comparable with 26th MW sowing dates. The pod yield per plant was influenced significantly due to various dates of sowing. Sowing on 26th MW produced maximum yield of pods per plant which was significantly higher than other dates of sowing but on par with 24th MW. The weight of pods per plant was decreased with delayed sowing. The weight of pods per plant was significantly lowest with sowing on 28th MW. The pod yield per plot was influenced significantly due to various dates of sowing. Sowing on 26th MW produced maximum weight of pods per plot which was significantly superior to other dates of sowing but on par with variety 24th MW. The weight of pods per plant was decreased with delayed sowing on 28th MW. The yield of dry pods differed significantly due to various dates of sowing. Sowing on 26th MW yielded maximum dry pods which were significantly superior to all the other sowing dates. The sowing on 24th MW and 28th MW gave significantly lower yields of dry pods as compared to sowing on 26th MW. Similar results were reported by Sardana and Kandhola (2007). The haulm yield was influenced significantly due to various dates of sowing. Sowing on 26th MW produced maximum haulm yield per plot which was significantly superior to other dates of sowing but on par with 24th MW sowing. Haulm yield per plot was decreased as sowing was delayed. The haulm yield per plot was minimum with sowing on 28th MW.The variety JL-501 produced a maximum number of pod per plant which out yielded rest of the varieties but comparable with variety JL-24. The variety TAG-24 had the significantly lowest number of per plant. Result found similar those reported by Bharud*et al.* (2005). The weight of pods per plant was influenced significantly due to varieties. However, the weight of pod per plant was maximum in variety JL-501 which was significantly higher than other varieties under comparison. The weight of pods per plot was influenced significantly due to varieties. The weight of pods per plot was maximum in variety JL-501, which was significantly superior to rest of varieties, expect JL-24. It would be seen from the data that dry pod yields were influenced significantly due to varieties. However, the variety JL-501 produced maximum dry pod yield which is significantly superior to other varieties and the lower yield obtained by the variety TAG-24. Similar results were reported by Sardana and Kandhola (2007). The haulm yield per plot was maximum in variety JL-501 but on par with variety JL-24.

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Effect of genotypes and tillage practices on seed yield and economics of wheat

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Seed is a "Miracle of Life" and most critical input for sustainable agriculture production in a cost effective way. Despite the all-good research efforts, availability of improved seeds in adequate quantities is a major constraint for realizing the potential crop yields in many parts of world. It is estimated that the direct contribution of quality seed alone to the total production is about 20–25% depending upon the crop and it can be further raised up to 45% with efficient management of other inputs. Hence availability of quality seeds of improved genotypes will consequently result in increased production and farm income to resource poor farmers of eastern IGP.Intensive tillage based cropping systems cause' soil degradation and promotes the mineralization of soil organic matter and thus its loss over time. To address these challenges field experiments were carried out during the winter season of 2012 and 2013 at IISR, Kushmaur, Mau, Uttar Pradesh to evaluate the effect of different tillage practices and genotypes on seed yield and economics of wheat (*Triticum aestivum* L.).

METHODOLOGY

The field experiments were carried out at Indian Institute of Seed Science,Kushmaur, Mau,Uttar Pradesh during the winter season of 2012 and 2013.The experiment consist of 18 treatment combinations comprising of 3 tillage systems viz., Zero tillage (ZT), Conventional tillage (CT) and Raised Beds (RB) as main plots while 6 wheat genotypes viz., KRL 213, HD 2733, PBW 550, HD 2967, KRL 210 and DBW 39 were assigned in sub-plots in split-plot design with three replications. The soil of the experimental field was clay loam in texture, slightly alkaline reaction, low in organic carbon and available N, medium in available P and available K. The wheat crop was sown under ZT after application of Glyphosate @ 0.5 kg *a.i.*/ha before sowing at proper moisture, while CT crop was sown as farmers practices with a tractor-drawn seed drill using a seed rate of 100 kg/ha and a spacing of 20 cm. In RB, 2 rows of wheat on each bed (30 cm apart) was established using 75 kg/ha seed rate while under ZT plots, the crop was sown without any preparatory tillage using zero-till seed-cum-fertiliser drill with a seed rate of 100 kg/ha and spacing of 20 cm. The recommended dose of N: P: K(120:50:40 kg/ha)was applied through urea,diammonium phosphate and MOP, respectively. A full dose of P and K along with half dose of N were applied as a basal and remaining N was applied in 2 splits at crown root initiation (CRI) and ear initiation (EI) stages of the crop. The weeds in experimental plots were controlled using post-emergence herbicides application through 2,4-D (500 g *a.i.*/ha) and Sulfosulfuron (25 g *a.i.*/ha) at 25 to 30 DAS. The first irrigation was given 20 to 25 days after sowing and thereafter the experiment plots were irrigated every 20 to 25 days until the end of the season a total of 3 to 4 irrigations were applied to crops. Processed seed yield was computed based on the data on seed yield and expressed in tons/ha. The cost of cultivation and net returns were calculated by taking into account the prevailing cost of inputs, seed price (grain MSP+20% higher) and local market price of straw. All the data were statistically analyzed using the analysis of the variance (ANOVA) technique. The critical differences at 0.05% level of probability were calculated to assess the significance between treatments if significant.

RESULTS

The research findings revealed that tillage and genotypes had significant effect on seed yield of wheat (Table 1 and Fig. 1). In present finding, wheat seed and biological yield as well as harvest index was highest in ZT which was on par with CT and significantly higher than RB. The magnitude to increased mean seed, biological yield and HIunder ZT over CT and RB were 2.9, 0.8, 1.93; 30.7, 26.5 and 6.0%, respectively. This increments might be due to higher number of effective tiller m^2under ZT planted wheat as compared to CT and RB.Seed yield of wheat in ZT was more than the CT and RB could be attributed to the better utilization of soil moisture, water use efficiency, nutrients uptake and less fluctuation in the soil temperature (Mali *et al.* 2006). Further soil organic matter in the ZT was more due to residue retention which increased the holding water capacity, soil aggregation, microbial activity; soil porosity resulted reduced the water and wind erosion. Among the genotypes, HD 2967 performed better throughout the experiment and produced the significantly higher seed yield (4.72 t/ha) than the KRL 210 (3.76 t/ha), PBW 550

Table3. Seed yields of wheat, as affected by different tillage and genotypes in rice–wheat rotation (Pooled over 2 years)

Treatment	Seed yield (t/ha)	Biological yield (t/ha)	HI (%)	Cost of cultivation (₹×10³/ha)	Net returns (₹×10³/ha)
Tillage method					
ZT	4.82	10.36	46.6	23.7	75.5
CT	4.68	10.25	45.7	31.1	65.6
RB	3.34	7.61	43.8	28.1	41.1
CD (P=0.05)	0.37	0.58	1.67		
Genotype					
KRL 213	4.46	9.41	47.2	27.6	61.9
HD 2733	4.24	9.48	44.4	27.6	61.0
PBW 550	4.10	8.95	45.9	27.6	55.8
HD 2967	4.72	10.28	46.0	27.6	67.5
KRL 210	3.76	8.92	42.0	27.6	56.4
DBW 39	4.42	9.42b	46.7	27.6	61.5
CD (P=0.05)	0.26	0.55	2.39		

(4.10 t/ha) and HD 2733 (4.24 t/ha). However, the genotype, KRL 213 (4.46 t/ha) and DBW 39 (4.42 t/ha) were also performed better and found on par with HD 2967. Similar trends were also found for biological yield. This is due to more number of effective tillers m^{2}was higher which leads to more seed yield in HD 2967 as compared to other genotypes.The maximum mean cost of cultivation was recorded under CT (31,100/ha) followed by RB (28,100/ha) and lowest in ZT (23,700/ha) while mean net returns were observed highest under ZT (75,500/ha) followed by CT (65,600/ha) and least in RB (41,100/ha). The saving in total cost of cultivation due to ZT was7,400 and 5,000/ha, while under ZT additional net returns gain was9,900 and 34,400/ha as compared to CT and RB, respectively. These saving in cost of cultivation under ZT mainly due to no-requirement of preparatory tillage unlike CT & RB, where intensive tillage operations needed before wheat seeding. Tillage and crop establishment account shared major part of total cultivation cost (Jat *et al.* 2014).

CONCLUSION

Based on the results of our study we suggest that zero tillage system is pathway for improving wheat productivity, income and food security of eastern IGP as compared to conventional system. However, more efforts will be needed to improve ZT and RB technology a location/site specific basis for wheat seed production.

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Effect of crop intensification and establishment techniques on system productivity in rice-wheat cropping system under irrigated condition

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The rice-wheat is the principal cropping system in south Asian countries that occupies about 13.5 million hectares in the Indo-Gangetic Plains, of which 10 million hectares are in India. This cropping system is dominant in most Indian states as Punjab, Haryana, Bihar, Uttrakhand, Uttar Pradesh and Madhya Pradesh, and contributes to 75% of the national food grain production (Gupta and Seth, 2007). To meet the increasing food demand, the productivity of the rice-wheat cropping system need to increase and continued. Development or adoption of new crop establishment methods and inclusion of new crops in the system may be some of the ways of increasing productivity and resource conservation.

METHODOLOGY

A field experiment was conducted in E_2 Block of Norman E. Borlaug Crop Research center, G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand (India), during 2014 - 2015. The experiment was laid out in a randomized block Design (RBD) with nine treatment combinations viz; T_1 (Rice (TPR) – Wheat – Continue), T_2 (Rice (TPR) - Vegetable pea - Groundnut, T_3 (Rice (DSR) - Vegetable pea - Maize (Grain), T_4 (Rice (DSR) - Potato -Cowpea (Grain), T_5 (Rice (DSR) - Vegetable pea - Maize (cob + fodder), T_6 (Rice (DSR) - Yellow Sarson - Black Gram, T_7 Rice (DSR) (B)+Sesbania (F)- 2:1 (FIRBS 45cm * 30 cm) -Vegetable pea (B) + Toria (F)-2:1 (FIRBS) - Maize (B) (cob + fodder) + Mentha (F) 1:1(FIRBS), T_8 Soybean (B)+Rice (DSR) (F)-2:1 (NBS 60cm * 30 cm) - Wheat + Mentha (3:1) (NBS 60cm * 30 cm) - Continue (NBS 60cm * 30 cm), T_9 Maize (B) (cob + fodder) + Cowpea (B) + Sesbania (F)-2:1:2 (BBF 105cm * 30 cm) - Vegetable pea + Toria-3:1 (BBF) - Groundnut+Mentha-3:1(BBF) and replicated thrice.

RESULTS

Total system productivity as tabulated and depicted in (Table 1) shows that, total system productivity in terms of rice equivalent yield (t/ha/year and kg/ha/day) was the highest under Rice (DSR) – Potato - Cowpea (T_4) (30.91 t/ha/yr or 84.68 kg/ha/day).it was followed by Maize + Cowpea +

Table 1. Rice equivalent yield (REY), total system productivity, production efficiency crop growing periods, land use efficiency (LUE) and relative production efficiency as influenced by different cropping system.

Treatment	REY (t/ha)			SP(t REY /ha)	PE (kg REY /ha/day)	CGP (days)	LUE (%)	RE (%)
	Kharif	Rabi	Summer					
T_1	4.25	5.42	-	9.67	26.49	264	72.32	-
T_2	4.40	8.19	7.19	19.78	54.19	290	79.45	104.55
T_3	4.37	11.31	-	15.67	42.93	300	82.19	62.05
T_4	4.27	20.66	5.99	30.91	84.68	319	87.39	219.65
T_5	4.50	7.26	6.93	18.68	51.18	296	81.09	93.17
T_6	4.19	3.42	5.93	13.54	37.10	325	89.04	40.02
T_7	3.33	6.74	9.66	19.73	54.05	348	95.34	104.03
T_8	6.06	4.69	2.99	13.74	37.64	340	93.15	42.08
T_9	7.71	7.58	6.06	21.35	58.49	332	90.95	120.07
CD (P=0.05)	0.36	0.49	0.19	6.14	-	-	-	-

T: Treatment, TPR: Transplanted rice, DSR: Direct seeded rice B.: On raised bed F: Furrow, FIRB: Furrow raised bed system, NBS: Narrow bed system and BBF: Broad bed system, SP: System productivity, PE: Production efficiency, CGP: Crop growing period, RE: Relative efficiency.

Sesbania- Veg. Pea+Toria– Ground nut+Mentha (T_9) system (21.35 t/ha/yr or 58.49 kg/ha/day) with lowest value in control i.e. Rice–Wheat (T_1) cropping system (9.67t/ha/yr or26.49 kg/ha/day). The cropping system Rice (DSR) + Sesbania- Vegetable pea+ Toria – Maize + Mentha treatment (T_7) occupied land for more number of days (348 days) followed by Soybean + Rice – Wheat + Mentha - Mentha (T_8) (340 days). The cropping system of Rice – Wheat (T_1) treatment occupied land for a minimum number of days (264 days). (Gangwar and Ram, 2005) reported that maximum yield equivalent was highest in rice-potato-greengram sequence compared to another cropping sequence. The land use efficiency was highest in Rice (DSR) + Sesbania- Vegetable pea+ Toria – Maize + Mentha treatment (T_7) (95.34%) over all the other cropping systems followed by Soybean + Rice – Wheat + Mentha continued (T_8) (93.15%). The lowest land use efficiency was registered under Rice - Wheat (T_1) treatment with 72.32%. Relative production efficiency (%) under Rice (DSR) – Potato - Cowpea (T_4) was found maximum (219.65%) due to higher tuber yield of potato in this cropping system compared to Rice (TPR) - Wheat (Conv.) treatment (T_1) cropping system.

CONCLUSION

Rice (DSR) – Potato - Cowpea seems to be most productive followed by Maize + Cowpea + Sesbania- Veg. Pea +Toria – Groundnut + Mentha over other cropping systems.

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Sustainable fodder production management in Uttarakhand Hills

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Livestock rearing is an integral part of the Hills. Besides, contributing to a balanced diet, and income; livestock impart sustainability to Crop Production Systems by providing much-needed farm power and manure for the hill agriculture. Cultivation of fodder is rarely practiced in hills due to small and fragmented land holdings, lack of irrigation, difficult terrain and poor socio-economic conditions. At present, almost whole livestock population thrives on grazing nearby hills slopes, which are of poor nutritive value. There is a big gap between the availability and requirement of fodder. In the state of Uttarakhand, fodder availability is only 40- 50% of the requirement. Therefore, any future increase in fodder production will have to be from waste lands (8,696 Km^2) and forests. The whole cultivated land which is around 10-13 % of total geographical area is used for cultivation of cereals, pulses and oil seeds. Range lands and forest which are around 50 to 70% of total geographical area are the major sources of forage for sheep, goats, rabbits, cattle and other animals. Studies conducted by the scientists of ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora,with the objectives i.e. fodder production through utilization of marginal land, fodder production management during lean period have led to the development of appropriate technologies for proper fodder production management in hills.

METHODOLOGY

These include management of natural grasslands, production of improved grasses under trees in wastelands , sloping and degraded lands, utilization of terrace risers by growing erect growing grasses, planting fuel-cum-fodder trees by improved pit methods, fodder production from marshy lands, energy plantation and silvi-pastoral system. Several grasses were tested under these conditions.

RESULTS

In case of grassland management it was found that two years of effective closure increase forage production up to four folds (3.83 t/ha vs. 0.97 t/ha). Introduction of improved grasses such as *Digetaria decumbense, Cynodon plectortachus, Panicum coloratum, Chloris gyana, Panicum maxicum, Setaria kazungula* can successfully enhance the fodder yields. Application of nitrogen and phosphorus on natural pastureland can increase the forage yield. Stage and frequency of cutting significantly influenced the quantity and quality of forage. On the sloping and degraded lands and under pine and deodar trees Hybrid Napier was found to be the best. It produced 25.0-35.0 t/ha green fodder during first year and 45.0- 75.0 t/ha during second year onwards. In degraded steep slopes (30-40% slope or more) and shallow lands, *Grewia optiva, Morus alba, Robinia pseudoacacia* and *Quercus leucotrichophora* can be grown through improved pits. Improved pit planting yielded maximum green forage followed by square pit. Erect growing grasses like *Setaria kazungula, Setaria nandi,, Panicum coloratum*, and *Pennisetum purpureum* can be grown on the field terrace risers. *Pennisetum purpureum* produced the highest green forage yield (30.0 t/ha) followed by *Setaria* spp. Kudzu vine (*Pureria thumbergiana*), a very hardy and fast growing legume was found extremely suitable for protecting unstable, sensitive and highly degraded sites. In hills, marginal and submarginal lands can be utilized by adopting silvipastoral system of forage production. A silvipastoral system including combination of *Digetaria decumbense* with *Bauhinia purpurea Quercus leucotrichophora*. In silvi horti system turmeric (12.0 t/ha) and ginger (8.0 t/ha) produced significantly higher rhizome yield under *Quercus leucotrichophora*. Green forage yield varied from 5.7 kg/tree by *Quercus leucotrichophora* to 7.7 kg/tree by *Bauhinia vereigata*. In case of grassland management it was found that two years of effective closure increase forage production up to four folds (3.83 t/ha vs. 0.97 t/ha) in control. Introduction of improved grasses such as *Digetaria decumbense, Cynodon plectortachus, Panicum coloratum, Chloris gyana, Panicum maxicum, Setaria kazungula* can successfully enhance the fodder yields. Application of nitrogen and phosphorus on natural pastureland can increase the forage yield. Stage and frequency of cutting significantly influenced the quantity and quality of forage. In hills during winter months green fodder availability is a major problem due to sub-zero temperatures and heavy frosting. *Lolium parene*, *Festuca arundinacea*, and Grassland manawa gave encouraging yields ranging from 20.0 to 30.0 t/ha. Among legumes white and red clover were found promising. Dual purpose varieties of wheat (VL Gehun 829 and 616) developed by VPKAS, Almora are capable of providing substantial quantity of green forage (7.0-8.0 t/ha) during phase of initial growth without initial growth significant reduction in grain yield (Bisht *et.al.,*2011).

CONCLUSION

By adoption of improved planting techniques and management practices degraded and wastelands can be successfully developed for production of forages in mid hills. Thus, the production of fodder from the waste lands will be able to reduce the gap between demand and availability and well fed livestock will help ensure higher productivity and income to hill farmers in addition to ensuring environmental security of the hills.

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Evaluation of pulses and oilseed under different crop establishment methods in rice-fallows of Eastern India

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Rice-fallows basically imply to those lowland areas of *kharif* sown rice, which remain uncropped during winter due to lack of irrigation or excessive soil moisture. Of the total 11.65 m ha area in India, the Eastern states account for 83.51% (9.73 m ha) (Subbarao *et al.*, 2001). In rice-based cropping systems, the productivity of succeeding winter crops is considerably influenced by crop establishment methods. The late harvesting of high yielding transplanted rice varieties particularly in eastern part of the country delays sowing of succeeding pulses and oilseeds, resulting in lower crop yields

(Mishra and Singh, 2011). The residual moisture left in the soil at the time of rice harvest is sufficient to raise the suitable short-season pulses and oilseeds. Development and popularization of improved varieties of these crops suiting to the rice fallow of different agro-ecological region coupled with improved production technology will boost the production, thus improve income and livelihood security of the farming community. In view of the success of conservation technology in wheat under rice-wheat system, continued energy crisis and ever increasing prices of pulses and oilseeds, the present investigation was undertaken to evaluate the relative performances of pulses and oilseeds under different crop establishment techniques in rice-fallows of Eastern India.

METHODOLOGY

A field experiment was conducted during winter season of 2015-16 at ICAR Research Complex for Eastern Region, Patna. The soil of the experimental plot was clay (sand : 11.04, silt : 39.84 and clay : 49.12), low in organic carbon (0.47%), available N (238.33 kg N/ha), high in available P (25.68 kg P/ha) and available K (478 kg K/ha), with neutral in reaction (*p*H 7.71). Experiment was laid out in a split-plot design comprising three crop establishment methods i.e. *utera* (sowing crops in standing rice10 days before rice harvest), zero tillage (ZT) and ZT with straw mulch @ 5 t/ha) in main-plots; five pulses and oilseeds *viz*. lathyrus (Ratna), chickpea (JG-14), lentil (HUL-57), linseed (T-397) and Indian mustard (Pusa Mustard) in sub-plots and replicated thrice. Crop was sown on 9th Nov. and 24th Nov. 2015 under *utera* and zero tillage, respectively. Overnight soaking of seeds of pulses and oilseeds was done to hasten the germination and to get the optimum crop stand in *utera* cropping. The foliar application of 2% urea at flowering and pod formation stages of the crops was done as a part of the nutrient management strategy under *utera* system. Nipping practices was followed to enhance fruiting branches in chickpea and lathyrus at 40 days after sowing.

RESULTS

Significantly higher plant population was recorded with *utera* system (799×10^3 ha) as compared to ZT with straw mulch @ 5 t/ha (696×10^3 ha) and ZT (550×10^3 ha). This might be due to the optimum moisture content in the soil at sowing, which helps the crop seeds to establish better. The yield attributes of pulses and oilseed were found to be significantly superior with respect to different crop establishment method. The pods or siliqua/plant and seeds/pod or silique were recorded significantly higher with *utera* as compared to ZT and ZT with straw mulch @ 5 t/ha (Table 1). Further, the markedly higher yield attributes were also noted under ZT with straw mulch @ 5 t/ha as compared to ZT. Significantly higher rice equivalent yield (REY) was recorded with *utera* system (2029 kg/ha) as compared to ZT with straw mulch @ 5 t/ha (1424 kg/ha) and ZT (1187 kg/ha). The system rice equivalent yield (SREY) was also found markedly higher with *utera* (6409 kg/ha) as compared to ZT with straw mulch @ 5 t/ha (5833 kg/ha) and ZT (5581kg/ha). The *utera* system depleted the maximum soil moisture from the soil (121.46 mm) followed by ZT (62.03 mm) and ZT with straw mulch @ 5 t/ha (49.8 mm). Among the different crops grown, the moisture depletion rate in soil ranged 70.01 mm in linseed to 84.36 mm in lentil.

CONCLUSION

The above study suggest that after transplanted rice in *kharif*, growing of lathyrus/lentil/ linseed through *utera* system during *rabi* is a better option for realizing the higher system productivity in rice fallow in Eastern India.

Table 1. Yield attributes and rice equivalent yield of crops as influenced by different crop establishment method.

Treatment	Plant population (×10^3 ha)	Pods or siliqua/plant (no.)	Seed/pod orsiliqua (no.)	REY (kg/ha)	SREY (kg/ha)	Total moisture depletion (mm)
Establishment method						
Utera	799	71.7	6.97	2029	6409	121.46
Zero tillage	550	55.8	4.73	1187	5581	62.03
Zero tillage with straw mulch @ 5 t/ha	696	64.8	5.73	1424	5833	49.8
CD (P=0.05)	98	7.28	0.90	199	587	9.40
Crop						
Lathyrus	396	34.0	3.91	2727	7124	78.57
Chickpea	169	36.5	2.23	754	5143	80.41
Lentil	969	104.9	2.73	1702	6080	84.36
Mustard	441	82.9	11.18	590	4985	75.46
Linseed	1434	62.1	8.99	1961	6372	70.01
CD (P=0.05)	97	5.74	0.80	162	223	8.55

REY: Rice equivalent yield, SREY: System rice equivalent yield

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Study on bio-efficacy, phytotoxicity and residue analysis of herbicide in non-cropped area

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Among all the biotic constraints for crop production 'Weed' is the most problematic one. In India, weeds generally reduce crop yield by 36.5% during rainy season and 22.7% during winter and in some cases cause complete crop failure. Economic analysis has shown that among various methods of weed control, use of herbicides is much economical than mechanical/ manual methods.

METHODOLOGY

A field experiment was conducted at the Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during post *kharif* season of 2014-'15 in non- cropped area. The field was laid out in a randomized block design (RBD) having 9 treatments replicated thrice. The treatments were glyphosate 71%SG @ 710, 1420, 2130, 2840, 3550, and 4260 g a.i/ha., Mera 71% (cheek) commercial sample @ 2130 g a.i./ha , untreated control and weed free cheek. Observations on a) population of monocotyledonous and dicotyledonous weeds b) dry weight of weeds in g/m^2 at 0, 30 and 60 days after application and c) weed control efficiency (WCE) were recorded and statistically analyzed.

RESULTS

Among the six doses of the herbicide namely glyphosate 71% SG @ 710, 1420, 2130, 2840, 3550, and 4260 g a.i/ha, it has been found that all the doses of the herbicide had performed well in respect of controlling weeds but glyphosate 71%SG @ 4260 g a.i./ha came out as the best one. So far as population of weeds, dry weight of weeds and WCE at 30 and 60 DAA were concerned, glyphosate 71%SG @ 4260 g a.i./ha exhibited most superior performance being statistically different from all other treatments. As treatment glyphosate 71% SG @ 2130 g a.i. /ha gave sufficient control of weeds in non-cropped area at *terai* region of West Bengal, it can be recommended.

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Response of different seed rates on growth and yield of mungbean (*Vigna radiata*) cultivars

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A field experiment was conducted in a randomized block design (Factorial) with three replications to response of different seed rates on growth and yield on mungbean (*Vigna radiata* L.) cultivars was conducted during the *kharif* season of 2012 at the plot no. 200 of the Crop Research Farm, Department of Agronomy, Allahabad School of Agricultural, Sam Higginbottom Institute of Agriculture Technology and Sciences, Allahabad on was sandy loam in texture, neutral pH (7.4), low in organic carbon content (0.28%), low in available nitrogen (225 kg/ha), medium in available phosphorus (21.5 kg/ha) and low in available potassium (87 kg/ha). The three factors are variety and seed rate levels. Variety has three levels i.e. Samrat, SML-668 and HUM-12, and three levels of seed rate 15 kg/ha, 25 kg/ha and 35 kg/ha. The other common packages of practices were followed time to time and periodically are observations were recorded on growth and yield for evaluating the treatment effects. Variety SML-668 with 25 kg/ha seed rate recorded highest plant height, maximum no. of branches, maximum plant dry weight and yield attributes namely number of pod/plant, grains/pod, test weight and seed yield.

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Yield and yield attributes of safflower cultivars as affected by sowing dates

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Safflower [*Carthamus tinctorius* (L.) Moench] is a very useful oilseed crop for rainfed or dryland areas. Generally it is known as Kusum or Kardi. Safflower is a member of the family Compositae and originally grown for the flowers that were used in making red and yellow dyes. Planting date is very important in agricultural production management decisions, especially at region having environmental restrictions such as sooner or later coldness or serves (Emami *et al.* 2011). Cultivar selection is also a key management component in any cropping system even more critical in sowing date for crop production (Soleymani *et al.* 2011). All the varieties may not be suitable for timely as well as the late sowing. The differences in production of timely sown and late sown crops may be attributed to the unfavourable temperature prevailing at different growth stages, such as low temperature at the time of germination which may delay crop emergence. It was reported that the sowing date and cultivars of safflower vary depending on ecological conditions (Daltalab *et. al.* 2013). Therefore, in order to obtain safflower with high yield and quality, it is essential to determine the suitable growth conditions and cultivation techniques. So the aim of this study was to evaluate the "Yield and yield attributes of safflower cultivars as affected by sowing dates".

METHODOLGY

An experiment was conducted during the year 2013–14 under All India Coordinated Research Project on safflower, at RVSKVV, College of Agriculture, Indore (M.P.). A set of 9 treatment combinations comprising 3 dates of sowing (1st November, 15th November, 30th November) as main plots and 3 cultivars (A-1, NARI-6, NARI-57) as subplots laid out in split plot design with 4 replication. The soil of experimental field was a typical medium black soil (vertisol), soil pH 8.2, EC (0.432 ds/m), low in organic (0.36 %), medium in available Nitrogen (235 kg/ha) and available phosphorus (14.9 kg/ha but high in available potash (411 kg/ha). Seeds were used with 20 kg/ha With Planting geometry (R×P) 45 × 20 cm. The recommended dose of fertilizer (60 N + 40 P_2O_5 + 20 K_2O kg/ha) was applied in safflower. Harvest operation done manually. Studied attributes that selected using 5 plants randomized in each plot. The data was analyzed by the method of "Analysis of Variance" as described by Panse and Sukhatme 1985.

RESULTS

The data showed in Table 1, indicated that the Sowing date and cultivars had significant effect on yield and yield attributing characters. It was observed that sowing of safflower on 1st November recorded significantly higher Yield attributing characters viz. number of capitula/plant (26.21), weight of capitula (78.60 g/plant), Number of seeds/capitula (22.21), 100 seed weight (6.20 g) as compared to 15th November and 30th November respectively. Increase in different yield attributing characters in 1st November sowing might be due to more availability of favorable environmental condition at the vegetative and reproductive phase of the crop and might be due to better uptake of nutrients and translocation of photosynthates during the reproductive phase of the crop, thus increasing the size and weight of seeds. Similar result was found by Emami *et al.* 2011 and Odivi *et al.* 2013 reported that delay in sowing resulted generally decrease in the yield attributes.

Among the cultivars of safflower, A-1 had significantly higher yield attributing characters viz. capitula/plant (27.21), weight of capitula (96.72 g/plant), and 100 seed weight (6.55 g) over NARI-57 and NARI-6. The variation in these yield attributing parameters of the cultivars might be related to inherent differences and high vigour in these cultivars. Similar results were reported by Ali Reza Badri *et al.* 2011.

The data presented in Table 1, indicated that highest seed yield (1701 kg/ha), straw yield (5,683 kg/ ha) and oil yield (484 kg/ha) was obtained under 1st November sown crop, which was significantly higher over 15th November and 30th November sown crop. The positive effect of date of sowing on straw yield may be due to the pronounced growth during early stages of crop. Similar result was noted by Odivi *et al.* 2013.

Among the cultivars of safflower, A-1 gave the highest seed yield (1700 kg/ha), straw yield (5,535 kg/ha) and oil yield (416 kg/ha) as compared to NARI-57 and NARI-6. Similar results were reported by Muralidharudu *et al.*1989, Hulihalli *et al.* 1997. The findings are in close confirmity with Sheykhlou *et al.* (2012).

CONCLUSION

The experiment was conducted at different cultivar at different sowing date. The results indicated significant differences among different sowing dates and cultivars for seed yield, straw yield and oil yield with the highest from crop grown on 1st November. This is probably due to different moisture and temperature conditions at sowing and seed development stage. As a result of this study, it was concluded that sowing date affected seed and oil yield of safflower. Delayed sowing date decreased seed and oil yield per unit of area. By planting safflower earlier, plants are able to get the full benefit of soil moisture and nutrients during the extended growing season, allowing more total seeds capitula-1 to form because of sufficient time to fill. Consequently, among the cultivars, A-1 proved to be the most suitable in the maximum seed and oil yield. Therefore, it can be recommended to cul-

Table 1. Mean comparison for experimental characteristics

Treatments		Number of capitula plant^{-1}	Weight of capitula (g plant^{-1})	Number of seeds capitula^{-1}	100 seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Oil yield (kg ha^{-1})
Sowing dates	1 November	26.21	78.60	22.21	6.20	1701	5683	484
	15 November	23.92	69.27	20.25	5.49	1314	4787	345
	30 November	20.79	58.83	19.54	5.22	1041	4260	248
	SEm	0.48	2.01	0.21	0.05	11.58	48.55	3.00
	CD at 5 %	1.65	6.97	0.74	0.18	40.07	168.02	10.38
Cultivars	A-1	27.21	96.72	19.67	6.55	1700	5535	416
	NARI-6	19.25	52.48	21.92	4.80	1022	4429	276
	NARI-57	24.46	57.51	20.42	5.56	1333	4767	384
	SEm	0.33	1.28	0.18	0.05	8.37	34.56	2.32
	CD at 5 %	0.99	3.79	0.52	0.15	24.87	102.67	6.90

tivate safflower cultivar A-1 sown in 1st November for higher seed and oil yield in safflower production in Madhya Pradesh.

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Effect of planting geometry on yield and economics of baby corn (*Zea mays* L.) varieties

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Among the different kinds of corn, baby corn is a delicious and nutritive vegetable and is consumed as a natural food. It is a specialty corn that provides carbohydrates, proteins, fats, sugars, minerals and vitamins in palatable and digestible form.The earliness facilitates crop diversification, increases overall cropping intensity in a year and enhances profitability.Identification of high yielding variety is the most vital agronomic input as the entire cob is harvested as one baby corn. Slender and upright varieties that can easily fit in narrow row spacing and can yield number of cobs per plant is suitable for the cultivation of baby corn. However, the full potentiality of a variety could be exploited only when they grow under optimum planting geometry (Shobhana *et al*., 2012). Hence, the present investigation was taken up to study the influence of planting geometry on yield and economics of baby corn varieties.

METHODOLOGY

A field experiment was conducted during *rabi* 2014-15 at the College farm, College of Agriculture, Rajendranagar, Hyderabad, Telangana. The experiment was laid out in a randomized block design with factorial concept. Three varieties (‘30V92’, ‘Seed Tech-740’ and ‘VL-42’) along with four planting geometries (45 cm x 15 cm, 45 x 20 cm, 60 x 10 cm and 60 cm x 15 cm) were accommodated and replicated thrice. Tassels were removed from all the plants as and when emerged. The cobs were harvested at green stage within 2-3 days of silking. Harvesting of 30V92 and Seed Tech-740

Table 1. Yield and economics of baby corn varieties as influenced by planting geometries

Treatment	Cob yield (kg/ha)	Corn yield (kg/ha)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Variety (V)						
'30V92'	4310	1774	43,621	1,13,083	69,463	2.58
'Seed Tech-740'	4112	1637	38,373	1,07,037	68,665	2.78
'VL-42'	5997	2421	46,003	1,53,953	1,07,951	3.34
CD (P=0.05)	130	84	-	-	2831	-
Planting geometry (P)						
45 cm x 15 cm	5296	2193	43,165	1,33,754	94,389	3.17
45 x 20 cm	4497	1799	42,071	1,16,097	74,026	2.75
60 x 10 cm	5005	1980	43,355	1,31,102	87,748	3.01
60 cm x 15 cm	4426	1768	42,071	1,14,010	71,939	2.69
CD (P=0.05)	135	89	-	-	2847	-

started at 76 and 75 DAS respectively and finished in 3 pickings whereas for VL-42 harvesting started at 55 DAS and finished in 5 pickings. Observations were analysed by standard statistical procedure.

RESULTS

Cob and corn yield differed significantly among the three varieties. Higher yields were observed in 'VL-42' followed by '30V92' and 'Seed Tech-740'. The increase in corn yield in VL-42 over 30V92 and Seed Tech-740 was 36 and 27% respectively. Variation in yield among the varieties was due to significant differences in the number of cobs/plant. 'VL-42' had significantly higher number of cobs/plant (3) which resulted in higher yield. The cost of cultivation was highest for 'VL-42' followed by '30V92' whereas it was lowest for 'Seed Tech-740'. Gross returns were higher in 'VL-42' followed by '30V92' and 'Seed Tech-740'. Net returns were significantly higher in 'VL-42' but 'Seed Tech-740' gave lower net returns which were on par with '30V92'. Benefit cost ratio was highest in 'VL-42' followed by 'Seed Tech-740' whereas lowest benefit-cost ratio was observed in '30V92'.Varying planting geometry showed marked differences in yield of baby corn. Planting geometry of 45 cm x 15 cm with 1, 48,148 plants / ha gave significantly higher cob and corn yield followed by 60 x 10 cm with 1,66,666 plants /ha. The lower yield was observed with 60 cm x 15 cm which was on par with 45 x 20 cm with the same plant population of 1,11,111 /ha. The increase in plant density from 1,48,148 /ha to 1,66,666 /ha drastically decreased the cob and corn weight/plant because of acute competition for growth factors that even increased plant population could not compensate the loss in cob and corn yield. Net returns were significantly higher with the planting geometry 45 cm x 15 cm whereas 60 cm x 15 cm gave significantly lower net returns. Maximum benefit-cost ratio was recorded with 45 cm x 15 cm whereas it was minimum with 60 cm x 15 cm. Significantly higher net returns and benefit–cost ratio with the planting geometry of 45 cm x 15 cm having plant population of 1, 48,148/ha was due to higher cob yield than other planting geometries.

CONCLUSION

The results showed that higher cob, corn yield and net returns were obtained from 'VL-42' with a spacing of 45 cm x 15 cm whereas significantly lower net returns were obtained from 'Seed Tech-740' with the planting geometry of 60 cm x 15 cm. Thus, baby corn variety 'VL-42' under optimum planting geometry of 45 cm x 15 cm is a viable option for crop diversification in peri-urban areas.

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Extended Summaries Vol. 2 : 4th International Agronomy Congress, Nov. 22–26, 2016, New Delhi, India

Effect of planting geometry on yield performance of ginger (*Zingiber officinale*) intercropped with maize (*Zea mays*)

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Ginger (*Zingiber officinale* Rosc.) is one of the important spices grown throughout India for its pleasant aroma and pungency, used for culinary and medicinal purposes. It is cultivated in an area of 1,32,620 ha with a production of 6,55,060 tonnes during 2013-14. We also export the ginger and earn foreign exchange. Ginger is grown both as rainfed and irrigated crops and cultivated in different land configuration systems such as ridges and furrows, raised beds, small mount etc. depending on the land slope, rainfall/irrigation/soil type. The duration of the crop in the field vary depending on rhizome use, if it is for vegetable purpose, harvested five months after planting and for dried produce and other industrial use it is harvested between 7 and 10 months. It offers very good scope for intercropping and many short duration cereals, pulses, vegetables are intercropped with ginger (Kandiannan *et al*., 1996). Kerala is an important ginger producing state, where ginger is cultivated in rainfed as quantum of rainfall receipt is more >3000mm per annum with good distribution. The earlier experiment indicated that maize can be successfully grown with ginger without affecting both the crops yield (Kandiannan *et al*., 1999). The objective of this study was to identify optimum population of maize to grow with ginger.

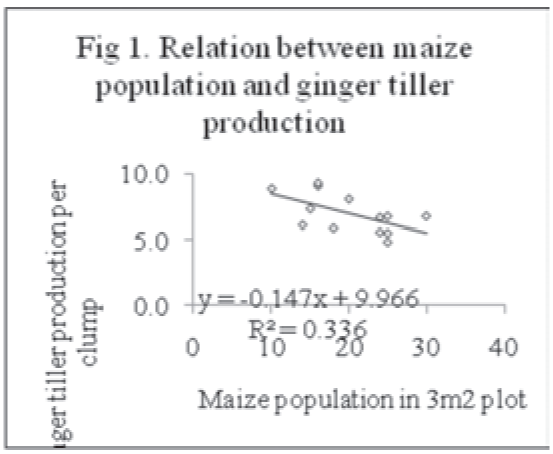
METHODOLOGY

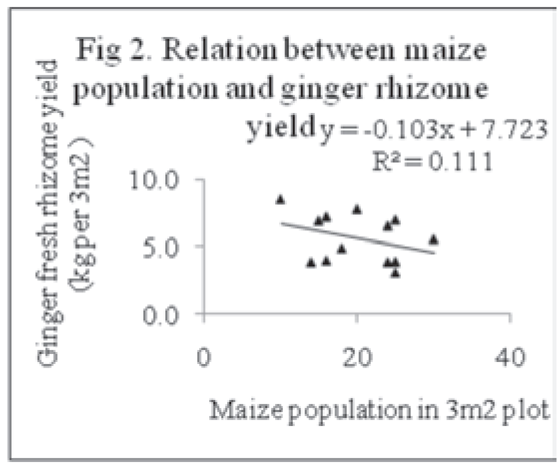
The experiment was conducted at ICAR-Indian Institute of Spices Research(IISR), Kozhikode during 2014-15. The soil of the experimental field was laterite. There were thirteen treatments of ginger + maize intercropping system with additive and replacement series. The treatment was replicated thrice in RBD. ICAR-IISR recommended packages practices were adopted and there is no extra manure for maize was added. Ginger cultivated on a raised bed of 3m x 1m size having four rows each with 10 plants per row. Normal spacing adopted for ginger is 25cm x 30cm, i.e., row to row spacing is 25 cm and plant to plant is 30 cm. The treatment T1- Normal ginger planting with four rows and maize planted on either lengthwise side of the raised bed with nine plants per side(Ginger 40 plants + Maize 18 plants); T2- Normal ginger planting with four rows and maize planted on either lengthwise side of the raised bed and one row in centre between two ginger rows with eight plants per row, (Ginger 40 plants + Maize 24 plants), T3- Two rows of ginger in between three rows of maize alternatively (Ginger 20 plants + Maize 24 plants); T4- Three rows of ginger and two rows of maize alternatively(Ginger 30 plants + Maize 14 plants(7 plants per row); T5- Two rows of ginger in the centre and two rows of maize on either side(Ginger 20 plants + Maize 16 plants(8 plants per row); T6- Three rows of ginger in the centre and two rows of maize on either lengthwise side(Ginger 30 plants + Maize 16 plants(8 plants per row); T7- Normal ginger planting with four rows and maize planted on either width wise side of the raised bed with five plants per row(Ginger 40 plants + Maize 10 plants); T8- Normal ginger planting with four rows and maize planted on either width wise side and one row across in centre with five plants per row(Ginger 40 plants + Maize 15 plants); T9- Normal ginger planting with four rows and maize planted on either width wise side and two rows across with equal distance in centre with five plants per row(Ginger 40 plants + Maize 20 plants); T10- Normal ginger planting with four rows and maize planted on either width wise side and three rows across with equal distance in the centre with five plants per row(Ginger 40 plants + Maize 25 plants); T11- Normal ginger planting with four rows and maize planted on either width wise side and four rows across with equal distance in the centre with five plants per row(Ginger 40 plants + Maize 30 plants); T12- Normal ginger planting with four rows and maize planted five rows across ginger rows alternate to two ginger plants (Ginger 40 plants + Maize 25 plants) and T13- Normal ginger planting with four rows and maize planted five rows across ginger rows alternate to one ginger plant in the edges and alternate to two ginger plants in the middle (Ginger 40 plants + Maize 25 plants). Ginger (IISR Varada variety) and maize (Syngenta Hybrid) were planted on 17/6/2014, maize cob was harvested as and when matures and straw was harvested on 18/9/2014,ginger tiller count was made on 19/9/2014 and ginger final population count and harvest was done on 15/3/2015. The data analysed statistically by adopting standard procedures.

Table 1. Effect ginger + maize cropping system on tiller production and yield of ginger

Treatment	Ginger population in 3 m^2 plot	Maize population in 3 m^2 plot	Number of maizecob harvested/plot	Ginger tiller production/ clump	Ginger fresh rhizome yield (kg/3 m^2 plot)
T1	40(35)*	18	21.0	5.9	4.9
T2	40(39)	24	16.3	6.7	6.6
T3	20(18)	24	23.3	5.6	3.9
T4	30(27)	14	20.0	6.1	3.9
T5	20(19)	16	16.7	9.1	4.0
T6	30(28)	16	13.7	9.3	7.2
T7	40(37)	10	11.7	8.9	8.5
T8	40(34)	15	15.0	7.4	6.9
T9	40(38)	20	20.3	8.1	7.8
T10	40(38)	25	22.7	6.8	7.0
T11	40(35)	30	28.0	6.8	5.6
T12	40(38)	25	30.0	5.5	3.9
T13	40(38)	25	34.0	4.8	3.1
SEd±	1.99	0.51	0.75		
CD (P=0.05)	4.05	1.06	1.54		

*Figures in the bract are final population at the time of harvest





RESULTS

Intercropping maize in ginger influenced the tiller production and rhizome yield of ginger (Table 1). Ginger tiller production has varied between 4.8 and 9.3 per clump and fresh rhizome yield also varies from 3.1 kg to 8.5 kg/plot of 3m^2 raised bed. In general, increasing maize population reduced the ginger tiller production and yield. The relation between maize population and ginger tiller production (Fig 1) and yield (Fig 2) were negative $Y = -0.1036x + 7.723$ (R^2=0.1111) and $Y = -0.1471x + 9.966$ (R^2=0.3365), respectively. Increasing ginger population had a positive effect on its production $y = 0.1039x + 2.2458$($R^2 = 0.1826$). In our surlier study only four maize plants were planted on four corners of bed that did not affect the ginger yield (Kandiannan *et al*., 1999) due to less competition.

CONCLUSION

Maize is potential intercrop in ginger field it can be grown for grain purpose or fodder purpose in this experiment green cob harvested and sold and straw was utilized for making vermi-compost. In a 3m^2 plot of raised bed that is commonly followed in hill slopes and high rainfall areas for ginger production one can accommodate 10 to 20 maize plants without affecting main crop yield.

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Sustainability of cassava (*Manihot esculenta* Crantz) for continuous cultivation: a decade experience in an Ultisol of Kerala, India

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Tropical tuber crops are one among the major food crops, which can contribute to the food, nutritional, economic and employment security of more than 500 million people globally. Among the tropical tuber crops, cassava is the most important owing to its high biological efficiency (250 k cal/ha/d), yield potential (25-50 t/ha), ability to sustain under marginal environments, tolerance to pests and diseases, high starch extraction rate and the excellent physico-chemical properties of cassava starch. The research experience over half a century on plant nutrition of cassava points to its high and positive response to manures and fertilizers. At ICAR-CTCRI, a long-term fertilizer experiment (LTFE) has been in progress since 1977 and is running presently in the third phase since 2005.This paper establishes the sustainability of cassava for continuous cultivation in the same field based on 10 years data since 2005 focussing on an absolute control treatment where no fertilizers and manures were applied for cassava and the same was compared with different levels of fertilizers with respect to tuber yield, sustainability index (Singh *et al*., 1990) and economic analysis.

METHODOLOGY

The experiment originally consisted of 20 treatments replicated thrice in RBD and the cassava variety grown was a hybrid H1687 (Sree Visakham). For the purpose of this paper, four treatments viz., T1-NPK @125:50:125 kg/ha+ FYM @ 12.5 t/ha), T2 - (PoP-NPK @ 100:50:100 kg/ha+ FYM @ 12.5 t/ha), T3- Soil test based fertilizer cum maurial recommendation (STBFR) (mean recommendation was FYM@ 7.25 t/ha + 83:0:64 kg/ha) NPK @ and T4- Absolute control were taken. Soil test based fertilizer cum manurial recommendation (T3) was arrived at based on the post harvest soil status of organic carbon, available P and K following the procedure of Aiyer and Nair (1985) for major nutrients viz., N,P,K and Susan John *et al*. (2010) for organic manure *viz.,* FYM. The tuber yield over a period of 10 years under absolute control was compared over rest of the treatments to confirm the sustainability of cassava for long term cultivation in the same field.

RESULTS

The data on tuber yield over a period of 10 years under the influence of the four selected treatments indicated that T1 is on par with T2 and T3 during all these years except in three years viz., 2007, 2012 and 2014. During all these years, without P and with N to the tune of 78-91% and K to the tune of 25-106% under T3 recorded a tuber yield on par with PoP. The pooled mean over these 10 years revealed T1 as significantly highest with a tuber yield of 27.302 t/ha which in turn was on par with T2 (26.069 t/ha) and which in turn is on par with T3 (23.901 t/ha) (Table 1). The absolute control treatment without any manures and fertilizers gave the lowest tuber yield among the four treatments in the range of 6.5 - 18 t/ha with a mean yield of 14.53 t/ha. The low or poor yield reflected in the absolute control compared to other treatments can be attributed to the shortage of nutrients for yield realization as reported by Sanchez and Swaminathan, (2005). It is clearly revealed that, where the supply of nutrients in the soil

Table 1. Tuber yield (t/ha) as influenced by the treatments over a period of 10 years

Treatment	Years										
	06	07	08	09	10	11	12	13	14	15	Pooled Mean
T1	24.316	18.531	28.048	32.030	29.225	33.110	29.790	25.098	30.844	32.851	28.384
T2	23.795	12.624	30.965	31.020	32.571	32.130	24.700	24.901	25.173	27.615	26.549
T3	23.546	15.851	31.065	26.159	26.236	27.121	21.320	22.871	22.571	22.272	23.901
T4	17.015	6.583	17.999	13.975	15.926	11.027	17.280	12.140	17.933	15.171	14.529
CD (P=005)	3.092	2.001	3.198	7.927	8.092	6.816	6.356	6.395	5.867	7.109	2.665

Table 2. Economic analysis of the different treatments (Pooled mean over 10 years)

Treatment	Tuber yield (t/ha)	B:C ratio	Input cost (Rs./ha)	Cost of cultivation	Gross Income	Net income
T1	28.38	2.219	17944	191894	425764	233871
T2	26.55	2.087	16855	190805	398241	207436
T3	23.90	1.959	9148	183098	358518	175420
T4	14.50	1.251	0	173950	217574	43623

either as native or externally applied is adequate, crops are more likely to grow well and produce large amounts of biomass. The continuous mining of nutrients from the soil resulting from unbalanced fertilizer practices can lead to unhealthy soils and plants as evident from the result and therefore fertilizers should be applied in sufficient quantities and in balanced proportions. However, the yield under absolute control indicates the sustainability of the crop for long term cultivation in the same field without applying any manures and fertilizers. However, the sustenance of the crop under absolute control can be attributed to the high leaf dry matter (2.0- 7.7 t/ha) production and high leaf nutrient content especially N (3-5%) coupled with the innate physiological mechanism of leaf shedding character of the crop which in turn can nourish the soil both physically and chemically for better tuberization and tuber bulking. Moreover, cassava leaves are rich in all nutrients and the mean (10 years) content of nutrients viz., N, P, K, Ca, Mg, Fe, Cu, Mn and Zn in cassava leaves accounts to the tune of 4.41, 0.28, 1.25, 0.21, 0.321, 0.016, 0.0008, 0.0154 and 0.0064 % respectively. Hence, the high nutrient content coupled with the high carbon content in the leaves attributed to the better soil productivity and hence the crop productivity.

The absolute control without any plant nutrition resulted in a sustainable yield index of 0.455, a net income of Rs. 43,000/ and a B:C ratio of 1.251 indicating the potential of cassava as the most sustainable crop for long term cultivation in the same field (Table 2).

CONCLUSION

The experience over 10 years under the long-term fertilizer experiment in cassava at ICAR-CTCRI clearly confirmed the fact that, cassava is a most suited sustainable crop for continuous cultivation in the same field even without any manures and fertilizers. However, as most of the field crops respond negatively to repeated growing in the same field, the potential of cassava as a sustainable crop for long-term cultivation deserves special mention especially under the present scenario of global climate change.

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Seed priming and zero tillage -low cost technology for chickpea production in lateritic soil of West Bengal

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Chickpea (*Cicer arietinum* L.) is an annual grain legume crop grown mainly for human consumption and one of the most important protein crops throughout the world. It plays an important role in human nutrition as a source of protein, energy, fiber, vitamins and minerals for large population sectors in the developing world and is considered a healthy food in many developed countries (Abbo *et al*., 2003). Chickpea is grown mainly with residual soil moisture in arid and semi-arid zones under rainfed condition and where water scarcity is major limitations. Inadequate soil moisture causes a series of morphological, physiological and molecular changes that adversely affect crop growth and productivity. Crop establishment through zero tillage is one of the best opportunities for soil moisture conservation as well as its proper utilization. Seed priming is a better option from an economical perspective as less micronutrient is needed, it is easy to apply and seedling growth is improved (Johnson *et al.,* 2005). Keeping in view a study was conducted on the "tillage and nutripriming on chickpea productivity in lateritic soil of West Bengal".

METHODOLOGY

A field experiment was conducted in medium upland soil under rain fed condition during

season of 2014-15 at Agriculture college farm, Visva-Bharati, Sriniketan, West Bengal. The soil of the experiment site was sandy-loam in texture having high percentage of sand (62.5) and low percentage of clay (26.0). The soil was slightly acidic (6.1), low in soil organic carbon (0.49%), available nitrogen (136 kg/ha) and phosphorus (11.5kg/ha) and medium in potassium (160.5 kg/ha). The field experiment was carried out in split plot design with two tillage system *viz*., conventional tillage (CT) and zero tillage (ZT) and five nutripriming *viz.,* control (NP_1), hydropriming (NP_2), zinc sulphate (6g $ZnSO_4$ /kg of seed, NP_3), boric acid (1.25g H_3BO_3/kg of seed, NP_4) and zinc sulphate + boric acid (NP_5).The chick pea variety "Anuradha" was sown immediately after the harvest of the previous crop rice. In the zero-tillage treatment, weeds were removed before planting and a slot or narrow furrow was made manually to place fertilizer and seed with without any preparatory tillage after the harvest of rice crop.In the conventional tillage treatment, plots were ploughed thoroughly cross wise with soil turning plough and two harrowing were done followed by one laddering.For nutripriming, seeds were soaked in respective solution or waterfor 8 hours at

Table 1. Effect of tillage and nutripriming on growth and branches of chickpea

Treatment	LAI at 80 DAS	Dry matter accumulation (g/plant) at 80 DAS	RLWC (%) at 80 DAS	Total chlorophyll (mg/g of fresh leaf)	Primary branches /plant at harvest
Tillage					
CT	1.4	10.0	63.5	2.26	3.3
ZT	1.54	12.1	71.2	2.46	3.7
SEm±	0.01	0.05	1.0	0.02	0.04
CD (P=0.05)	0.05	0.30	6.0	0.10	0.25
Nutripriming					
NP_1	1.34	10.3	57.7	2.26	3.3
NP_2	1.45	10.3	61.5	2.31	3.3
NP_3	1.49	11.6	72.3	2.41	3.9
NP_4	1.48	10.4	70.4	2.38	3.2
NP_5	1.61	12.9	75.0	2.47	4.5
SEm±	0.02	0.20	1.3	0.04	0.21
CD (P=0.05)	0.07	0.59	3.8	0.13	0.63

Table 2. Effect of tillage and nutripriming on yield parameters, yield and economic of chickpea

Treatment	Pods/plant	Grains/plant	Grain yield (kg/ha)	Net return (/ha)	B:C ratio
Tillage					
CT	27.3	44.8	768	13716	1.62
ZT	30.3	52.2	881	22137	2.36
SEm±	0.45	0.48	14	654	0.03
CD (P=0.05)	2.72	2.89	87	3976	0.20
Nutripriming					
NP_1	20.9	30.7	644	9790	1.49
NP_2	28.8	39.3	765	15371	1.78
NP_3	29.7	55.2	914	21889	2.08
NP_4	28.3	48.2	820	17813	1.88
NP_5	36.3	69.0	979	24771	2.22
SEm±	1.04	1.94	23	1074	0.05
CD (P=0.05)	3.12	5.81	70	3219	0.16

room temperature (25±2°C). Seed weight to solution volume ratio was 1:1.5 (w/v). Thereafter seeds were removed, given three surface washings and re-dried with forced air near to its original weight. Untreated seeds were used as control treatment.Chickpea was sown 23November, 2014 in zero tillage and 1 December in conventional tillage, 2014.

RESULTS

The result showed that tillage and nutripriming exerted significant influence on growth of chickpea. The crop under zero tillage and nutripriming with zinc sulphate + boric acid recorded maximum leaf area index, dry matter production, relative leaf water content (RLWC) and chlorophyll content and branches/plant over the crop under conventional tillage (Table 1). Higher growth under zero tillage and might be due to the availability of more soil moisture contents in the soil profile during entire growth period because the soil is not tilled and exposed to the drying (evaporative) elements of the atmosphere. Similarly, zero tillage and zinc sulphate + boric acid recorded greater number of branches/plant, number of pods/ plant, grain yield, net return and benefit:cost ratio in comparison to those obtained from the crop grown under conventional tillage and other primed treatments (Table 2). Zero tillage recorded significantly higher net return/ha (22137) and benefit: cost ratio of 2.36. Nutri-priming with zinc sulphate + boric acid recorded significantly higher net return/ha (24771) and higher benefit: cost ratio of 2.22.

CONCLUSION

It may be concluded that higher grainyield of chickpea can be achieved under zero tillage with 6g $ZnSO_4$ +1.25g H_3BO_3 /kg of seed.

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Screening of rice F_5 families for resistance to *Rhizoctonia solani*

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Rice is a major cereal crop that contributes significantly to global food security. Biotic stresses, including the rice sheath blight fungus, causes severe yield losses that significantly impair rice production worldwide. Sheath blight is usually not noticed until late tillering to midseason (panicle differentiation). Early symptoms include oval sheath spots (lesions) at or just above the water line, often at the junction of the leaf and sheath. Early lesions are pale green to off-white with a narrow purple-brown or brown border, usually 2" or less wide and 1-2" long on most varieties. Lesions may join as the disease moves up the plant. The rapid genetic evolution of the fungus often overcomes the resistance conferred by major genes after a few years of intensive agricultural use. Therefore, resistance breeding requires continuous efforts of enriching the reservoir of resistance genes/alleles to effectively tackle the disease. Seed banks represent a rich stock of genetic diversity, however, they are still under-explored for identifying novel genes and/or their functional alleles. Hence in the present study, we conducted a large-scale field screening for sheath blight resistance sources in fifty F_5 families of rice obtained from the cross MTU 7029/ PAU 3140-126-1 will enable us to identify rice varieties resistant to this disease.

METHODOLOGY

In the present study, during *kharif* 2015, all the fifty F_5 families obtained from the cross MTU 7029/ PAU 3140-126-1 along with their susceptible check (MTU 7029) were sown in two rows each with a spacing of 20 x 15 cm and were screened against sheath blight by adopting typha leaf bit method of artificial inoculation done at 69 DAS followed by field screening at maximum tillering stage and panicle initiation stage when 95% of check variety was affected using 0-9 scale of Standard Evaluation System given by IRRI, 2014. Fertilizer management and plant protection measures were followed as per recommendations in this field so as to make the field free from other pests and diseases.This method was first used by Bhaktavastalam *et al.* (1978) for mass multiplication of Sheath blight causing fungus. In this method, uniform sized typha bits were cut and sterilized in autoclave and inoculated with *Rhizoctoniasolani*. The material is kept under wet condition for multiplication of the fungus. After complete coverage of the typha bits with fungal mat, the bits were used for artificial inoculation. Two bits per hill were used for artificial inoculation. The bits were inserted in between the tillers at the base of the plant and tied with thread so as to come in contact with the neighbouring tillers. Inoculated hills were observed for the appearance of the symptoms twice, initially at maximum tillering stage and later at panicle initiation stage and scores were recorded as per 0-9 scale of SES, IRRI, 2014. Highest score among the two was considered as final one.One should note that in both seedling and field tests, folded young leaves and old leaves or leaves with symptoms of nutrient deficiency or other diseases should be avoided for inoculation.

RESULTS

The screening was conducted at Andhra Pradesh Rice Research Institute and Regional Agricultural Research Station, Maruteru during *kharif*, 2015 based on SES, IRRI, 2014. All the fifty F_5 families were grouped into five classes based on their susceptibility to that disease *viz.*, plants showing score 1 were treated as immune, those with score 3 were taken as resistant plants while those recorded score 5 were termed as moderately resistant, plants with score 7 were considered as susceptible ones and those plants recorded score 9 were taken as highly susceptible ones. When the host pIant doesn't show

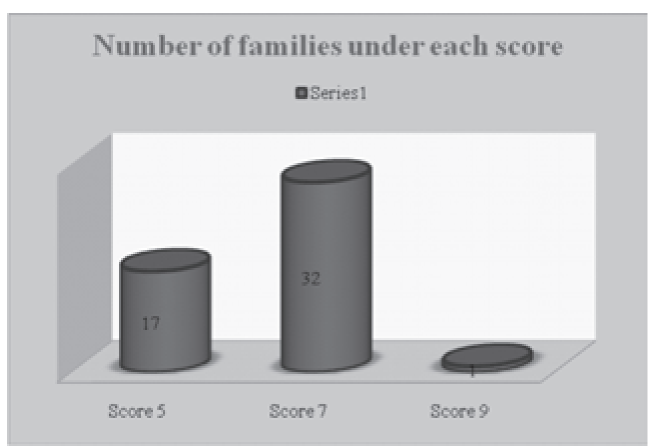

Fig. 1. Number of families under each score

any symptoms of disease, it is considered as immune to that disease and there will be no yield loss in such case. If the host plant reports little symptoms of the disease but the yield loss is very low or negligible, such condition is termed as resistance. When the host plant shows disease symptoms but can tolerate the disease to some extent giving moderate to high yield, then the plant is said to be moderately resistant. Susceptible and highly susceptible plants show maximum yield loss, sometimes leads to total crop failure. Practically it is very difficult to develop immune varieties. Hence**,** plant breeders concentrate on developing resistant and moderately resistant varieties.In the present study, among the fifty F_5 families screened against sheath blight no family was found to be immune or resistant (Table 2). Seventeen families (MTU 2469-28-1-1, MTU 2469-7-2-1, MTU 2469-22-1-1, MTU 2469-38-1-1, MTU 2469-33-1-1, MTU 2469-2-1-1, MTU 2469-23-1-1, MTU 2469-36-2-1, MTU 2469-18-3-1, MTU 2469-32-3-2, MTU 2469-34-1-1, MTU 2469-9-2-1, MTU 2469-68-3-1, MTU 2469-34-3-1, MTU 2469-30-2-1 and MTU 2469-30-1-1) recorded moderate resistance to sheath blight while thirty two families (MTU 2469-32-3-1, MTU 2469-4-3-1, MTU 2469-6-1-1, MTU 2469-69-3-1, MTU 2469-39-2-1, MTU 2469-64-1-1, MTU 2469-41-3-1, MTU 2469-4-4-1, MTU 2469-48-2-1, MTU 2469-41-1-1, MTU 2469-32-4-1, MTU 2469-12-2-1, MTU 2469-17-2-1, MTU 2469-57-3-1, MTU 2469-41-2-1, MTU 2469-35-3-1, MTU 2469-57-1-1, MTU 2469-39-5-1, MTU 2469-4-1-1, MTU 2469-39-4-1, MTU 2469-2-2-1, MTU 2469-29-1-1, MTU 2469-42-2-1, MTU 2469-58-1-1, MTU 2469-35-1-1, MTU 2469-69-1-1, MTU 2469-28-1-2, MTU 2469-57-2-1, MTU 2469-9-1-1, MTU 2469-4-2-1, MTU 2469-12-2-2, MTU 2469-37-3-1) showed susceptibility in addition to one family(MTU 2469-73-2-1) which were highly susceptible. A number of families for under each score was shown in fig 1.

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Paper tube nursery technique–breakthrough in cotton transplanting

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Transplanting of cotton has reduces main field duration, maintaining of plant population, manipulate the time of sowing to achieve optimum time, fitting crop into low length of growing period region, advantage in cropping system by reducing main field duration, beneficial over sowing seeds under delayed crop raising situations, and also suitable for the farm has undesirable quality of irrigation water for germination. However in crops like cotton, which are not highly amenable for transplanting. The tap root system of cotton is the bottle neck in transplanting. Many attempts have been made on transplanting but it is successful only at gap filling level. The paper tube method of nursery technique is attempted in cotton and the advantage of transplanting in different late planting is assessed.

METHODOLOGY

Paper tube Nursery technique was developed by following vigorous testing procedures during the year of 2013-14 and 2014-15 at Central Institute for Cotton Research, Regional Station, Coimbatore. Subsequently, field trial was conducted during 2015-16. The field experiment was attempted with two method of planting (transplanting and direct sown) and three planting times (27th August, 15th September (late planting), and 5th October (late planting)). The experimental soil was clay loam in texture, with a pH of 8.2 and organic carbon of 0.52%. Growth characters yield, and economics were worked out. Seedlings at the age of 21 days were transplanted in hole made by crow bar and pressed gently to avoid air pockets and irrigated immediately. The technique is summarized as follows; paper tube with size of 1cm diameter and height of 20 cm were filled (top 1 cm left unfilled to pore water) with equal portion of vermicompost, sand and soil and packed gently. The compactness of packing should be ensured in every tubes for proper germination. The healthy single seed

Table 1. Seed cotton yield (t/ha) and gross return (Rs./ha) as influenced by different dates of transplanting

Date of planting	Seed cotton yield			Gross returns		
	Transplanting	Direct sown	Mean	Transplanting	Direct sown	Mean
T1. 25th August	2.18	1.89	2.04	109000	94500	101750
T2. 15th September	1.78	1.26	1.52	89000	63000	76000
T3. 5th October	1.12	0.68	0.90	56000	34000	45000
Mean	1.69	1.28	1.49	84667	63833	74250
CD (P=0.05)	3.05	2.49	NS	10088	8236	14256

was dibbled in each tube and water was sprinkled from the top. The tubes were kept in iron tray filled with moist sand at bottom and covered with wire mesh facilitate to keep paper tubes in upwards. The seedlings at the age of 21 days were transplanted. Application of urea after transplanting helps to speed up the recovery of the transplanted seedling. The advantage of transplanting of cotton by using seedlings produced from paper tube nursery techniques experimented in 2015-16.

RESULTS

The interaction results revealed that 25th August transplanting registered 15.34 percent higher seed cotton yield as compared to corresponding date of direct sown crop (Table 1). However 5th October transplanting registered enhanced performance of 64.7 percent higher seed cotton yield as compared to corresponding date of direct sown crop. The results revealed that 25th August transplanting realized 4.8% higher net return but transplanting of 5th October arrived as 273.5 per cent of higher net return as compared to direct sown of same date respectively. Transplanted cotton gave increased seed cotton yield of 21.2% over direct sown cotton (Liu *et al.*, 1984). The lint yield by transplanting using straw nursery pots (SNPs), (which utilize agricultural residues such as wheat straw and corn stalks as raw materials) was 11.5 and 17.5% greater than for PNPs (plastic nursery pots) and direct sowing (DS) respectively (Zhang *et al.*, 2012). The results concluded that the visible advantage of transplanting observed in late sown situations.

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Studies on the performance of barley cultivars at different dates of sowing under irrigated condition

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Barley is coarse cereal crop of great importance in the world. Area under barley is mostly concentrated in the northern and north eastern plains of India. In India, major barley growing states are Rajasthan, Uttar Pradesh, Haryana, Punjab, Madhya Pradesh, Uttarakhand, Himachal Pradesh, Bihar, Jammu and Kashmir, West Bengal, Chhattisgarh and Sikkim. Now, barley is being cultivated in marginal and problematic lands as *rainfed* crop consequently resulting to the decreased in the production of barley. But as the crop is having high industrial importance, the agronomic aspects need specific attention to address the increased productivity of the crop. Higher grain yield of barley under timely sown condition as compared to other sowing dates of barley is well established (Ram *et al.*, 2010). Inspite of all the constraint, there are some

Table 1. Effect of dates of sowing on yield of different barley cultivars

Treatment	Grain yield (t/ha)		Straw yield (t/ha)		Harvest index (%)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Date of sowing						
19th to 23rd November	1.6	1.99	3.91	4.11	28.94	32.36
29th November to 3rd December	1.34	1.85	3.85	3.78	25.47	32.47
9th to 13th December	1.15	1.37	3.51	3.05	24.19	30.82
SEm±	0.03	0.04	0.04	0.07	0.39	0.91
CD (P= 0.05)	0.13	0.17	0.17	0.26	1.53	NS
Barley cultivar						
V1(HUB-113)	1.03	1.27	3.26	3.5	24.47	26.55
V2(K-603)	1.06	1.64	3.66	3.19	26.63	33.96
V3(K-409)	1.64	1.97	4.11	3.74	19.92	32.57
V4(K-551)	2.12	2.41	4.68	4.13	30.59	39.23
V5(K-560)	1.34	1.89	3.73	4	31.19	32.28
V6(K-201)	1	1.22	3.09	3.33	24.39	26.72
SEm±	0.07	0.06	0.09	0.11	0.91	0.86
CD (P= 0.05)	0.19	0.18	0.26	0.32	2.62	2.47
Interaction effect Dates of sowing x Variety						
SEm±	0.09	0.08	0.13	0.16	1.28	1.21
CD(P= 0.05)	0.27	0.25	0.37	0.45	3.71	3.49
Interaction effect Variety x Dates of sowing						
SEm±	0.08	0.08	0.12	0.15	1.22	1.38
CD (P= 0.05)	0.27	0.28	0.37	0.47	3.64	4.51

natural advantages for cultivation of *rabi* crops like long winter spell and high residual moisture in the soil during the initial phase of crop growth due to late cessation of monsoon rain. In order to utilise these advantageous situation barley can give better yield in this zone.

METHODOLOGY

The experiment was conducted at Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India in 2014-15 and 2015-16. The experiment was laid out in a split-plot design having 3 dates of sowing in main plots and 6 varieties in sub plots with 3 replication. Varieties were allocated randomly in sub plots. The sizes of each experimental plot were 4 m x 3.15 m. The recommended doses of fertilizer were applied with 3 numbers of irrigation and time to time plant protection measures were taken. The crop were harvested at different time for different dates of sowing viz. D_1, D_2,D_3 at 26.3.2015, 1.4.2015, 1.4.2015 during 2014-15 and 21.3.2015, 21.3.2015, 25.3.2016 during 2015-16 respectively.

RESULTS

The results from the experiment revealed that the timely sown (D_1) barley crop significantly increased the grain yield. Crop sown under timely sown (D_1) condition record the highest grain yield of 1.60 (t /ha) and 1.99 (t /ha) during 2014-15 and 2015-16 respectively. Among the six cultivars, the cultivar K-551 (V_4) perform best in respect of spike m^{-2}, number of grains/m^2 and test weight (g) of grains. Due to these factors, K-551(V_4) got the highest yield which was at par with K-409 (V_3). Among the varieties, K-551, being highest yielder under all three dates of sowing, recorded maximum net return *vis-a-vis* B:C ratio. Higher return in second year of experimentation was due to better yield performances for all the varieties compared with the first year.

CONCLUSION

The 3rd week of November is the optimum date of sowing for barley in the Eastern Indo-gangetic plain region.

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Crop geometry in relation to mechanical harvesting of sugarcane

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In sugarcane production the mechanization is limited up to land preparation, planting and intercultural operations. Presently, harvesting of sugarcane is done manually with different knives/tools giving an average output of 0.8 to 1.0 tonnes per man days (Singh *et al* 2013). Harvesting of sugarcane includes base cutting of standing cane stalks, detopping of green top and removal of dry trash, bundle making of cleaned cane stalks and loading to transport vehicle. Sugarcane harvesting is an energy intensive operation and total man power required for manual harvesting of sugarcane is about 175 man-days/ha. As the availability of labour is precarious and varies with season, the supply of sugarcane to mills becomes uncertain. This necessitates the mechanization of harvesting operation. Sugarcane harvesters operate best at120 cm or wider row spacing. But in Punjab the recommended row spacing is 75 cm, 90 cm and 90: 30 cm (paired row trench) according to need and season of the crop. In Punjab, one sugar mill started the sugarcane harvesting by sugarcane harvesters and some others are planning for these harvesters. So there is a need to find the crop geometry suitable for harvesters without compromising cane yield for making mechanical harvesting cost effective.

METHODOLOGY

The experiments were conducted at Punjab Agricultural University, Regional Research Station, Faridkot during 2012-13and 2014-15 with different row spacing of 120 cm, 150 cm and 120:30 cm (paired row trench). After that the experiment was also conducted at Faridkot, Kapurthala, Gurdaspur and Department of Farm Power and Machinery, Ludhiana with five row spacings i.e. 75, 90, 120, 90:30 and 120:30 cm in 2015-16. The sugarcane was planted in spring season in March at all locations during all the years. The sugarcane seed was used @ 12 buds/meter running row length.Chlorpyriphos 20 EC was sprayed over cane setts before covering them with soil to protect from termite and early shoot borer. The 150 kg N ha^{-1} was applied in two equal splits; half at first irrigation and half in May through urea. Cane yield was recorded after detopping of green top and trash stripping and given as t/ha.

RESULTS

During 2012-13, 2013-14 and 2014-15, at wider row spacing of 150 cm there is significant reduction in millable canes and cane yield but with improvement in single cane weight (Table 1). In paired row (120:30 cm) there is significant reduction in cane weight but more number of millable canes (NMC)resulted in higher cane yield. After these three year results the experiments was conducted at four locations with five row spacing in sugarcane. At Kapurthala and Gurdaspur the yield 90 cm was at par with sugarcane planted at 120 cm. (Table 2). As we know that the requirement of row spacing is 120 cm or more so on the basis of these experiments it was recommended that for mechanical harvesting, sugarcane can be planted at 120:30 cm in paired rows or at 120cm wider rows without reduction in cane yield. However, when spacing

Table 1. Yield and yield contributing characters of sugarcane under different planting methods at Faridkot

Row spacing	2012-13			2013-14			2014-15			Average		
	NMC '000/ha	Cane wt (g)	Cane yield (t/ha)	NMC 000/ha	Cane wt (g)	Cane yield (t/ha)	NMC 000/ha	Cane wt (g)	Cane yield (t/ha)	NMC 000/ha	Cane wt (g)	Cane yield (t/ha)
120 cm row spacing	88.6	1031	73.7	89.4	1247	90.2	88.2	1471	98.6	88.7	1250	87.5
150 cm row spacing	70.1	1066	58.1	77.7	1325	75.8	68.2	1544	86.5	72.0	1312	73.5
120: 30 cm (paired row)	106.6	841	74.4	120.8	1097	98.4	112.9	1137	107.8	113.4	1025	93.5
CD (P=0.05)	11.7	129	7.1	15.8	100	16.4	10.9	324	11.1			

NMC-number of millable canes

Table 2. Cane yield (t/ha) under different row spacing at different locations during 2015-16

Row Spacing	Cane yield (t/ha)				Mean
	Faridkot	Gurdaspur	Ludhiana	Kapurthala	
120 cm spacing	98.5	82.3	108.2	82.8	94.5
120: 30 cm paired row trenches	106.6	88.1	110.8	88.8	98.8
90: 30 cm paired row trenches	100.8	87.4	99.5	90.2	91.6
90 cm spacing	89.7	80.1	93.7	78.8	84.4
75 cm spacing	78.7	76.6	92.4	74.2	81.6
CD (P=0.05)	8.2	6.1	7.2	6.8	

is further increased up to 150 cm then there is significant reduction in cane yield. Rao and Rao (2013) also reported that spaced plantation in paired row (135:15 cm) can be followed successfully

CONCLUSION

On the basis of four year study it can be concluded that for mechanical harvesting of sugarcane, it can be planted at120:30 cm in paired rows or at 120 cm wider rows without reduction in cane yield.

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Enhancing productivity in American cotton using Mepiquat Chloride

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Cotton is an important commercial crop of south-western parts of Punjab for sustainable productivity. Cotton crop sometimes attains excessive vegetative growth due to reasons like high soil fertility, coincidence of vegetative growth period with rainy season coupled with high humidity. Thick crop canopy prevents penetration of light besides shading of bolls and utilization of plant energy on the formation of vegetative stature results in shedding of flower buds, flowers, immature bolls. Excessive vegetative growth often occurs at the expense of reproductive growth and a large fraction of squares and small bolls on the lower sympods either shed or open poorly resulting in low yield. The loss of reproductive structures alters the physiological growth and development of the plant by redirecting assimilates which normally are incorporated into these abscised organs to other plant parts. Under such circumstances, plant growth regulators may enhance seed cotton yield by increasing the retention of photosynthates into developing bolls. Therefore, the present study was carried out to evaluate the performance of Mepiquat Chloride in influencing productivity of *Bt* cotton.

METHODOLOGY

The experiment was conducted during *Kharif* 2015 at Punjab Agricultural University, Research Station, Faridkot which lies in Trans-Gangetic agro-climatic zone, representing the Indo-Gangetic alluvial plains ($30^0 40'$N & $74^0 44'$E) of Punjab, a typical representative of semi-arid south-western cotton belt, Zone IV, situated at 200 m above MSL. Field experiment comprised of eight treatments arranged in randomized block design with three replications using *Bt* cotton hy-

Table 1. Growth, seed cotton yield and yield attributes of American cotton under different treatments

Treatment	Plant height (cm)	Bolls/ plant	Boll weight (g)	Seed cotton yield (kg/ha)
T_1 : Control	135.2	33.4	3.42	1732
T_2: Mepiquat chloride @ 1000 ml/ha; Single application at 80-85 DAS	115.0	41.5	3.74	2028
T_3: Mepiquat chloride @1250 ml/ ha; Single application at 80-85 DAS	112.8	43.2	3.81	2201
T_4 : Mepiquat chloride @ 1500 ml/ha; Single application at 80-85 DAS	106.8	46.0	3.97	2315
T_5 : Mepiquat chloride@ 1500 ml/ha; (i.e 500 ml/ha each at 60,75 and 90 DAS) 3 applications	108.7	50.0	4.13	2529
T_6: Mepiquat chloride @ 1500 ml/ha; (i.e 750 ml/ha each at 75 and 90 DAS) 2 applications	101.4	48.7	3.87	2455
T_7: Mepiquat chloride @ 1750 ml/ha; (i.e @ 500 ml/ha + 625 ml/ha+ 625ml/ha at 60, 75 and 90 DAS) 3 applications	93.4	36.1	3.30	1816
T_8: De-topping at 70-75 DAS	103.8	40.0	3.74	2074
CD (P=0.05)	9.8	5.9	0.34	286

brid (NCS 855 BGII). The experimental soil was typically alluvial one with sandy loam texture, normal (pH 8.4, E.C 0.18 m mhos/cm), low in carbon (0.42%), medium in available P (21.7 kg P_2O_5/ha) but high in available K (750 kg K_2O/ha). The crop was sown on April 25, 2015 by dibbling 2-3 seeds/hill which were later thinned to one seedling per hill. Sowing was done at a planting geometry of 67.5 cm x 75 cm. Data on growth and yield attributes were recorded from five randomly selected plants in each treatment plot while seed cotton yield was recorded from whole plot.

RESULTS

Plant height and monopods per plant were significantly reduced with application of mepiquat chloride whereas boll number and boll weight improved statistically over the control. Kumar *et al.* (2005) also observed reduced intermodal length, which in turn reduced plant height and stimulated the translocation of photosynthesis towards reproductive sinks (developing cotton bolls) by use of mepiquat chloride, ultimately resulting in better yields. In our studies, boll count was highest (50.0) with Mepiquat chloride @1500 ml/ha in T_5 (i.e. 3 applications of 500 ml/ha each at 60,75 and 90 DAS) followed by T_6 (48.7) while least boll count (33.4) was recorded under Control. As a result, highest seed cotton yield (2529 kg/ha) was observed with application of Mepiquat chloride@1500 ml/ha in T_5 followed by T_6 (2455 kg/ha) with least yield of 1732 kg/ha under Control. Though, T_5 and T_6 treatments were at par for seed cotton yield but there was saving of one labour day in the later case as only 2 sprays were required instead of 3 sprays in T_5. Furthermore, highest dose of Mepiquat chloride @1750 ml/ha (i.e 3 applications @ 500 ml/ha + 625 ml/ha+ 625ml/ha at 60,75 and 90 DAS) lead to significant reduction in seed cotton yield (1816 kg/ha) primarily due to toxicity as was also indicated from maximum reduction in plant height (93.4 cm). Kumari *et al.* (2013) has also reported beneficial effect of applied growth regulator i.e stance 110 SC in improving yield attributes and seed cotton yield of American cotton in vertisols under rainfed conditions.

CONCLUSION

Application of Mepiquat chloride @ 1500 ml/ha (i.e. 2 applications @ 750 ml/ha each at 75 and 90 DAS) reduces excessive vegetative growth in high fertility soils and enhances seed cotton yield of American cotton.

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Performance of maize (*Zea mays*) hybrids at different fertility levels

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Maize is the third most important cereal crop after rice and wheat in India. Maize is known as the 'Queen of Cereals'. It is a principal staple food in many countries particularly in the tropics and subtropics. It has greater worldwide significance as human food, animal feed, fodder and source of large number of industrial products. In India, maize occupies about 8.67 m ha of area with total production and productivity of 22.26 m t and 2566 kg/ha, respectively (Govt. of India, 2014). In Rajasthan, it occupies 0.90 m/ha of area having a production of 1.56 m t with an average productivity of 1724 kg /ha (Govt. of Rajasthan, 2014). Arid climate of Rajasthan is especially suited for maize cultivation where it is grown mainly at Udaipur, Chittorgarh, Bhilwara and Dungarpur districts in southern part of Rajasthan.

METHODOLOGY

The field experiment was conducted during *kharif* 2014 at Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur with the objectives to work out suitable nutrient management practice for hybrid maize through SSNM. The experiment consisted of 15 treatment combinations comprising five hybrids (PHM-1, PHM-3, HQPM-1, CMH-08-350, CMH-08-292) and three fertility levels SSNM (110 kg N + 47 kg P_2O_5 +41 kg K_2O /ha), RDF (90 kg N + 40 kg P_2O_5 + 30 kg K_2O /ha) & farmer's practice (1 ton FYM + 54 kg N + 20 kg P_2O_5 /ha) laid out in factorial randomized block design replicated thrice.

RESULTS

Highest plant height (274.87 cm), dry matter (210.80 g/plant) at harvest and crop growth rate between 25-50 DAS (14.25 g/m^2/day)) and between 50-75 DAS (32.85 g/m^2/day) recorded with CMH-08-292 but hybrids did not show variation in relative growth rate. Highest LAI at 25, 50, 75 DAS and chlorophyll content (2.885 mg/g) at 50 % silking stage were recorded with CMH-08-292. Among yield attributes, cobs/plant (1.3), cob length (18.55cm), grains weight/cob (98.46 g) and 1000 grains weight (225.17 g) were recorded highest with hybrid CMH-08-292. The results of the present investigation are in close conformity with the findings of AICRP on maize (DMR, 2014).The highest grain (5753.33 kg /ha), stover (9001.11 kg /ha) and biological yields (14754.44 kg /ha) were recorded with CMH-08-292 followed by PHM-3 (Table 1). Amongst hybrids, CMH-08-292 fetched highest gross returns (₹ 85580.72 /ha), net returns (64072.52 /ha) and B-C ratio (2.98) and proved its superiority. PMH-3 proved

Table 1. Effect of hybrids and fertility levels on yields and harvest index

Treatments	Yields (kg/ha) Grain yield	Stover yield	Biological yield	Harvest index (%)	Net returns (₹/ha)	B-C ratio
Hybrid						
PMH-1	3911	6084	9996	39.12	34795	1.49
PMH-3	5032	7881	12913	38.97	51817	2.24
HQPM-1	2951	4262	7213	40.91	20855	0.93
CMH-08-350	4573	6978	11551	39.59	45917	2.10
CMH-08-292	5753	9002	14754	38.99	64072	2.98
CD (P=0.05)	386	542	814	NS	5290	0.24
Fertility level						
SSNM	5092	7887	12979	39.23	52989	2.35
RDF	4679	7217	11897	39.33	47011	2.11
FP	3561	5420	8981	39.65	30473	1.38
CD (P=0.05)	299	420	630	NS	4098	0.18

next best hybrid in terms of gross, net returns and B-C ratio.Application of SSNM significantly increased yield components *viz*. number of cobs/plant (1.25), cob length (18.14 cm), grains weight/cob (93.08 g), 1000 grains weight (228.72 g) and shelling percentage (86.31%) consequently grain (5092 kg/ha), stover (7886.67 kg/ha) and biological yield (12978.67 kg/ha) over RDF and farmer's practice (Table 1). Kumar, 2013 also reported positive response of maize crop to SSNM. The available N, P and K status of soil at harvest increase significantly with SSNM. Application of SSNM proved economically beneficial as it recorded significantly higher gross returns (75619.73 /ha), net returns (52989.75 /ha) and B-C ratio (2.35) over RDF and farmer's practice.

CONCLUSION

Maize hybrid CMH-08-292 proved the best followed by Hybrid PMH-3 under southern Rajasthan conditions. Application of SSNM appears to be the suitable economic fertility level for maize hybrid as it recorded higher grain yield (5092 kg /ha), net returns (52989 /ha) and B-C ratio (2.35).

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Sunshine hours and rainfall effects on rice productivity in Punjab

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Rice is the most important crop in Asia. More than 90 per cent of the world's rice is grown and consumed in Asia alone. Under changing climatic scenario, extreme of weather events are occurring and also predicted in future. These events will ultimately make stresses more common and severe. Recent studies indicate that the monsoon has changed in two significant ways during the past half-century; firstly it has weakened (less total rainfall during June-September) and secondly distribution of rainfall within monsoon season has become more extreme. Rice production in India is highly correlated with monsoon rainfall. The relationships between rainfall variation and rice production have attracted significant interest at a country scale, however, regional differences within the country remain unclear. In Punjab during *kharif* the amount of rainfall received and its distribution are important for rice productivity. The last 15 years rainfall data of Punjab indicates that the rainfall deficit years are more as compared to normal or excess rainfall years. Rice crop also requires abundant sunshine hours during its reproductive phase. The rice productivity in Punjab during drought years is comparatively higher owing to assured irrigation facilities. There is a lot of variation in rice productivity even during drought years. But still there is a need to quantify the relationships between rice yield, rainfall and sunshine hours. Keeping this in view, analysis was conducted to study the effect of rainfall and sunshine hours on rice productivity during drought years.

METHODOLOGY

To study the effect of rainfall variability and sunshine hours, data were collected from the Agromet. Observatory, School of Climate Change and Agril. Meteorology, PAU, Ludhiana. The detailed analysis of sunshine hours and rainfall was done using R Statistical Programme (R Core Team, 2015).

RESULTS

The *kharif* 2014 and 2015 were drought years in Punjab with rainfall deficit of 51 per cent and and 31 per cent during 2014 and 2015 respectively. The rice yield during both the years was comparatively higher. As compared to high rainfall years. During 2015 the rice productivity of Ludhiana district was higher as compared to 2014. The water requirement of rice crop is comparatively higher than any other crop of the same duration. Assured and timely supply of irrigation water has a considerable influence on the productivity of rice crop. During the crop growth period, the water requirement is generally high during initial seedling establishment stage. The higher rainfall received in July, 2015 was proved beneficial for good establishment of the crop. In September also during first fortnight 144.4mm rainfall was received in 2014 compared to 85.4 mm rainfall in 2015 (Table 1). The rainfall during the month of September is detrimental to the crop because it washed away the pollens as happened in case of 2014 when good of rainfall (first fortnight of September) was received during flowering period. Cloudy and rainy days are detrimental to the rice crop, particularly from flowering to maturity. It is not only the amount of rainfall but the distribution of rainfall during reproductive stage of rice crop plays a significant role.

Table 1. Monthly rainfall during 2014 and 2015

Month	Total rainfall (mm)		Difference from
	2014	2015	2014 (mm)
July	154.2	256.3	+102.1
August	89.6	165.6	+76
September	144.4	85.4	-59.0

The kernel density plot showed probability density distribution against amount of rainfall over *kharif* 2014 and 2015 (Fig.1). The highest data density was observed near 0 to 10 mm rainfall during both the years and decreased with increasing rainfall amount. This depicts poor distribution of rainfall in both the seasons.

Rice crop requires abundant sunshine hours at panicle initiation and flowering stages. In Punjab, generally heading/panicle initiation starts at 75-80 days after transplanting of rice crop. So the sunshine hours at this stage of rice crop are very important. It is well known fact that during reproductive period, solar radiation/sunshine hours affects spikelet number/m^2 and during ripening period it affects the filled grain percentage. The analysis of sunshine hours during 2014 and 2015 reveals that from 1-20 Sept., 2015, the sunshine hours were higher (+44.8) as compared to 2014 (Table 2).The bright sunshine hours during September month contributed higher productivity in 2015 as compared to 2014. Similar results were reported by Sandhu *et al.* (2013).

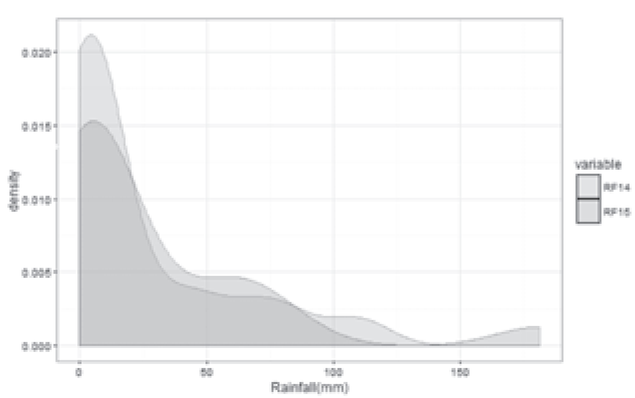

Fig. 1. Kernel density plot distribution of rainfall during *kharif* 2014 and 2015 Hours

Table 2. Sunshine hours during August and September

Sun Shine (hours)	2014	2015
0-2.5	9	11
2.5-5.0	8	7
5.0-7.5	11	6
7.5-10	26	18
>10	7	19

The direct solar radiation, which plays greater role in plant production, in terms of sunshine hours was depicted as box plots for the *kharif* 2014 and 2015 (Fig. 2). The mean sunshine duration was 7.52 (± 2.65) during *kharif* 2014 which was at par with sunshine duration recorded during *kharif* 2015 (7.05±2.65). Eventually there was no significant difference observed between two seasons.

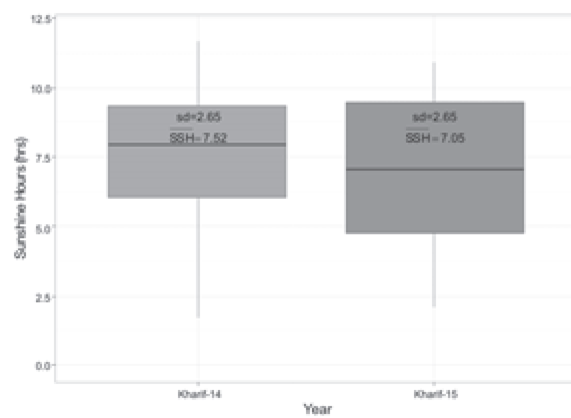

Fig. 2. Sunshine hours during kharif 2014 and 2015

CONCLUSION

Rice productivity is not only affected by amount of rainfall but also the distribution of rainfall during growing season. The rainfall received during first fortnight of September is harmful for rice productivity. Abundant sunshine hours during September month contributed for higher productivity in 2015. The insect and disease incidence during drought years is comparatively low which also contributes to higher productivity. Improved high yielding varieties, low incidence of insects and diseases and low favourable weather may have contributed for higher productivity in the state during 2015 as compared to 2014.

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Effect of sowing dates and seed rate on grain sorghum genotypes

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Sorghum is one of the major cereal crop consumed in India after rice and wheat. The identification of superior sorghum genotypes and development of location specific production technology offers an excellent opportunity to provide stable food for human as well as to bridge the deficit food better for human population. The number of plants required per unit area is one of the prime considerations for higher biomass production which depends upon the nature of the crop, growth habit and environment. During last few years change in climate is observed which causes change in plant behavior too the rate of plant development at successive stages of growth is important in determining climatic limits for economic production. An investigation conducted during *kharif*, 2012 and 2013 at Instructional Farm Agronomy, Rajasthan College of Agriculture, Udaipur to assess comparative performance of sorghum genotypes with different seed rates and date of sowing for maximizing of yield.

METHODOLOGY

The experiment consisted of 24 treatments combinations and replicated three times. It was laid out in factorial RBD with three dates of sowing (30^{th} June, 15^{th} July and 30^{th} July) and four genotypes (CSH 16, CSV 17, CSV 23 and CSH 23) and two seed rates (100% recommended i.e.10 kg/ha and 125% of recommended i.e.12.5 kg/ha). The soil was medium in available nitrogen (275.40 and 283.80 kg/ha) and low in phosphorus (20.50 and 20.70 kg/ha) and high in available potassium (338.20 and 341.40 kg/ha). Fertilizer application was made at normal recommended dose (80 kg N, 40 kg, P_2O_5 and 40 kg K_2O/ha). Full dose of phosphorus, potash and half dose of nitrogen were applied at the time of sowing through DAP, MOP and urea as a basal application. The quantity of nitrogen supplied through DAP was adjusted with urea. The remaining dose of nitrogen was top dressed at 30 DAS. Crop was planted at the spacing of 45cm x 10cm. Atrazine @ 0.50 kg/ha as pre-emergence was sprayed one day after sowing.

RESULTS

Among the genotypes of sorghum CSH-16 recorded maximum weight of panicle, grain weight/panicle^{-1}, test weight, protein content in grain and stover, nitrogen, phosphorus and potassium content in grain and stover, nitrogen, phosphorus and potassium uptake by grain & total uptake by genotype CSH-16. This genotype also recorded significantly highest grain yield (3341 kg /ha) over CSH-23, CSV-23 and CSV-17 which was 15.47, 5.17 and 3.55 per cent higher, respectively. Further, it was observed that CSV-23 came out as most promising when judged in terms of plant height, dry matter accumulation (various growth stages), LAI and number of grains/ panicle. This variety also recorded significantly highest stover and biological yields as compared to CSH-16, CSV-17 and CSH-23. Days to 50% flowering and maturity early observed in CSV-17. Whereas highest net returns (₹ 42483 /ha) and B: C ratio (1.76) was recorded by genotype CSH-16. The result showed that sowing of sorghum on 30^{th} June, recorded significantly higher, plant height, dry matter accumulation (at various growth stages), LAI, days to 50 % flowering, days to maturity, number of grains/panicle, weight/panicle, grain weight/panicle, test weight, grain and stover yield, nitrogen, phosphorus and potassium content (in grain and stover) at harvest, nitrogen, phosphorus and potassium uptake by grain and total uptake by the crop, protein content in grain & stover and yield as compared to 15th July and 30th July sowings. The 30th June sowing recorded (4233 kg/ha grain yield) as compared to 30th July which was 26.29 per cent higher. 15th July sown crop recorded significantly higher harvest index (27.49%). Highest net returns (₹46753 /ha) and B-C ratio (1.93) was recorded by 30th June sown. The seed rate 10 kg / ha produced significantly higher LAI and dry matter accumulation at (various growth stages), weight/panicle, grain weight/ panicle, test weight, harvest index, nitrogen, phosphorus and potassium content (in grain and stover) at harvest, nitrogen, phosphorus and potassium uptake (by grain) by the sorghum crop, and grain yield as compared to seed rate 12.5 kg/ha. Seed rate @ 12.5 kg/ha recorded significantly higher stover and biological yield (11664 and 15132 kg/ha) over seed rate 10 kg /ha. Genotypes CSH-16 with seed rate 10 kg /ha sown on 30th June recorded higher seed yield (3965 kg /ha) with maximum net returns of ₹42483/ha.

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Impact of varying planting dates on incidence of false smut disease of rice

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Anamorph: *Ustilaginoideavirens*; Teleomorph: *Villosiclavavirens*), once considered as the indicator of bumper yield, is getting worldwide importance because of its gradual increase in terms of yield and quality loss.The pathogen infect young ovary of individual spikelet and transforms them into yellow, olive green to blackish spore balls known as smut.Apart from yield loss this pathogen contaminates seed by producing mycotoxins which is poisonous to both humans and animals (Shan *et.al*. 2012). Management of this disease is tricky because the disease is observed normally after formation of ball, when the loss already is incurred. For proper management forewarning based study is necessary. Objective of present experimentwas to study the impact of planting date on disease incidence and yield loss.

METHODOLOGY

This study was undertaken during the wet of 2014 -16 in the experimental farm of the ICAR-Central Rice Research Institute, Cuttack, (20°252N, 48 85°552E; 24 m above mean sea level) situated in the eastern part of India. Three different varieties viz., Tapaswini (HYV, non-photosensitive), Pooja (HYV, photosensitive) and Ajay (Hybrid) were sown in three different date of sowing viz., early (3rd July), normal (18th July) and late (3rdAugust) and transplanted accordingly following split plot design with 4 replication and date of planting as main and variety as subplot. Normal agronomic practices were followed except high dose of nitrogenous fertilizer and no pesticide and fungicide were sprayed for controlling any other pest and diseases. Data were collected from each of the replicated plot based on random sampling basis and 50 panicles each of healthy (panicle free from false smut) and diseased (panicles infected by false smut)were collected randomly from each replication for yield loss estimation. Standard methodology for estimation of yield loss was followed (Atia, 2004).

RESULTS

No incidence was observed in Tapaswini and Ajay which were early plantedon 3rd Aug and matured during last week of October,whereas moderate incidence was observed inPooja which is photosensitive and flowering occurredduring the same time with normal(18th August) and late transplanting (3rd September).Moderate to high disease incidence was observed in normal and late transplantedvarieties. Per cent hill infection (%HI), per cent tiller infection (%TI) and appearance of false smut ball (AFB) are significantly difference ($p<0.01$) both w.r.t planting date (TP), variety (Var) and TP*Var interaction. Late planting is not ideal for managing false smut disease as it was evident from the graph that yield loss is positively correlated with %HI, %TI and appearance of AFB (Fig.1). The normal and late transplanted rice in the present experimental site was exposed to comparatively low tempera-

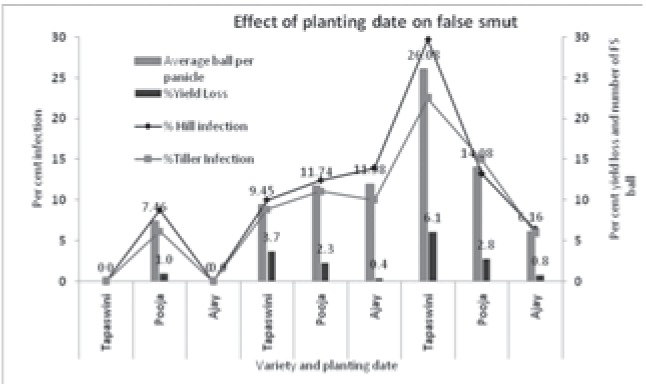

Fig. 1.

ture and high humidity and frequent rain which supply constant moisture favourable for infection process, colonization and later spore formation of the pathogen *U. virens* that helped in development of more smut balls than early planted rice.

CONCLUSION

High incidence of false smut disease can be avoided by early planting or the disease can be managed through prophylactic spray of fungicides based on the planting date particularly in case of late planting which also might be expose to frequent rainy days and low temperature compare to the plant transplanted during early or normal date.

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Effect of front line demonstration trials on chickpea in rainfed condition of Western Rajasthan

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Chickpea production has gone up from 3.65 to 7.35 million tons between 1950-51 and 2014-15, registering a growth of 0.58% annually (DOA,2015). During the period, area has marginally declined from 7.57 to 6.67 million hectare and the productivity has steadily increased to 844kg/ha from 482kg/ha. Notwithstanding its distribution throughout the country, six states viz., Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Karnataka and Andhra Pradesh together contribute 91% of the production and 90% of the area of the country. In Pali district chickpea traditionally grown as a rabi crop.Arid region is considered to be the pulse bowl of Rajasthan as it share about 55% area ans 40% of total pulse production of state. Keeping this in view chickpea variety cv. RSG-888 with a potential grain yield of 16.70 and straw yield of 2.05t/ha was used under front line demonstrations so as to encourage farmers to adopt high yielding variety.

METHODOLOGY

In the present study performance of chickpea variety RSG-888 against local check was evaluated through front line demonstrations conducted at farmer's field during *rabi* season of 2013, 2014 and 2015. A total of 56 demonstrations were laid on 9 hectare area in 10 adopted villages across 6 blocks of Pali district. Soils of the study area are mostly sandy loam in texture with low nitrogen, medium phosphorus and high available potassium besides being slightly saline in nature. During the crop growing season minimum and maximum temperature extremes ranged between 15.9 ^{0}C to 25.7^{0}C and 33.80^{0}C to 36.57^{0}C, respectively. Sowing was done using residual soil moisture of dry condition from 15 October to 10 November every year. At harvesting five random samples of one meter square area from each demonstration field were harvested and composite sample was weighed for total biological yield. After weighing grains were separated by beating ear heads and cleaned grains were weighed for grain yield. Harvest yield index, technological gap, extension gap and technology index were calculated as per the standard procedures.

RESULTS

Performance of chickpea variety RSG-888 during different years from 2013 to 2015 in different blocks of arid region is depicted in Table 1. Data pertaining to total grain yield, yield

Table 1. Yield, yield gaps and technology index of chickpea variety RSG-888

Name of the blocks	Potential grain yield (t/ha)	Demonstration yield (t/ha)	Local check yield (t/ha)	% increase over local check	Technological gap (t/ha)	Extension gap (t/ha)	Technology index (%)
Sumerpur	2.40	1.62	1.04	28.77	0.73	0.42	28.08
Raipur	2.40	1.80	0.99	28.99	0.82	0.40	31.54
Jaitaran	2.40	1.58	0.94	49.61	0.67	0.64	25.77
Sojat	2.40	1.66	0.89	43.45	0.52	0.63	20.00
Rohat	2.40	1.60	1.01	46.67	0.84	0.56	32.31
Banli	2.40	1.71	1.16	36.96	0.71	0.51	27.30
Mean	2.40	1.67	1.00	39.08	0.72	0.53	27.50

Table 2. Economic analysis of chickpea variety RSG-888 in arid region

Name of blocks	Cost of cultivation (Rs/ha)				Gross income (Rs./ha)			Net income
	Seed	Fertilizers	Labour	Total	Straw	Grian	Total	(Rs./ha)
Sumerpur	4,200	1,200	1,000	6,400	3,500	40,500	44,000	37,600
Raipur	4,200	1,200	1,000	6,400	3,400	45,000	48,400	42,000
Jaitaran	4,200	1,200	1,000	6,400	3,300	39,500	42,800	39,500
Sojat	4,200	1,200	1,000	6,400	3,800	41,500	45,300	38,900
Rohat	4,200	1,200	1,000	6,400	3,700	40,000	43,700	37,300
Banli	4,200	1,200	1,000	6,400	3,600	42,750	46,350	39,950
Mean	4,200	1,200	1,000	6,400	3,550	41,542	42,125	39,208
Local check	4,400	760	1,000	6,160	2,350	25,200	27,500	21,390

gaps, technological gap, extension gap and technology index (%) is presented in table. Demonstration yield was recorded maximum in Raipur block (1.8 t/ha) where as on an average demonstration yield in arid region was 1.67 t/ha increase of 67% over local check, where in the grain yield harvested was only 1.0 t/ha. However, overall average technological gap in the region was 0.72 t/ha. Similarly, huge extension gap of 0.53 t/ha was recorded in the region with maximum extension gap recorded in Jaitaran and Sojat blocks (0.64 and 0.63 t/ha). Extension gap indicates that there is a tremendous scope of extension activities in the region. Mass awareness through print electronic media is the need of the hour. Package of practices for the chickpea crop as devised need to be followed strictly particularly seed rate, optimum application of nutrients and other management practices. The recommended packages of practices will definitely increase the yield and subsequently reduce the extension gap. Technology index in the present caser varied between 20.00 to 32.31% and average 27.50% over six blocks of arid region. Table 2 gives the economics of growing RSG-888 in the region. The data clearly indicates the advantage of growing released variety over local check. Since grain yield as well as straw yield is more in the variety used under front line demonstrations, therefore naturally income generated is also more. Total gross income from both grain and straw is Rs. 42125/- hectare as against only Rs. 27,500/- in the local check. Net income obtained under FLD was Rs. 39,208/- which was 83.3% more the local check, where the net income was only Rs. 21,390/- per hectare, respectively.

CONCLUSION

It may be concluded that thedrought tolerance released varieties of chickpea RSG-888 performed better with an average grain yield of 1.67t/ha that was 67% more than the local variety. Technological and extension gaps existed which can be bridged by popularizing package of practices with emphasis on use of proper seed rate and balanced nutrient application. Replacement of local variety with the released variety would increase the production and net income of by more than fifty thousand rupees.

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Seed priming improves irrigation water use efficiency, yield and yield components of cowpea under moisture stress conditions

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Cowpea is an important food legume and vegetable crop cultivated in rainfed areas of India where rainfall is not only low but also variable. Seed priming with potassium nitrate and hydropriming improved biological and grain yield of rapeseed per unit area through enhancing rate and percentage of seedling establishment. However, the information related to vigorous seed germination, uniformity and to withstand environmental adversity after sowing after employing seed priming technique is much scanty in cowpea. Hence, an investigation in this direction was chosen in order to study the drought induction in enhancing productivity of cowpea seed with different priming chemicals as influenced by different levels of irrigation.

METHODOLOGY

Field experiment was conducted at Indian Institute of Horticultural Research, Bangalore to study the effect of irrigation levels (I_1–0.9 E_{pan}, I_2–0.7 E_{pan} and I_3–0.5 E_{pan}) and seed priming treatments P_1-GA_3 (100 ppm), P_2-$CaCl_2$ (10^{-3}M), P_3-Ammonium Molybdate (10^{-3} M), P_4-KBr (10^{-3} M), P_5-Magnesium Nitrate (10^{-3}M), P_6-Zinc Sulphate (10^{-3}M) (Chemical Priming) and P_7-hydro-priming for 24 hours at 15°C using P_8-dry seed (non-primed) as a control on various morphological, physiological parameters, yield and yield components in cowpea. The experiment was laid out in split plot design with three replications with spacing of 40 cm between rows and 15 cm between plants during the summer season of 2012 and 2013.

RESULTS

The results of the field experiment revealed that seeds invigourated with GA_3 and ammonium molybdate showed significantly reduced mean emergence time, promoted uniform germination, plant height, number of leaves and branches/plant, leaf area index, reduced number of days to initiation of flowering and days to 50 percent flowering, over control. The increased plant height, number of leaves and number of branches may be due to cell division, cell number due to multiplication in various plant tissue, auxin multiplication, cell wall plasticity and permeability of cell membrane, increasing photosynthates, cell enlargement and rapid cell

Table 1. Effect of seed priming and irrigation regimes on plant height,number of pods / plant, grain yield, biological yield and IWUE

Treatment	Plant height (cm)	Total DMA/ plant (g)	Grain yield (kg/ha)	Biological yield (kg/ha)	IWUE (kg/ha/mm)
Irrigation (I)					
I_1	93.3	46.3	1324.2	4204.2	3.70
I_2	80.9	38.5	1140.8	3940.3	4.03
I_3	67.4	31.4	933.4	3399.5	4.45
SEm±	0.63	0.27	23.4	25.5	0.008
CD (P=0.05) *Priming*	1.92	0.93	87.7	96.9	0.031
P_1	84.1	41.1	1282.3	4112.2	4.56
P_2	81.4	39.7	1163.3	4038.1	4.18
P_3	84.4	40.8	1262.3	4147.6	4.53
P_4	80.5	39.2	1186.9	4027.7	4.28
P_5	81.0	38.9	1137.3	3884.3	4.12
P_6	80.8	38.7	1100.5	3783.7	3.93
P_7	78.9	37.0	1041.1	3629.9	3.73
P_8	73.0	34.3	888.2	3160.8	3.12
SEm±	1.03	0.46	38.2	41.6	0.013
CD (P=0.05)	3.93	1.38	115.3	133.6	0.053

wall elongation (Salisbury and Ross, 1992). A significantly greater number of pods/m^2, number of grain/pods, 1000 grain weight, seed yield per plant, seed yield per hectare, biological yield, harvest index, and irrigation water use efficiency was recorded for primed seed, when compared with unprimed seeds. This may be attributed to early and synchronized field emergence which resulted in more leaf area and early canopy development. Seed priming improved IWUE at all irrigation regimes.Seed priming can be helpful in increasing the drought tolerance of crop plants. Seed priming with GA_3, ammonium molybdate, $CaCl_2$ and KBr recorded significantly higher N, P and K uptake by cowpea crop compared to hydro – priming and control.

CONCLUSION

The results of the present investigation with regarding to seed priming and irrigation levels revealed that seed priming with ammonium molybdate (10^{-3}M) and GA_3 (100ppm) found significantly superior in yield over unprimed control under both optimum as well as limited condition.

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Effect of row orientation and intercrops on yield attributes, yield, economic returns and competitive indices of bed planted wheat

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Small farmers of the developing countries like India are getting low production due to the availability of limited farm resources. Intercropping is a possible way of increasing the productivity on small farms as it provides security against potential losses of monoculture (Ghosh, 2004). Intercropping results in increased overall yield of the mixture as compared to any of the component crops. A uniform distribution and proper orientation of plants over a cropped area are needed for greater light interception and maximum photosynthetic efficiency. Intercrops can be grown in furrows during early growth stages of bed planted wheat. This study was carried out to investigate the effects of row orientation on the growth and yield of wheat and intercrops and also to get the information regarding highly productive and economically viable bed planted wheat based intercropping system.

METHODOLOGY

The experiment was carried out during *rabi* seasons of 2012-13 and 2013-14 at the research farm of the Department of Agronomy, Punjab Agricultural University, Ludhiana. Soil of the experimental field was loamy sand with pH 7.2. It was moderately fertile being low in organic carbon (0.21%), available nitrogen (63.5 kg/ha), available potassium (122.1 kg/ha) and medium in available phosphorus (19.5 kg/ha). The experiment was laid out in a split-plot design with two direction of sowing north-south and east-west in the main plot. Each main plot was divided into five sub plots to allocate the intercropping systems with wheat, i.e. wheat + spinach, wheat + fenugreek, wheat + oats fodder, wheat + canola and wheat + linseed. Wheat and intercrops were also sown in sole plots with four replications. The recommended dose of N, P and K fertilizer was applied to wheat and intercrops on area basis. The control of weeds on both beds and furrow was done by hand weeding. Other package of practices for wheat and intercrops were followed as per PAU recommendations.

RESULTS

Row orientations and intercropping system had significant influence on yield attributes and yield of wheat. Ears/m row length grains/ear and grain yield were significantly higher in east-west row orientation as compared to north-south row orientation in both the growing seasons. Higher no. of ear/m row length and grains/ear was found in wheat + spinach intercropping system which was statistically at par with wheat +

Table 1. Effect of row orientations and intercropping systems on yield attributing characters of bed planted wheat

Treatment	Ear/m row length(no.)	Grains/ ear (no.)	Grain yield (t/ha)	Wheat equivalent yield (t/ ha)
Row orientation				
North-south (N-S)	77.8	57.1	4.81	4.99
East-west (E-W)	84.3	63.2	5.51	5.57
CD (P=0.05)	3.1	2.1	0.14	0.125
Intercropping systems				
Wheat + Spinach	83.9	61.5	5.49	6.25
Wheat + Fenugreek	82.5	60.9	5.37	5.79
Wheat + Oats fodder	80.9	60.3	5.15	7.03
Wheat + Canola	75.2	56.8	4.33	5.98
Wheat + Linseed	79.4	58.7	5.08	5.67
Sole Spinach	-	-	-	5.79
Sole Fenugreek	-	-	-	5.09
Sole Oats fodder	-	-	-	4.16
Sole Canola	-	-	-	4.09
Sole Linseed	-	-	-	2.66
Sole Wheat	84.7	62.7	5.57	5.57
CD (P=0.05)	4.1	2.3	0.47	0.42

fenugreek, wheat + oats fodder but significantly higher than wheat + linseed and wheat + canola intercropping system. Generally when water and nutrients are not limiting, production of plant dry matter is determined by the amount of solar radiation in field canopy. Plants with east-west row orientation possibly received higher solar radiation and contributed to more photosynthate partitioned to shoot and developed seed. Wheat grown on beds with an east-west orientation produced more no. of ear heads/ area, more seed/ ear head, and higher grain yields than the wheat planted on beds with a north-south orientation (Day *et al*., 1976). These results also confirmed by Hozayn *et al.* (2012). Among the intercropping systems higher grain yield of wheat was found in wheat + spinach (5.49 t/ha) intercropping system which was statistically at par with wheat + fenugreek (5.37 t/ha), wheat + oats fodder (5.15 t/ha) but significantly higher than wheat + linseed (5.08 t/ha) and wheat + canola (4.33 t/ha) intercropping system. Significantly lowest value of grain yield was observed in wheat + canola intercropping system than the rest of the intercropping systems. It is because of canola is more aggressive, dominant and competitive to the wheat than rest of the intercrops, viz. spinach, fenugreek, oats fodder and linseed in intercropping system. Wheat equivalent yield was significantly higher in east-west row orientation as compared to north-south row orientation. Wheat + oats fodder intercropping system produced significantly higher wheat equivalent yield (7.03 t/ha) than the others wheat based intercropping systems and their respective sole planting of wheat and the component crops.

CONCLUSION

From the study, it was concluded that there were higher yield advantage and wheat equivalent yield by raising the wheat crop in east-west row orientation as compared to north-south row orientation. Wheat + oats fodder intercropping system produced significantly higher wheat equivalent yield than the others wheat based intercropping systems and their respective sole planting of wheat and the component crops.

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Effect of date of sowing, varieties and stage of harvesting on yield and quality of barley (*Hordeum vulgare*) fodder

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The field experiment was carried out during 2013-15 at Research Farm of Forage Research and Management Centre, National Dairy Research Institute (NDRI), Karnal to assess the yield and quality of barley fodder. The experiment was laid out in split-plot design with four treatment of date of sowing (21st October, 31st October, 10th November and 20th November) in main plots, three varieties (RD-2552, RD-2035 and RD-2715) in sub plots and three stage of harvesting (45 DAS, 55 DAS and 65 DAS) in sub-sub plots with three replications in total 108 numbers of plots. The results were revealed on the basis of pooled data for two years. The highest green fodder yield (17.60 t/ha) and dry matter yield (2.06 t/ha) was obtained from variety RD 2715 sown on 10th November at the harvesting of 65 DAS (days after sowing). The variety RD 2715 produced higher fodder yield i.e. 10.5% over to variety RD 2035 and 15.34% over to variety RD 2552. The variety RD 2552 produced green fodder yield of 14.90 t/ha and highest grain yield (3.66 t/ha) and straw yield (5.01 t/ha) when sown at first date of sowing i.e. 21st October with harvesting of 45 DAS for green fodder purpose all three varieties differed significantly with the RD 2035 variety. Sowing between 21st October to 10th November was found to be the ideal time for dual purpose barley for production of higher fodder, grain and straw. The performance of variety RD 2552 in terms of green fodder as well as grain production was found to be superior to other varieties. Harvesting of crop at 65 DAS resulted in highest green fodder yield, dry matter yield, plant height, ADF, NDF and hemicelluloses while harvesting at 45 DAS showed highest grain yield, straw yield test weight, leaf: stem ratio, crude protein and ether extract. Harvesting barley for fodder and leaving for the re-growth for grain production will help in getting green fodder during the period of fodder scarcity and increasing the productivity without sacrificing its grain yield.

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Effect of seaweed extracts on productivity and quality of rice

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Sea weeds are marine algae, saltwater dwelling, and simple organisms that fall into the rather outdated general category of "plants". Seaweed extracts are bioactive substances extracted from marine algae which are used in agricultural and horticultural crops and many beneficial effects including increased crop yields, resistance of plants to frost, increased uptake of

Table 1. Effect of sea weed extracts on the total chlorophyll, grain yield, hulling %, head rice recovery and return per rupee invested (Pooled over two years)

Treatment	Total Chlorophyll (mg/g)	Grain yield (t/ha)	Hulling%	Head rice recovery (%)	Return per Rupee invested (Rs.)
T_1 – Water spray and RDF	1.47	4.44	63.71	54.45	1.53
T_2 – 2.5% *Kappaphycus* + RDF	1.55	4.76	66.50	57.42	1.57
T_3 – 5% *Kappaphycus* + RDF	1.64	5.00	67.78	59.48	1.60
T_4 – 7.5% *Kappaphycus* + RDF	1.74	5.30	70.22	61.33	1.70
T_5 – 10% *Kappaphycus* + RDF	1.92	5.47	73.36	62.52	1.72
T_6 – 15% *Kappaphycus* + RDF	2.01	5.74	75.03	65.69	1.78
T_7 – 2.5% *Gracilaria*+ RDF	1.54	4.72	65.46	57.71	1.56
T_8 – 5% *Gracilaria*+ RDF	1.61	4.93	68.09	60.80	1.60
T_9 – 7.5% *Gracilaria*+ RDF	1.74	5.22	69.41	61.83	1.67
T_{10} – 10% *Gracilaria*+ RDF	1.92	5.61	72.00	63.37	1.77
T_{11} – 15% *Gracilaria*+ RDF	1.98	5.69	73.68	65.29	1.76
T_{12} – 7.5%*Kappaphycus* + 50% RDF	1.46	4.42	64.93	54.95	1.49
T_{13} – 7.5% *Gracilaria*+ 50% RDF	1.44	4.33	64.48	54.67	1.47
SEm (±)	0.06	0.19	2.01	1.79	0.07
CD (P=0.05)	0.18	0.57	5.86	5.22	0.20

inorganic constituents from the soil, more resistance to stress conditions and reduction in storage losses of fruit may be achieved in its potential use in organic and sustainable agriculture (Blunden, 1991).

METHODOLOGY

A field experiment was conducted during the *Kharif* season of 2012 and 2013 at the Agricultural farm of Institute of Agriculture, Visva-Bharati, Sriniketan, Birbhum, West Bengal. The sea weed extracts of *Kapphaphycus (K)* and *Gracilaria* (G) as per treatments were sprayed in the Rice field at active tillering stage, flowering stage and at grain filling stage. The experiment was conducted in Randomized Block Design (RBD) with three replications and thirteen treatments combinations where K and G extracts at 2.5%, 5%, 7.5% and 10% concentrations were applied along with RDF or 50% RDF. The concentration of extract application varied on v/v basis as per treatments. The quantity of water was @ 600 litres /ha in each spray.

RESULTS

The total chlorophyll, grain yield and quality parameters like hulling percentage, head rice recovery of Rice were significantly affected by the treatments. Maximum total chlorophyll content was obtained from the treatment 15% *Kappaphycus* + RDF and was at par with 15% *Gracilaria* + RDF**.** Presence of cytokinins, auxins and betaines (Blunden 1991) may be the reason behind the increased chlorophyll content in leaf. Crop treated with 10% K + RDF recorded the highest seed yield which was however statistically at par with all other treatments except application of 7.5 % K +50% RDF and WS +RDF. Such increment might be due to the fact that seaweed extract is a biostimulant, which provide the rice plant with micro, macro nutrients and significant amounts of cytokinins, auxins and betaines (Blunden 1991) ultimately increasing the chlorophyll production by boosting the photosynthetic process, thereby stimulating vegetative growth. The highest hulling percentage was recorded in 10% G+RDF and it was statistically at par with all treatments except 2.5% K +RDF, 2.5% G+RDF, 7.5% K + 50% RDF and WS +RDF. The head rice recovery was highest in 10% K +RDF and it was statistically at par with all treatments except 2.5% K + RDF, 2.5% G + RDF, 7.5% K + 50% RDF and WS +RDF. Results are in conformity with the findings of Pramanick *et al*. (2014).

CONCLUSION

It can be concluded that rice crop variety Swarna give good responses to the spray application of sea weed extracts during the critical growth stages like tillering, flowering and grain development. The chlorophyll content, yield, quality parameters and economics improved strikingly up to the application of 10% concentration thereafter the values were mostly statistically at par with the 15% concentration of both the saps.

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Influence of crop establishment methods and varieties on root growth and grain yield of wet season rice

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Rice is life to a majority of people in Asia. Its productivity is getting constrained by several factors including growing water shortage and labour scarcity, escalatinginput costs and labour wages, etc. There is a need to identify alternative establishment methods in place of conventional transplanting of rice (CTR). Direct wet seeding of rice (DWSR) using drum seeder in puddled soil has been emerging as a potential method in various rice growing countries of the world. As a resource-conserving and climate-resilient methodology, the System of Rice Intensification (SRI) has also been gaining widespread popularity. Besides, root studies are important pre-requisites for identifying an appropriate crop establishment method to explore the possibility of harnessing the fullest genotypic yield potentialities and exploiting the sub-soil resources. Hence, the present study was taken up to study the influence of crop establishment methods and varieties on rooting behaviour and productivity of wet season rice.

METHODOLOGY

A field experiment was carried out during wet (*kharif*) season of 2011 and 2012 at Rice Research Station, Chinsurah, West Bengal to identify suitable rice varieties of varying duration groups under different crop establishment methods.Four levels of establishment methods in puddled soil *viz.* SRI, DWSR, CTR and broadcasting of sprouted seeds (BSS) in main plots and four different rice varieties *viz.* Anjali (IET 16430), Khitish (IET 4094), Triguna (IET 12875) and KRH 2 (IET 15065) in sub-plots were assigned in split-plot design with three replications.Data were recorded on rooting depth and root volume at 30 and 60 days after sowing (DAS for DWSR and BSS) / transplanting (DAT for SRI and CTR), using standard procedures. Grain yields were recorded at the time of crop harvest.

RESULTS

Among crop establishment methods (Table 1), SRI main-

Table 1. Effect of establishment methods and varieties on root traits and grain yield of wet season rice (pooled data of 2011 and 2012)

Treatment	Rooting depth (cm)		Root volume (cc/hill)		Grain yield
	30 DAS/DAT	60 DAS/DAT	30 DAS/DAT	60 DAS/DAT	(t/ha)
Establishment methods					
SRI	22.74	31.33	14.47	50.33	5.10
DWSR	21.25	29.66	13.50	44.04	4.61
CTR	21.26	28.63	13.95	42.43	4.66
BSS	20.36	27.94	11.95	40.19	3.79
SEm±	0.13	0.17	0.11	0.27	0.03
CD (P=0.05)	0.43	0.57	0.35	0.87	0.09
Varieties					
Anjali	21.67	29.71	13.49	49.60	3.23
Khitish	20.96	29.16	12.97	42.21	5.01
Triguna	20.50	28.35	12.75	39.25	4.71
KRH 2	22.48	30.35	14.66	45.94	5.22
SEm±	0.16	0.15	0.18	0.19	0.04
CD (P=0.05)	0.45	0.43	0.50	0.54	0.10

tained its superiority over the others in terms of maximum rooting depth (22.74 and 31.33 cm) and root volume (14.47 and 50.33cc/hill) at 30 and 60 DAT, respectively, thereby exhibiting the highest grain yield (5.10t/ha). Chapagain*et al*. (2011) were of similar opinion. Of the other methods, DWSR (4.61t/ha) and CTR (4.66t/ha) remained at par with each other in terms of grain yield althoughthey differed significantly in respect of root growth at 60 DAS/DAT (rooting depth of 29.66and 28.63cm, and root volume of 44.04and 42.43cc/hill, respectively). However, root proliferation was better under SRI and DWSR due to negative transplantation shock, improved soil aeration and limited root degeneration, compared with the others. Irrespective of crop establishment methods, the hybrid KRH 2 significantly produced the highest grain yield (5.22 t/ha), owing to its greater rooting depth (22.48and 30.35 cm) and root volume (14.66 and 45.94cc/hill), facilitating better nutrient acquisition. Ahmed *et al.* (2015) reported similar findings with the hybrids. Amongst three high-yielding varieties, Khitish registered the highest grain yield (5.01t/ha) with the root volume (42.21cc/hill at 60 DAS/DAT), followed by Triguna (grain yield of 4.71t/ha; root volume of 39.25cc/hill at 60 DAS/DAT).Despite maintaining better rooting depth (21.67 and 29.71 cm) and root volume (13.49 and 49.60cc/hill) at 30 and 60 DAS/DAT, respectively (Table 1),Anjali significantly recorded the lowest grain yield (3.23t/ha)only because of its shorter duration.

CONCLUSION

Root traits of rice varieties were strongly affected by different management conditions specific for varying crop establishment methods. All the rice varieties evaluated for the study could excel under SRI, exhibiting maximum rooting depth, root volume and productivity. Amongst them, the hybrid performed better than the high-yielding varieties. DWSR with increased root growth and comparable productivity also proved to be a viable alternative to CTR.

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Rhizosphere and crop productivity

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Rhizosphere, ‘the soil-root interface’ with abundance occurrence and compositionally different microbial population represents the zone of intense biological and chemical activities. Thus, the dynamic nature of ‘Soil-Root-Microbes’ governs the long term crop productivity and its sustainability. However, continuous intensive cropping of Rice-Wheat and/or Wheat-Sugarcane-Ratoon-Wheat in Irrigated Agro-Ecosystem aimed at higher crop productivity with heavy chemical inputs resulted in the deterioration of physico-chemical and biological properties of soil. This causes soil compaction, allelopathic interaction and soil sickness which inturn adversely affect the crop responses within a soil and atmospheric environments to produce a high yield per unit area, time and input (crop productivity). This calls for bringing an improvement in rhizospheric environment to exploit plant morphological (or structural) and plant physiological (or functional) responses leading to high crop productivity. Adoption of appropriate tillage, inclusion of legumes in the cropping systems, *insitu* crop residues incorporation and application of organics in right quantity, proportion and frequency would modulate the rhizosphere in terms of soil organic carbon-OC, soil microbial biomass carbon (up to 4% of OC) and microbial biomass nitrogen which are sensitive indicators of soil quantity. The rhizosphere consists of microbial pool with wide range of functional activities viz., N_2–Fixers: *Gluconacetobacter diazotrophicus, Azotobacter, Azospirillum* P Solubilizers: *Bacillus spp., Pseudomonas spp. Aspergillus awamori* Plant Growth Promoters: *Pseudomonas spp., Serratia, Basillus* and *Trichoderma* Pathogenic Antagonizers: *Pseudomanas fluorescens, Serratia marcescens, Streptomyces spp., Trichoderma spp*. Consequently these would enhance crop productivity by optimizing soil-water-air relations, Capitalizing allelopathic interaction, Buffering against any kind of ill-effects, Chelating toxic constituents, Increasing soil organic matter, Enhancing cation exchange capacity-CEC of soil as well as of roots, Scaling-up nutrient and water productivity, Cementing for formation of water stable soil aggregates, Stabilizing crop productivity in space and time, Improving integrated input use efficiency.

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Performance of wheat genotypes under different sowing time

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Wheat (*Triticum aestivum* L.) is the second most important cereal crop after rice, grown under diverse agro-climatic conditions on 30.97 mha area, 86.53 mt production with a productivity of 2794 kg/hain India. Increasing population leads to an increased demand of wheat with no possibility in further increase in area due to growing urbanization. Among production factors, sowing time and wheat varieties are the most crucial factors deciding its productivity.Sowing time of wheat is one of the most important factors that governs the crop phenological development and efficient conversion of biomass into economic yield. Normal sowing has longer growth duration which consequently provides an opportunity to accumulate more biomass as compared to late sowing and henceforth manifested in higher grain and biological yield (Kumar and Kumar, 2014). Whereas in case of delayed sowing, the wheat crop is exposed to sub-optimal temperatures at establishment and supra-optimal temperature at reproductive phases that leads to forced maturity and reduction in grain yield. Selection of suitable variety on appropriate time is essential for ensuring optimum productivity. Being a thermo-sensitive crop, choice of suitable variety for different seeding time further gets prime importance (Singh and Dwivedi, 2015). Keeping this in view, an attempt was made to determine the most suitable variety and sowing date for Haryana conditions.

METHODOLOGY

A field experiment was conducted at Research Farm of CCS Haryana Agricultural University, Hisar, India (29°10'N latitude, 75º46’E longitude and 215.2 M altitude) during *rabi* season of 2012-13 and 2013-14. The soil of the field was sandy loam in texture, slightly alkaline in pH (7.9), low in organic carbon, poor in available nitrogen and medium in available phosphorus and available potassium. The experiment was laid out in split plot design with three replications with treatments comprising two dates of sowing *viz*, timely (November 6) and late sown (December 12) in main plots and six wheat genotypes*viz*. DBW 88, HD 2967, DPW 621-50, HD 3086, WH 1105 and PBW 550 in sub-plots. The crop was sown manually with hand plough during both the years of study using the seed rate of 100 kg/ha at a row to row spacing of 20 cm. Half dose of nitrogen and full dose of phosphorus (75 kg N/ha and 60 kg P_2O_5/ha) was applied as basal at the time of sowing and remaining half dose of nitrogen (75 kg N/ha) was applied at first irrigation.Data on number of effective tillers, number of grains/earhead, 1000 grain weight, grain yield and straw yield were recorded by using standard procedure. During 2012-13, crop was harvested on 16th Apriland 25thApril, while in 2013-14, crop was harvested on 16thApril and 28thApril, respectively in timely and late sowing conditions.The other management practices were followed as per recommendations given by CCS Haryana Agricultural University, Hisar.

RESULTS

The yield attributes and yield were significantly influenced by sowing times and varieties during both the years (Table 1). Timely sown crop produced significantly higher grain yield (4.95 and 5.84 t/ha) than late sown crop (4.01 and 4.91 t/ha) during 2012-13 and 2013-14, respectively.Timely sown crop recorded significantly higher straw yield (10.34t/ha) than late sown crop (8.55t/ha) in 2012-13, however, difference was non significant during 2013-14. Higher yield in timely sown crop was due to significantly higher yield attributes *viz*., effective tillers/m^2 (501 and 455 during 2012-13 &2013-14, respectively) and test weight (39.05 g and 40.42 g during 2012-13 & 2013-14, respectively)as compared to late sown crop during both the years of study. However, number of grains/spike were not influenced by date of sowing during both years. This might be due to prevailing of favourable temperature for wheat crop for higher photosynthates accumulation conse-

Table 1. Effect of date of sowing on yield attributes and yields of wheat genotypes

Treatment	Effective tillers/m^2		No. of grains/spike		Test weight (g)		Grain yield (t/ha)	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Date of sowing								
Timely sowing	501	455	25.56	32.01	39.05	40.42	4.95	5.84
Late sowing	464	428	24.96	30.50	34.80	37.83	4.01	4.91
SEm±	2.85	3.79	0.39	0.54	0.28	0.18	0.06	0.05
CD (p=0.05)	17.6	23.4	NS	NS	1.75	1.13	0.38	0.33
Variety								
DBW 88	493	427	26.83	30.82	36.67	40.22	4.84	5.29
HD 2967	456	428	24.11	30.26	35.62	42.43	3.91	5.51
DPW 621-50	500	432	27.05	30.90	33.51	39.80	4.53	5.30
HD 3086	514	478	23.53	29.75	36.56	39.39	4.42	5.59
WH 1105	469	432	22.50	35.99	42.28	35.98	4.45	5.60
PBW 550	464	451	27.57	29.83	36.93	36.95	4.73	4.96
SEm±	14.87	11.72	0.75	1.08	0.58	0.58	0.15	0.14
CD (P=0.05)	NS	34.6	2.20	3.19	1.70	1.72	0.44	0.41

quently resulting in higher yield parameters in timely sown crop.Among the varieties, DWR 88 recorded highest grain yield (4.84 t/ha) in 2012-13, which was significantly higher than HD 2967 (39.1 t/ha) but statistically at par with all other varieties, whereas during 2013-14, WH 1105produced highest grain yield (5.60 t/ha), which was significantly higher than PBW 550 (4.96 t/ha), but statistically at par with all other varieties. Significantly higher straw yield was recorded by DPW 621-50 (10.08 and 10.45t/ha) than all other varieties during 2012-13 and 2013-14, respectively. Effective tillers were not affected by varieties in 2012-13, but in 2013-14, HD 3086 recorded significantly higher effective tillers (478) than all other varieties. Maximum grains/spike were recorded in PBW 550 (27.57) in 2012-13 but in 2013-14, WH 1105 recorded significantly higher number of grains/spike (35.99) than other varieties.Genotype WH 1105 had maximum 1000 grain weight (42.28 g) in 2012-13, but in 2013-14, HD 2967 produced bolder seed (42.43 g) than all other varieties.

CONCLUSION

Timely sowing of wheat crop results in higher yield without involving extra input as it helps varieties to express their full growth potential.Timely sown crop produced significantly higher effective tillers, 1000-seed weight, straw yield and grain yield than late sown crop. Among the varieties, DPW 88 recorded highest grain yield during 2012-13, whereas, WH 1105 produced highest grain yield among the varieties during 2013-14.

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Effect of sowing time and varieties on blackgram

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Sowing time is a non monitory input and it is the single most important factor to optimum yield from black gram. The harvesting time of different *kharif* pulses crops varies from middle August to September end. So determination of optimum sowing time for black gram is inevitable which can be adjusted during this period. Optimum sowing time of black gram may vary from variety to variety and season to season due to variation in agro-ecological conditions. Therefore, there must be a specific sowing dates, especially in *kharif* season to obtain maximum yield at lowest economical cost of cultivation. Delayed sowing and early sowing may be reducing yield and increased economical cost of cultivation of *kharif* black gram. Mid-June to mid July is found to be optimum time for *kharif s*eason. Early planting in first week of July results in higher yield and any delay in sowing beyond these dates causes reduction in yield. Keeping this view, this study was to investigate different sowing dates with varietal response of black gram.

METHODLOGY

The soil samples were drawn for studying the soil properties and then the experiment was laid out at Agronomy Section Farm of College of Agriculture, Nagpur during the year *kharif* season of 2014-2015 in Randomized block design (Factorial) with two factors ie. sowing dates and varieties replicated thrice. Four sowing date D_1 (25th MW), D_2 (26th MW), D_3 (27th MW) and D_4 (28th MW) as main plot treatment and three varieties (V1- TAU 1, V2- Yashoda 58 and V3- AKU 15) as sub plot treatment, thus making twelve treatment combinations, replicated thrice. The distance between two replications was 0.90m and 0.60m between two plots. The gross and net plot size were 4.8 m × 3.6 m and 4.5 m × 3.0 m, respectively. The data were recorded and statistically analysed as per Panse and Sukhatme (1971).

RESULTS

Sowing of black gram during different sowing dates sig-

Table 1. Influence of various sowing dates and varieties on different traits for blackgram.

Treatments	Plant height (cm)					Number of branches plant^{-1}				
	28 DAS	42 DAS	56 DAS	70 DAS	At harvest	28 DAS	42 DAS	56 DAS	70 DAS	At harvest
Sowing Dates										
D_1 – 25th MW	34.29	51.22	63.09	64.02	64.12	2.36	3.36	7.57	8.47	8.47
D_2 – 26th MW	35.94	52.35	64.77	65.67	65.72	2.79	3.75	8.34	9.10	9.10
D_3 – 27th MW	34.55	51.38	63.49	65.03	65.42	2.71	3.49	7.89	8.67	8.67
D_4 – 28th MW	33.37	50.46	62.22	63.19	63.31	2.26	3.13	7.01	8.08	8.08
SE (m)±	0.92	0.38	0.56	0.51	0.52	0.17	0.12	0.24	0.19	0.19
CD at 5%	NS	1.12	1.66	1.50	1.53	NS	0.37	0.72	0.56	0.56
Varieties										
V_1 –TAU 1	35.99	52.45	64.41	65.16	65.37	2.72	3.69	8.19	8.94	8.94
V_2 -Yashoda 58	33.02	50.12	62.34	63.32	63.53	2.26	3.24	7.18	8.20	8.20
V3 – AKU 15	34.61	51.48	63.43	64.96	65.03	2.60	3.37	7.73	8.59	8.59
SE (m)±	0.80	0.33	0.49	0.44	0.45	0.15	0.10	0.21	0.16	0.16
CD at 5%	2.35	0.97	1.44	1.30	1.33	NS	0.32	0.63	0.49	0.49
Interaction										
SE (m)±	1.60	0.66	0.98	0.88	0.90	0.30	0.21	0.43	0.33	0.33
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	34.53	51.35	63.39	64.47	64.64	2.52	3.43	7.70	8.57	8.57

Treatments	Dry matter at harvest	Maturity duration	Number of pods plant^{-1}	Weight of dry pods plant^{-1}	Grain yield plant^{-1}	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest Index (%)	B:C
Sowing Dates										
D_1 – 25th MW	11.63	71.17	24.11	8.39	5.69	39.84	7.67	13.33	36.52	3.78
D_2 – 26th MW	12.40	68.14	26.44	9.97	6.72	41.92	8.63	14.47	37.35	4.25
D_3 – 27th MW	12.08	71.08	25.69	9.31	6.31	41.17	8.13	14.05	36.65	4.00
D_4 – 28th MW	11.16	72.44	23.06	8.00	5.18	39.10	7.22	12.88	35.92	3.56
SEm±	0.21	1.00	0.57	0.31	0.30	0.69	0.27	0.37	-	-
CD at 5%	0.64	2.94	1.67	0.93	0.90	2.03	0.81	1.11	-	-
Varieties										
V_1 –TAU 1	12.31	68.80	26.02	9.59	6.62	41.90	8.45	14.30	37.14	4.16
V_2 - Yashoda 58	11.37	72.16	23.50	8.30	5.32	39.46	7.21	13.01	35.65	3.56
V3 – AKU 15	11.78	71.17	24.96	8.86	5.99	40.17	8.07	13.74	37.00	3.98
SEm±	0.18	0.86	0.49	0.27	0.26	0.60	0.23	0.32	-	-
CD at 5%	0.55	2.54	1.44	0.81	0.78	1.76	0.70	0.96	-	-
Interaction										
SEm±	0.37	1.73	0.98	0.54	0.53	1.20	0.47	0.65	-	-
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	-	-
GM	11.87	70.70	24.82	8.91	5.97	40.50	7.91	13.68	36.60	3.89

nificantly influenced growth and yield parameters. The growth attributing characters *viz.* Plant height, dry matter accumulation plant^{-1}, number of branches plant^{-1} and days of maturity were significantly more when black gram sown during 26th MW. The yield attributing characters *viz.* number of pods plant^{-1}, weight of dry pods plant^{-1}, weight of seed plant^{-1}, test weight, grain and straw yield ha^{-1} and harvest index were favourably influenced when black gram was sown during 26th MW.

Different varieties of black gram showed a significant influence on growth and yield parameters. Variety TAU-1 recorded higher growth contributing characters as well as yield contributing characters like plant height, dry matter accumulation plant^{-1}, number of branches plant^{-1}, days of maturity, number of pods plant^{-1}, weight of dry pod plant^{-1}, weight of seed plant^{-1}, test weight, grain and straw yield per ha^{-1} and harvest index than varieties Yashoda-58 and AKU-15.

The effect of interaction between sowing dates and varieties was non significant for all the growth and yield contributing characters during the experiment.

CONCLUSIONS

It is concluded from this study that sowing of black gram during 26th MW would be suitable and variety TAU-1 would be better which also is likely to give maximum benefit : cost ratio of 4.25 and 4.16 respectively.

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Weed management practices on winter French bean (*Phaseolus vulgaris*) under irrigated conditions of western Uttar Pradesh

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Weeds is one of the important factor, which hinders its overall growth and productivity since initial growth rate of French bean is slow compared to weeds and the interspaces covered by weeds severely affected crop growth and yield. Although the yield losses due to weed depend on composition of weed flora, extent of infestation and the crop canopy decides yield loss but it has been estimated that weeds alone can reduce the yield to the tune of 20-60 per cent. A study was conducted to compared 12 weed management options in French bean *viz.* weedy check, hand weeding at 30 days after sowing, weed free, fluchloralin@ 0.75 kg/ha, fluchloralin@ 1.0 kg/ha, fluchloralin@ 0.75 kg/ha with hand weeding at 30 days after sowing, pendimethalin@ 0.75 kg/ha, pendimethalin@ 1.0 kg/ha, pendimethalin@ 0.75 kg/ha with hand weeding at 30 days after sowing, oxyfluorfen@ 0.15 kg/ha, oxyfluorfen 0.20 kg/ha, oxyfluorfen@ 0.15 kg/ha with hand weeding at 30 days after sowing. Among the different herbicidal treatment options pre-planting of fluchloralin @ 1.0 kg *a.i.*/ha had maximum weed control efficiency (79.8%), which was at par to pre-emergence application of pendimethalin1.0 kg/ha (78.7%). The effect of these herbicides were also pronomced in terms of different growth and yield attributes of french bean crop and had maximum number of branches/plant (6.16 to 6.23), leaf area index (1.06 to 1.07), number of pods/plant (5.51 to 5.53) and 100-seed weight (316.2 to 316.7). The highest yield (1.11 to 1.10 t/ha) and N uptake (52.52 to 52.95 kg/ha) was noticed under fluchloralin or pendimethalin applied plot 1.0 kg/ha also it had reduced N losses through weeds. Economic evaluation in terms of returns Rs./Re invested was maximum under fluchloralin or pendimethalin applied plot reveals the significance of these herbicides in western Uttar Pradesh.

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Use of plant growth regulators for enhanced growth and yield of sugarcane (*Saccharum* species hybrid complex)

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Sugarcane is one of the most important field crops grown in the tropics and sub-tropics. The productivity of sugarcane in sub-tropical region is far below as compared to tropical region. Extremes of climate and use of sub-optimal agro-technologies are mainly responsible for low sugarcane productivity in sub-tropical India, where 60-70% of millable canes are comprised of tillers, whereas in tropical parts of the country only 20-30% of millable canes are formed from tillers. This may be one of the major reasons for lower yield under sub-tropical regions than the tropical part of the country. Higher sugarcane yield can be achieved by increasing the number of mother shoots instead of tillers (Chand *et al.,* 2011) and higher mother shoots can be achievable by increasing the germination percentage. Almubarak *et al.* (2012) achieved highest cane height with the application of gibbrellic acid. In the light of above, the present study was undertaken to find out the suitability of plant growth regulators for enhancing the germination, growth and yield of sugarcane in sub-tropical condition.

METHODOLOGY

A field experiment was conducted during the spring season of 2015-16 at Sugarcane Research Institute farm, Pusa, Bihar. The soil was sandy loam, having 8.2 pH, 0.48% OC, 25.8% free $CaCO_{3,}$ 1.48 g/cc bulk density and low in available N (221 kg/ha), medium in available P (10 kg/ha) and low in available K (105 kg/ha). Eight treatments, viz. T_1, Conventional planting/farmers practice (03-bud setts); T_2, Planting of setts after overnight soaking in water; T_3, Planting of setts after overnight soaking in 50 ppm ethephon solution; T_4, Planting of setts after overnight soaking in 100 ppm ethephon solution; T_5, T_1+ GA_3 spray @ 35 ppm at 90, 120 and 150 DAP; T_6, T_2 + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP; T_7, T_3 + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP; and T_8, T_4 + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP were arranged in randomized block design with 3 replications. The crop was uniformly fertilized with 150 kg N, 37.1 kg P and 49.8 kg K/ha. Half of the recommended dose of nitrogen and full dose of phosphorus and potassium was applied basal and remaining half of the nitrogen was applied in two equal splits after first irrigation and at the time of earthing up. Sugarcane variety 'BO 153' was planted on 01 April 2015 with a row spacing of 90 cm. Germination count was recorded from 20 DAP to 50 DAP. Plant population was counted at 120 DAP. Whole cane samples were taken at the time of harvest and analysed for sucrose (%) juice (Spencer and Meade, 1955). The total amount of rainfall received during the crop season was 899 mm. Sugarcane was harvested on 10 February 2016.

RESULTS

The different treatments had significant impact on germination, plant population, millable canes and cane yield while, the effect on plant height and sucrose content juice were non-significant (Table 1). Results clearly showed that highest germination percentage at 20, 30, 40 and 50 DAP were recorded from planting of setts after overnight soaking in 50 ppm ethephon solution which was significantly higher over conventional planting/farmers practice (3-bud setts) and planting of setts after overnight soaking in water except at 30 DAP, where planting of setts after overnight soaking in water was statistically comparable to plating of setts after overnight soaking in 50 ppm ethephon solution (Table 1). It was due to favourable condition for germination under ethephon treatment. Planting of setts after overnight soaking in 50 ppm ethephon solution + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP recorded significantly higher plant population (2,28,700/ha) of sugarcane than conventional planting/farmers practice + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP (1,62,300/ha) and conventional planting/farmers practice (1,59,500/ha) but remained at par with others. However, the mean plant height in different treatments ranged from 272 to 320 cm. Highest millable canes (1,56,600/ha) were recoded with the planting of setts after overnight soaking in 50 ppm ethephon solution + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP, being significantly higher over planting of setts after overnight soaking in water + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP, planting of setts after overnight soaking in water, conventional planting + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP and conventional planning/ farmers practice, but it remained statistically at par with rest of the treatments. The improvement in millable canes with ethephon treatment was mainly due to variation in germination and plant population. Similarly, the higher cane yield (103.2 t/ha) was produced with the planting of setts after overnight soaking in 50 ppm ethephon solution combined with GA_3 spray @ 35 ppm at 90, 120 and 150 DAP was statisti-

Table 1. Effect of plant growth regulators on growth, yield and quality of sugarcane

Treatment		Germination (%)				Plant population ($\times 10^3$/ha) 120 DAP	Plant height (cm) at harvest	Millable canes ($x10^3$/ha)	Cane yield (t/ha)	Sucrose (%)
		20 DAP	30 DAP	40 DAP	50 DAP					
T1	Conventional planting/ Farmers practice (3-bud setts)	3.2	15.7	20.0	29.0	159.5	272	118.6	80.5	17.01
T2	Planting of setts after overnight soaking in water	9.8	20.0	23.7	37.0	197.2	275	128.6	88.2	17.07
T3	Planting of setts after overnight soaking in 50 ppm ethephon solution	13.5	22.8	28.5	50.1	220.3	290	147.2	91.3	17.58
T4	Planting of setts after overnight soaking in 100 ppm ethephon solution	11.1	21.5	26.3	45.0	220.0	281	145.0	90.9	16.81
T5	T1+GA3 spray @ 35 ppm at 90, 120 and 150 DAP	3.1	16.0	20.6	28.6	162.3	278	120.8	87.2	17.00
T6	T2+GA3 spray @ 35 ppm at 90, 120 and 150 DAP	9.8	20.8	23.9	36.4	201.6	288	130.3	95.7	17.11
T7	T3+GA3 spray @ 35 ppm at 90, 120 and 150 DAP	13.4	19.4	27.1	45.7	228.7	320	156.6	103.2	16.98
T8	T4+GA3 spray @ 35 ppm at 90, 120 and 150 DAP	12.7	21.5	26.9	45.3	227.5	308	149.1	99.4	16.90
SEm±		0.76	1.40	1.50	2.60	11.48	13.5	7.80	3.95	0.38
CD (P=0.05)		2.3	4.3	4.6	8.1	34.8	NS	23.9	12.0	NS

cally at par with planting of setts after overnight soaking in 100 ppm ethephon solution + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP, planting of setts after overnight soaking in water + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP and planting of setts after overnight soaking in 50 ppm ethephon solution, but was significantly superior over others. The magnitude of significant increase in cane yield with planting of setts after overnight soaking in 50 ppm ethephon solution + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP was 28.2% over the conventional planting/farmers practice. Increase in cane yield might be owing to improvement in growth and yield attributes, which might have increased tonnage However, the mean sucrose content in juice ranged from 16.81 to 17.58%.

CONCLUSION

The results showed that planting of setts after overnight soaking in 50 ppm ethephon solution + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP may be used for getting higher growth and yield of sugarcane in the region.

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Native $CaCO_3$ mineral precipitation-dissolution and ESP development with poor quality water

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Reclamation and rehabilitation of sodic soil has potential to support agricultural production. Sodic soils reclamation was initiated by applying inorganic substances *viz.* gypsum, pyrites, aluminium chloride etc. Due to declining availability of quality gypsum and competing industrial demand, it is needed to reduce the level of exchangeable Na and soil pH by enhancing the solubility of native $CaCO_3$ of calcareous sodic soils. We hypothesized that water quality irrigation have potential to dissolute native $CaCO_3$ mineral.

METHODOLOGY

A laboratory soil column study was conducted with 3 different soils *viz.*, Sodic Inceptisols, Calcareous sodic Inceptisols, and Cacareous sodic Vertisols were used with completely randomized factorial design with three replications (Table 1). Water quality of 10 dS/m electrical conductivity and SAR 10 $mmol^{1/2}\,L^{-1/2}$ was applied in packed soil column (15.0 cm depth × 13.5 cm *i.d.* column) with fixed soil bulk density of 1.35 Mg/m^3. Twenty pore volumes of water quality were passed and followed by leachate at the end of each pore volume were collected. Water quality parameters of soil leachates were analysed. After the leaching process ended, the soils in the columns were drained under gravity for 24 h, and then were evenly sectioned into five slices, 3 cm each, and air dried. The pH_2, EC_2, exchangeable sodium percentage (Rowell, 1994) and calcium carbonate percent (Allison and Moodie, 1965) in soil slices were determined.

RESULTS

Application of saline water decreased pH and increased the EC of the soil leachates following the entire pore volume for Sodic Inceptisols > Calcareous sodic Inceptisols > Cacareous sodic Vertisols. Higher values of sodium adsorption ratio (SAR) were detected in entire soil leachates compared to in-

Table 1. Physico-chemical properties of the experimental soils

Soil	Texture	pH_2	EC_2	EC_e	ESP	CEC	Organic C	Clay	$CaCO_3$
Sodic Inceptisols	Clay	8.9	1.44	4.10	28.3	19.5	0.35	40.0	2.1
Calareous Sodic Inceptisols	Loam	9.4	0.56	1.44	45.0	7.0	0.35	17.6	17.1
Calcareous Sodic Vertisols	Clay	9.1	0.34	0.90	10.1	38.9	0.25	60.0	8.0

[pH_2 and EC_2: pH and electrical conductivity at 1:2 soil-water suspension; EC_e: Electrical conductivity of saturation paste in dS m^{-1}; ESP: Exchangeable-Na percentage; CEC: cation exchange capacity in $cmol_{(P+)}$/kg; CaCO3: calcium carbonate %]

coming solution (Fig. 1). Leachates SAR was equilibrated with incoming water quality for Sodic Inceptisols from pore volume (PV) IIIrd onwards. However, these values were nearly 2 times higher in rest two soils compared to incoming water quality. Soil pH_2 was drastically reduced throughout the depth of soil for all studied soils (Fig. 2). The calculated saturation index (SI) of each leachates compared to SI in soil saturation extract indicates studied quality water had potentiality of $CaCO_3$ dissolution. However, the dissolution of $CaCO_3$ varied on soil type and depth of soil column (Fig. 2). Among the studied soils maximum quantity of $CaCO_3$ dissolution appeared in Sodic Inceptisols > Calcareous Soil Inceptisols> Sodic Vertisols. Across the soil depth, ESP development in soils was highest for Sodic Vertisols > Sodic Inceptisols > Calcareous Sodic Inceptisols compared to inherent ESP of respective soils (Fig. 2).

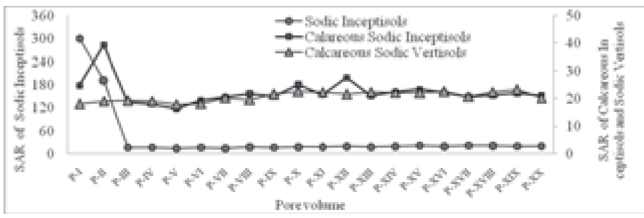

Fig 1. Changes in SAR in soil leachates along varied pore volumes for three soils

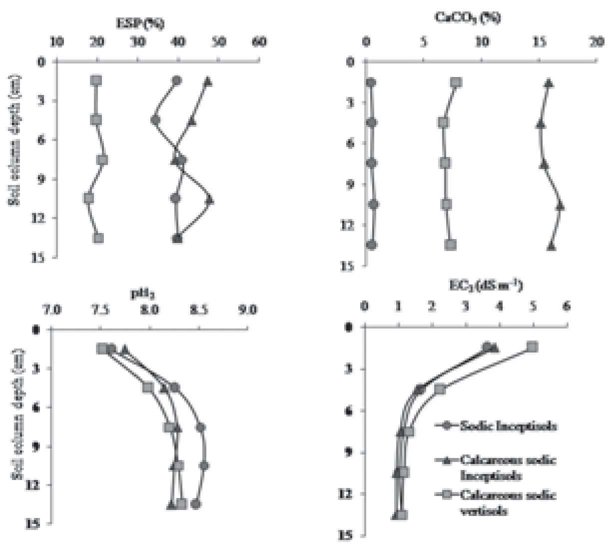

Fig. 2. The measured soil ESP, $CaCO_3$, pH_2 and EC_2 after leaching versus the soil depth for three soils

CONCLUSION

Entire soil leachates detected greater values of SAR than incoming solution. A drastic decreased in soil pH is detected at all soil depth for all soils. Among the studied soils maximum quantity of $CaCO_3$ dissolution was appeared in Sodic Inceptisols > Calcareous Soil Inceptisols> Sodic Vertisols. ESP development in soils across soil depth was in order of Calcareous Sodic Inceptisols> Sodic Inceptisols > Sodic Vertisols compared to inherent soil ESP values of respective soils under the influenced for applied quality water.

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Improving the quality of farmers saved seed through seed village programme

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The seed replacement rate in the agriculturally developed states like Punjab, Haryana, Western UP and Uttaranchal is 30-40% which indicates that 60-70% of the farmers sow their own saved seed. Unavailability and short supply of quality seed is a constraint in higher production of food grains. To cover large area in the country like India farmer's participation in seed production is much needed to ensure supply of quality seed to each and every farmer and to enhance seed replacement rate. To upgrade the quality of farmer-saved seed, Seed Village Programme sponsored by DAC, Ministry of Agriculture, GOI was started under the supervision of scientists at ICAR-IARI, Regional Station, Karnal since Kharif 2009 and continue till date for farmer-to-farmer horizontal spread of seeds of latest popular varieties of Rice, Wheat and Berseem. The objective was to increase availability and horizontal spread of quality seed of improved varieties with the participation of resource poor farmers by capacity building through Seed Village Programme.

METHODOLOGY

In the Seed Village Programmethe target group is resource poor farmers including women farmers were selected in cluster from different villages around Karnal in the year 2009 to 2014-15. Under theProgramme quality seed of latest variety of Wheat, Paddy and Berseem crop for one acre was supplied at 50% subsidy to each farmer. Three trainings on different aspects of quality seed production were provided to farmers under seed village programmeat different crop stages of each crop season.In the first training information on importance of quality seed, seed treatment, agronomic management including nursery management,seed rate, time and method of sowing, spacing, fertilizer, weed and irrigation management was given. Second training was given at farmer's field by the group of scientists on fertility problems, plant protection measures and rouging to improve the quality of seed. Third training wasgiven to share the knowledge on harvesting, cleaning, drying, post-harvest precautions including protection from insects during seed storage.Farmer was free to sell the surplus seed to neighboring farmers in the village for the horizontal spread of quality seed. Seed village programme was taken for two years in each village.

Table 1. Seed Production by farmers under Seed Village Programme

Season	Village	No. of Farmers	Crop	No. of trainings	Seed production (area/ha)	Seed production(t)
Kharif 2009	1	32	Paddy*	6	6.4	27.2
Rabi 2009-10	6	224	Wheat**	13	44.8	224.0
Kharif 2010	4	76	Paddy	7	15.2	57.8
Rabi 2010-11	5	76	Wheat	6	15.2	76.0
Kharif 2011	3	80	Paddy	5	16.0	72.0
Rabi 2011-12	3	80	Wheat	4	16.0	96.0
*Kharif*2012	3	80	Paddy	5	16.0	75.2
Rabi 2012-13	2	80	Wheat	4	16.0	88.0
Rabi 2012-13	2	10	Berseem***	4	2.0	88.0
Kharif 2013	2	80	Paddy	4	16.0	0.5
Rabi 2013-14	4	136	Wheat	7	27.2	69.6
Rabi 2013-14	4	28	Berseem	7	13.6	144.2
Kharif 2014	6	96	Paddy	6	38.4	1.7
Rabi 2014-15	6	96	Wheat	7	38.4	211.2
Rabi 2014-15	5	16	Berseem	7	1.28	188.2
Total	-	1190	-	74	279.6	2.6

* Paddy – Cv PB1121, PB 1509; **Wheat – Cv HD 2894, HD – 2967, HD – 3086: *** BerseemCv – BL 42

RESULTS

After two years association with ICAR- IARI, Regional Station, Karnal, and through active participation in the trainings following production technologies were adopted by farmers &their level of knowledge for production of quality seed by scientific interventions has increased. Raising of green manure crop and mixing in soil improves physical condition of soil, promote root growth and increase soil fertility there by reducing doses of nitrogen fertilizer particularly in basmati rice.Seed treatment before sowing protects the crop from diseases pests.Sowing of seed crops in rows helps in fertilizer application, plant protection measures to be taken, removal of volunteer plants and rouging of "off type "plants to maintain genetic purity of the crop.Balanced use of nitrogen fertilizer not only saved the fertilizer but also check the increased vegetative growth of the crop which helped to protect the crop from lodging and reduction in seed yield and quality.Use of herbicides at proper time and in proper dose controlled the objectionable weeds and improved the physical purity of crop and put fewer burdens on processing.To protect the crop from diseases and insect pest, pesticides were applied at proper time to avoid crop loss.Safe storage of seed at proper moisture for next cropping season.

CONCLUSION

Farmers are becoming aware about the importance and use of quality seed as local varieties are being replaced with high yielding new varieties.Seed production in group helps in the monitoring of seed crops. Risk of mixture in seed is reduced due to single variety coverage on a particular area. Farmers of neighboring villages showed interest to learn seed production technology due to seed production technology demonstration at farmers' field.

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Strengthening integrated cropping system through IARI-NGO collaboration

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Improved farming methods are essential for agricultural productivity and food security. The adoption of improved technologies is heralded as a major factor in the success of the green revolution experienced by Asian countries (Ravallion and Chen, 2004). Those technologies could be linked with higher earnings and lower poverty (Minten *et al*., 2007 and Kassie *et al.*, 2011), improved nutritional status (Kumar and Quisumbing, 2010), lower staple food prices (Karanja *et al.*, 2003), and increased employment opportunities as well as earnings for landless labourers. Beyond Green Revolution in the late sixties and early seventies, now there is a continuous surge for diversified agriculture in terms of crops, primarily on economic considerations. Agricultural production in eastern Uttar Pradesh particularly in *tarai* region has ever remained low despite bounty of natural and human resources. The major reason behind the poor agriculture production is traditional cropping pattern of rice- wheat system, lack of diversification, poor natural resource management, and poor access to improved agricultural technologies. In view of this since 2010-11, IARI has collaborated with Participatory Rural Development Foundation (PRDF) an NGO working in Eastern UP for transfer of agricultural technology among the small and marginal farmers.

METHODOLOGY

The voluntary organizations working at the grass root level have deep penetration in rural society whereas they lack in capacity for technological backstopping. IARI being a premier research Institute in agriculture has the strength of improved agricultural technologies. This partnership project has been implemented to synergize collaborative strength to promote crop diversification, upscale IARI technologies and ensuring self sustaining seed and food production ecosystem. The NGO has established its credibility among the rural masses of districts of Gorakhpur, Deoria, Maharajganj, Siddharth Nagar, SantKabir Nagar and Kushinagar in the area of agriculture and rural development. To implement the project efficiently,the nodal officer from the NGO, PRDF attend the workshops,organized twice a year with all partner NGOs,and provide feedback about the performance of the technology and plan for the interventions in subsequent cropping seasons. The scientists from the Institute also visit the of the NGO project villages for monitoring demonstrations,to participate in field days for generating awareness among farmers and to collect the data regarding yield, economic performance, and other agronomical parameters. The feedback of the farmers about physical, economic and other relevant parameters are also collected for analyzing qualitative performance of the crop. Technological interventions such as improved varieties of different crops are demonstrated on the farmer's fields. Quality seed materials have been provided for organizing demonstrations.The NGO partner has also been developed as a hub for seed production for technology upscaling particularly for the wheat crop which will ensure sustainability of production.

RESULTS

Total 82 tonnes of seed have been produced on farmers' fields. The seed produced thereby have been redistributed to farmers. Under this project from *rabi* 2010-11 to *rabi* 2014-15, location specific improved varieties of wheat, gram, pigeon pea, lentil, mustard and pea were demonstrated for diversification on the selected farmers' fields. A total of 354 demonstrations were conducted covering an area of 156 hectare. The feedback generated from demonstrated plots of the farmers showed that they were convinced with production potential of improved varieties. As a result of these demonstrations, the increased yields of wheat varieties was upto 66.6%, mustard, 68.28%, pea 51.35%, gram 22.32%, lentil 64.67% and pigeon pea 45.70% were recorded in comparison to local varieties. The calculated B:C ratio for wheat (3.27), Mustard (5.15), pea (4.14), Lentil (2.69), Gram (5.25) and pigeon pea (5.25) indicate economic potential of improved technologies. With increased production and better quality, farmers could get higher economic returns from all the crops and earn better. To popularized bio-fertilizers, *Azotobacter* and PSB were demonstrated in wheat crops and farmers opined that, bio-fertilizer resulted in clear green leaf, bold grain, long head and healthy crop. The intervention saves the cost of one bag of urea per acre reducing the cost of production by 10%. As a result of this project, wheat variety HD 2733 is nowthe most popular one in the region. About 150,000 ha cropped area has been estimated to be under HD2733 (15% of total area) in 7 districts of Basti & Gorakhpur divisions. HD2967 has performed well as a new variety, least affected by cyclone *Hudhud* as the crop did not lodge during March 2015. It was also free from any rusts and Karnal Bunt. Famers of the region prefer small-seeded varieties like L-75 lentil. Pea variety Pusa Pragati is liked by most of the farmers.

CONCLUSION

The paper concludes the experiences and success of outscaling agricultural technologies through participatory programme involving Non Government Organization.

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Response of *Bt* cotton to planting densities as influenced by growth regulators

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A field experiment was conducted from 2014-15 to 2015-16 at Agronomy Farm, College of Agriculture, Parbhani. The soil was medium deep black with low in available nitrogen, medium available in phosphorus and high in available potassium. The experiment was laid out in split plot design with 4 main plot treatments i.e. S_1- 120 cm x 45 cm, S_2- 90 cm x 45 cm, S_3- 90 cm x 30 cm, S_4-90 cm x 15 cm and 6 sub-main plot treatments i.e. G_1-CCC (60 ppm) at square formation and flowering, G_2-CCC (60 ppm) at flowering and boll formation, G_3-Mepiquat chloride (50 g/ha) at square formation and flowering, G_4-Mepiquat chloride (50 g/ha) at flowering and boll formation, G_5- Nitrobenzene (400 ppm) at square formation and flowering, G_6- Nitrobenzene (400 ppm) at flowering and boll formation in 3 replication having plot size is 7.2 m X 5.4 m with an objectives to find out optimum spacing for *Bt* cotton, to study the effect of different growth regulators on growth and yield of *Bt* Cotton, to study the interaction effect of planting densities and growth regulators in *Bt* cotton and to work out the economics of the treatments. The result of experiment revealed that, plant density 120 cm x 45 cm recorded increased number of monopodial and sympodial branches per plant, functional leaves, leaf area and dry matter production per plant, numbers of picked bolls per plant, boll weight, seed cotton yield per plant where as the highest seed cotton yield (1676 kg/ha), maximum gross returns (Rs 75811), net monetary return (Rs 52970) and B:C ratio (3.24) in pooled analysis were recorded in plant density 90 cm x 30 cm. In case of growth regulators treatments G_3 Mepiquat chloride (50 g/ha) at square formation and flowering found effective in reducing plant height and recorded highest yield attributes and seed cotton yield (1663 kg/ha), maximum gross returns (Rs 75392), net monetary returns (Rs 51710) and B:C ratio (3.16) in pooled analysis. However, interaction effects were found to be non-significant.

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Resource use efficiency and yield advantage of sugarcane based intercropping system in tropical India

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Intercropping is higher productivity per unit area. Rapidly increasing population, insufficient food, limited scope for extension of cultivation to new areas, diversified needs of small farmers for food and cash etc. have forced the adoption of intercropping systems. Sugarcane is a long duration crop and takes about 3-5 months for canopy development, which allows room for growing intercrops during early stage. Sugarcane growers take this advantage and grow various short duration crops like pulses, vegetables etc as intercrops to get interim return since small sugarcane growers cannot wait for a long time to get financial return from sole crop sugarcane. Since sugarcane is an important commercial crop all over the world and is most suitable for intercropping, it is necessary to find a possible ways of increasing economic benefit from sugarcane cultivation. With these views, the present investigation was conducted to evaluate suitable intercrop in sugarcanein tropical India.

METHODOLOGY

A field experiment was taken up during 2015 under wide row spacing at ICAR- Sugarcane Breeding Institute (11°N latitude and 77°E longitude), Coimbatore. The soil of the experimental fields is moderately drained with adequate drainage, taxonomically classified as *typic haplustalf*. The soil type was black clay soil with the available major nutrients content of 278 kg/ha N, 45kg/ha P and 640kg/ha K.The experiment was laid out in split plot design with three levels of N (100, 75 and 50% of recommended dose of nitrogen (RDN)) to sugarcane as main plot treatments and six intercrops namely, finger millet, black gram, soybean, sesame, amaranthus and sunn hemp along with sole crop of sugarcane as subplot treatments. The fertilizer recommendation followed for sugarcane was 280:62.5:120 kg N: P_2O_5:K_2O /ha.Since the population of the intercrops was 50% of the sole crop, half the recommended doses of fertilizers were applied to the intercrops; no fertilizer was applied to sunn hemp.

RESULTS

The overall performance of intercrops such as amaranthus, ragi and sunhemp was good whereas the performance of soybean, blackgram and gingelly was poor. The highest NMC was recorded with RDF (112.7/ha) followed by 75% N application (100.5/ha) and 50% N application (79.9/ha). There was no significant difference among the intercropping system followed.The cane yield at 100% RDN (139.7 t/ha) was on par with 75% RDN (128.0 t/ha) whereas it was significantly

Table 1. Resource use efficiency and yield advantage of cropping system as measured by cane yield, land equivalent ratio (LER) and economics in sugarcane based intercropping

Treatments	NMC 10^3 ha^{-1}	Cane yield (t/ha)	Land Equivalent Ratio (LER)	Percent Increase/ decrease in cane yield over sole crop	Cost of cultivation	Total income	Net Income	B:C ratio
N Levels								
100 % N	112.7	139.7	-	-	214852	370205	155353	1.72
75 % N	100.5	128.0	-	-	213952	339200	125248	1.59
50 % N	79.9	89.5	-	-	213052	237175	24123	1.11
SEd	24.8	12.57	-	-	-	-	-	-
CD (P=0.05)	NS	34.91	-					
Cropping System								
Sole SC	98.6	117.2-	1.00	-	214852	310580	95728	1.45
SC+ Finger millet	98.9	110.2 (6.26)	1.52	“ 5.9	215946	302829	86883	1.40
SC+ Black gram	102.6	120.8-	-	+ 2.4	215212	320120	104908	1.49
SC+ Soybean	99.0	126.4-	-	+ 7.8	215452	334960	119508	1.55
SC+ Sesame	96.5	116.8 (2.33)	1.29	“ 0.9	215793	321170	105377	1.48
SC+ Amaranthus	103.0	131.1 (31.5)	1.32	+ 11.7	215452	385215	169763	1.78
SC+ Sunn hemp	108.8	125.1 (76.4)	1.29	“ 5.2	215052	331515	116463	1.53
SEd	37.8	8.30	0.00	-	-	-	-	-
CD (P=0.05)	NS	NS	0.01					

Value in paranthesis are intercrop yields in q/ha

higher than 50% RDN (89.59 t/ha). Cane yield under different intercropping system was non-significant; indicating that all intercrops has equal effect on cane yield. The cane yield was not influenced by different intercrops.

The reduction in cane yield with SC + Finger millet (5.9%) was highest followed by SC + sunn hemp (5.2%), While there was an increase in cane yield with SC + amaranthus (11.7%), followed by SC + Soybean (7.8%) and SC + black gram (2.4%). Reduction in cane yield as a result of different intercrops was attributed to exhaustive competition between the component crops for essential nutrients, water and other growth factors. (Nazir *et al* 2002). The intercrops amaranthus, soybean and blackgram did not affect the cane yield adversely rather there was slight improvement over the pure cane. Soybean and blackgram has not been harvested since there was a coincidence of unexpected summer shower during flowering and the yield was adversely affected. The low competition with main crop and its nitrogen fixing capacity could be the factor responsible for this behavior. A similar result was observed by Saini *et al*. (2003).

Application of 100% N has recorded significantly higher LER than the other two levels irrespective of the intercrops. This might be due to the higher biomass and yield of the system. The LER of different intercrops compared to their sole SC was found higher. This showed that different intercrops geometries were biologically more efficient as compared to their sole SC.Among the cropping systems, Sugarcane + finger millet has recorded significantly higher LER (1.52), than amaranthus (1.32), sunn hemp (1.36) and sesame (1.29). The LER gives an accurate assessment of the greater biological efficiency of the intercropping situation. The higher the LER, the greater is the yield advantage. (Gosh, 2004).

The economic benefits was worked out for different N levels and cropping systems. The highest net return was obtained from 100% N (Rs.155353) followed from 75% N (Rs. 125248 ha^{-1}). Among the cropping system, highest net return (Rs. 169763 ha^{-1}) was obtained from SC + amaranthus. Thelowest net return (Rs. 95729 ha"1) was noted at sole sugarcane. The B:C ratio of sole sugarcane was 1.45. Maximum benefit cost ratio of 1.72 was in 100% N among the N levels and1.78 in SC + amaranthus was observed among the cropping systems.

CONCLUSION

From the results, it is inferred that, cultivation of crops such as finger millet and amaranthus in sugarcane as profitable intercrops under wide row (150cm) system of planting with 100% of recommended N application to the main crop and 50% of the RDF to the intercrop is highly beneficialand hence could be carried out in tropical region of India to increase the productivity and net return/unit area.

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Productivity trends and impact of technology in the rice-wheat system of the Indo-Gangetic plains

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Evolution of the rice-wheat cropping system (RWS) in the Indo-Gangetic Plains in a way represents the path of agricultural development in South Asia. The national and international research organizations and donors have made concerted efforts to improve productivity and environmental sustainability of RWS. Integration of research efforts of the CGIAR Centres and the national agricultural research systems in the region and mobilization of additional resources from international donors have been attempted through several programs and research consortia. In terms of research focus, major thrusts areas pursued were development of high yielding varieties of rice and wheat, tillage and crop residue management, weed control, reclamation of salt-affected lands and water and nutrient management. Small-scale mechanization, system diversification, analysis of socio-economic issues and on-farm experimentations and demonstrations also received considerable attention (RWC, 2004). These programmes resulted into several important outcomes. In particular, resource conservation technologies like zero and reduced tillage made significant impact (Vijaylaxmi *et al*., 2007 and Erenstein *et al*., 2008). Considerable work is in progress on water-saving methods of rice cultivation but these are yet to make some impact on farmers' fields. There has been significant progress in terms of development and spread of rice and wheat varieties, especially superfine rice. This study analyses adoption and impacts of these plant varieties and resource management practices. The paper specifically deals with recent trends in the RWS, and adoption and economic impacts of new plant varieties and RCTs. Empirical evidences are however confined to the Indian region of RWS.

METHODOLOGY

Economic surplus method is applied to estimate economic benefits of commodity research. The technologies considered here are perfect examples of commodity-specific research and therefore this method was applied for rice and wheat. The estimation of economic surplus needs information on market (demand, supply, production, prices etc) parameters, reduction in the per unit cost of production and adoption level. Following, change in economic surplus is computed as:

$$D\,CS = PQ\,Z\,(1+.5\,Zh)$$

$$D\,PS = PQ\,(K-Z)\,(1+.5\,Zh)$$

$$D\,TS = D\,CS + D\,PS = PQ\,K\,(1+.5\,Zh)$$

where $Z = K\,e / (e+h)$; K is vertical shift in supply function as proportion of initial price; h is elasticity of demand (absolute); and e is elasticity of supply.

RESULTS

The successful interventions include improved varieties of rice and wheat, and zero and reduced tillage in wheat. Another important technological intervention in IGP is the introduction of zero-tillage for wheat which occupied substantial wheat area. The main advantage of this technology is cost reduction due to no or reduced tillage and saving of irrigation water in wheat. Incorporation of paddy stubbles also enriches soil, resulting moderate yield gains in some locations. The spread of these technologies is quite significant in terms of area coverage. However, most of the adoption area is limited to Punjab, Haryana and west UP. The efforts are in progress to demonstrate and encourage adoption of these technologies in

Table 1. Parameters for estimation of economic benefits and the rate of returns

Parameter	Zero-tillage	Wheat variety	Basmati rice variety	Common rice variety
Yield advantage (%)	6	11.7	25	18.8
Ceiling level of adoption (%)	25	61	60	29
Price (Rs/tone, 2012)	11,200	11,200	28,829	12,500
Production (million tonnes)	29.8	64.8	7.79	35.46
Research cost (million Rs, 1999)	2741			
R&D lag (years)	10			
Net present value (Rs billion)	169			
IRR (%)	38%			

the eastern IGP. Dissemination of improved varieties was quite smooth as there are number of seed agencies for multiplication and distribution of seed of paddy and wheat. Recently, some exporters and rice millers have also shown interest in promotion of basmati rice varieties because of their commercial interest. Therefore, the spread of basmati varieties is much faster and these are now grown on larger area. The adoption of zero-tillage was rather slow initially and it took few years to spread the technology on larger area. There are important lessons from the adoption of zero-tillage. First, small refinement of technology like modification of tine and furrow opener blade, could lead to large-scale adoption. Second, active participation of the manufacturers has improved availability of ZT drill and thus facilitating the adoption process. Training and encouragement provided to the drill manufactures by the government and research organizations encouraged their participation. This means that input suppliers, whether in public or private sector, should be seen as partners in technology dissemination process- an aspect which was not given due attention until now. Lastly, persistence in the efforts to disseminate a resource conservation technology and it modification to suit local conditions can even take farmers out of outdated beliefs and help them embrace modern agricultural technologies and practices. Of late, a large number of farmers shifted from zero tillage to reduced tillage with rotavator. The estimate of downward vertical shift in the supply function is calculated as proportionate change in per unit cost of production. This change in the cost is realized due to cost savings in zero-tillage in wheat and reduction in yield losses due to various stresses for wheat and rice (common) varieties. In case of basmati rice variety, per unit cost of production decreased because of higher yield of new varieties (Pusa 1121, CSR 30) over the traditional basmati, or improved bastmati bred earlier like Pusa Basmati 1. Economic surplus with close economy was applied for wheat variety and zero-tillage, while the open economy model was used for basmati rice as nearly half of total basmati rice production in India is exported. These data are presented in Table 1.

CONCLUSION

This paper has examined the productivity trends, technological interventions and their impacts in RWS in IGP. The results confirm the trend of slowing down of productivity growth of rice and wheat in IGP, except for rice and Punjab and Haryana where the growth has accelerated due to significant increase in the productivity of superfine rice. The rate of varietal improvement and notification has increased for both the crops, but there is varietal concentration in both the crops. For example, top three varieties contributed more than three-fourths of total seed sale for wheat in the region. Private sector supply an increasing proportion of quality seed and the share of farm-saved seed is reduced to less than one-fifth. The zero tillage in wheat and crop variety improvement is the major technological interventions in the systems, which have generated the returns to the order of Rs 169 billion since 2000. The estimated IRR is 38% and the ratio of net benefits to the cost is 16.6%, which are slightly lower than the rates reported in the past.

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Oilseed based cropping systems productivity in response to land configuration practices in vertisols under rainfed conditions

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The Vertisols and associated soils of Peninsular India are located in the heartland of the dry farming region of India where majority of oilseed area is present. In the changing climatic conditions, declining rainfall amount as well as rainy days affects soil moisture availability which is a concern for sustainable oilseed production (Padmavathi and Virmani, 2013). Land configuration is one of the approaches to improve soil moisture availability and moisture use by system. Therefore different oilseed based cropping systems were evaluated on different land configuration practices to identify oilseed based cropping system specific land configuration practice.

METHODOLOGY

A field experiment was conducted in Vertisols under rainfed conditions at ICRISAT-IIOR farm in 2013-14 with four land configuration practices and five oilseed based cropping systems. The four land configuration practices viz.broad beds of 1.2 m, 1.5 m, 1.8 m and 2.1 m with uniform furrow of 0.3 m as mainplots (500 m^2). The five oilseed based cropping systems viz.fallow-safflower; pearlmillet-chickpea+safflower (3:1); fallow-sunflower; soybean-sunflower and soybean+pigeonpea (4:2) as subplots (100 m^2). The trial was unreplicated and each subplot size was 100 m^2.*Kharif* crops were sown on 4 July 2013 while *rabi* crops were sown on 31 October 2013. The recommended levels of nitrogen, phosphorus and potassium were applied as basal to *kharif* as well as *rabi* crops. In case of intercropping systems (soybean + pigeionpea; chickpea+safflower), the area occupied by each crop was the basis for amount of total fertilizer applied. The amount of rainfall received during cropping season was 1012 mm. The crops did not suffer from moisture stress. *Rabi* crops were sown immediately after harvest of *kharif* crops.The seed yield of other crops viz. millet, soybean, pigeonpea, chickpea and sunflower were converted into safflower equivalent yield which was calculated as under.

Safflower equivalent yield (kg/ha) = Yield of other crop (kg/ha) x Price of other crop (Rs /kg)/ Price of safflower (Rs/kg).

RESULTS

Among the different oilseed based cropping systems, fallow-safflower system variation with land configuration treatments was minimum (*STDEV*: 82), while soybean-sunflower system variation was maximum (*STDEV*: 330). The variability of oilseed system productivity to land configuration treatment was minimum in 1.2 m broad bed (*STDEV*: 1340) and maximum in 1.5 m broad bed (*STDEV*: 1600).

Across different land configuration practices, soybean + pigeonpea system productivity (4625 kg/ha) was superior followed by soybean-sunflower (3175 kg/ha), millet-chickpea + safflower (1500 kg/ha), fallow-sunflower (1500 kg/ha) and fallow-safflower (1200 kg/ha). It indicates that, for soybean based cropping systems, either 1.8 m or 2.1 m broad bed for soybean-sunflower system; 1.5 m broad bed for soybean+pigeonpea intercropping system were found better

Table 1. Effect of land configuration practices on oilseed systems productivity

Cropping system	Safflower equivalent yield (kg/ha) Land configuration (Broad bed and furrow)				STDEV
	1.2 + 0.3 m	1.5 + 0.3 m	1.8 + 0.3 m	2.1 + 0.3 m	
Fallow – Safflower	1200	1300	1100	1200	82
Millet – Chickpea+Safflower	1300	1350	1650	1750	221
Fallow – Sunflower	1750	1500	1400	1300	193
Soybean – Sunflower	2800	3000	3500	3400	330
Soybean+Pigeonpea	4400	5000	4600	4500	263
STDEV	1339	1600	1524	1456	

than that of other land configuration practices. When kharif season was kept fallow, the original BBF (1.2 m) was found better compared to other practices.

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Effect of tillage and sowing methods in groundnut after rice–fallow ecosystem

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In North Telangana region there is a scope to expand the groundnut area in rice fallow ecosystem especially during the summer season. Groundnut as a legume crop not only enhances the overall productivity but also improves the physico-chemical properties of the soil. Poor soil physical condition caused by puddling is the major limiting factor for successful cropping in rice- fallow system (Tripathi *et al.,* 2003). Tillage in rice- based cropping system assumes greater importance due to disturbed soil structure caused by the puddle conditions. Under such circumstances proper tillage practice could be a valid option to reduce the cost and establishment and yield of crops. Keeping these points in view, the present investigation was under taken with the following objectives to study the effect of tillage on groundnut and to find out the effective sowing method in groundnut after rice fallow system.

METHODOLOGY

A field experiment was conducted at Regional Agricultural Research Station, Polasa, Jagtial, Karimnagar, Telangana state during 2009 - 2011. The treatments comprised of three tillage methods as main plots viz. conventional tillage (control), Zero tillage and Rotavator as main plots and four method of sowing *viz*, conventional sowing, seed-cum-fertilizer drill, paired rows (20/30 × 20) and Criss - cross (20x20) as sub plots. The treatments were laid out in strip plot design with three replications using groundnut cultivar Kadiri 6. The recommended doses of NPK were applied through urea, single super phosphate and muriate of potash, respectively in rice crop. In case of groundnut recommended phosphorous (Single super phosphate 250 kg /ha) and potash (Murate of Potash 83 kg/ ha) were applied. *Rhizobium* @ 250 g per 10 kg seed as seed treatment was applied.

RESULTS

The results of the pooled data of three years indicated that, among the tillage practices adopted in the in rice fallow – groundnut system, rotavator method of tillage practice was found superior in Rice follow situation (2251 kg/ha) over conventional tillage (1982 kg/ha) and Zero tillage (1675 kg/ ha). Among the sowing methods adopted, Seed cum fertilizer drill practice recorded higher pod yield (2171 kg/ha) and remaining three methods i.e. criss-cross method (1974 kg/ha), conventional sowing (1952 kg/ha) and paired row method of sowing (1812 kg/ha) were also found on par with each other in recording the yield in groundnut. Among different treatment combinations, significant interaction differences were observed only with rotavator and sowing with Seed cum fertilizer drill (Table 1). The next best treatment was obtained with rotavator and modified method of criss cross sowing for increasing the yield of the crop. Among tillage practices highest number of pods and nodules/plant was recorded with Rotavator (33.9 and 215.4) which was on par to conventional tillage (31.2 and 187.9) as compared to Zero tillage (25.5 and 186.1). Among the sowing methods seed cum fertilizer drill recorded the highest pod (36.5) was on par to criss - cross (32.9). Significant interaction effect was observed in case of pods/plant. Tillage with Rotavator in groundnut has incurred highest cost benefit ratio of 1.52 due to highest gross returns (Rs. 53518/ha) and net returns (Rs. 17833/ha) with less cost of cultivation (Rs. 33703/ha). Among the sowing methods, seed cum fertilizer drill has incurred a highest cost benefit ratio of 1.57 due to highest gross returns (Rs. 51584/ ha) and net returns (Rs. 17993/ha) with less cost of cultivation (Rs. 31500/ha) (Table 2).

Table 1. Yield components as influenced by tillage and sowing methods in groundnut during *Rabi/summer* (Pooled data 2009-10 to 2011-12)

Treatments	Test weight (g)	Shelling (%)	SMK (%)	Yield (kg/ha)		HI (%)
				Dry pod	Haulm	
Main plots – Tillage practices:						
M1- Conventional tillage (control)	37.6	67.3	92.6	1982	4297	31.6
M2- Zero tillage	36.9	62.9	91.7	1675	4389	28.4
M3- Rotavator	39.2	68.0	94.0	2251	4413	33.6
SEm±	0.51	3.1	1.11	86.3	187.4	6.71
CD (P=0.05)	NS	NS	NS	254.5	461.1	NS
Sub plots-Sowing methods						
S1-Conventional sowing (Control) (appr. 40 x 10 cm)	38.1	66.0	93.0	1952	4272	31.3
S2-Seed cum fertilizer drill(30 x 10 cm)	39.0	67.0	93.5	2171	4506	32.2
S3-Paired row (20/30 x 20 cm)	38.0	65.6	92.6	1812	3710	32.9
S4-Criss cross (20 x 20 cm)	38.1	65.7	93.0	1974	4215	31.8
SEm±	1.71	2.7	1.20	89.1	170.0	0.81
CD (P=0.05)	NS	NS	NS	229.3	436.1	NS
CV (%)	13.6	14.1	13.0	15.3	14.2	14.7
Interactions						
SEm±	2.1	3.41	1.28	96.7	192.8	0.92
CD (P=0.05)	NS	NS	NS	168.0	325.1	NS

Table 2. Economics of groundnut as influenced by tillage and sowing methods during *Rabi/summer* (Pooled data 2009-10 to 2011-12)

Treatments	Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit : Cost
Main plots – Tillage practices			
M1- Conventional tillage (control)	47100	12936	1.38
M2- Zero tillage	39816	7674	1.25
M3- Rotavator	53518	17833	1.52
Sub plots- Sowing methods			
S1-Conventional sowing (Control) (appr. 40 x 10 cm)	46397	14484	1.47
S2-Seed cum fertilizer drill(30 x 10 cm)	51584	17993	1.57
S3-Paired row (20/30 x 20 cm)	43126	10975	1.35
S4-Criss cross (20 x 20 cm)	46894	14127	1.45

CONCLUSION

Land preparation with rotavator and sowing with seed cum fertilizer drill was found superior in enhancing yield and yield components in groundnut after rice fallow eco system.

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Influence of different sowing windows on growth and yield of rabi sorghum genotypes

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Sorghum is fifth most important cereal crop followed by rice, wheat, maize and barley in the world. Sorghum is cultivated in tropical and subtropical climates. Sorghum plant is nutritious fodder for dairy animals which is used as both green and dry fodder. Grains are also used in production of alcoholic beverages and bio-diesel. In India, sorghum is extensively produced as both hybrid and improved varieties. The area under rabi sorghum is concentrated in the states of Maharashtra, Karnataka and Telangana. The success or failure of dryland rainfed crops depends mostly on the pattern and distribution of monsoon rains. Winter crops are vulnerable to high temperature during reproductive stages and differential response of temperature changes to various crops. To mitigate these losses of *rabi* sorghum, a field experiment was conducted to find out the suitable sowing window and variety for sustainable yield of rainfed rabi sorghum.

METHODOLOGY

The field experiment was conducted at Agricultural Research Station, Tandur, Ranga Reddy (Dist.), Telangana state during the winter season for the years 2014-15 and 2015-16. The trial was laid out in randomized block design with three replications comprised of five planting dates 36th Meteorological Week, 38th Meteorological Week, 40th Meteorological Week, 42nd Meteorological Week and 44th Meteorological Week with five rabi sorghum varieties CSH-15 R, CSV-22R, Phule Anuradha, Phule Vasudha and Phule Revati. The gross plot size was 4.5 x 5 m^2 and net plot size 3.6 x 4.6 m^2. The sowing of seed was done by dibbling at a spacing of 45 x 20 cm. Recommended crop management practices like thinning, weeding, fertilizer and pesticide were uniformly followed for the experiment. Observations were recorded on five plants randomly selected per treatment.

RESULTS

Results indicated that 38th meteorological week sowing recorded significantly highest plant height of 214 cm, the mean days to flowering (75 days), 119 days to attain physiological maturity, seed weight (3.55 g/plant), while grain and fodder yields of 2871, 2800 and 5882, 6096 kg/ha, respectively was significantly higher and on par with 36th Meteorological Week than sowing in other meteorological weeks. This may be due to the rainfall distribution i.e., 134 mm in 10 rainy days and 178 mm in 14 rainy days and the heat units accumulated (1790, 1893) during the years 2014-15 and 2015-16 respectively. Karhale *et al.* (2014) observed that early sowing of the *kharif* sorghum hybrids resulted in higher yield than later sowing. Among the five cultivars Phule Revati, recorded significantly superior plant height of 211 cm, the mean days to flowering (72 days), 118 days to attain physiological maturity, grain and fodder yields of 2995, 5989 kg/ha respectively over the other varieties. The mean increase in grain and fodder yield with Phule Revati was 0.14 to 0.87 and 0.35 to 0.99 t/ha. The mean grain yield was reduced by the lower yields of Phule Anuradha and Phule Vasudha. Interactions remain non-significant.

CONCLUSION

The results could be concluded that 36th or 38th meteorological week sowing resulted in significantly on par and highest yield than later meteorological week sowing with the grain and fodder yields of 2871, 2800 kg/ha and 5882, 6096 kg/ha respectively. Among the varieties Phule Revati can be recommended for sowing in rabi season for the highest grain and fodder yield at Tandur region.

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Effect of planting time on seed yield and oil content of safflower under rainfed condition of Vidarbha region

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This study was carried out to determine the effect of optimum planting time for achieving highest seed and oil yield under rainfed condition of Vidarbha region. The experiment was conducted at Oilseeds Research unit, Dr. P. D. K. V, Akola, during *rabi* season 2015-16 using a split-plot design with four replications along with three planting date and three cultivars viz., National check Annigeri-1 and high oil content varieties viz., NARI-6 and NARI-57. It was observed that planting time affected branches per plant, effective capsules per plant, 100 seed weight, seed yield, oil yield, biological yield and oil content. The sowing of safflower during second fortnight of September i.e. is 29th September had highest branches per plant (12.7), effective capsules/plant (28.7), 100 seed weight (3.2), seed yield (1009 kg/ha), oil yield (300 kg/ha), biological yield (5183 kg/ha)) and oil content (29.85) than delay in planting time. Planting time has no significant influence on oil content. Annigeri-1 produced significantly higher seed yield (1173kg/ha) and oil yield (344 kg/ha) followed by NARI-6 (822kg/ha and 237 kg/ha) and lowest seed yield was recorded in NARI 57 (720 kg/ha & 224 kg/ha)). Interaction between planting time and variety were found to be significant. Seed yield of safflower variety Annigeri-1 yielded 1380 kg/ha to recommended date of sowing (IInd fortnight of September) and at par with second sowing date (15 days interval after recommended sowing) yielded 1181 kg/ha. Among the varieties, Annigeri-1 significantly superior over the other varieties. The yield of safflower decreases as the crop sown at an interval of fifteen days to normal sowing date. Similar trend were also observed in GMR, NMR and B: C ratio.

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Influence of time of planting and method of curing on quality parameters and nutrient uptake in oriental tobacco (*Nicotiana tabacum*)

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Tobacco is an important non-food commercial crop and plays a major role in world's economy. It is valued in the world trade mainly for leaf. In the face of mounting evidence on the health hazards of tobacco the consumption is not reduced and it is one of the important sources to country's economy. In recent past due to increased awareness and ill effects of smoking the consumer's preference has been shifted towards soft blended light type of cigarettes. Oriental tobacco is one such type of tobacco which is used as important component of the world's premium blended cigarettes characterised with small, aromatic, flavourful, readily combustible and has good filling properties. Oriental tobacco is a low input requiring, labour intensive and remunerative crop under rainfed conditions. As the crop is grown under rainfed conditions, time of planting with suitable method of curing plays a significant role to get good yield and better quality of leaf. The lowest nicotine content and highest total sugars were recorded in the tobacco planted during October first fortnight which was comparable with the crop planted during October second fortnight. The highest nicotine and lowest amount of total sugars were found in the crop planted during November second fortnight. Curing of primed leaves under 25% ventilated polyhouse curing method recorded the highest amount of total sugars and lowest nicotine content. Open rack sun curing method recorded the highest nicotine content and lowest total sugars. Among the treatmental combinations the highest amount of total sugars and lowest nicotine content was recorded in the crop planted during October first fortnight cured with 25 % ventilated polyhouse curing which were comparable with planting of crop during October second fortnight curing under same method. Potassium being an important parameter in improving the burning quality of leaf its content in leaf plays a major role in promoting fire holding capacity of tobacco leaf. The highest potassium content was found in the crop planted during second fortnight of October cured under 25% ventilated polyhouse curing method. The lowest potassium content was found in the crop planted during second fortnight of November cured under Open rack curing method. The planting time significantly influences the nutrient uptake in oriental tobacco. The highest nitrogen, phosphorus and potassium uptake was observed in the crop planted during second fortnight of October which was higher than the other dates of planting. The lowest nutrient uptake was observed in the crop planted during second fortnight of November is due to lower dry matter per unit area coupled with lower nutrient content. The study revealed that planting of oriental tobacco during October second fortnight with 25% ventilated polyhouse curing has resulted in superior quality and higher net returns.

Table 1. Total nitrogen, phosphorus and potassium uptake (kg/ha) at harvest by oriental tobacco as influenced by time of planting

Time of planting	Crop uptake (kg/ha)		
	Nitrogen	Phosphorus	Potassium
I FN Oct	75.7	17.0	57.2
II FN Oct	87.9	19.5	64.0
I FN Nov	56.1	12.1	27.2
II FN Nov	48.2	10.6	20.9

Table 2. Influence of time of planting and method of curing on nicotine content, total sugars and potassium content (%) in Oriental tobacco

Treatment	Nicotine content	Total sugars	Potassium content
Time of planting			
I FN Oct	0.83	20.01	0.94
II FN Oct	0.90	19.52	1.04
I FN Nov	1.22	16.60	0.75
II FN Nov	1.63	14.84	0.60
SEm±	0.32	0.170	0.012
CD (P=0.05)	0.10	0.51	0.03
Curing			
Open sun	1.25	16.19	0.79
25% vent.	0.99	19.55	0.88
50% vent.	1.22	17.49	0.84
SEm±	0.028	0.120	0.010
Time of planting × Curing			
CD (P=0.05)	0.08	0.34	0.03
SEm±	0.056	0.230	0.020
CD (P=0.05)	0.19	0.81	0.07

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Crop growth and productivity of castor (*Ricinus communis*) under varied dates of sowing in Western Haryana region

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Castor is an important non-edible oilseed crop in India. Despite phenomenal increase in the production and productivity of castor over the past decade, there is wide disparity in productivity among various growing regions of India. High yield in castor can achieve through better management practices such as time of sowing which are considered as the principal non-monetary inputs. Although Haryana holds very less in terms of area (2000 ha) and production (3000 tonnes) but productivity of castor is quite high in Haryana (1500 kg/ha) as comparable to leading states like Gujarat (1988 kg/ha) and Rajasthan (1530 kg/ha) (INDIASTAT, 2013). The variety DCH-177 exhibit enormous results and reaping better yields under irrigated conditions in western Haryana conditions. Hence to generate production technological components like optimum date of sowing under crop growing niches of western Haryana, the present field study was conducted.

METHODOLOGY

The field experiment was conducted at regional research station, Bawal, CCS Haryana Agricultural University during 2013-14 and 2014-15 crop seasons. The treatments comprised of four different dates of sowing i.e. 20th June, 5th July, 20th July and 5th August was laid out in Randomized Block design with three replications. The soil of the experiment is loamy sand in texture, alkaline in the reaction with pH 8.3, available nitrogen 148 kg/ha, available phosphorous 15 kg/ha, and available potassium 182 kg/ha, respectively. All the treatments were supplied with recommended dose fertilizers i.e.80 kg N, 50 kg P_2O_5 in form of urea and DAP. Half of N (40 kg/ha) and a full dose of P_2O_5 (50 kg/ha) was applied as basal dose and remaining 50 percent N (40 kg/ha) was top dressed in two equal splits at 120 days crop growth stage and 30 days thereafter. Seeds were scarified by rubbing against rough surface to enhance germination. Seeds were soaked before sowing in water for 24 hours and dried under shade before sowing. Seeds were treated with carbendazim @ 1g/kg of seed to protect from seed borne diseases. The spacing adopted was 120×90 cm. The crop was kept free from diseases through suitable protection measures. The crop was harvested in six to seven pickings manually based on physiological maturity of the capsules. Total rainfall of 797.5 and 860.9 mm was received during 2013-14 and 2014-15 crop seasons.

RESULTS

Sowing the crop on 20th June produced the tallest plants (Table 1) during both 2013-14 and 2014-15 crop seasons when compared to remaining dates of sowing. Dry matter production of the crop sown during 20th June was maximum and found to be superior compared to remaining dates of sowing. Optimum temperature and solar radiation are the most important parameters for increased dry matter production in June sowing of all the sowing dates and reduced dry matter production was observed in 5th August delayed sowing date Crop sown during delayed sowing i.e. 5th August recorded higher

Table 1. Growth, yield attributes and yields of castor as influenced by various dates of sowing

Treatment	Plant height (cm) at 120 DAS (Pooled)	Number of capsules primary/spike (Pooled)	Number of spikes/plant at harvest (Pooled)	100 Seed weight (Pooled)	Seed yield (kg/ha) (Pooled)
Date of sowing					
20th June	122.0	78.2	18.4	28.8	5285
5th July	115.3	79.2	16.9	29.3	5179
20th July	108.8	81.1	16.2	31.3	4484
5th August	90.1	82.7	14.1	32.0	3680
CD (P=0.05)	4.5	2.3	0.9	0.6	67

capsules per spike and 100 seed weight as compared to early sowings dates. In western Haryana conditions. Sowing the crop during 20th June recorded the highest seed yield (5157 kg/ha and 5412 kg/ha) followed by 5th July (5094 kg/ha and 5264 kg/ha) yield which was significantly higher than 20th July and 5th August sowing dates. Lowest seed yield was recorded in delayed sowing i.e. 5th August date of sowing. Delay in sowing resulted in decrease of grain yield of 43.6% when compared to early sowing date. The increase in yield may be attributed to more number of effective spikes and higher dry matter production of crop elevated yield structure resulting in higher yield.

CONCLUSION

From the foregoing account, it is concluded that 20th June date of sowing is a better suitable time for growing of castor with respect to growth, yield of castor as compared to other sowing dates in western Haryana conditions.

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Effect of seed rates on new genotypes of wheat under late sown irrigated condition

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Wheat (*Triticum spp*.) is a crop plant of poaceae family. It is widely cultivated as staple food crop throughout the world. Normal seed rate results in lower yield than higher seed rate under late sown conditions. Yield in wheat is dependent mainly on the number of spikes per unit area and average seed yield per spike, where the number of spikes per unit area can well be compensated by using higher seed rate as practiced in several other wheat growing parts of the world. Seed rate plays a vital role for optimum plant densities which is a pre-requisite for increased seed yield. It influences the yield and yield attributes of wheat. The broadcasting method requires more seeds than line sowing. Higher seed rate produces more plants in unit area resulting in less intra-crop competition hereby affecting the yield and production cost. On the other hand, lower seed rate may reduce the yield drastically .The objectives of present investigation is different seed rates might have significant effect on growth, yield and economics of wheat; because of sowing at different seed rates ameliorates the microclimates to a reasonable extent, which results in variation in yield of the different genotypes. The main aim of finding a suitable seed rates is to provide the number of plants in a unit area, which will not create competition among crop plants for want of light, moisture and nutrients. Keeping this in view, the present studies on "Effect of seed rates on new genotypes of wheat under late sown irrigated condition" was initiated at Wheat Research Unit, Dr. Panjabrao Deshmukh Krishi Vidaypeeth, Akola, Maharashtra, India.

METHODOLOGY

A field experiment was conducted with a Factorial Randomized Block Design with three replicates having eight treatment with combination were formed with first factor consisted of two genotypes and second factor consisted of four levels of seed rates. Main-plot treatment consisted of genotypes; G1: AKAW 4627, G_2 : AKAW 4210-6 with sub-plot treatments of four seed rates of120, 150,180 and 210 kg/ha. The experiment was conducted during Rabi 2014-15 at Wheat Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) India. The gross and net plot size were 2.16 X 6.0 m^2 and 1.80 X 5.00 m^2 respectively. The Recommended dose of fertilizer 80 N kg/ha, 40 P Kg/ha, 40 K kg/ha was used. The fertilizer dose of 80 kg nitrogen was applied in two equal splits i.e. half dose (40 kg N) was applied at the time of sowing and remaining half dose (40 kg N) was applied at 30 days after sowing. Full dose of phosphorus and potash was given to all plots at the time of sowing.

RESULTS

It was revealed from the data that among two genotypes, AKAW 4210-6 was superior over AKAW 4627 in respect of plant height (cm), number of effective tillers/plant, dry matter accumulation/plant (g), number of grains/spike, weight of spike (g), grain weight/spike (g) grain yield (3.92 t/ha), straw yield (7.79t/ha). Genotype AKAW 4210-6 was most economi-

Table 1. Growth, yields and economics attributes of wheat at harvest as influenced by different treatments

Treatment	Effective tillers/plant at harvest	Grain/spike	Grain yield (t/ha)	Straw yield (t/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Genotype							
AKAW 4627	15.80	36.56	3.48	6.94	53972	30052	2.26
AKAW 4210-6	14.94	39.80	3.92	7.79	60768	36848	2.54
SEm±	0.11	0.79	0.09	0.01	1324	930	
CD (P=0.05)	0.32	2.38	0.27	0.03	4015	2821	
Seed rate							
120 kg/ha	4.40	41.43	3.15	6.49	48986	26506	2.18
150 kg/ha	4.10	39.79	4.23	8.10	65490	42050	2.79
180 kg/ha	3.49	36.38	3.90	7.61	60441	36041	2.48
210 kg/ha	3.31	35.13	3.51	7.26	54563	29202	2.15
SEm±	0.12	1.11	0.01	0.02	1872	1315	
CD (P=0.05)	0.35	3.37	0.03	0.07	5678	3989	
Interaction G X S							
SEm±	0.16	1.57	0.132	0.251	2647	1860	
CD (P=0.05)	NS	NS	0.398	0.753	NS	NS	

cal under late sown irrigated condition. The growth and yield attributes showed significant increase when use of wheat seed rate at 120 kg/ha and yield showed significant increase when use of wheat seed rate at 150 kg/ha. Grain yield (4.27 t/ha) straw yield (8.10 t/ha) obtained was significantly higher at seed rate of 150 kg/ha than seed rates of 180, 210 and 120 kg/ha. Use of wheat seed rate at 150 kg/ha was found to most economical under late sown irrigated condition. The wheat genotype AKAW 4210-6 was higher N, P, K uptake (kg/ha) by grain and straw with use of 150 kg/ha seed rate. The wheat genotype AKAW 4210-6 showed higher gross monetary returns, net monetary returns and benefit cost ratio with use of 150 kg/ha seed rate.

CONCLUSION

It was concluded that wheat genotype AKAW 4210-6 give higher grain yield and economic returns with 150 kg/ha seed rate used.

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Potentiality of municipal solid waste composts on reclamation of saline-sodic soil under the influence of water sodicity

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Salinity and sodicity are the most vital abiotic stresses which badly impedes the sustainability and prosperity of global agriculture. The problem of salt accumulation is further compounded by the irrigation with saline/sodic groundwaters. Gypsum, farm yard manure, green manuring, sheep or poultry manure have used to cope the effect of sodicity (Meena *et al*., 2016; Jalali and Ranjbar, 2009). A mixed success has appeared in these findings. Today, bio-degradable municipal solid wastes are a problem for disposal. Hon'ble Supreme Court of India made mandatory recommendations for use of municipal solid waste (MSW) as multiple use *viz*., as nutrients source, raw material for compost preparation or soil conditioners *etc*. Therefore, there is need to identify and explore the potentiality of MSW compost for reclamation.

METHODOLOGY

Surface bulk soil samples of saline-sodic in categories [pH_2 10.7; EC_2 3.01 dS/m; exchangeable sodium percent 77.1;

Table 1. pH and EC (dS/m) of soil before and after leaching in different treatments

Treatment	After incubation		After Leaching		Change	
	pH_2	EC_2	pH_2	EC_2	“pH_2	“EC_2
Control	10.71a	3.71d	8.87ab	0.97ab	1.85a	2.75e
GR25	10.59b	3.93cd	8.88ab	0.92b	1.71cb	3.01d
GR50	10.40d	4.11abc	8.78bc	1.01ab	1.63c	3.10cd
GR25F10	10.53c	4.19abc	8.91a	0.97ab	1.63c	3.23bc
GR25F20	10.52c	4.30ab	8.87ab	1.00ab	1.64c	3.30ab
GR25KC10	10.54bc	4.30ab	8.89ab	0.97ab	1.66c	3.33ab
GR25KC20	10.53c	4.26ab	8.89ab	0.98ab	1.65c	3.29ab
GR25DC10	10.53c	4.36a	8.84ab	0.93b	1.69c	3.42a
GR25DC20	10.49c	4.04bc	8.66c	1.08a	1.83ab	2.96d

Different small letters within the same column show the significant difference at P = 0.05 according to Duncan Multiple Range Test (DMRT) for separation of mean

100% gypsum requirement (GR) 22.7 t/ha] were collected from Saraswati range area in Kaithal of Haryana state of India. Prepared bulk soil were separately incubated for one month with GR25, GR50, GR25 + farm yard manure (10 t ha^{-1}; GR25F10), GR25 + farm yard manure (20 t/ha; GR25F20); GR25 + Karnal compost (10 t/ha; GR25KC10), GR25 + Karnal compost (20 t/ha; GR25KC20); GR25 + Delhi compost (10 t/ ha; GR25DC10), GR25 + Delhi compost (20 t/ha; GR25DC20) at field capacity moisture and room temperature (25–30 °C). After the incubation period, the soils were air-dried and passed through a 2-mm mesh sieve and packed soil column (15-cm long, 10.5-cm *i.d.*) with fixed soil bulk density of 1.35 Mg/m^3. Ten pore volumes of two varied SAR water of 5 and 15 with fixed 6 dS/m EC level water quality were passed and followed by leachate at the end of each pore volume were collected. Water quality parameters of soil leachates were analysed (data not presented). After the leaching process ended, the soils in the columns were drained under gravity for 24 h, and then were evenly sectioned into three slices, 5 cm each, and air dried. The pH_2, and EC_2 of soil were determined.

RESULTS

Application of gypsum and integrated application of GR25+ F10/20; KC10/20; DC10/20 decreased pH_2 and increased EC_2 of soil for subjected to incubation with amendment (Table 1). However, efficiency in decrement of pH_2 were GR50 > GR25KC10/DC10 =GR25KC20/DC20= GR25F20= GR25F10> GR25. Incubation with gypsum/ gypsum + organic amendments elevated soil EC_2 as soil was supplied with electrolytes. Leaching with quality waters had paramount influence on decrement of both pH_2 ($P < 0.0001$) and EC_2 ($P < 0.01$) (Table 1). As expected SAR 5 decreased soil pH_2 at 8.66 (n=81; $P <0.05$) compared to 9.03 for SAR 15 (n=81; <0.05 Fig 1; n=163). Further, EC_2 for soil were lowered on changing SAR 15 by SAR 5 (from 1.00 to 0.95 dS/m). Nature, quantity and their independent integration of amendments had positive influenced on decrement of soil alkalinity and leaching of salts ($P < 0.0001$ and $P < 0.01$ for pH_2 and EC_2). GR25DC20 decreased both soil pH_2 and EC_2 irrespective of leaching with SAR of incoming water. Next to this GR50 was efficient for decrement of soil pH_2. Nearly similar decrements of soil alkalinity were reported on application of GR25 or GR25F20; KC10/ KC20/ DC10. Maximum decrement of soil EC_2 appeared in GR25 followed GR25DC10, GR25F10= GR25KC10= Control= GR25KC20= GR25KC10= GR50= GR25DC20. Decrement in pH_2 along soil depth were followed as 0-5 cm > 5-10 cm > 10-15 cm with 8.86, 8.81 and 9.26 for n=54 no. samples. Conversely, decrement in soil EC_2 appeared as oppositely with 1.22 > 0.87> 0.85 dS $m^{-1}$for soil depth 0-5, 5-10 and 10-15 cm (Fig 1).

CONCLUSION

Water quality has paramount influence on reclamation of saline-sodic soil. Care should be taken for use of high sodic water on leaching of salts or irrigating soil for cultivation. Among the used amendments, integrated use of GR25 with Delhi compost @ 20 t/ha decreased both soil pH_2 and EC_2 irrespective of leaching with SAR of incoming water.

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Extended Summaries Vol. 2 : 4th International Agronomy Congress, Nov. 22–26, 2016, New Delhi, India

Effect of plant growth regulator trinexapac-ethyl on growth and productivity of aromatic rice variety Gobinda bhog

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The Indians have a long tradition of rice cultivation. Bengal's aromatic Gobinda bhog rice gives higher productivity and remuneration. Lodging is a severe problem in this variety of Rice and it is more prevalent with heavy rains & strong winds at the beginning of the grain-filling period and causes significant yield losses. In this situation, plant growth regulator plays a vital role to reduce or prevent lodging and increase the crop yield. Trinexapac-ethyl is a synthetic Plant Growth Regulator (PGR) that inhibits gibberellins biosynthesis thereby increasing root growth and reducing the internodal growth to give thicker and stronger stems which prevent lodging and increase the productivity. The objective of this experiment is to study the effect of plant growth regulator Trinexapac-ethyl on the growth and productivity of Gobinda bhog Rice variety.

METHODOLOGY

The field experiment was conducted in the Agricultural farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, during *kharif* season of 2015. The experiment consisted of seven treatments (T_1-Untreated check, T_2-Trinexapac-ethyl @10g a.i/ha, T_3-Trinexapac-ethyl @20g a.i/ha, T_4-Trinexapac-ethyl @30g a.i/ha, T_5-Trinexapac-ethyl @40g a.i/ha, T_6-Trinexapac-ethyl @50g a.i/ha, T_7-Chlormequat Chloride 50% SL @ 900g a.i/ha) which was laid out in randomized block design with three replications. Fertilizers were ($N:P_2O_5:K_2O$) applied uniformly in the entire field at a dose of 40:20:20::$N:P_2O_5:K_2O$ kg/ha. The plant growth regulators were applied at 55 DAT.

RESULTS

The data presented in Table 1 indicated that the maximum root length and stem thickness at 70 DAT, minimum internode length and maximum grain yield was recorded with the application of T_5 treatment which was statistically at par with T_6 and T_7. Trinexapac-ethyl is antagonist of the plant hormone gibberellins and inhibits gibberellins biosynthesis which reduces the internode length (Pricinotto *et al.,* 2015). The highest values of undamaged or recoverable lodging severity percentage (Table 1), gross return, net return and return per rupee invested (Fig. 1) was recorded in case of T_6 which was closely followed by T_7 and T_5. The results are in conformity with the findings of Merry *et al.* (2015) and Bridgemohan *et al.* (2014).

Table 1. Effect of Plant growth regulator on Internode length, Root length, Stem thickness at 70 DAT undamaged/recoverable lodging severity (%) and Grain yield of Gobinda bhog rice

Treatments	Internode length (cm)	Root length (cm)	Stem thickness (cm)	Undamaged/ Recoverable (%)	Grain yield (t/ha)
T_1: Untreated check	7.61	660.71	1.11	30.5	2.73
T_2: Trinexapac-ethyl @ 10 g a.i./ ha	6.07	720.46	1.15	46.9	3.03
T_3: Trinexapac-ethyl @ 20 g a.i./ ha	5.93	783.76	1.25	66.5	3.29
T_4: Trinexapac-ethyl @ 30 g a.i./ ha	5.69	789.92	1.69	83.6	3.55
T_5: Trinexapac-ethyl @ 40 g a.i./ ha	5.39	806.79	1.74	89.7	3.86
T_6: Trinexapac-ethyl @ 50 g a.i./ ha	5.40	803.88	1.73	95.5	3.78
T_7: Chlormequat Chloride 50% SL @ 900 g a.i./ha	5.40	801.36	1.74	93.8	3.79
SEm ±	0.15	46.97	0.04	-	0.20
CD (P=0.05)	0.46	144.73	0.11	-	0.60

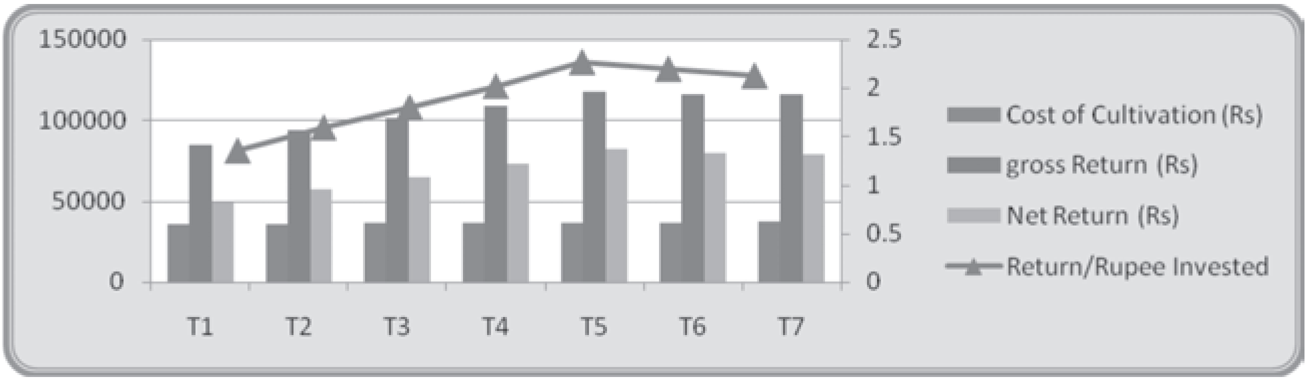

Fig. 1. Effect of PGR on economics of Gobinda bhog rice cultivation

CONCLUSION

Dose of Trinexapac-ethyl @ 40g a.i./ ha at 55 DAT (T_5) may be the optimum dose of plant growth regulator (PGR) for the cultivation of Gobinda bhog rice in lateritic soil of West Bengal for ensuring higher productivity, better lodging protection better and higher profitability.

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Effect of transplanting dates on performance of different aromatic rice varieties under *Terai* zone of West Bengal

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Transplanting of rice at optimum period is critical to achieve high grain yield. The optimum rice planting dates are regional and vary with location and genotypes. Choosing optimum date of plantation occupies an important part of high production package. Sowing and transplanting at the optimum time are important for obtaining high grain yield of rice. Too early or too late transplanting causes yield reduction due to crop sterility and lower number of productive tillers, respectively. In view of the above importance the present investigation entitled "Effect of transplanting dates on the performance of different aromatic rice varieties under Terai zone of West Bengal" was conducted at to ascertain "the effects of nutrient content and its combination on growth, yield and quality parameters of aromatic rice under different transplanting dates" and "to identify the suitable aromatic rice cultivars for different dates of transplanting".

METHODOLOGY

The experiment which was conducted in split plot design under three different date of sowing of 10^{th} July (1^{st} date of transplanting), 25^{th} July (2^{nd} date of transplanting) and 10^{th}August (3^{rd} date of transplanting) in main plot and four varieties namely Kalononia, Khasa, Gobindobhog and Tulaipanji in sub-plot. The hulling and milling per cent were recorded more with the early planting on 15^{th} July which was reported by AICRIP (1991). The results which were recorded on different observation parameters viz. growth characters, yield attributing characters, quality parameter and microbial population are summarized as below.

RESULTS

The most important growth parameter such as plant height, number of leaves, number of tillers /hill, chlorophyll content, leaf area index and crop growth rate and ultimate task of farming in grain yield which varies with the choice of crop varieties as well as transplanting dates. The results showed that among the varieties, 'Khasa' recorded highest grain yield of 2.65 t/ha and it remained statistically at par with 'Gobindobog' and 'Kalononia' with 2.58 t/ha and 2.48 t/ha, respectively. The lowest grain yield of 2.17 t/ha was obtained by Tulaipanji. The results also revealed that milling percentage (66%), hulling percentage (75%), head ear recovery (55%), and protein content (58.10 milligram/gm) significantly increased with subsequent 1^{st} date of transplanting. The growth and yield contributing characters like plant height at 30, 60, 90 and 120 DAT (72.42 cm, 110.90 cm, 127.68 cm and 126.48 cm respectively), number of effective tillers (24.11), number of grain/panicles (250.05) and 1000 grains (21.83) were highest in 10^{th} July transplanted 'Khasa' variety which was at par with Gobindobog variety.

CONCLUSION

From the present study, it can be concluded that first date of transplanting (10^{th} July) was better among all the other dates of transplanting and for all the varieties. Among the varieties, 'Khasa' produced higher grain yield which was *at par* with 'Gobindobog' and 'Kalononia'

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Effect of age and number of seedlings on engineering parameters, yield and economics of machine transplanted rice (*Oryza sativa*)

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Twenty days old seedlings were most suitable for transplanters namely QUAT, CRRI and Yanji and performance of paddy transplanter depends on density and seedlings age. Therefore, it is necessary to optimize the age of seedlings for proper functioning of the transplanters (Aswini*et al.*., 2009). Number of seedlings transplanted per hill in Sri Lanka is only one,five to seven seedlings are transplanted in Philippines. Results in India indicated that the number of fertile tillers were greater with 3-4 seedlings. Mechanical transplanting facilitates better stand establishment of rice crop at right time. Therefore, it is high time for mechanizing the transplanting operation in rice cultivation as it has been considered as the most promising option because it saves labour to the tune of 90 per cent, minimizes stress and drudgery (Behera, 2000).

METHODOLOGY

Field experiment was conducted at Agricultural Research Station, Gangavathi, UAS, Raichur, Karnataka, during *kharif,* 2012 and 2013 laid in strip-plot design. The experiment consisted three different age of seedlings *viz.,* $A_{1:}$20 days old seedlings, A_2 :25 days old seedlings and A_3 : 30 days old seedlings and three different number of seedlings per hill planted by transplanter *viz.,* N_1: 3-4, N_2: 5-6 and N_3:7-8. The land was prepared as per the regular practice and the seedlings raised

Table 1. Transplanting time yield and economics of machine transplanted rice as influenced by age and number of seedlings (Pooled data of two years)

Treatment	Transplanting time (%)	Adjustment/ repair	Grain yield (kg/ha)	Straw yield (kg/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B : C ratio
Main treatments (L)							
A_1	78.11	8.13	4803	5996	85808	40307	1.91
A_2	81.34	5.19	5101	6335	91141	45178	2.01
A_3	79.16	7.25	4889	6122	87356	41371	1.92
SEm.±	0.47	0.19	57	63	702	716	0.01
CD (P=0.05)	2.18	0.90	226	247	2756	2812	0.04
Sub treatments (S)							
N_1	79.24	7.13	5330	6585	95190	49165	2.10
N_2	79.84	6.59	4869	6128	87030	41244	1.93
N_3	79.57	6.85	4595	5740	82085	36447	1.82
S.Em.±	1.79	0.32	67	85	946	977	0.02
CD (P=0.05)	NS	NS	263	332	3715	3835	0.06
Interaction (L x S)							
SEm.±	2.56	0.31	100	142	1599	1774	0.05
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

NS – Non significant; A_1: 20 days old seedlings; A_2: 25 days old seedlings; A_3: 30 days old seedlings; N_1: 3-4 seedlings per hill; N_2: 5-6 seedlings per hill; N_3: 7-8 seedlings per hill

as per the seedling age treatments were planted on the same day. Recommended package of practices were followed for the experiment. The crop was harvested at physiological maturity, threshed and cleaned manually,both grain and straw were sun dried for a week and dry weights were recorded. For computing the cost of cultivation, the cost on seeds, fertilizers, irrigation, plant protection chemicals, hiring charges of transplanter, fuel cost and labour charges prevailed in market during 2012 and 2013 were considered.

RESULTS

Among the different engineering parameters studied, only the transplanting time and adjustment/repair parameters were influenced by age of the seedling. Significantly higher transplanting time (4.14 %) and lower time lost due to adjustment/ repair (63.8 %) were recorded with planting of 25 days old seedlings when compared to planting of 20 days old seedlings. During both the years of study, none of the engineering parameters differed significantly due to the planting of different number of seedlings per hill.Seedlings age had significant influence on yield and economics of machine transplanted rice. Significantly higher grain yield (6.20 %), straw yield (5.65 %), gross returns (6.22 %), net returns (12.08 %) and B: C (5.24 %) were noticed by planting of 25 days old seedlings over planting of 20 daysold seedlings. This might be due to the production of secondary and tertiary tillers in the main field by low aged tillers which are incapable for production of panicle.Planting of 3-4 seedlings per hill produced significantly higher grain yield (16 %), and straw (14.72 %),gross returns (15.97 %), net returns (34.89 %) and B:C (15.38 %) as compared to planting of 7-8 seedlings per hill.

CONCLUSION

Planting of 25 days old and 3-4 seedlings per hill was found optimum for transplanting with self propelled mechanical transplanter.

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Evaluation of suitable crop combination for fodder production in arid zone

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The economy of western arid Rajasthan is mainly depended on livestock. Fodder plays an important role in economizing the cost of production of livestock products especially of milk. Fodder comprises a major protein of dairy ration of milch animals and therefore cultivation of nutritious and high yielding fodder is inevitable. With increase in number of animal population & shrinking land resources, the problem to provide adequate feed and forage become so acute. Therefore, here needs to increase its fodder production with good quality, in large amounts, and in appropriate cost to feed its grazing animals. Barley (*Hordeum vulgare* L.) harvested as feed and hay is a significant source of forage for livestock producers in most arid and semiarid regions because it can be an inexpensive and readily available feed source. Forage barley has good yield and has been found to have higher nutritive value and lower fiber concentration than other small grains (Cherney and Marten, 1982; Brink and Marten, 1986). Similarly, Oats (*Avena sativa*) are grown during winter season in northern India for use as grain as well as forage and fodder, straw for bedding, hay, haylage, silage and chaff. In India, oats have a wider adaptability, particularly in western and north western regions of the country because of its excellent growing habitats, quick re-growth and better nutritional value. With these, white mustard (*Brassica cowdentus*) is an annual plant of the family Brassicaceae. It is sometimes also referred to as *Brassica alba* or B. *hirta*. Grown for its probably originated in the Mediterranean region. The plant's leaves can be eaten during the winter, before it blooms.

METHODOLOGY

A field experiment was conducted during two consecutive *Rabi* seasons of 2013-14& 2014–15 at Research farm of Agriculture Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner. Eleven fodder crop combination treatments comprising of viz. Oat (sole), Barley (sole), mustard (sole), Oat + Barley (1:1 as intercrop), Oat + Barley (mixed), Oat + mustard (1:1 as intercrop), Oat + mustard (mixed), Barley + mustard (1:1 as intercrop), Barley + mustard (mixed), Barley + mustard + Oat (1:1:1as intercrop) and Barley + mustard + Oat (mixed) were evaluated in randomized block design with three replications. The soil of experimental site was loamy sand having 0.08% organic carbon, 8.23 pH, 78, 22 and 215 kg/ha available N, P and K, respectively.

RESULTS

On the mean basis (Table 1) data reveal that growing of Oat + mustard (1:1) and Barley + mustard (1:1) for green

Table 1. Effect of crops and their combinations on green fodder production

Treatment	I Cut (q/ha)			II Cut (q/ha)			Total (q/ha)		
	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean
Oat	69.00	64.00	66.50	40.59	38.59	39.59	109.59	102.65	106.12
Barley	67.33	65.00	66.17	44.89	43.89	44.39	112.22	108.89	110.56
mustard	77.33	75.33	76.33	30.24	9.42	19.83	107.57	84.92	96.24
Oat + Barley(1:1)	86.33	84.00	85.17	53.95	51.57	52.76	140.28	135.57	137.93
Oat + Barley	85.00	82.33	83.67	51.96	50.47	51.21	136.96	132.87	134.91
Oat + mustard(1:1)	93.33	92.00	92.67	52.14	34.50	43.32	145.47	126.57	136.02
Oat + mustard	90.67	89.33	90.00	46.16	40.00	43.08	136.83	129.35	133.09
Barley + mustard(1:1)	92.00	93.33	92.67	55.15	43.20	49.17	147.15	136.55	141.85
Barley + mustard	91.33	90.00	90.67	51.65	43.00	47.33	142.99	133.13	138.06
Barley + mustard + Oat(1:1:1)	91.00	88.67	89.83	56.41	54.30	55.35	147.41	143.13	145.27
Barley + mustard + Oat	90.00	87.00	88.50	46.67	41.33	44.00	136.67	128.33	132.50
SEm±	3.33	1.12	–	2.32	1.96	–	5.65	3.41	–
CD (P=0.05)	9.81	6.25	–	6.86	5.78	–	16.66	10.05	

fodder production gave superior yield as first whereas, as second cut and total green fodder production the treatment combination Barley + mustard + Oat (1: 1: 1) gave highest green fodder yield followed by Barley + mustard (1:1), Barley + mustard, Oat + Barley (1:1), Oat + mustard (1:1), Oat + Barley, Oat + mustard, Barley + mustard + Oat, Barley, Oat, mustard.

CONCLUSION

It may be concluded that to harvest maximum fodder production Barley, oat and white mustard should be grown in1:1:1 ratio as intercrop.

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Performance of makhana crop (*Euryale ferox*) under varied crop geometries and planting dates in wetland situation of Assam

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Gorgon nut or fox nut commonly known as makhana is an aquatic cash crop with large floating leaves and prickled petiole, pedicel and fruit (Kumar *et al.*, 2011). There are large scopes for makhana cultivation in Assam. The natural wetland which covers about 0.1million ha in Assam can be utilized for cultivation of this crop. In low-lying areas where rice cultivation is not remunerative or in flood prone area the crop can be cultivated. Research on agronomic aspects of the crop is almost nil. In view of this, an investigation was carried out to find out the proper planting geometries and dates in wet land situation of Assam and also to see the possibility for enhancement of wetland water productivity through its cultivation.

METHODOLOGY

The experiment was conducted at ICR Farm, Assam Agricultural University, Jorhat during 2014-15. The soil was sandy loam with p^H 5.2, Organic carbon 1.01%, available N 282.10 kg/ha, available P 13.80 Kg/ha and available K 136Kg /ha. The experiment was laid out in randomized block design with 3 replications. The experiment consisted of 4 treatments of crop geometries (1.00m x1.20m, 1.25m x1.20m, 1.50m x1.20m, 1.75m x1.20m) and 4 dates of planting (15 March, 30 March, 15 April and 30 April). The variety "Swarn Baridehi" was sown at nursery bed on 20 December, 2014 @ 20Kg/ha and was harvested on 8-15 October, 2015. Numbers of fruits/plant, seeds / fruits, seed yield/plant, seed weight and seed yield / plot were recorded with statistically acceptable procedure. Water use for a particular treatment was calculated by using standard procedure. The values of water use was used in the formula of Water Productivity (Kg/m^3) = Economic yield (Kg/ha)/Water used (m^3)

RESULTS

Different crop geometries treatments could not bring about any significant influence in100- seed weight (Table 1). However, the seed yield /ha was found to be significantly higher (22.12 t/ha) under crop geometry 1.25m x 1.20m. Significant influences were also recorded in cases of nos. of fruits/plant, nos. of seeds/fruit and seed yield/plant. Recording the highest seed yield/plant (0.3 kg) from the 1.25m x 1.20m supported in getting the highest seed yield/ha from the same treatment. Higher seed yield under 1.25m x 1.20m might be due to the optimum micro-environment in the crop field. Effect of dates of planting was significant in respects to nos. of fruits/plant, nos. of seeds/fruit; seed yield/plant (Table 1). Planting on 30 March recorded the significantly highest seed yield (20.18 t/ha) which was at par with 15 March planting (19.91t/ha). Better results with these treatments were supported by the cumulative influence of all the yield attributes. Such results are obvious as transplanting at earlier dates provide optimum time for better growth than late planted one on same date of harvesting. Crop water productivity under different dates of

Table 1. Effect of crop geometries and dates of planting on yield and yield attributes of makhana

Treatment	No. of fruits/plant	No. of seeds/fruit	Seed yield/ plant (kg)	100 seed wt. (g)	Seed yield (t/ha)
Crop geometries					
120cm×100cm	8.00	35.75	0.29	95.33	17.80
125cm×120cm	8.40	38.75	0.30	95.76	22.12
150cm×120cm	8.70	39.00	0.28	94 .72	16.09
175cm×120cm	8.83	39.42	0.24	94.55	15.73
SEm±	0.05	0.95	0.01	0.33	0.62
CD (P=0.05)	0.17	2.74	0.03	NS	1.80
Dates of planting					
15 March	9.30	39.67	0.29	95.78	19.91
30 March	8.27	39.58	0.32	95.03	20.18
15 April	8.75	38.42	0.28	94.95	16.41
30 April	9.00	35.25	0.24	94.60	15.24
SEm±	0.17	0.95	0.01	0.33	0.62
CD (P = 0.05)	0.50	2.74	0.03	NS	1.80
Interaction	NS	NS	NS	NS	NS

Table 2. Crop water productivity of makhana under different dates of planting

Treatments	Total rain-fall (cm)	Irrigation applied (cm)	Pan evaporation (cm)	Water loss (cm)	Total water used (m^3)	Water productivity (Kg/m^3)
Dates of Planting						
15 March	170.90	33.37	66.30	107.02	3095	0.643
30 March	164.10	32.20	61.70	107.02	2740	0.736
15 April	162.00	29.60	57.30	107.02	2728	0.601
30 April	161.00	25.11	54.90	107.02	2419	0.603

planting was found to be the highest ($0.736 kg/m^3$) at 30 March planting followed by 15 March (Table 2), might be due to the seed yield consequent upon the better use of water (DWM, 2011). Thus, considering the performances of crop under different treatments, the crop may be transplanted from 15 March to 30 March with optimum crop geometry of 1.25m x 1.20 m with possibility of obtaining higher water productivity.

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Extended Summaries Vol. 2 : 4th International Agronomy Congress, Nov. 22–26, 2016, New Delhi, India

Appropriate agronomical practices to enhance the yield of scented rice (*Oryza sativa*) under the concept of system of rice intensification

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Rice (*Oryza sativa* L.) is the major staple food grain crop of India. It is widely grown in south-eastern part of the country in the global context India stands first with second in an annual production. Productivity of rice in India is quite low as compared to other rice growing countries like Japan, Korea, China and Indonesia. Chhattisgarh is called "Rice bowl" because rice is an important crop grown in nearly 3.47 million ha area and production is 4.58 million tonnes. The annual rainfall of the state is sufficient to grow rice in the state with higher productivity. But productivity is quite low (1.3 t/ha) as compared to national productivity. Among various factors methods of cultivation play a dominant role in reducing the productivity. In recent years, SRI is emerging water saving technology, with many fold increase in crop yield. System of rice intensification (SRI) was first developed in Madagascar in 1980's. By adopting this system of cultivation we could save water, protect soil productivity, save environment by checking methane gas and bring down the input cost, besides increasing the production for providing food to the growing population.

METHODOLOGY

The present investigation entitled "Appropriate agronomical practices to enhance the yield of scented rice (*Oryza sativa* L.) under the concept of System of Rice Intensification" was carried out at the Instructional farm, IGKV during *Kharif-Rabi*-2007-08 and 2008-09. The soil of the experimental field was clay loam in texture (alfisol), the soil was neutral in reaction and had medium organic carbon, low available nitrogen, medium available phosphorus and high exchangeable potassium with normal electrical conductivity. Geographically, Raipur is situated in the centre of Chhattisgarh and lies between 21°16¢ E Latitude and 81°26¢ N Longitude at an altitude of 289.56 meters above the mean sea level. Climatologically, Raipur is classified as slightly moist-hot zone. In *Kharif* season the experiment was laid out in RBD with three replication and 14 treatments consist of *viz.* 1- Standard SRI; 2- SRI + 12-15 DOS; 3- SRI + 15-18 DOS; 4- SRI + 2 SPH + 20X20; 5- SRI + 20X20; 6- SRI + 1 CW + 1HW; 7- SRI + whipsuper + almix; 8- SRI + saturation for Life Cycle; 9- SRI + saturation upto tillering + 5±2 upto PI then saturate up to PM; 10- SRI + 10 t FYM + 75% NPK + PSB + BGA; 11- SRI + 5 t FYM + 100% NPK + PSB + BGA; 12- Standard transplanting; 13- Transplanting + 12-15 DOS, 2-3 SPH, 20 X 20 cm and whipsuper + almix and 14- Transplanting + 15-18 DOS, 2-3 SPH, 20 X 20 cm, 2,4-D, FYM 5 t/ha. (DOS = days old seedlings, SPH = seedlings per hill, CW = conoweeder, HW = hand weeding, PM = physiological maturity)

RESULTS

The data on number of filled grains/panicleas affected by different SRI and transplanting based input management strategies are presented in fig. Under SRI management strategies, standard SRI (T_1) recorded significantly highest number of filled grains/panicle (215.4 which was at par with T_{13} (Transplanting + 12-15 DOS, 2-3 hill$^-$, 20 X 20 and whipsuper + almix), followed by T_3 and it was at par with others strategies during first year except T_{12}. The data on effective number of tillers/mas affected by different SRI and transplanting based input management strategies are presented in fig. Under SRI and transplanting based input management strategies, standard transplanting (T_{12}) recorded significantly highest number of

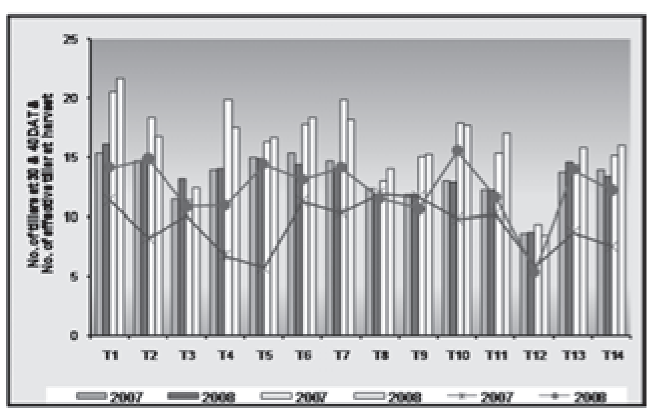

Fig. 1. Number of tillers plant^{-1} and No. of effective tillers plant^{-1} in secented rice as influenced by different SRI based inputs

effective tillers/m (291.7 and 295.8 during first and second year, respectively) over other strategies followed by T_{13} during both the years. Under SRI based input management strategies highest grain yield of rice (34.6 q/ha) was observed under T_1 (standard SRI) followed by T_6 and T_8 during first year whereas, during second year it was higher under T_{11} (SRI + 5 t FYM + 100% NPK + PSB + BGA) which was followed by T_6. In case of transplanting management strategies highest grain yield of rice was observed under T_{13} (Transplanting + 12-15 DOS, 2-3 SPH, 20X20 and whipsuper + almix) during both the years and lowest grain yield of rice (24.36 q/ha) was observed under T_{12} (Standard transplanting) during both the years. In case of transplanting of old seedling under SRI, it was found that 10-12 days old seedling respond better (T_1) than 12-15 (T_2) or 15-18 (T_3) days old seedling, similarly under planting geometry management it was found that 25 x 25 cm under SRI (T_1) proved best than the 20 x 20 cm (T_4 and T_5) when all other resource inputs are same as in case of standard SRI (T_1). In case of weed management treatments used (T_6 and T_7), it was observed that, either using of conoweeder twice (T_1) or once CW + one HW (T_6) were comparable during both the years than the use of weedicide (T_7). However, under water management situation (T_8 and T_9), it was registered that saturation upto maximum tillering followed by submergence (5±2 cm) upto grain filling (T_1) gave good response than either saturation for whole life cycle (T_8) or saturation upto tillering, followed by submergence (5±2 cm) upto panicle initiation and thereafter saturation upto physiological

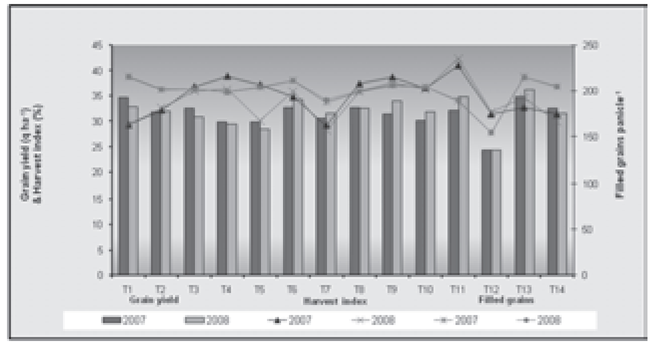

Fig. 2. Grain yield, harvest index and filled grains panicle^{-1} in scented rice as influencedby different SRI based inputs

maturity (T_9) during both the years. The critical analysis of grain yield also revealed that, in case of nutrient management strategies under SRI (T_{10} and T_{11}), application of 15 t FYM per ha + BGA and PSB gave comparable yield of rice as in case of application of 5 t FYM per ha + 100% NPK + PSB + BGA (T_{11}) as compared to T_{10} during both the years. Traditional management strategies also revealed that (T_{12} to T_{14}), transplant the 12-15 days old seedling with 2-3 SPH at 20 x 20 cm spacing and spray of whipsuper + almix for control of weeds (T_{13}) gave the higher grain yield of rice, even over the standard SRI (T_1) and other transplanting management strategies (T_{14}) and standard transplanting method (T_{12}) as generally adopted by the local farmers.

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Enhancement of seed cotton yield by using paclobutrazolin in cotton (*Gossypium spp.*)

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Cotton (*Gossypium hirsutum*) is widely grown fibre crop across the globe.It is the *kharif* crop of tropical and sub-tropical areas which requires 6 to 8 months to mature with uniformly high temperature varying between 21°C and 30°C. The growth of cotton is retarded when the temperature falls below 20°C. Cotton provides the basic raw material (cotton fibre) to cotton textile industry. Its' seed (binola) is used in vanaspati industry and can also be used as part of feed for milch cattle's to get better milk.The use of plant growth regulators (PGRs) in cotton encompasses a broad category of compounds that promote, inhibit or otherwise modify plant physiological or morphological processes as well as to increase seed cotton yield and lint quality. Commercially available PGRs can often be divided into two basic groups: growth inhibitors and promoters. PGRs, such as chlorocholine chloride, paclobutrazol, and mepiquat chloride, act as stem shorteners and effectively control plant height, which can assist with mechanical seed harvest (Kumar *et al*., 2012).Among PGRs, paclobutrazol, a triazole compound, is widely used as a growth retardant for controlling vegetative growth in a large range of plant species; it impedes plant growth by inhibiting sterol and gibberellin biosynthesis (Khalil and Rahman, 1995; Khan, 2009. The boll, or fruit, is the most important component of cotton production.Cotton bolls range in size from under 3 grams to over 6 grams per boll. Seed accounts for about 60% of this weight; the remainder is lint. Cotton square and boll shedding (abscission) has received much attention because lost squares and bolls represent yield loss, such that if shedding decreased, then productivity would be increased.

METHODOLOGY

Field experiment was conducted at the instructional farm of Rajasthan College of Agriculture,MPUAT, Udaipur, Rajasthan, India during the rainy (*kharif*) seasons of2014 and 2015 with a fixed layout plan on the same site. Total amount of rainfall received during crop growth period was 659.0 mm in the year 2014 and 508.2 mm in 2015. The initial soil status of the experimental field was 0.72% organic carbon, 265.6 kg/ha available nitrogen, 19.26 kg/ha phosphorus, and 342.40 kg/ha potassium. Jai BG-II (Bollgard II) variety of cotton was sown on 18July, 2014 and on 09June, 2015 at 90 cm × 90 cm spacing. The experiment was conducted in randomized block design with three replication keeping eight treatments under study viz.,untreated control, paclobutrazol 23% SC 28.75g a.i./ha,paclobutrazol 23% SC 34.50g a.i/ha,paclobutrazol 23% SC 40.25g a.i./ha, paclobutrazol 23% SC 80.50g a.i./ha,alpha napthyl acetic acid 4.5% SL20 ppm (444 g/ha),gibberellic acid 0.001% L 0.018g a.i./ha,mepiquat chloride 5 % AS 50.00g a.i./ha.The fertilizer was applied as per recommended dose of Udaipur i.e. 120 kg N+60 kg P_2O_{5+}60 kg K_2O/ha. The investigation was focused on spraying of varying doses of vegetative growth restrictive chemicals twice at 60 and 80 DAS and data were recorded before 1st& 2nd spray and 20 days after 2nd spray. Plant height, internodal distance and square and boll numbers were recorded on randomly selected 10 plants in each plot before 1st spray (60 DAS), before 2nd spray (80 DAS) and 20 days after 2nd spray during both the years. Average green boll weight was recorded at harvest from 5 bolls of each randomly selected 3 plants in each plot. The lint weight was recorded of 10 open bolls of randomly selected 3 plants in each plot. The data were statistically analyzed.

RESULTS

Crop sprayed with paclobutrazol 23% w/w SC had a significant effect on the growth and yield attributing characters during both the years of investigation, where minimum plant height,minimum last four internodes distance from top to bottom and maximum number of squares and bolls, and green boll and lint weight(Table 1) were recorded with application of paclobutrazol 23% w/w SC 40.25 g a.i./hawhile remained at par to its lower dose 34.50g a.i./habefore 2nd spray and 20 days after 2nd spray, during both the years on pooled basis.Simultaneously untreated control plot recorded a minimum number of squares and bolls and green boll weight (Table 1).The seed cotton yield in different treatments was ranged from 2.09 to 2.72 t/ha on pooled basis (Table 1). The paclobutrazol 23% w/w SC 40.25 g a.i./ha recorded maximum seed cotton yield followed with paclobutrazol 23% w/w SC 34.50 g a.i./ha. Both these treatments (34.50 g a.i./haand 40.25 g a.i./ha) were found significantly superior over untreated control plot paclobutrazol 23% w/w SC 28.75 g a.i./ha, NAA 4.5 % SL 20 ppm, gibberellic acid 0.001% L 0.018 g a.i./haand mepiquat chloride 5% AS 50 g a.i./ha.

CONCLUSION

It can be concluded that paclobutrazol 23% w/w SC 40.25 g a.i./ha have shown a remarkable effect on all the growth parameters as well as yield attributes and yield to restrict vegetative growth, prevent shedding of squares/bolls & yield en-

Table 1. Effect of Paclobutrazol 23 % w/w SC on yield attributing characters and yield of cotton

Treatment	*Square (no.) before 1st spray	*Square (no.) before 2nd spray	*Square (no.) 20 days after 2nd spray	*Bolls (no.) before 2nd spray	*Bolls (no.) 20 days after 2nd spray	**Lint wt (g)	**Seed cotton yield (t/ha)
Untreated control	49.54	34.62	7.53	8.42	38.67	55.77	2.09
Paclobutrazol 23% w/w SC 28.75 g.a.i./ ha	50.50	37.75	8.94	12.00	40.25	57.98	2.39
Paclobutrazol 23% w/w SC 34.50 g.a.i./ ha	51.95	40.47	10.93	12.90	42.45	60.94	2.67
Paclobutrazol 23% w/w SC 40.25 g.a.i./ ha	47.28	41.63	11.22	14.38	42.83	61.35	2.72
NaphthylAceticAcid 4.5% SL 20ppm	53.60	38.23	9.68	10.37	41.40	59.36	2.51
Gibberellic Acid 0.001% L 0.018 g.a.i./ha	55.55	37.18	8.23	9.19	40.48	58.42	2.34
Mepiquatchloride 5 % AS 50 g.a.i./ha	51.40	35.40	7.58	9.07	39.41	56.87	2.18
CD (P=0.05)	2.74	2.20	0.53	0.63	1.78	2.22	0.14

*Observations based on average of 10 plants; ** Observations based on average of 03 plants hancement compared to rest of the doses of paclobutrazol and other plant growth regulators.

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Evaluation of competing ability of rice genotypes direct seeded in North East Haryana

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In North East Haryana, *kharif* rice cultivation depends on monsoon rains and tube well water supplies. Rice is grown by manual transplanting of seedlings into puddle soil. During the era of Green Revolution, rice contributed immensely to increased food production. However, the continuous puddling operation of rice production has led to disadvantages such as excessive loss of ground water, formation of hard pan below plough layer, deterioration of soil structure and quality for next crop and high energy requirement. Water shortage is becoming severe in these areas, prompting the introduction of a water-saving direct seeding rice production. Farmers are shifting from manual transplanting to direct seeding to seek higher profitability to offset increasing cost. By direct seeding system, rice is more rapidly and easily planted, less labour intensive, consumes less water, mature earlier and have fewer methane emissions and more conducive to mechanization. However, weeds were treated as the most important biological constraints to successful production of rice under direct planting. Differences between rice cultivars in response to weed competition have been recognized (Suzuki *et al*., 2002; Zhao *et al*., 2007). There are many reports of successful weed management in rice under direct seeding. But varietal identification and development for direct seeding has been neglected which may explain why it has not become popular. The studies on competitive ability of rice cultivars under direct seeding are scanty. The present study was aimed at to evaluate the performance of nine genotypes of scented and coarse grain rice under direct seeding to select suitable rice cultivars.

METHODOLOGY

A field experiment was conducted at Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Karnal, India. Nine rice genotypes viz. three scented rice- PB 1121, HB 2 and CSR 30 and six coarse grain rice varieties viz. HKR 47, HKR 48, HKR 127, HKR 128, PR 121 and PR 122 were used as the plant materials. The experiment was laid out in strip plot design using three replications with method of planting in main plot and ten rice genotypes in sub plot. The method of planting was direct seeding (DSR) and puddle transplanting (PTR). Soil of experimental plot was clay loam in texture, slightly alkaline in reaction, low in available nitrogen and phosphorus and high in available potassium. The crop was sown on 14 June 2014 under DSR in rows 20 cm apart by using 8 kg seed/acre. Under PTR, the seedlings were transplanted on 14 July 2014 in rows 20 cm and plant to plant spacing of 15 cm apart. Recommended full dose of phosphorous (60 kg/ha for coarse grain rice and 30 kg/ha for scented rice) and $ZnSO_4$ (25 kg/ha) was applied at the time of preparatory tillage under PTR and drilled under DSR. Application of N (150 kg/ha for coarse grain, 60 kg/ha for scented rice) was applied in three split doses i.e. 1/3rd at transplanting, 1/3rd at 21 days and 1/3rd at 42 days after transplanting in PTR. Under DSR, N was applied at 21 and 42 days after sowing. Under PTR, frequent irrigations were given to maintain 5± 2 cm standing water up to 15 days after transplanting. After that irrigation was given as and when required to maintain the saturated conditions of soil. For DSR, first irrigation was given at 7 days after sowing with follow up irrigations at weekly interval keeping rainfall in consideration. Irrigation was stopped one week before harvesting of the crop. Effective weed control was obtained by pre-emergence application of pretilachlor @ 1.0 kg/ha in standing water at 3 days after transplanting in PTR. In DSR, pendimethalin @ 1.0 kg/ha was applied just after sowing and spray of bispyribac sodium @ 25 g/ha 20 days after sowing to control weeds. Data were analysed by Online Statistical Package (OPSTAT, CCS Haryana Agricultural University, Hisar).

RESULTS

Direct seeding of scented rice has been reported remunerative and its cultivation under DSR has been recommended in North east Haryana (Yadav *et al.*, 2011). All the recommended cultivars for DSR are primarily bred for puddle transplanting. Almost no varietal selection and breeding efforts have been made for developing rice cultivars suitable for DSR. The results of this study revealed that performance of both scented and coarse grain rice genotypes varied between DSR and PTR. On an average, grain yield was significantly lower (14.67%) in DSR than in PTR. Grain yield of scented rice was lower by 3.40%, whereas those of coarse grain rice were lowered by 17.15% in DSR compared to PTR. The genotypic variation in yield reduction ranged between 1.74-5.07% in scented and 6.06-23.48% in coarse grain rice. Similarly, biomass reduction was 0.04-3.32% in scented rice and 8.03-18.53% in coarse grain rice. Coarse grain rice HKR 48 performed fairly well under DSR with 6.06% decline in grain yield. Biomass was strongly correlated to grain yield (R^2=0.89). The reason for decline in grain yield under DSR may be due to decrease in biomass. Grain yield was also positively related to number of grains/panicle (R^2=0.60) but negatively to number of panicles/ unit area (R^2=0.60). The reduction in number of grains/panicle was 28.97% in DSR compared to PTR, and 21.28 and 31.51%, respectively in scented and coarse grain rice. This indicated that high spikelet sterility and tiller mortality occurred in DSR resulting into lower yield. Therefore, in order to achieve high grain number, sink demand should be met by high canopy photosynthesis at pre-anthesis and high remobilization ability, which is reported to be governed by maintenance of favourable tissue water relations as a result of greater soil moisture availability which requires optimum soil water availability during reproductive period in rice especially direct seeded.

CONCLUSION

In conclusion, the ideal genotype for DSR must combine a reasonably high yield potential with plant characters which could buffer yield against terminal moisture stress as indicated by large spikelet sterility and tiller mortality. There was large genotypic variation for yield and yield attributes in both scented and coarse grain rice, which may provide substantial scope for the improvement of productivity. Bridging large yield gap between DSR and PTR requires targeting of cultivars specifically for DSR. Therefore, selection of cultivars plays an important role to get high yields under DSR.

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Sustainable intensification of rice-wheat cropping system of eastern Indo-Gangatic plain: food and nutrition security with employment opportunities

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Water, energy and labour scarcity, increasing cost of production, diminishing farm profits and emerging uncertainty of weather events are major challenges faced by the farmers under intensive tillage based conventional rice-wheat (RW) production system of Eastern Indo-Gangetic Plains. The growing window (July to mid-April) in traditionally management rice-wheat rotation allows farmers to harvest only two crops with sub-optimal yields and profits. Innovations in optimizing RW rotation window through sustainable intensification (SI); a system where agricultural yields are increased without adverse environmental impact and without the conversion of additional non-agricultural land (Pretty, 2008; Pretty and Bharucha, 2014) may help addressing the emerging challenges in Eastern IGP. We therefore, carried-out a study on sustainable intensification of RW rotation with conservation agriculture based management practices integrating adapted genotypes with optimization of planting time. We present summary of two year results related to increase in cropping intensity, crop (cereal and legumes) productivity, farm profitability as well as employment opportunities in smallholder systems of E-IGP.

METHODOLOGY

A systematic strategic research trial on sustainable intensification of rice-wheat rotation was carried-out during 2012 to 2015 at the research farm of BISA, Pusa (Samastipur), Bihar, India. Treatments consisting of four scenarios of the combination of differential duration rice and wheat varieties planted with and without mungbean in rotation (Table 1)to optimize the planting enabling introduction of short duration legume (mungbean) without any yield penalty on RW system. The experiment was conducted in split-plot design with three replications. All rice varieties were planted as direct-seeded rice (DSR) under zero tillage in first week of June. Three different duration wheat varieties were planted just after harvesting of different duration rice varieties i.e. October 20, November 05 and November 25. Mungbean crop was planted on March 25, April 10 and April 15 just after harvesting of wheat crop planted at different dates. All good agronomic practices (GAP) for water weed, nutrient etc. were used in all the treatments.

RESULTS

Results of the study demonstrate that long duration rice varieties gave slightly higher yield than the short duration varieties but planting of short duration rice varieties enabled early planting of wheat helped in longer wheat growing window, escaping terminal heat stress and vacating field early so as to plant succeeding summer mung bean crop on time. Pooled analysis of 3 year data presented in figure 1 revealed that although the difference in biomass / grain production in scenario I and II were meagre (annual grain productivity was

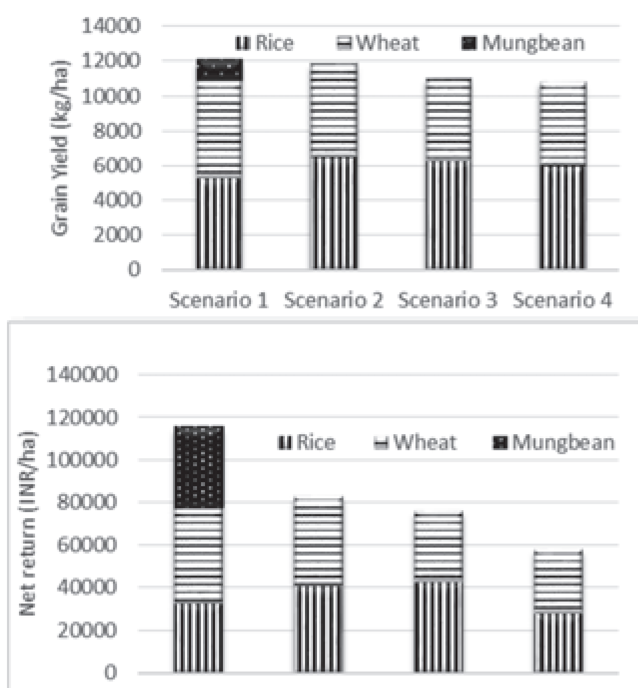

Fig. 1. Productivity and Profitability of different scenarios

Table 1. Cropping system scenario

Scenario #	Kharif (June –Oct)	Rabi (Oct- March/April)	Summer(March/April-June)
1	120 day rice cultivar (Rajender Bhagwati)	Wheat sown on 20th Oct CSW18, HD2733, HD2967	Mungbean(Pusa Vishal) sown on March 25
2	140 day rice cultivar (Arize 6444)	Wheat sown on 5th NovCSW16, HD2733, HD2967	Mungbean (Pusa Vishal) sown on April 10
3	155 day rice cultivar (Rajender mahasuri)	Wheat sown on 25th Nov CSW16, HD2733, HD2967	Mungbean(Pusa Vishal) sown on April 15
Conventional (4)	Long duration late rice crop (Rajender mahasuri) was PTR	Wheat crop seeded after land preparation in 3rd week of Nov	No Mung crop was taken after rice harvest

~12 tons / ha) due to numerically laser yield value of economically high value mung bean crop but the net returns were significantly higher in scenario I as compared to other scenarios. Even, the net profit in scenarios II and III were remarkably higher than scenario IV (conventionally managed RW system). Even though the cropping intensity in scenarios II and III were also similar (300%) to that of I but the economic yield of mungbean could not be realized due to late planting of mung bean owing to late harvest of wheat and early monsoon rains as well as heavy infestation of insect-pests. Because of these reasons, the farmers in Bihar generally either do not get opportunity window or not attempt to plant summer mung bean after wheat harvest. The lowest system productivity was recorded in scenario 4 (10.7 t/ha) and highest close to 12 t/ha in scenario 1 & 2. Introduction of a green gram crop in a cereal- cereal system such as rice-wheat not only enhances economic sustainability but also improve the soil C build up and mops up residual $NO_3^{-}N$ before it is leached out by the monsoon rains.

The mungbean is one of the important low cost sources of protein for resource poor populations of the region. Munbean crop with average productivity of 1.1 t $ha^{-1}$and 24% of its protein content produced 464 kg ha^{-1} protein which can support to one day protein requirement of 4714 people's. The general tradition of harvesting mung bean crop In Bihar, pod picking in green gram crop is a job generally assigned to woman folks in the community. They share the crop produce (grains) on 25:75 basis. The field study revealed that pod plucking of green gram crop in one hectare generated 625 hrs of labour employment (78 man-days). Women labour shared nearly 312 kg of whole grain green gram pulse for their house hold consumption (Fig. 2). Thus the introduction of the pulse crop in rice-wheat system not only breaks the monotony of the cereal production system but also improves nutrition security and provide local employment to the extent of close to 70-man days/ha/ year.

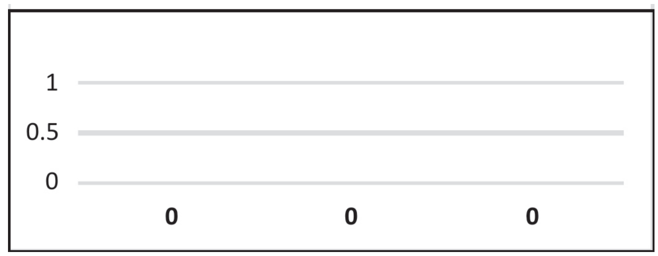

Fig. 2. Effect of introduction of green gram in rice wheat system on nutrition security and employment opportunities

CONCLUSION

Our study suggests that sustainable intensification of smallholder rice-wheat system of eastern IGP is crucial for sustainable food and nutrition security as well as employment opportunities for resource poor farmers. This can be achieved through CA-based management optimization layered with precise choice of system adapted rice cultivars; use of weakly vernalised wheat varieties for planting in last week of October that allows capturing residual moisture and escape terminal heat through early harvest and enabling planting a summer mungbean.

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Growth, yield and seed quality of wheat (*Triticum aestivum*) as influenced by seed rate, genotypes and growth regulators

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Wheat is one of the most important cereal crops and India is the second largest producer in the world after China. During the year 2013-14, about 95.91 m t of wheat was produced from an area of 31.19 m ha (Anonymous, 2015). The massive increase in wheat production became possible only by wide adoption of improved agro-techniques, high yielding varieties, optimum sowing time and judicious water and nutrient management. However, national average wheat yield (3075 kg/ha) is still less than agriculturally advanced countries. Pre-sowing seed treatment with plant growth regulators is an easy, low cost and low risk technique and is also an alternative approach recently used to overcome the effect of abiotic stresses in agricultural production. It has also been reported that seed priming improves emergence, stand establishment, tillering, grain and straw yields, and harvest index. Previous studies have also shown that pre-sowing seed treatment in various concentration of IAA (Gulnaz *et al.*, 1999) and GA_3 (Angrish *et al.*, 2001) may significantly alter the seedling growth. Among various approaches to achieve higher productivity, large coverage of wheat area under quality seed sowing appears to be effective as quality seed alone can enhance crop productivity by 15-20%. Area coverage under quality seed can be enhanced either through increased quality seed production or by reducing the seed rate for sowing of wheat. Recommended seed rate for wheat sowing varies from 100 to 120 kg/ha. However, sowing with seed drills effectively saves 25-30% of the seed by uniform placement of seeds at proper depth. Further, if effective tillers/hill could be raised to 4-5 from existing 2-3 through the use of growth regulators, same yield can be achieved even at half of the recommended seed rate. This would effectively enhance the seed replacement rate to enabling higher wheat production in the country. In view of poor seed replacement rate (32.55) for wheat, seed rate is required to be effectively reduced through suitable agro-techniques capable of ensuring synchronous effective tillering in greater number under field conditions.

METHODOLOGY

An experiment was conducted at the ICAR- IISS, Mau, U.P. during the winter (*rabi*) season of 2014-15, to assess the effect of seed rate on growth, seed yield and yield attributes and seed quality for wheat crop. It was laid out in SPD with three replications. There were 27 treatment combinations comprised of three seed rate (50, 75 and 100 kg/ha) and three genotypes (HD 2733, PBW 550 & PBW 502) in the main plots. In sub-plots, three growth regulators viz. control, 100 ppm GA_3 & IAA were taken. The sandy loam soil of the experimental field had 0.24 organic carbon, 245.0kg/ha available N, 15.0 kg/ha available Pand 189.0 kg/ha available K with pH 7.9 during 2014-15, respectively. Those seeds were thoroughly washed after surface sterilization. After completing the period of priming the seeds were taken out from the container and allowed for shade drying. The recommended dose of NPK fertilizer for wheat crop was 120:60:50:25 kg/ha, using urea (46% N), DAP (46% P_2O_5& 18% N), MOP (62% K_2O) and zinc sulphate (21 %) as a source of fertilizers. Full dose of P, K and $ZnSO_4$along with half of N were applied as a basal at the time of sowing and remaining N was applied in 2 splits at crown root initiation and ear initiation stages of the crop during the year of experimentation. Wheat varieties were sown manually in rows at 4-5 cm depth on 4 December, 2014 using 50, 75 and 100 kg/ha seed rate with 22.5x10 cm, 22.5x7.5 cm & 22.5x5 cm spacing. It was harvested in second fortnight of April 2015. All the other recommended package of practices was adopted during the crop growth period. Ten plants were chosen randomly from the centre row of each plot to determine the growth parameter, yield and yield attributes and seed quality parameters respectively.

RESULTS

Results on seed yield (t/ha) and harvest index of wheat were affected by seed rate with spacing, genotypes and growth regulators have been presented in (Table 1). It is evident from the data that 75 kg/ha seed rate with spacing (22.5x7.50 cm) have favourable effect on seed yield (4.31 t/ha) and harvest index (38.19) and were significantly increased on the application of 100 kg/ha seed rate with spacing (22.5x5.0 cm) over 50 kg/ha seed rate with spacing (22.5x10 cm). Impact of genotypes on yield and yield attributing traits was positive and significant on trait viz. seed yield, biological yield (t/ha) and harvest index except for straw yield (t/ha). Among the genotypes PBW 502 showed positive more response, which increased the yield traits viz., seed yield (4.34/ha), biological yield (11.47/ha) and harvest index (37.83) as compared to PBW 550 and HD 2733. The seed treated with IAA significantly increase the seed yield (4.32 /ha), straw yield (7.20t /ha) and biological yield (11.51 t/ha) over all other treatments (GA_3 and control). Seed quality parameters i.e. germination %, root length, shoot length, seedling length, seedling dry weight and vigour index I & II differed significantly due to different treatments (Table 1). Significant improvement in the seed quality parameters viz. root length (23.24 cm), shoot length (14.11 cm), seedling length (37.21 cm) and vigour index I (3365.50) were significantly higher at 50 kg/ha seed rate with spacing (22.5x10 cm) as compared to 75 and 100 kg/ha seed rate with spacing (22.5x7.50 and 22.5x5.0 cm). No significant differences were observed for traits viz. germination %, seedling dry weight (g) and vigour index I. Among the genotypes HD 2733 recorded significantly higher values of seed quality parameters viz. germination (97.78%), root length (23.35 cm),seedling length (37.39 cm), seedling dry weight (0.214 g) and vigour index I and II (3664.8 and 20.99) as compared to PBW 502 and PBW 550.No significant difference was observed for trait viz. shoot length (cm). The seed treated with IAA significantly increase the seed quality parameters viz. germination (98.07%), root length (23.80 cm), shoot length (14.96 cm), seedling length (38.20 cm), seedling dry weight (0.212 g) and vigour index I and II (3742.8 and 20.84) as compared to GA_3 over control treatment.

CONCLUSION

From the experiment it was concluded that a 75 kg/ha seed rate and growth regulator IAA may be recommended to farming community to enhance their seed yield potential in the variety PBW 502. Pre-sowing seed treatment with growth regulators (GA_3 and IAA) in 100 ppm concentration considerably enhances the yield and seed quality parameters in wheat seeds. However, application of IAA was significantly superior in respect of above parameters over rest of the treatments including control.

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Improving productivity and profitability of wheat through relay seeding into standing cotton in cotton-wheat system in South Asia

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Cotton–wheat (CW) is the second most important cropping system after rice–wheat system in South Asia. Wheat sowing after cotton is generally delayed due to late pickings of cotton and subsequent tillage and field operations for wheat. On an average, the productivity of wheat after cotton is about 32% lower compared to that after rice mainly due to its late sowing by about 30 days. Relay seeding of wheat into standing cotton can help achieve timely sowing and increase profitability of CW system. A two-year (2013-2015) field experiment was conducted to evaluate relay seeding of wheat in standing cotton planted on flat and raised beds of 67.5 cm and 102 cm size including Conventional practice (CT) on yield and economics in CW system. On 102 cm wide beds cotton was either planted in the centre or on the alternate corners. Relay planting of wheat allowed one additional boll picking in cotton and thereby increased the seed cotton yield by about 12-22 % compared with CT. The productivity and net return of relay wheat in paired rows on 102 cm wide raised permanent beds were 50% and 141% higher compared to CT (2 yrs' mean). Wheat and net returns were significantly lower in case of cotton planted on alternate corners followed by three rows of relay wheat compared to cotton planted in the centre of the beds followed by two paired rows of wheat on either side of the cotton row. Results from our study showed that relay planting of wheat in paired rows in standing cotton on 102 cm wide beds helped in achieving high wheat productivity and profitability in CW system.

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Performance of wheat genotypes under system of wheat intensification

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Wheat is the most important staple foodgrain crop of the world. It is widely cultivated in diverse ecosystems around the world, which contributes more calories and protein to human diet. During past decades, wheat productivity is declining by degrees due to use of highly input habituate technologies. This mode of cultivation may not meet the food demand of the ever-growing population on a sustainable manner. To meet the food demand of burgeoning Indian population, we have to intensify crop production through modification in the cultivation practices like seed rate, sowing methods, precise water and weed management to ensure higher ratios of tillers to mother seedling, increased number of effective tillers per unit area, enhanced panicle length and bolder grains or in short enhanced input use efficiency and crop yield. The System of Wheat Intensification (SWI) is an emerging wheat establishment technique which involves innovations in wheat cultivation practices such as sowing, weeding, irrigation and nutrient management. The SWI practices are derived from the System of Rice Intensification (SRI) principles. Although, SWI is a labour intensive technology yet, resource-poor households seeking to get maximum yield from the small landholdings to them find that the additional effort and care in crop management enhance net returns as well as livelihood security (Dhar *et al*., 2015).

METHODOLOGY

The field experiments were conducted during r*abi* seasons of the 2014-15 and 2015-16 at the research farm of ICAR-IARI, New Delhi located at 28.35°N latitude and 77.12°E longitude and 228.6 m above mean sea level (MSL). The soil of the experimental site was having sandy clay loam texture, bulk density of 1.6 g/cm^3, organic carbon of 0.39%, $KMnO_4$ oxidizable N of 155.2 kg/ha, 0.5 N $NaHCO_3$ extractable P of 14.2 kg/ha, 1.0 N NH_4OACexchangeable K of 235.1 kg/ha, pH of 7.8 and EC of 0.40 dS/mat the beginning of experiment. The experiment was laid out in strip plot design with three cultivation methods (conventional, SWI: 20×20 cm and SWI: 20×10 cm) assigned to horizontal plots and four wheat varieties (HD 2967, HD 3086, HD 2851 and HD 2894) assigned to vertical plots and replicated thrice. Under conventional method, wheat was sown at 22.5 cm line apart by seed drill with100 kg ha^{-1}seedrate, recommended dose of fertilizer(150:60:60 kg N, P_2O_5 and K_2O/ha) and six irrigations (at crown root initiation tillering, late jointing, booting, flowering, milking and at grain filling stage). Sulfosulfuron was applied at 25 g/ha for weed control under this method. In SWI, seeds treated with a mixture of jaggery, cow urine, compost and hot water were sown at 25 kg/ha for 20×20 cm and at 30 kg/ha for 20×10 cm spacing. For both the spacing two sprouted seeds were dibbled/ hill. The *Trichoderma*-treated (2.5 kg/t) compost at 2.0 t/ha plus 68 kg DAP and 33 kg/ haMOP were applied before sowing and 68 kg urea/ha was applied on sixteenth day; vermi-compost at 500 kg/ha plus PSB culture at 6.25kg/ha on twentieth day; 34 kg urea/ha and 34 kg MOP/ha on thirty-sixth day; vermi-compost at 500 kg/ ha on fortieth day. Five shallow irrigations were given as per SWI protocol at 15, 35, 60, 95, and at 105 days after sowing (DAS). Three manual hoeings were performed for weed management using cono-weeder at 20, 30 and 40 DAS.

Table 1. Wheat productivity and profitability under different cultivation methods and varieties (mean of 2 years)

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Cost of cultivation (×10³ ₹/ha)	Net returns (×10³ ₹/ha)	B:C ratio
Cultivation methods							
Conventional	5.19	8.10	13.29	39.1	38.22	77.35	2.02
SWI: 20×20 cm	7.23	11.40	18.62	38.8	51.36	110.22	2.15
SWI: 20×10 cm	7.05	11.13	18.19	38.8	51.53	106.21	2.06
SEm±	0.05	0.08	0.12	0.17		0.92	0.02
CD (P=0.05)	0.21	0.30	0.45	NS		3.60	0.08
Wheat varieties							
HD 2967	6.77	10.83	17.59	38.4	47.04	104.98	2.22
HD 3086	6.64	10.60	17.24	38.5	47.04	102.03	2.16
HD 2851	6.47	9.96	16.43	39.4	47.04	96.42	2.04
HD 2894	6.08	9.44	15.53	39.2	47.04	88.26	1.88
SEm±	0.03	0.08	0.08	0.21		0.42	0.09
CD (P=0.05)	0.09	0.29	0.27	0.71		1.45	0.03

RESULTS

The mean data of two years pertaining to wheat productivity and profitability are presented in Table 1. The cultivation methods and varieties were statistically varied for wheat productivity and profitability. The SWI spaced at 20×20 cm was accounted significantly higher wheat grain yield (7.23 t/ha), straw (11.40 t/ha) and biological yield (18.62 t/ha) as compared to the conventional method, while it was at par with modified SWI at 20×10 cm spacing. The SWI at 20×20 cm spacing produced higher grain, straw and biological yields over the conventional method by 39.30%, 40.70% and 40.11%, respectively. Harvest index was found non-significant across the cultivation methods. Among varieties, HD 2967 registered the higher grain, straw and biological yield and harvest index than HD 3086, HD 2851 and HD 2894. The above findings might be due to higher yield contributing characters, better soil aeration, enhanced root growth and soil biological activity due to hoeing practice. Moreover, the applications of organics through vermicompost have supplied necessary nutrients in balanced amount and for long time.The net returns and benefit-cost ratio (B:C) was found numerically highest (110.22×10^3 /ha; 2.15) with SWI at 20×20 cm followed by 106.21×10^3 /ha; 2.06 with 20×10 cm and 77.35×10^3 /ha; 2.02 in conventional method. The SWI spaced at 20×20 cm gave 1.42 and 1.04 times higher net returns than the 20×10 cm spaced and conventional method, respectively. The variety HD 2967 accounted for maximum net returns (104.98×10^3 /ha) and B: C ratio (2.22) as compared to the other varieties.

CONCLUSION

Based on present investigation it can be concluded that the grain, straw and biological yields; and net returns of the wheat have significantly increased with the adoption of SWI cultivation practices. This innovative method not only can help in mitigating the food insecurity for small and marginal farmers but also can enable the crop to withstand biotic and abiotic stresses which are becoming more and more severe under the changing climate scenario.

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Influence of sowing date and varieties on growth and yield of summer mungbean

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Mungbean (*Vigna radiata* L.), is one of the most important pulse crops in India and ranks third after chickpea and pigeonpea. India ranks first in the world in area as well as production of mungbean. The scope of short duration crop like mungbean is more in summer season, particularly in north-western plain zone. Summer cultivation enables the farmers to utilize their land and water resources which otherwise would have remained unutilized during that period. Further, due to dry weather (high temperature and low humidity) incidence of diseases, particularly yellow mosaic virus and insects are less, consequently higher productivity of mungbean may be obtained under adequate management in summer season. The agro-climatic conditions of sub-tropical plains of Jammu division can provide an option of growing summer season mungbean. Among the various production practices, sowing date and varieties are considered as the important factors which are having the vast potential to explore the maximum yield. Since no work has been done in this direction in sub tropical climatic conditions of Jammu region in particular, therefore, it becomes imperative with the objective to assess the effect of sowing date and varieties on growth and yield of summer mungbean.

METHODOLOGY

A field experiment was carried out during the summer season of 2014 at Research Farm, SKUAST-Jammu. The soil of experimental field was sandy clay loam, having initial pH 7.38, organic carbon (3.9 g/kg) and available N, P and K of 215.7, 16.26 and 172.2 kg/ha respectively. The experiment was laid-out in a split plot design, consisting of 4 sowing dates (20 March, 5 April, 20 April and 5 May) as main-plot treatments and 4 varieties 'SML 668', 'Samrat', 'Meha' and 'IPM 02-3' as subplot treatments, with 3 replications. All agronomic practices were except those under study were kept uniform for all the treatments. All the necessary observations were recorded as per established norms.

RESULTS

Significantly higher plant height was observed at harvest, with 20 April and 5 May sowing dates than 20 March and 5 April, which might be owing to the favourable environment like rainfall at later sowing dates. Similar findings were reported by Miah *et al*. (2009). Significant variation in plant height was recorded by different varieties at maturity which may be attributed to genetic character of the variety. Higher number of nodules per plant in pre-flowering stage was observed with early dates of sowing (20th March and 5th April) than delayed dates of sowing (20th April and 5th May) which might be because of favorable climate and dry weather for a longer period at early sowing dates rather than late sowing. Similar differences among sowing dates with respect to nodule number were observed Ram *et al*. (2011).Among the varieties, the variety Meha produced significantly highest nodules/plant as compared to 'SML 668', 'Samrat' and 'IPM 02-3'.The highest grain yield was recorded when sown on 20 March, which was statistically at par with 5 April and significantly superior to sowing dates 20 April and 5 May sowing. The more yield-attributing characters at 20 March and 5 April sowing dates, contributing the higher yield. Among the different mungbean varieties, the highest grain yield was observed in Samrat, which was statistically at par with 'SML 668' and significantly superior to 'IPM 02-3' and 'Meha'. This might be owing to higher yield attributes, viz. pods/plant and grains/pod, in variety 'Samrat' and owing to more 1,000-seed weight in case of 'SML 668'. The harvest index value being statistically at par with 5th April and 20th March sowing dates and which were significantly superior to 20th April and 5th May. This was due to higher grain yield at early sowing dates. These results are in lines with those of Rasul *et al*. (2012). Among the different varieties, the variety 'Samrat' recorded highest harvest index which was statistically at par with variety 'SML 668' and significantly superior to varieties 'IPM 02-3' and 'Meha'.

CONCLUSION

On the basis of 1-year study, it may be concluded that 20 March and 5 April sowing dates have been found more suitable as these gave significantly higher grain yield than 20

Table 1: Effect of sowing dates and varieties on growth and yield of summer mungbean

Treatment	Plant height at harvest (cm)	Root nodules/ plant at pre-flowering	Grain yield (t/ha)	Harvest index (%)
Sowing Date				
20 March	44.32	23.59	0.93	27.23
5 April	45.93	23.07	0.92	26.75
20 April	52.11	21.63	0.71	20.23
5 May	55.14	21.52	0.40	11.02
SEm ±	1.90	0.29	0.02	0.90
CD (P=0.05)	6.57	1.01	0.07	3.12
Variety				
SML 668	47.43	22.27	0.76	21.98
Samrat	47.48	22.24	0.78	22.93
Meha	52.78	23.45	0.69	19.49
IPM 02-3	49.82	21.84	0.73	20.82
SEm ±	1.36	0.28	0.01	0.51
CD (P=0.05)	3.96	0.83	0.04	1.48

April and 5 May sowing dates. Among the tested mungbean varieties, 'Samrat' and 'SML 668' are the most promising cultivars because of their higher yield than 'Meha' and 'IPM 02-3' in subtropical climatic conditions of Jammu, Jammu and Kashmir.

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Effect of seeding rate of rice nursery, seedling age and spacing on employment generation and productivity under System of Rice Intensification

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Rice (*Oryza sativa*) forms staple food crop, occupied 42.81 mha and produced 143.96 mt paddy (95.97 mt rice) (FAO 2013). Young seedlings prior to the start of the 4th phyllochron of growth (< 15 days) possess higher tillering potential which drastically decreases with advancing age. Transplanting at wider spacing relieves the plant of adverse effects of closer spacing namely- severe competition between plants resulting in poor tillering; square geometry gives room for profuse root and tiller growth through more efficient harvest of solar energy and other growth resources, achieving 'the border effect' throughout the whole field (Satayanarayana *et al*., 2007). Though, the System of Rice Intensification is a set of principles based on the alleged synergy among several agronomic practices and their interaction with crop biophysical environment and management, the optimum values of each one of these practices may vary with location.

Table 1. Effect of treatments on plant height, panicle initiation, yield and employment generation

Treatment	Plant height (At maturity)	Panicle initiation (days)	Grain yield (t/ha)	Straw yield (t/ha)	Employment (Man days)
Seedling age (days)					
10	99.9	62	5.39	7.42	113
17	100.9	63	5.41	7.53	110
24	96.9	63	5.26	7.15	108
SEm±	0.79	0.2	0.1395	0.2056	-
CD (P=0.05)	2.48	0.60	NS	NS	-
Spacing (cm)					
20 x 20	101.0	63	5.41	7.40	106
20 x 15	98.5	62	5.25	7.34	116
SEm±	0.64	0.2	0.1139	0.1678	-
CD (P=0.05)	2.03	NS	NS	NS	-
Seeding rate (g/m^2)					
25	100	63	5.30	7.25	113
30	99.3	63	5.30	7.57	112
35	100.1	62	5.39	7.28	110
40	97.6	62	5.42	7.35	108
SEm±	0.64	0.2	0.0808	0.1907	-
CD (P=0.05)	1.82	NS	NS	NS	-

METHODOLOGY

The experiment was conducted at the experimental farm of CSK Himachal Pradesh Krishi Vishvavidyalaya Rice and Wheat Research Centre, Malan *kharif* 2013 to study the effect of seeding rate, seedling age and spacing *vis-a-vis* seeding rates through seedling vigour on rice growth, development and productivity under system of rice intensification. The twenty-four treatments comprised of combinations of three seedling ages (10, 17 and 24 days) and two spacing (20 cm x 20 cm and 20 cm x 15 cm) in main plots and four seedling vigour from four seeding rates (25, 30, 35 and 40 g/m^2) evaluated in sub plots.

RESULTS

Growth parameters like plant height recorded at all stages whereas maximum height recorded at 130 DAS. Younger seedlings (10 or 17 days old) resulted in significantly taller rice plants than older ones (24 days old). Transplanting of seedlings from younger stage provides sufficient nutrients for vegetative growth and also for reproductive phase which ultimately leads to increased plant height. Spacing of 20 cm x 20 cm resulted in significantly higher plant height as compared to 20 cm x 15 cm. Plant height was influenced by seedling vigour at maturity stage (130 days) and 25 g/m^2, 30 g/m^2 and 35 g/m^2 statistically remaining at par resulted in significantly higher plant height than 40 g/m^2. Seedling age significantly influenced days taken to reach panicle initiation and maturity with 10 days old seedlings attaining one day earlier panicle initiation and 3-5 days earlier maturity over 24 days old seedlings. Plant spacing and seeding rates had no effect on the duration taken for the attainment of various phenological stages viz., maximum tillering, panicle initiation, maturity. The data on crop yield indicated that the seedling age, spacing and seeding rate failed to influence rice crop productivity significantly. It was indicated that as the seeding age increased man days required increased from the 106 to 114. Effect 24 days seedling age resulted in higher employment followed by 17 days seedling age. Closure spacing also of 20 cm x 15 cm generated more employment than 20 cm x 20 cm. Man days required decreased as the nursery seeding rate increased. Among seedling vigour, 25g/m^2 showed higher employment followed by 30 g/m^2 whereas 40g/m^2 generate lower among all the seedling vigour.

CONCLUSION

The overall finding indicating that 10 days old seedling, due to the delicate nature and difficulty in handling, required numerically more man days (113) in comparison to 17 days (110) and 24 days(108) old seedlings. Closer spacing of 20 cm x 15 cm supporting one third higher plant population utilizes more man power (116 man-days) than wider spacing (106 man-days) whereas lower seeding rates in rice nursery required somewhat more man days in comparison to higher seeding rates.

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Developing package of practices for quinoa cultivation

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Quinoa (*Chenopodium quinoa* Wild.) is an annual dicotyledonous crop plant of amaranthaceae family. Quinoa is a domesticated staple food in Andean South America and used as a human food includes leaves as vegetable and grain. The quinoa grain can be used as a substitute of rice. Because of its ability to tolerate extreme frost, drought and salinity, quinoa is adapted to high altitude environments greater than 4000 m to 300 m above sea leveland considered as "Crop of future". The grain is rich in protein with high content of essential amino acids, and natural antioxidants and a wide range of vitamins and minerals (Repo-Carrasco *et al*., 2003). Recently, there has been growing interest in number of countries including India initiating introduction and research work on quinoa. Since it is new crop to India, there is lack of information on its cultivation practices. Therefore, this study was undertaken to develop package of practices for quinoa cultivation for Indian conditions.

METHODOLOGY

The experiment was carried out at National Bureau of Plant Genetic Resources, New Delhi, India in split-plot design with three replications to determine the response of quinoa to sowing dates, plant spacing and different levels of nitrogen fertilizer on silt loam soil. The quinoa genotype EC507742 was sown on two sowing dates; November 07 and December 01 as main factor; three plants spacing 30 x 20, 45 x 15 and 60 x 10 cm with four nitrogen levels (0, 40, 80 and 120 kg/ha) as split plot factors.Plot size was 3 m × 2 m. Observations for growth and yield parameters were recorded at crop maturity. Data analysis was done using SAS 9.3 soft-ware.

RESULTS

It is evident from the results (Table 1) that plant height was less when the crop was sown on November 07 (158.94 cm) while it was more on December 01sowing produced signifi-

Table 1. Effect of sowing dates, plant spacing and nitrogen levels on plant height, inflorescence length and grain weight of quinoa crop

Treatment	Plant height (cm)	Inflorescence length (cm)	Grain weight (g/10 ml vol. basis)	Grain yield (kg/ha)
Sowing Date				
November, 7	158.9^{B}	36.0^{B}	6.78^{A}	1234^{A}
December, 12	177.9^{A}	44.1^{A}	5.89^{B}	883^{B}
CD (P=0.05)	3.0	4.3	0.33	66.7
Plant Spacing (cm x cm)				
30 x 20	166.1	37.1^{B}	6.18^{B}	857^{C}
45 x 15	169.3	42.3^{A}	6.54^{A}	1211^{A}
60 x 10	169.9	40.7^{A}	6.29^{B}	1106^{B}
CD (P=0.05)	NS	3.6	0.11	71.8
Nitrogen level (kg/ha)				
0	160.2^{C}	36.8^{B}	6.09^{C}	822^{D}
40	166.9^{B}	38.6^{B}	6.25^{B}	949^{C}
80	173.6^{A}	42.6^{A}	6.54^{A}	1281^{A}
120	173.0^{A}	42.2^{A}	6.46^{A}	1181^{B}
CD (P=0.05)	3.2	2.0	0.11	58.3

[A,B,C,D] Different letters denote significant differences among treatments and same letter denotes no significant difference cantly ($P<0.05$) the tall plants (177.98 cm). There was no significant difference with plant spacing though the crop sown with 30 x 20 cm plant spacing tended to produce the small plants while, the higher plant height was achieved with 60 x 10 cm plant spacing. It was observed that each increment in nitrogen fertilizer significantly ($P<0.05$) produced taller plants of quinoa. The application of nitrogen at 120 kg/ha produced significantly ($P<0.05$) taller plants (173.06 cm) which was at par with 80 kg N/ha than 40 and zero kg N/ha. The inflorescence length was found higher with late sown on December 01 and was significantly longer than November 07 sowing. Plant geometry also affected the inflorescence and was longest with the 45 x 15 cm (42.38 cm) and it was at par with the 60 x 10 cm and at spacing of 30 x 20 cm produced shortest inflorescence. Inflorescence length increased significantly with of nitrogen application and was longest with 80 kg N/ha and it was at par with 120 kg N/ha. The results revealed that grain weight and grain yield of quinoa was decreased drastically with late sown on December 01while crop sown November 07 produced significantly ($P<0.05$) higher grain weight and grain yield. Further, plant spacing of 45 x 15cm produced significantly higher grain weight and yield while lowest was with 30 x 20cm spacing. Nitrogen application also produced significantly ($P<0.05$) higher grain weight and yield with each increment of nitrogen and was significantly higher with 80 kg N/ha. The grain yield was declined with application of 120 kg N/ha. Oelke *et al.*, (1992) also reported decline in yield of quinoa when greater levels of available nitrogen were present due to a slower maturity and more intense lodging.

CONCLUSION

Our results conclude that quinoa sown during first fortnight of November produced higher grain yield with plant spacing of 45 x 15 cm and application of 80 kg N/ha is optimum for producing high grain yield of quinoa.

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Productivity, profitability and quality of lentil under zero till condition in rice (*Oryza sativa*)–lentil (*Lens culinaris*) cropping sequence

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Rice–fallow areas which are about 11 million hectares in eastern India alone, should be brought under cultivation with pulse crops that can survive in residual moisture to increase land productivity for food and nutritional security. In Bihar and Jharkhand *Kharif*-rice area is 2.74 and 1.69 m ha, respectively, and rice fallow as of *kharif* rice is 36.8%. Lentil is the second most important winter legume crop of India and contains high amount of digestible protein,micronutrients, particularly Iron and Zinc and Vitamins, thus providing nutritional security to consumers. Zero or minimum tillage provide adequate time for planting after long duration rice crop in preceding season and beneficial in terms of utilize residual moisture from previous crop and reduced planting cost with better economics (20% higher B:C ratio) after the harvest of rice. The interactions among biofertilizers and plants are still not well understood in minimum tillageecosystem. Hence, keeping these views in mind the present investigation was made with objective to study the effect of biofertilizers (phosphate solubilizing bacteria and *rhizobium*) inoculation with fertilizers levels under zero tillage condition on productivity, soil andplant quality and resource use efficiency in rice-lentil cropping system.

METHODOLOGY

A field experiment was conducted at Ranchi, Jharkhand during 2015–16 in rice–lentil cropping system on acidic upland soil with pH 5.0 and 0.51 % organic carbon. Ten nutrient management practices (Table 1) comprising different combinations of biofertilizers (*Rhizobium* + Phosphate solubilizing bacteria) used as seed inoculation along with levels of chemical fertilizer (NPK) were accommodated in randomised block design with three replications in a fixed layout for rice and lentil.The harvesting of the rainy season (*kharif*) rice was done manually by leaving about 20 cm standing stubbles in the field. After harvesting of rice, lentil crop (cv. KLS 212) was sown under zero-till system. Lentil was sown by opening a narrow furrow in between two rows of rice using a manual furrow opener. The levels of recommended dose of fertilizerswere applied in furrows before sowing of biofertilizers treated lentil seeds and covered the seed with soil to give a good seed-soil contact. The crop was raised with residual soil moisture and two lifesaving irrigation was provided for better growth at pre-flowering and anthesis stage. The crop harvested from net plot area (18 m^2) used to express grain yield in q/ha. Economic analysis was done based on prevailing market prices of the prevailing year. The data recorded for different parameters were analysed with the help of analysis of variance(ANOVA) technique for randomised block design using MSTAT – C software. The results are presented at 5% level of significance (0.05).

RUSULTS

The grain and stover yield of lentil cultivar under investigation responded statistically significant due to different combinations of biofertilizers (*Rhizobium* and phosphate solubilizing bacteria) with different levels of recommended nitrogen (N), phosphorous (P) and potassium (K) fertilizers (Table 1). Results revealed that combined seed inoculation with *Rhizobium* and Phosphate solubilizing bacteria along with 15 kg N, 30 kg P, 15 kg K/ha fertilizers application produced higher lentil grain and stover yield (7.96 q/ha and 15.84 q/ha, respectively) and it remains at par with 20 kg N, 40 kg P, 20 kg K/ha + biofertilizers (*Rhizobium* + phosphate solubilizing bacteria) inoculation, both of treatment were superior over remaining combinations in respect of yield parameters and yields (Mishra *et al*. 2011).Combined use of biofertilizers culture, dual inoculation of *rhizobium* and PSB resulted in higher net returns and B:C ratio due to saving in money in terms of reduced fertilizer cost and marginally higher yield productions. The net returns and B:C ratio under various integrated nutrient management practices in combination of biofertlizers along with different levels of NPK fertilizers differed significantly.Maximum net returns (48.08×10^3 Rs./ha) and B:C ratio (3.01) was recorded under treatment 20 kg N, 40 kg P, 20 kg K/ha + *Rhizobium* + PSB and remains at par with 15 kg N, 30 kg P, 15 kg K/ha + *Rhizobium* + phosphate solubilizing bacteria, both the treatments were superior in monitory terms over the remaining combinations of biofertilisers and levels of NPK fertilizersSanghmitra *et al.* (2014).

Application of *Rhizobium* and PSBsignificantly enhanced the protein content in seed by various integrated nutrient management practices. maximum protein contents(Table 1) in seedswerefound in treatment 20 kg N, 40 kg P, 20 kg K/ha + *Rhizobium* + PSB and remains at par with 15 kg N, 30 kg P, 15 kg K/ha + *Rhizobium* + phosphate solubilizing bacteria and 20 kg N, 40 kg P, 20 kg K/ha + Rhizobium compared with the other integrations of biofertiliser and levels of chemical fertilizers (Chhaya and Jain, 2014). The higher nitrogen content in seeds brought about by increased nitrogen and phosphorous availability through biofertilizers and chemical fertilizers (Maryam *et al.* 2012).

CONCLUSION

Based on the above mentioned findings it may be concluded that 25 % substitution of recommended dose of nitrogen and phosphorouschemical fertilizers with the biofertilizers (*Rhizobium* and PSB) in lentil crop perform well in respect of yields and monetary returns and it remains at par with 100% recommended dose of NPK fertilizers along with

Table 1. Effect of nutrient management practices on productivity, economies and quality of lentil under minimum tillage after rice harvest

Treatment	Grain yield (q/ha)	Stover yield (q/ha)	Harvest Index (%)	Protein concentration (%)	Net Returns (10^3Rs./ha)	Benefit: cost ratio
Control	3.95	9.40	30.0	22.54	15.85	1.08
Rhizobium	5.53	10.90	33.6	23.15	27.34	1.87
PSB	5.45	11.23	33.2	23.27	26.85	1.83
Rhizobium + PSB	6.27	12.62	33.2	23.83	33.00	2.25
$N_{10}P_{20}K_{10}$ + Rhizobium	6.25	12.81	33.0	24.25	32.32	2.11
$N_{10}P_{20}K_{10}$ + Rhizobium + PSB	6.88	14.35	32.5	24.52	37.11	2.42
$N_{15}P_{30}K_{15}$+ Rhizobium	7.27	15.47	32.0	24.92	39.93	2.56
$N_{15}P_{30}K_{15}$ + Rhizobium + PSB	7.96	15.84	33.4	25.26	44.82	2.86
$N_{20}P_{40}K_{20}$ + Rhizobium	8.03	16.14	33.3	26.10	45.07	2.83
$N_{20}P_{40}K_{20}$ + *Rhizobium* +PSB	8.45	16.36	34.1	26.23	48.08	3.01
SEm±	0.35	0.86	2.5	0.32	2.38	0.15
CD (P=0.05)	1.06	2.58	7.5	0.96	7.10	0.47

biofertilizers. Proper agronomic management, use of bio-fertilizers and resource conservation technology, may not only improve production and productivity but also help to bring large area under lentil in rice fallow cropping system and provide food and nutritional security.

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Yield potential of cereals with forage legumes under pure stand and mixtures

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METHODOLOGY

A field experiment was conducted at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K) Shalimar, Srinagar for three consecutive years during *rabi* 2013-14, 2014-15, and 2015-16. The experiment was done under coordinated mode of All India Coordinated Research Project on Forage Crops and Utilization (AICRP-FC&U) and the objective of this study was to evaluate fodder yield potential and quality of cereals and legumes in mono as well as in mixed cropping. The treatments consisted of five sole and six intercrops (T1 - sole oat , T2 - sole barley, T3 - sole ryegrass , T4 – sole vetch (*Vicia sativa*), T5 – sole field pea, T6 – oat+ vetch (1:1), T7 - oat + field pea (1:1) , T8 – barley +vetch (1:1), T9 – barley +field pea (1:1), T10 – ryegrass +vetch (1:1) and T11- ryegrass + field pea (1:1) laid out in randomized block design with three replications.

RESULTS

The results of the experiment revealed that in pure stand, cereal crops showed maximum fresh weight than sole legumes and the highest green fodder yield (35.92 t/ha) was attained by oat crop, whereas, in mixtures, intercropping with vetch gives maximum fresh weight than field pea in all the cereal crops tested. Same is the trend in case of dry matter yield where maximum dry matter yield was obtained in oat crop followed by oat + field pea and the lowest in sole vetch (4.38 t/ha). It was also observed that sole vetch had maximum crude protein yield (0.93 t/ha) followed by sole field pea (0.88 t/ha) and the minimum was found in sole ryegrass (0.36 t/ha), thus indicating that cereal-legume intercropping showed maximum crude protein yield compared to sole cropping of cereals.

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Studies on linseed based intercropping systems

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Intercropping is a useful proposition for increasing the productivity and income per unit area/time in modern agriculture. Besides enhancing the water and land use efficiently under rainfed and irrigated conditions especially small holding conditions. Intercropping is gaining interest among small farmers as a potentially beneficial system of crop production. This necessitates development of an appropriate intercropping technology for different crops especially minor crops which are grown on a limited area. Linseed is one among minor crops which is of economic value because of its common usage in animal feed, oil extraction etc. Consequently, the present study was planned to assess the bio-economic efficiency of linseed based intercropping systems in different row proportions with possible *rabi crops.*

METHODOLOGY

A field experiment on linseed based intercropping systems conducted at Regional Agricultural Research Station, Vijayapura (Karnataka) in medium black soils under rainfed conditions. There were thirteen treatments under study *viz,* eight intercropping systems, linseed+sorghum (2:1 and 4:2 row proportions), linseed+bengalgram (2:1 and 4:2 row proportions), linseed+safflower (2:1 and 4:2 row proportions), linseed+lentil (2:1 and 4:2 row proportions), five sole crop treatments *viz*., sole linseed, sole sorghum, sole bengalgram, sole lentil and sole safflower. The experiment was laid out in randomized complete block design with an area of 0.2 ha for each treatment. The critical inputs were applied as per the treatment. Plant nutrients are applied through urea, di- ammonium phosphate and Muriate of potash. The plant protection measures were taken as and when pests and diseases were noticed. The growth and yield observations were recorded from the 10 m x 10 m quadrate selected randomly in each treatment in four locations and taken as four replication data and grain yield of base and intercrops were converted on hectare basis (in kg). Later linseed equivalent yield (LEY) and LER was worked out.

RESULTS

Pooled data of three years (2009, 2010 and 2011) showed that linseed yield differed appreciably due to intercropping of different crops. Yield of linseed decreased in intercropping system as compared to sole cropping (0.455 t/ha) (Table 1). Highest linseed yield among inter cropping system was recorded in the intercropping system of linseed+bengalgram (0.329 t/ha) in 2:1 row proportion which was followed by linseed+lentil intercropping system (0.325 t/ha) in 2:1 row proportion. The yield of intercrops was also differed with respect to intercropping system. Among different intercrops, higher grain yield was recorded by sorghum (1.09 t/ha) under linseed+sorghum intercropping system in 2:1 row proportion which was followed by sorghum crop intercropped with linseed in 4:2 row proportion (1.01 t/ha). However, results indicated that yield of sole crops were higher than those respective intercrops. The higher yield in sole crop of linseed over intercropped linseed was due to superior growth parameters and yield attributing characters recorded in the sole crop. Similar results were also recorded by Rani and Reddy (2010). Linseed equivalent yield was significantly higher with sole crop of sorghum (1.70 t/ha) over other intercropping systems (Table 1). Among intercropping systems significantly higher linseed equivalent yield was recorded by linseed+sorghum intercropping system in 2:1 row proportion (0.86 t/ha) which was followed by linseed+sorghum in 4:2 row proportion (0.858 t/ha). Similar results of decreased intercrop yields as compared to sole crops were also reported by Vishwanatha, 2009. Land equivalent ratio (LER) was higher in intercropping systems except that linseed+safflower either in 4:2(0.93) or 2:1(0.99) row proportions on pooled basis (Table 1). Significantly higher LER was recorded with intercropping of linseed in linseed+sorghum system in 2:1 row proportion (1.22) and which was also on par with 4:2 row proportions (1.21). Significantly lowest LER was noticed with intercropping of linseed+safflower in 2:1 row proportion (0.93) and was at far with same system with 4:2 row proportion (0.90). Similar observations was also made by Rani and Reddy (2010). The pooled data on net returns and B:C revealed that, notably higher values were obtained under intercropping systems than sole linseed crop except that linseed+safflower intercropping system in 2:1 row proportion for B:C. Among the sole crops significantly higher net returns and B:C were recorded with sorghum (24767/ha and 4.72) which was followed by bengalgram (19444/ha and 3.81). In intercropping system, significantly higher net returns and B:C were realized with

Table 1. Pooled data of three years (2009, 2010 and 2011) on grain yield, intercrop yield, LEY, LER, Net returns and B:C of linseed and other intercrops as influenced by linseed based intercropping systems in different row proportions.

Treatment	Linseed yield (t/ha)	Intercrops yield (t/ha)	Linseed equivalent yield (t/ha)	Land Equivalent Ratio	Net returns (Rs/ha)	B:C
Linseed+sorghum (2:1)	0.245	1.09	0.860	1.22	21289	4.66
Linseed+sorghum (4:2)	0.270	1.01	0.858	1.21	21152	4.63
Linseed+Bengalgram (2:1)	0.329	0.449	0.691	1.11	15348	3.39
Linseed+Bengalgram (4:2)	0.216	0.459	0.669	1.10	13828	3.13
Linseed+Safflower (2:1)	0.287	0.238	0.477	0.93	9281	2.16
Linseed+Safflower (4:2)	0.301	0.279	0.508	0.99	10163	2.77
Linseed+Lentil (2:1)	0.325	0.146	0.455	1.08	8910	2.62
Linseed+Lentil (4:2)	0.322	0.158	0.461	1.10	8877	2.59
Sole Linseed	0.455	-	0.544	1.0	8837	2.64
Sole Sorghum	-	1.70	1.70	1.0	24767	4.72
Sole Bengalgram	-	1.097	1.097	1.0	19444	3.81
Sole Safflower	-	0.788	0.788	1.0	12914	3.02
Sole lentil	-	0.437	0.437	1.0	5995	2.10
SEm±			0.0299	0.03	672.23	0.17
CD (P=0.05)			0.0842	0.07	1891.81	0.48

linseed+sorghum in 2:1 row proportion (21289/ha and 4.66) followed by linseed+sorghum in 4:2 row proportion (21152 /ha and 4.63). The higher net and B:C realized in sole sorghum as well linseed intercropped with sorghum might be due to higher market price prevailed for sorghum grain coupled with congenial weather conditions prevailed for these two crops for optimum growth and development under rainfed condition. Similar results were also found by Sharma *et al.,* 1998 and Halvankar *et al.,* 2000. (Table 1).

CONCLUSION

The sole linseed crop performed better than the intercropped linseed yield with other crops in different row proportion. However, considerably higher intercrop yield, linseed equivalent yield, LER, net and B:C were obtained with linseed+sorghum intercrop followed by linseed+bengalram.

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Effect of sowing windows on yield of new cowpea genotypes during *kharif* in northern transition zone of Karnataka

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Pulses are the important sources of protein, vitamins and minerals for predominantly vegetarian population of India which are known as poor man's meat and rich man's vegetable (Singh and Singh, 1992). Among the various pulses, cowpea is an important one which is grown on an area of 1.5 lakh ha^{-1} with low productivity of 420 kg/ha as against 567 kg/ha of national level. Low cowpea yield in Karnataka is mainly due to growing very old variety C-150 having indeterminate growth habit, long duration and highly susceptible for rust disease. So, high yielding, early maturing and determinate varieties *viz* DC-15, DC-16 and DCS 47-1 were developed at UAS Dharwad and tested for their suitability and yield.

METHODOLOGY

A field experiment was conducted to study the effect of sowing windows on yield of recently developed cowpea genotypes on medium black soil at MARS, UAS, Dharwad during *Kharif* 2014-15 under rainfed condition which was laid out in split-plot design with four sowing dates (D1: II fortnight of June; D2:I fortnight of July; D3: II fortnight of July and D4: I fortnight of August) as main plots and recently developed four genotypes (three new - G1: DC-15; G2: DC-16; G3:DCS 47-1 and G4: control C-152) as sub plots in three replications. The yearly rainfall received during the year 2014 was 962 mm and 682 mm during the cropping period which was well distributed.

RESULTS

The earliest sowing on II fortnight of June (27th) recorded significantly higher seed yield (1548 kg/ha) over delayed sowings on II fortnight of July (1287 kg/ha) and I fortnight of August (1128 kg/ha) but it was on par with crop sown in I fortnight of July (1505 kg/ha). The increasing the yield with early sowing in II fortnight June (D1) was to the extent of 3, 20 and 37% over D_2, D_3 and D_4 respectively. The higher yield in early sowing was mainly due to sufficient moisture, higher temperature and radiation for a longer period resulting in higher photosynthesis and pods per plant. The Genotype DC 15 recorded significantly higher seed yield (1534 kg/ha) than DCS 47-1 (1355 kg/ha) and C 152 (1127 kg/ha), but it was on par with DC 16 (1453 kg/ha). Compared to control C-152, new genotypes DC-15, DC-16 and DCS-47-1 have recorded 36, 28 and 20 per cent higher yield respectively. The higher yield of new genotypes might be due to better genetic potential (Abdur *et al.,* 2004), determinate growth habit, and more

Table 1. Number of pods/plant and grain yield (kg/ha) of cowpea genotypes as influenced by sowing windows

Genotype	Pods/plant					Grain yield (kg/ha)				
	Dates of sowing					Dates of sowing				
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean
G_1 - DC 15	15.91	15.10	13.26	12.49	14.19	1700	1669	1440	1325	1534
G_2 - DC 16	14.87	14.03	12.13	10.30	12.83	1649	1615	1417	1132	1453
G_3 - DCS 47-1	12.42	11.80	10.09	9.07	10.85	1548	1492	1255	1124	1355
G_4 - C 152	10.46	10.10	9.20	8.43	9.55	1296	1242	1034	934	1127
Mean	13.41	12.76	11.17	10.07		1548	1505	1287	1128	
Sources	SEm±			CD (P=0.05)		SEm±			CD (P=0.05)	
D	0.22			0.67		23.58			82	
G	0.46			1.38		28.12			82	
D x G	0.57			1.72		56.23			164	

number of pods/plant. Among the treatment combinations, early sowing of DC-15 in II fortnight of June recorded the highest grain yield (1700 kg/ha) followed by DC-15 sown on I[st] fortnight of July (1669 kg/ha) compare to the lowest yield of check C-152 (935 kg/ha) sown I[st] fortnight of August.

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Index based approach of yield forecasting for sugarcane (*Saccharum officinarum*) crop in India

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Forecasting of crop yield well before harvest is crucial, especially in the country characterized by climate uncertainties like India. In current prospects of changing climate, increasing vulnerability and insecurity of food, reliable crop forecasting may become a tool for insuring food security. Early yield assessment at regional and national scales is becoming increasingly important to numerous user-groups e.g., agriculture planner, policy makers, crop insurance companies and researchers community (Van Wart *et al.*, 2013). It enables planners and decision makers to predict how much to import in case of shortfall or optionally, to export in case of surplus. Crop yield estimation in many countries is based on conventional techniques of data collection. Such techniques are often subjective, costly, time consuming and are prone to large errors due to incomplete ground observations, leading to poor crop yield assessment. Remotely sensed crop data offers considerable opportunities for agricultural decision makers via the possible improvement in crop yield predictions and crop loss assessment (Lobell, 2013 and Rao *et al.*, 2002). Assessment of crop condition with a new outlook was made possible after invention of recent advances in the satellite remote sensing technology. These approaches provide repeated measurements at particular spatial scales and spectral bandwidths which enable multifarious environmental conditions, such as vegetation cover, to be monitored with significant accuracy. Now a day's several remotely sensed indices such as Normalized Difference Vegetation Index (NDVI) and Vegetation Condition Index (VCI) used extensively for agronomic monitoring, especially vegetation stress and crop yield assessments. The VCI is an indicator of the vigour of the vegetation cover as a function of NDVI minima and maxima for a given land area. It normalizes NDVI according to its average over many years and results in a consistent index for different land cover types. If data are recorded over long periods during where extremes in climate are experienced, the VCI indicates potential crop yields. VCI is considered the ideal candidate as an index in Index based Insurance because it is highly correlated with crop yields and hence able to accurately track yield losses. In this context the study was carried out to evaluate the VCI for yield estimation of crops in Indian condition.

METHODOLOGY

Study had been conducted in 52 major Sugarcane growing districts of5 states *i.e.* Gujarat (4 district), Haryana (7 district), Karnataka (5 district), Maharashtra (14 district) and Uttar Pradesh (22 district). In each state major Sugarcane growing districts which has higher area were selected for study. Under ideal conditions of good rainfall, adequate nutrients and management inputs, the crop in a region could grow to its maximum, producing maximum NDVI for that year. On the contrary, in a drought year, less rainfall and inadequate inputs result in very low NDVI. This maximum and minimum NDVI are the conceivable limits of the vegetation ecology over the several years considered. When the current year NDVI is related to the maximum and the minimum values, it helps in getting a fair idea of the present status of vegetation compared to the historic maximum and minimum. Vegetation Condition Index (VCI) helps in isolating the short-term weather signals in the NDVI from the long-term ecological signal. In present study, 13-year historic data base (2003–2015) of NDVI was used to derive the VCI. NDVI products (MOD-13A2) of MODIS instrument on board Terra satellite at 16 days interval from first fortnight of June to second fortnight of October (peak growing period) were used to calculate the NDVI. Historical yield data for the same period of selected districts were obtained from Directorate of Economics and Statistics (DES) Govt. of India. Sum product of VCI was calculated using fortnightly VCI data of each year with estimated correlation coefficient. Correlation coefficient was estimated between fortnightly VCI values with actual yield. Empirical relation between yield and estimated VCI sum product of each district was derived using step wise multiple linear regression technique, as defined by Agrawal (2011). For this purpose SPSS *v.*16.0 (statistical package) was used.

RESULTS

VCI based forecasted yield was good in agreement with DES yield for all districts. The difference is below ± 20 percent except few districts in Maharashtra. District-wise R^2, SEE, and F value was calculated using regression equation and range of the values presented in Table 1. Data pertaining to R square revealed that the state wise value ranges from 0.40-0.78, 0.33-0.68, 0.26-0.85, 0.12-0.66, and 0.35-0.85; SEE ranges from 1.69-10.04, 4.02-11.02, 3.45-9.90, 8.08-22.29 and 1.21-04.55 as well as F value ranges from 4.72-24.84, 4.53-19.28, 2.53-39.91, 1.23-18.13 and 4.51-52.61 for Gujarat, Haryana, Karnataka, Maharashtra and Uttar Pradesh respectively. Lowest R^2 value was noticed in Maharashtra (0.12) with higher SEE because of many variations in estimated VCI based yield and actual yield. In Karnataka and Uttar Pradesh (0.85) state highest R^2 was noticed.

Table 1. Statewise range of Coeficient of Determination (R square), Statndard Error of Estimates (SEE) and F values.

State	Range		
	R2	SEE	F value
Gujarat	0.40-0.78	1.69-10.04	4.72-24.84
Haryana	0.33-0.68	4.02-11.02	4.53-19.28
Karnataka	0.26-0.85	3.45-9.90	2.53-39.91
Maharashtra	0.12-0.66	8.08-22.29	1.23-18.13
Uttar Pradesh	0.35-0.85	1.21-04.55	4.51-52.61

CONCLUSION

The study showed that VCI can be used as input parameters for district level Sugarcane yield estimation in India. However, to use this in operational approaches there is need to validate against actual yield values.

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Productivity and profitability of rice genotypes under direct seeding with seed priming and different methods of sowing

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Rice cultivation by direct seeding is potentially useful for the farmers and environment particularly on the issue of water and soil health over conventional practice of puddling for transplanted rice. This alternative method of rice cultivation is becoming popular as it can save water and labour (Gupta *et al.*, 2006).Both agronomic management and a suitable variety with appropriate traits are needed to achieve maximum potential under direct-seeded rice (DSR). Much research and many

Table 1. Effect of method of sowing, genotype and seed priming on yield and economics of direct-seeded rice

Treatment	Grain yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Net return (Rs/ha)	B:C ratio
Method of sowing					
Line sowing	4.95	10.61	46.5	30935	1.21
Dibbling	5.92	12.69	47.1	42369	1.6
SEm±	0.19	0.45	1.3	-	-
CD (P=0.05)	0.59	1.37	-	-	-
Genotype (G)					
GB 1	6.28	12.81	49.0	44360	1.74
IR 36	4.59	10.49	44.5	28943	1.14
SEm±	0.19	0.45	1.3	-	-
CD (P=0.05)	0.59	1.37	3.9	-	-
Seed priming (P)					
No priming	5.43	12.06	45.4	37187	1.46
Hydro priming	5.43	11.24	48.2	36117	1.42
SEm±	0.19	0.45	1.3	-	-
CD (P=0.05)	NS	NS	NS	-	-

adoptive evaluations carried out during the past decade have provided management options, including improved drills to precisely place seed and fertilizer. Generally, rice varieties bred for puddled transplanting are used in direct seeding. The lack of suitable varieties is a major constraint to achieving maximum potential of direct seeding. Selection of cultivars plays an important role to get the desired yield. The choice of cultivars is determined as per the availability of irrigation water and soil types (Kumar and Ladha, 2011).One of the short term and the most pragmatic approaches to overcome the drought stress effects is seed priming. Seed priming tools have the potential to improve emergence and stand establishment under a wide range of field conditions. These techniques can also enhance rice performance in DSR culture. It involves partial hydration to a point where germination-related metabolic processes begin but radical emergence does not occur (Farooq *et al*., 2006). Although refinements in agronomy and management will continue to be important, targeting varietal improvements in rice under DSR is likely to crucial for improving the potential of direct seeding.

METHODOLOGY

Field experiment was carried out during *kharif* season of 2011 at Agriculture Farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati University, Sriniketan, West Bengal. The experiment was laid out in factorial randomized block design with three replications. The treatments comprised of combinations of two methods of sowing (line sowing and dibbling), two rice genotypes (Gothra Bidhan-1 and IR-36) and seed priming (no priming and hydro priming). The seed rate used for line sowing is 60 kg/ha and for dibbling is 20 kg/ha. All other recommended agronomic practices and plant protection measures were adopted to raise the crop. The experiment was conducted purely under rainfed condition with reduced tillage.

RESULTS

Data presented in Table 1 showed that dibbling method of sowing had significantly influenced the grain yield (5.92 t/ha) and biological yield (12.69 t/ha) over line sowing. Dibbling recorded higher harvest index over line sowing though there is no significant effect on harvest index. Among the methods of sowing dibbling recorded higher net returns and B: C ratio over line sowing due to its higher productivity. Among the genotypes tested in the experimentation GB 1 responded well to direct seeded rice over IR 36 and recorded higher grain yield (6.28 t/ha), biological yield (12.81 t/ha) and harvest index (49.0%)significantly. The GB 1 variety tested recorded 36.81 % higher yield over IR 36. The GB 1 paid higher net returns and B: C ratio over commercially popularized IR 36 variety. Simple hydro-priming of seeds could not impress with any significant effect on productivity of rice under the experiment.

CONCLUSION

It may be concluded that dibbling method of sowing of direct seeded rice under reduced tillage and rainfed condition was found to be superior over line sowing in terms of yield and economics. The rice genotype GB 1 performed significantly better than existing IR 36 variety in direct seeded rice. Hydropriming of seeds was not effective in direct seeded rice.

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Assessment of genetic diversity for fibre yield and component traits in roselle (*Hibiscuss sabdariffa*) germplasm

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Mesta, a lignocellulosic bast fibre crop is originated from Afro- Asian countries(Gomez-Leyva *et al*., 2008), ranks next to jute in importance.It is more adaptive and drought tolerant than jute under diverse conditions of climate and soil(Tomes, 1990). Mesta comprises of two major distinct cultivated species, *Hibiscus cannabinus* (Kenaf) and *Hibiscus sabdariffa* (Roselle). In India, area under mesta is around 85 thousand hectares with a fibre production of 6.2 lakh bales.Andhra Pradesh is a leading state in the country with respect to both area and production. Screening of available germplasm of any crop including roselle is the pre-requisite for improving yield and quality of the produce. It is awell-established fact that the progress in improving a cropdepends on the degree of the variability in the desiredcharacter in the base material *vis-à-vis* germplasmcollection. However, the genetic variability for manytraits is limited in cultivated germplasm. However, an attempt was made to screen available roselle germplasm lines along with suitable check varieties for fibre yield and its attributing traits.

METHODOLOGY

In order to select promising germplasm for utilization in hybridization programme,51 diverse genotypes of roselle were evaluated for fibre yield potential with suitable check varieties HS 4288 and AMV 5 at ICAR-CRIJAF, Barrackpore. The trial was laid in completely Randomized Block Design with three replications during kharif-2015. All recommended cultivation practices were followed and data on fibre yield and its contributing traits namely, plant height, base diameter, green biomass, dry stick yield and percentage fibre recoveryon green weight basis were recorded and analysed.

RESULTS

Plant height of roselle germplam varied from 119-258 cm with a mean value of 271 cm whereas 11 lines were found to be taller than the superior check variety (Table 1). Similarly, base diameter, green biomass, dry stick yield, dry fibre yield and fibre recovery ranged from 9.8-18.9 mm, 35-477 g/plant,

Table 1. Mean performance of 51 roselle germplasm for fibre yield and attributing traits

Attribute	Plant height (cm)	Base diameter (mm)	Green biomass (g/plant)	Dry stick yield (g/plant)	Dry fibre yield (g/plant)	Fibre % of green biomass
Mean performance of 53 germplasm	271	14.9	254	39.41	13.44	5.21
Range	119-358	9.8-18.9	35- 477	2.9-85.5	1.1-27.9	1.7-7.2
SD	72	2.4	123	22.50	7.09	1.02
No. of lines better than superior Check variety	11	19	16	9	12	2
Performance of superior check variety	334	16.1	346	61.20	19.67	6.85
Five best performing lines	R-319	AS-80-9	AS-80-9	R-319	AS-80-9	AR-40
	REX-4	AR-95	R-319	R-92	R-92	ER-67
	R-92	REX-66	R-219	AS-80-9	R-319	AR-51
	8464/68	R-319	6283/44	R-96	RTNB	6283-49
	RTNB	R-96	R-96	REX-4	AR-13A	R-203

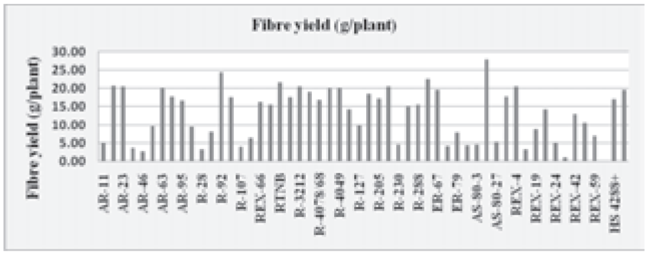

Fig. 1. Performance of 51 germplasm and check varieties of rosellefor dry fibre yield

2.9-85.5 g/plant, 1.1-27.9 g/plant and 1.7-7.2% with a mean value of 14.9 mm, 254 g/plant, 39.41 g/plant, 13.44 g/plant 5.21 %, respectively. Out of 51 germplasm lines 19, 16, 9, 12 and 2 accessions performed better than the superior check variety for base diameter, green biomass, dry stick yield, dryfibre yield and fibre recovery traits, respectively. The performance of superior check variety was334 cm, 16.1 mm, 346 g/plant, 61.20 g/plant, 19.67 g/plant and 6.85%, respectively for plant height, base diameter, green biomass, dry stick yield, dry fibre yield and fibre recovery. It indicated that wide range of variability exists for fibre yield and its attributing traits in the roselle germplasm under evaluation. Similar results were reported by many workers (Ibrahim *et al*., 2013).

CONCLUSION

It is evident that wide range of variability exists in the germplasm under evaluation for fibre yield and other agronomic traits. Some of the germplasm performed better than the superior check variety which could be worthwhile to utilize these lines under intensive breeding programme for the improvement of specific traits in roselle. Out of 51 lines 12 germplasm outperformed the superior check variety AMV 5 (19.67 g/plant) for fibre yield (Fig. 1). The five best performing roselle lines for fibre yield g/ plant were AS—80-9 (27.90), R-92 (24.50), R-319 (22.56), RTNB (21.80) and AR-13A (20.87). These promising lines can effectively be utilized in breeding programme for further improving the fibre yield potential of roselle mesta

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Effect of different sowing dates, spacing and topping management on seed yield of Jute (*Corchorus olitorius*)

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Jute is one of the most important commercial crops of eastern Indian states of West Bengal, Assam, Bihar, Orissa and eastern Uttar Pradesh, being an important foreign exchange earner and supporting nearly 7 million small and marginal families, industrial employees and trade (Kumar *et al.,* 2010). Non-availability of quality jute seed to the farmers at a lower price and proper time is one of the major constraints faced by jute farmers with these objectives study was undertaken to find out optimum sowing date, spacing along with topping management practices in seed yield and economics of Jute.

METHODOLOGY

A Field experiment was carried out for *kharif* season of 2015 at Jute and Allied Fibre crops, MPKV, Rahuri (MS),

Table 1.Effect of sowing dates, spacings and topping managements on growth and seed yield of jute

Treatment	Plant height (cm)	No of branches/plant	Basal diameter (mm)	No of pods/ plant	Seed yield (t/ha)
Sowing date					
24th MW	247.28	21.58	23.21	130.50	1.79
26th MW	194.23	16.06	16.32	101.38	1.50
28th MW	201.40	14.81	17.35	87.42	1.31
SEm±	2.31	0.44	0.26	3.03	0.04
CD (P=0.05)	9.09	1.72	0.78	11.91	0.15
Spacing					
45cmX15cm	219.81	14.41	18.84	94.04	1.59
45 cm × 30 cm	219.33	18.67	19.63	112.41	1.58
60 cm × 15 cm	223.98	21.83	18.64	126.06	1.73
60 cm × 30 cm	221.09	20.37	21.97	131.26	1.70
SEm±	2.74	0.35	0.27	2.27	0.03
CD (P=0.5)	NS	1.03	0.82	6.74	0.09
Topping					
1. No topping	240.40	17.43	19.06	106.31	1.52
2. 30 DAS	202.15	18.75	20.37	117.58	1.64
3. 45 DAS	220.61	20.28	19.83	123.93	1.76
SEm±	1.74	0.39	0.19	1.43	0.03
CD (P=0.05)	4.76	1.10	0.55	4.07	0.09

with three dates of sowing D_1-24th MW,(11-17th June), D_2-26th MW (25th June-1st July) and D_3-28 MW (8-15th July), three spacings (S_1-45 x 10 cm, S_2-45 x 15 cm, S_3-60 cm x 15 cm and S_4-60 cm x 15 cm) and three topping management techniques (T_1-No Topping, T_1- 30 DAS and T_2- 45 DAS) were laid out in split-split plot design and replicated thrice. The experimental soil was vertisol in nature with low in available nitrogen (172.23 kg/ha), medium in available phosphorus (15.02 kg/ha) and high in available potassium (426.0 kg/ha). The soil was moderately alkaline in reaction (pH 8.2). The electrical conductivity, organic carbon and $CaCO_3$ were 0.19 dS/m, 0.56 and 4.59%, respectively. Fertilizer doses of 60, 30 and 30 kg/ha N, P_2O_5 and K_2O were applied respectively. N was applied in two equal split doses one as basal dose and another top dressed at 30 DAS when hand weeding was done. Application of three irrigations, usual weed and pest control measures as per recommendations.

RESULTS

The crop sown in 24th MW was significantly recorded highest plant height (247.2 cm) as well as number of branches (21.28) per plant than 26th MW and 28th MW in jute. Similarly, the higher growth attributes were reflected in higher yield attributes and seed yield *viz.,* basal diameter per plant(23.21 mm) and number of pods per plant (130.50) during this year. Sowing date of 24th MW was resulted into higher jute seed yield (1.79 t/ ha) as compared to 26th MW (1.52 t/ ha) and 28th MW (1.31 t/ ha) and it was 19.44 % higher than 26th MW and 37.15 % higher than 28th MW during the *kharif* season of 2015.The Spacing of 60 cm x 15 cm was significantly recorded higher growth and yield attributes than spacing of 45 cm x 15 cm and 45 cm x 30 cm but at par with spacing of 60 cm x 30 cm. Similarly, seed yield of spacing, 60 cm x 15 cm (1.73 t/ha) was registered significantly higher than rest of spacings but at par with spacing of 60 cm x 30 cm (1.70 t/ha) in Table 1.Earlier topping i.e. topping at 30 DAS had harmful effect on plant height but rendered beneficial effect in terms of other growth parameters like basal diameter per plant. This could be because of the fact that in 30 DAS, early removal of apical portion of the plant checked the vertical growth from early growing stage (Table 1). Topping at 45 DAS exhibited superior performance with regard to all the growth and yield parameters *viz.,* number of branches per plant (20.28), number of pods per plant (123.93). This might due to be topping at 30 DAS promoted much vegetative growth but better reproductive growth was obtained with topping at 45 DAS.Topping at 45 DAS registered significantly higher seed yield (1.79 t/ha) than over no topping and topping at 30 DAS.

CONCLUSION

Sowing of jute (*Colitorius*) during 24th MW week (8-16th June) with optimum spacing of 60 cm x 15 cm and topping at 45 DAS is beneficial for higher growth and seed yield of jute under protective irrigated conditions.

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Yield attributes and yield of Castor (*Ricinus communis*) as influenced by sowing date and plant spacing in Rajasthan

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Castor (*Ricinus communis* L.) is an important nonedible oil seed crop of India being grown during rainy season is often affected by early/mid/terminal drought leading to partial loss or even complete crop failure. Planting date which is a non-monetary input in crop production can influence the castor yield. The ratio of female to male flowers is highly sensitive to environmental conditions (Zuchi *et al*., 2010). As far as post rainy season castor is concerned, the crop may be subjected to low temperature stress in the initial stages and high temperature stress in the terminal stages. Crop geometry is an important factor to achieve higher production by better utilization of moisture and nutrients from the soil and with above soil by harvesting the maximum possible solar radiation and in turn better photosynthates formation (Thavaprakaash *et al.,* 2005). The study of the plant response to the changes with certain land arrangement is necessary as the yield per unit area is dependent not only on the number of plants unit area but also on the arrangement of these plants on the ground. Thus keeping in view the importance of sowing date and plant spacing in castor, an experiment was carried out to study the effect of sowing date and plant spacing on castor.

METHODOLOGY

The study was conducted at farmers'field and instructional farm of KrishiVigyan Kendra, Keshwana, Jalore during *Kharif* 2011 and 2012 having silty loam soil. The experiment was laid out in a split-plot design with five replications. The treatments consisted of three main plots of sowing time (15 July, 30 July and 15 August) and three sub plots of plant spacing (60x45 cm, 90x45 cm and 90x 60 cm apart row and plant). Sowing of castor hybrid 'RHC- 1' was done as per the time of sowing treatment at different spacing. Besides time of sowing and plant spacing, the crop was raised with recommended package of practices.

RESULTS

As the three dates of sowing of castor were tested, the plant population, number of branches per plant, number of effective spikes per plant, number of capsules per spikes, 100 seed weight and seed yield, was decreased gradually to delay sowing dates from 15 July to 30 July and 15 August (Table 1). The gradual decrease in yield with subsequent delay in sowing might be due to prevailing low temperature and less remnant moisture in the soil and other environmental factors at vegetative growth phase period which in turn adversely affected the overall development of the plant. An appraisal of pooled data reveled that wider sowing of castor in spacing 90x60 cm statistically at par with spacing 90x 45 cm observed

Table 1. Effect of sowing dates and plant spacing on plant population, yield attributes and yield of castor(pooled of 2011 and 2012)

Treatment	Plant population/ ha	No. of branches/ plant	Spikes/ plant	Capsules/ spike	100 seed weight (g)	Seed yield (kg/ha)
Sowing date						
15-July	23642	18.36	17.09	27.15	26.47	3989.94
30-July	23438	16.87	14.74	22.28	28.02	3499.38
15-August	22851	14.69	11.34	16.56	29.06	2983.76
CD (P=0.05)	1412	1.01	1.55	2.27	0.95	226.22
Plant spacing						
60x45 cm	30828	15.67	12.35	20.48	26.89	3392.83
90x45 cm	21900	16.90	14.80	22.60	28.75	3534.79
90x60 cm	17203	17.35	16.02	22.92	27.91	3545.45
CD (P=0.05)	537	0.77	0.96	1.50	0.59	131.41

significantly higher plant height, number of branches per plant, number of effective spikes per plant, number of capsules per spikes, 100 seed weight and seed yield over 60x45 cm plant spacing (Table 1).This system allows more interception of solar radiation by the crop canopy on account of higher inter and intra row space. This might have enabled the crop to maintain higher net photosynthetic rate and resulted in greater dry matter production per unit area reflected in enhanced vigour and yield attributes which might have contributed in significantly higher seed stalk and biological yield of the crop.

CONCLUSION

The plant population, number of branches per plant, number of effective spikes per plant, number of capsules per spikes, 100 seed weight and seed yield was decreased gradually to delay sowing dates from 15 July to 30 July and 15 August. Further, wider sowing of castor in spacing 90x60 cm observed significantly higher plant height, number of branches per plant, number of effective spikes per plant, number of capsules per spikes, 100 seed weight and seed yield over 90x 45 cm and 60x45 cm plant spacing.

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Performance of oats and barley for dual purpose under dryland areas

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Oats and barley are important fodder crops widely grown during winter in different parts of the world. Al-Ajlouni *et al.* (2010) reported that barley is the major feeding crop grown in the dryland areas which are characterized by high variability. In India, total area covered under fodder crops about 1% of total cultivated area of the country (IGFRI, 2011). Under situations where water supply is limited and the farmers are not in a position to grow the forage crops having high water requirements like lucerne and berseem, oats and barley can grow successfully, which provides energy rich nutritious and palatable fodder for livestock. Recently, both these crops are becoming popular for their dual nature that is provides grain for human consumption and fodder for livestock. Therefore, present study was conducted to fulfil the objectives (i) to observe growth and yield of oats and barley under limited irrigation in light soils, and (ii) to find out WUE and quality parameters under arid condition.

RESULTS

The results reveal that growth characters viz. plant height,

Table 1. Effect of different water regimes on plant height, yield attributes and green fodder yield of oats and barley (Pooled of three years)

Treatment (water regimes)	Plant height (cm)		Tiller/m row length		Green fodder yield (t/ha)		Gains/ panicle		Test wt. (g)	
	Oats	Barley	Oats	Barley	Oats	Barley	Oats	Barley	Oats	Barley
Sufficient	101	75	86	60	22.34	8.72	23.2	41.2	44.0	52.4
Limited	99	74	89	70	18.07	7.04	21.9	40.1	42.8	51.5
Deficit	94	71	83	68	13.49	4.22	20.5	36.0	41.2	49.1
CD (P = 0.05)	3	NS	NS	3.5	2.95	0.69	1.4	3.1	2.3	2.2

Table 2. Effect of different water regimes on grain yield, straw yield, water use efficiency and crude protein % of oats and barley (Pooled of three years)

Treatment (water regimes)	Grain yield (t/ha)		Straw yield (q/ha)		Water use (mm)	Water use efficiency (mm/kg/ha)		Crude protein (%) in straw	
	Oats	Barley	Oats	Barley		Oats	Barley	Oats	Barley
Sufficient	3.08	3.03	53.2	58.7	327.2	9.3	9.4	10.3	10.5
Limited	2.77	2.68	49.9	52.2	277.2	9.7	10.0	10.1	10.5
Deficit	2.39	2.41	45.0	48.0	227.2	10.6	10.5	9.9	10.1
CD (P = 0.05)	0.24	0.40	2.6	9.6	-	-	-	0.3	0.4

tillers/m row length and green fodder yield were recorded higher in oats compared to barley under different water regimes. Whereas, grain yield attributes namely panicle length and test weight was noted higher in barley under varying water regimes. Further, grain yield was found at par both in oats and barley while straw yield was noted higher in barley under different water regimes. Also, water use efficiency increased by decreasing irrigation water application in both crops and higher values was computed under deficit condition followed by limited irrigation and the minimum under sufficient water regime. Crude protein content in fodder of both crops decreased with decreasing irrigations but at par, protein content was noted in barley under sufficient and limited irrigation condition. The results thus clearly show that both oats and barley crops are suitable for dual purpose (grain and fodder) under limited water condition in light soils of Western Rajasthan (Table 1& 2).

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Comparative analysis of secondary metabolites *in vitro* and *in vivo* in *Ruta graveolens*

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Ruta graveolens perennial herb, is a member of family Rutaceae. It is commonly called as Rue and is considered to be a promising species for production of Furanocoumarins (FC). Plants that induce photosensitising in human skin are used in the treatment of depigmentation disorders like vitiligo. FC’s which occur in plants are found to have photoreactive properties. Experiments have shown that *Rutagraveolens* serves as the best candidate with highest production of FC’s as compared to families Apiaceae ,Moraceae, Fabaceae. Among the four species of Ruta, *Rutagraveolens* is found to exhibit the highest production of biomass and FC production. Establishment of *Rutagraveolens* for the production of FC’s depends on the localization of these compounds in the plant organs. By analysis of different organs of plant for FC production, it was observed that highest amount was extracted from fruits followed by leaf, root, and stem. Moreover, the plants in fruiting stage produce more amount of FC as those compared in vegetative stage.Production is also dependent on growth stage, season, climatic and nutritional factors. Therapeutic effectiveness of FCs includes symptomatic treatment of vitiligo, psoriasis and mycosis fungoides, as they photo-induce defined adducts and inter-strand cross links with DNA. Three well known FC’s extracted from *Rutagraveolens* include Psoralen, bergapten (5-methoxypsoralen) and xanthotoxin (8-meth-oxypsoralen. These compounds have proved to have anti-tumorous, anti-cancerous, antioxidative, antimicrobial, anti-inflammatory and anti-mutagenic properties (Jan *et al.,* 2012). Inspite of its immense potential in production of FC's, it is not readily available in wild state and is endemic to few areas in Orrisa. Propagation through seeds is an intricate task due to the physical dormancy caused by an impermeable seed coat resulting in poor germination. Therefore, in-vitro culturing of the species serves as an alternative which gives more biomass and adequate amount of FC's as compared to in-vivo production thus reducing pressure on wild cultivars.

METHODOLOGY

In-vivo and *In-vitro* grown plant material was shade dried for about 1 week and made to a fine power. 0.500mg of fine power was weighed for each *in-vitro* and *in-vitro* samples. Acid hydrolysis was carried using 2N HCl in water bath at 60 °C followed by addition of equal amount of methanol and keeping at 60°C in water bath. The samples were then sonicated and centrifuged at 10,000 rpm for 10 minutes for removing the suspended plant material. Supernatant was used for furanocoumarin estimation. Spectrophotometric readings were taken for standard solutions of Bergapten and Xanthotoxin at 246 nm and 249nm respectively. Similarly readings for various *in-vivo* and *in-vitro* samples were taken for bergapten and xanthotoxin. Standard stock solution was made by dissolving 1mg of Xanthotoxin and bergapten in chloroform and ethanol respectively, as they are readily soluble in the mentioned solvents.

RESULTS

FC's are essential in the field of medicine. FC's are used in the treatment of depigmentation disorders like vitiligo. These compounds have proved to have anti-tumorous, anti-cancerous, anti-oxidative, antimicrobial, anti-inflammatory and anti-mutagenic properties. Hence the demand is high. Recent studies indicated the role of FC's in Coumarin Derivatives in Pharmacotherapy of Breast Cancer. It is not readily available in wild state and is endemic to few areas in Orrisa. Considering the importance of FC's it is essential to perform *in-vitro* culturing of the plant to meet the increasing demand of the product. The preparation of suspension cultures of plant cells by conventional method has been a slow and laborious process, involving subjecting callus tissue to prolonged low-intensity abrasion by continuous gentle, shaking or stirring in nutrient medium for a period of weeks, or even months, accompanied by periodic filtering and re-culturing. This procedure has considerable drawbacks when it is desired to initiate suspension cultures on a commercial scale. Therefore, this novel method for getting cell suspension culture would serve as an alternative to conventional method for raising multiple shoot initials and cell suspension in short span of time. Along with certain manipulations in medium composition and elicitors the biomass and production could also be increased using this new method of culturing.

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Effect of agro-techniques on yield maximization in Pigeon pea (*Cajanus cajan* L. Millsp.)

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Pigeonpea is the most important rainy season grain legume crop belong to the family *Leguminoseae*. It is rich source of protein and aminoacids like lycine, tryocene, cysteine and arginine. Pigeonpea crop has compensatory behavior in respect of plant population, crop geometry to economic yield. In that case, there is minimum adverse effect on yield with decrease or increase in plant population of the crop. Although chemical fertilizer are playing a crucial role to meet the nutrient requirements of the crop, continuous use of fertilizers affect the soil health adversly on physical, chemical and biological properties of soil. Hence integrated nutrient management is applied to get better yield with minimum use of chemical fertilizers. The basic concept of INM is the supply of required plant nutrients for sustaining the desired crop productivity with minimum deleterious effect on soil health environment (Balasubramanian, 1999). In *kharif* season because of

Table 1. Mean seed yield per plant, yield per ha and harvest of Pigeonpea as influenced by different treatments.

Treatment	Seed yield/ plant (g)	Seed yield (t/ha)	Harvest index (%)
T1=INM (FYM @ 5t /ha + RDF i.e. NPKSZn) + *Rhizobium* + PSB	51.19	0.92	20.31
T2=IWM (Pendimethalin @ 0.75 Kg/ha on 3 DAE + Imazethapyr @100 g a.i/ha on 10-15 DAE of weeds + 1 HW on 50 DAS.	62.23	1.13	20.86
T3=IPM (Indoxacarb 15.8 % EC at the time of Flowering @ 375 ml/ha + one Systemic insecticide spray 15 days after first spray.	44.14	0.81	18.79
T4 =INM + IWM.	62.80	1.22	20.81
T5 =INM+IPM	54.70	1.10	21.14
T6 =IWM + IPM.	60.01	1.21	20.52
T7 =INM +IWM + IPM.	94.22	1.57	23.69
T8 =Control (Farmer's practices)	56.75	1.12	20.89
CD (P=0.05)	13.26	2.03	NS

favourable climatic conditions, weed has become a major problem. Unavailability of timely and cheap labour has caused the problem of weed competition in crops and further it is aggravated making it imperative develop cheaper methods of weed control with herbicides alone or in combination with other mechanicalmethods.

METHODOLOGY

The Field investigation was conducted for Evaluation of agro-techniques for yield maximization in pigeonpea (*Cajanus cajan* L. Millsp.) at section of Agronomy, Agricultural research station, Badnapur during *kharif* season of 2014-15. The field experiments was laid out in randomized block design with eight treatments which includes INM;IWM; IPM; INM + IWM ; INM + IPM ;IWM + IPM ; INM + IWM +IPM and control (farmers practice) and replicated thrice. The gross and net plot sizes of each experimental unit was 5.4 m x 4.5 m and 3.6 m x 3.9 m, respectively. The sowing was done on 11th July 2014 by dibbling method by using variety BSMR-853. The recommended packages of practices were adopted for the growth of the crop. The crop was harvested on 19th February 2015.

RESULTS

The seed yield/plant ranged from 44.14 g to 94.22 g with mean value of 60.96 g. Maximum seed yield/plant (94.22 g) was recorded by INM + IWM + IPM treatment (T7) followed by INM + IWM (T4). Minimum seed yield/plant (44.14) was recorded in treatment IPM (T3) .The overall improvement in growth and yield might be due to more availability of nutrient ,moisture and less competition between weeds and crops and pest management. The yield contributory character viz., branches/plant, pod/plant, seed/plant and test weight resulted in increasing the grain yield in INM+IWM+IPM. Yield attributes were significantly lower in IPM. Seed yield (t/ha) ranged from 0.81 to 1.57 t with mean value of 1.13 t. Maximum seed yield (1.57 t/ha) was recorded by INM + IWM +IPM treatment (T7). The minimum seed yield (0.81 t/ha) was recorded by IPM treatment (T3). Increased availability of nutrients following combined use of FYM, bio-fertilizer and fertilizer might have enhanced the nutrient uptake vis-a-vis yield. Harvest index ranged from 18.79 to 23.69 with mean value of 20.87. Maximum harvest index (23.69) was recorded by INM + IWM +IPM (T_7) Minimum harvest index (23.69) was recorded in IPM (T_3).

CONCLUSION

For optimum growth, highest seed yield and net returns of pigeonpea ,application of Integrated nutrient management (INM) + Integrated weed management (IWM) + Integrated pest management (IPM) is necessary followed by Integrated nutrient management (INM) + Integrated weed management (IWM) and Integrated weed management (IWM) + Integrated pest management (IPM).For maximum productivity and increased net profit of pigeonpea, it is essential to undertake Integrated Nutrient Management (INM) + Integrated Weed Management (IWM) + Integrated Pest Management (IPM) practices.

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Influence of plant geometry and cultivars on grain yield of dry direct seeded rice under Varanasi region of eastern Uttar Pradesh

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Rice (*Oryza sativa* L.) is the staple food of India and Uttar Pradesh is a major contributor with growing area of 5.87 million ha (5.84 *Kharif* + 0.027 summer/*Rabi*) and annual production of 14.63 million tonnes in 2013-14 (Indiastat, 2016). The area under direct seeding rice is continued to increase rapidly over transplanted rice due to scarcity of irrigation water or low rainfall (Pathak *et al.,* 2011). Moreover, the knowledge about the selection of appropriate cultivars and plant geometry under direct seeded condition is still lacking to get the higher grain yield. Above facts keep in mind, the present investigation was undertaken to find out the suitable rice cultivar and crop geometry under direct seeded conditions for better productivity to the farmers in eastern region of Uttar Pradesh.

METHODOLOGY

A field investigation was conducted in during *kharif* season of 2014 at Agricultural Farm of Banaras Hindu University, Varanasi, Uttar Pradesh (83°03' E and 25°18' N; 81.71 m above mean sea level) to determine the influence of different crop geometry and cultivars/hybrid on grain yield of dry direct seeded rice. The soil chosen for experiment falls under the category of sandy loam texture having pH and electrical conductivity of 7.3 and 0.23 dS/m at 25^{o}C, respectively. Soil was low in organic carbon (0.47%) and available nitrogen (207.5 kg/ha) while medium in available phosphorus (21.5 kg/ha) and available potassium (223.6 kg/ha). The experiment was laid out in a split plot design replicating thrice. The five cultivars (Swarna/MTU 7029, NDR 97, HUR 105, HUR 4-3 and PRH-10) were allocated in main plots and three crop geometry (20 x 10 cm^2, 20 x 20 cm^2 and 25 x 25 cm^2) in subplots. The seed of different cultivars/hybrids was direct seeded under un-puddled un-ponded plots by dropping one to two seeds in each hole of 4-5 cm depth as per the spacing treatment with recommended package of practices. To maintain uniform plant population, thinning and gap filling were done two weeks after sowing. The irrigation was given as per the crop requirement and rainfall pattern. Data on panicle weight, days to 50% maturity and yield performance were recorded and analysed.

RESULTS

The significant variation in days to 50% maturity in dry direct seeded rice cultivars was found due to different plant spacing. Days to 50% maturity was significantly higher in cultivar MTU 7029 followed by HUR 4-3, HUR 105, PRH-10 and NDR 97, respectively (Table 1). The wider plant spacing of 25 x 25 cm^2 and 20 x 20 cm^2 took significantly higher days to 50% maturity than the closer plant spacing (20 x 10 cm^2-). The variations in days to 50% maturity at 25 x 25 cm^2- and 20 x 20 cm^2 were statistically at par. The significantly higher days taken to 50% physiological maturity in MTU 7029 was due to the fact of its longer life cycle while in NDR 97 the significantly lowest value of days to 50% physiological maturity was also associated with its short duration life cycle. The number of days taken for 50% physiological maturity by cultivars is a genetic characteristic of genotypes. PRH-10 registered significantly more panicle weight as compared to HUR 105, HUR 4-3, MTU 7029 and NDR 97, re-

Table 1. Effect of crop geometry and cultivars on days to 50% maturity, panicle weight and grain yield of dry direct seeded rice

Treatment	Days to 50% maturity	Panicle weight (g)	Grain yield (kg/ha)
Cultivar			
MTU 7029	142.22	3.10	5489.24
NDR 97	93.56	1.97	3397.82
HUR 105	126.78	3.85	5022.03
HUR 4-3	131.11	3.61	4612.99
PRH-10	112.44	4.95	5582.32
SEm±	0.17	0.16	218.79
CD (P=0.05)	0.56	0.55	713.51
Crop geometry (cm^2)			
20 x 10	120.47	3.32	4895.10
20 x 20	121.33	3.54	4601.74
25 x 25	121.87	3.62	4965.79
SEm±	0.18	0.05	100.42
CD (P=0.05)	0.54	0.14	296.23

spectively (Table 1). Furthermore, the cultivar NDR 97 had significantly lowest weight of panicle than all the remaining cultivars. The weight of panicle increased with an increase in plant spacing. Wider spacing of 25 x 25 cm^2 and 20 x 20 cm^2 recorded significantly higher panicle weight as compared to the closer spacing of 20 x 10 cm^2. However, the differences in panicle weight at plant spacing 25 x 25 cm^2 and 20 x 20 cm^2 were non-significant. The higher values of panicle weight recorded by rice hybrid PRH-10 over inbred cultivars might be due to more number of tillers per unit area, better crop growth and development, higher photosynthetic efficiency due to LAI at flowering and also towards physiological maturity. Rice hybrid PRH-10 exhibited significantly more grain yield than inbred cultivars HUR 4-3 and NDR 97 while MTU 7209 and HUR 105 had statistically comparable grain yield with PRH-10 (Table 1). Direct seeding of rice at a spacing of 25 x 25 cm^2 proved significantly superior over the spacing 20 x 20 cm^2 in grain yield. However, the spacing 25 x 25 cm^2 with 20 x 10 cm^2 and 20 x 10 cm^2 with 20 x 20 cm^2 had statistically comparable grain yield. The higher grain yield of rice hybrid PRH-10 over conventional cultivar was perceived mainly due to more panicle weight and the heterosis effect genotype (Virmani, 1996).

CONCLUSION

The rice hybrid PRH-10 obtained higher grain yield at crop geometry of 25 x 25 cm^2 under dry direct seeded conditions in Varanasi region of eastern Uttar Pradesh.

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Yield enhancement in lentil through cluster frontline demonstration

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Pulses not only source of the protein however, it gives sustainable soil health which is very important to sustain the productivity of any existing cropping system in particular region also. Both area and production of pulses declined in post green revolution period due to more emphasis given to cereal production system. Farmers obviously, cultivated the pulses under sub optimal conditions of farm inputs as well as soil. This situation becomes very serious to fulfill pulses demands of increasing population. To achieving the desired productivity, ICAR on behalf of Government of India has been taken initiative to pulse production in NFSM scheme through cluster front line demonstration. The present study was conducted in the Dehradun District of Uttarakhand to yield enhancement in lentil through FLDs during rabi 2015-16.

METHODOLOGY

Frontline demonstration on Lentil was conducted at40 farmer's field in Dehradun District with the technical guidance of KVK Dhakrani during rabi season of 2015-16. Lentil 'PL 08' was sown using the seed rate of 30 kg/ha, during 2nd fortnight of November 2015 and crop harvested in mid-March 2016. The crop was raised with recommended package of practices suggested by GBPUA&T, Pantnagar. To proper conductance the FLDs, a farmers meeting was organized prior to sowing, however, during crop season scheduled field visit to suggest the operations and monitoring the growth have been performed by the scientist. The data on grain yield recorded on individual farmers basis and computed as whole to find the average yield in t/ha. Economics was computed on the basis of information provided by the farmers and prevailing in local area.

RESULTS

Seed yield in frontline demonstration (FLDs) of Lentil PL-08 was recorded 0.86 t/ha, against 0.63 t/ha and 0.58 t/ha with farmers practice, district and state yield, respectively. Increase in yield with FLDs was higher by 36.5, 43.3 and 48.3% over FP, District and state level, respectively. Higher yield in FLDs

Table 1. Yield, yield gaps (t/ha) and economics on lentil FLDs during *rabi* 2015-16

Particular	Yield (t/ha)			Economics		
	Local Check	District	State	Gross cost (Rs/ha)	Gross return (Rs/ha)	B:C
Farmers practice (FP)	0.63	0.60	0.58	13500	54240	3.72
FLD	0.86	-	-	14500	68800	4.74
Increase % in yield over FP	36.5	43.3	48.3	-	-	-
Potential yield of PL-08 (q/ha)	1.2	-	-	-	-	-
Technology gap (t/ha)	0.34	-	-	-	-	-
Extension gap (t/ha)	0.23	-	-	-	-	-
Technology index (%)	28.3	-	-	-	-	-

mainly attributed to technological adoption of the farmers. To assess the efficiency of FLDs, extension gap (0.23 t/ha) and technological gap (0.34 t/ha) in yield was calculated. These gaps were minimized with the technology dissemination (FLDs)with the lower value of technology index. FLDs on lentil were also generated higher values of monetary returns with B: C ratio when it was compared to farmers practice.

CONCLUSION

The yield gaps can be minimized effectively through way of dissemination the technology to farmers with cluster front-line demonstration.

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Effect of different fodder maize varieties sown under varying intercropping systems with cowpea (*Vigna unguiculata*) on yield

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Maize (*Zea mays*), among the different fodder crops is regarded as one of the important dual purpose crop, used in human diet as well as animal feed. Maize has the potential to supply large amounts of energy-rich forage for daily animal di-ets and its fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid. Among different legumes as intercrop Cowpea (*Vigna unguiculata*), an annual legume with high level of can be mixed with maize to improve forage protein content of diets and thus, the cost of high quality forage production can be lowered. On the other hand Intercropping has many advan-tages over sole cropping. It provides an efficient utilization of environmental resources, reduces risk of the cost of pro-duction, provides greater financial stability for farmers, suppresses weed growth more than monocultures and improves soil fertility. Hence this study was undertaken to determine the effect of intercrop (cowpea) on main crop (maize) with the objective of finding suitable fodder maize cultivar and intercropping system.

METHODOLOGY

A field experiment was conducted during *spring* season of 2014 at SKUAST-Jammu in randomized block design with 3 replications. The soil of experimental field was clay loam in texture, slightly alkaline in pH, medium in organic carbon,

Table 1. Effect of different cultivars and intercropping systems on plant/m^2 dry biomass yield (t/ha) of fodder maize and cowpea

Treatment	Plant /m^2		Dry Biomass Yield (t/ha)		
	Maize	Cowpea	Maize	Cowpea	Total
Sole African Tall	21.84	-	4.81	-	4.81
Sole J-1006	21.02	-	4.62	-	4.62
Sole local variety	18.77	-	4.55	-	4.55
Sole cowpea var. CL-367	-	19.87	-	3.63	3.63
African Tall + cowpea (1:1)	20.73	19.93	3.92	3.02	6.94
African Tall + cowpea (2:1)	20.99	6.21	4.36	2.83	7.20
African Tall + cowpea(1:1 mix)	20.18	19.68	3.49	2.92	6.41
African Tall + cowpea(2:1 mix)	20.89	19.64	4.39	2.61	7.00
J-1006 + cowpea (1:1)	18.84	19.61	3.18	2.27	5.46
J-1006 + cowpea (2:1)	20.18	6.10	4.29	2.15	6.45
J-1006 + cowpea (1:1 mix)	18.75	19.15	3.02	2.28	5.30
J-1006 + cowpea (2:1 mix)	18.94	19.09	3.08	2.66	5.74
Local variety + cowpea (1:1)	17.35	16.21	2.86	1.78	4.65
Local variety + cowpea (2:1)	17.73	6.10	3.94	1.64	5.58
Local variety + cowpea (1:1 mix)	17.25	15.41	2.60	1.77	4.37
Local variety + cowpea (2:1 mix)	17.70	14.22	3.58	1.71	5.29
SEm±					3.14
LSD (P=0.05)					9.12

available phosphorus and potassium and low in available nitrogen. The experiment consisted of 16 treatments including sole fodder maize and sole chickpea. All recommended agronomic practices were followed throughout the crop period. The dry biomass yield was recorded from the net plot area and expressed as t/ha.

RESULTS

African tall cultivar recorded highest number of plants/m^2 (21.84) followed by sole J-1006 (21.02), Sole cowpea (19.87) and sole local variety (18.77). However, among the different intercropping treatments, higher number of fodder maize plants/m^2 (20.99) were observed with African tall cultivar intercropped with cowpea in 2:1 row ratio. Among the cowpea intercropping, African tall + cowpea 1:1 recorded highest plants/m^2 (19.93).The dry biomass accumulation is an important growth index to assess the performance of crop under the influence of different treatments. Dry matter yield continued to increase with the advancement in crop age and the increase was observed up to harvest. Among the various intercropping treatments significantly maximum dry biomass yield to the tune of 7.201 t/ha, was recorded with the African tall intercropped with cowpea in 2:1 row ratio which was at par with African tall intercropped with cowpea in 2:1 as well as 1:1 seed mix (7.00 and 6.41 t/ha). African tall intercropped with cowpea in 1:1 row ratio was 6.94 t/ha and J-1006 intercropped with cowpea in 2:1 row ratio was 6.45 t/ha. Various sole fodder maize cultivars and intercropping treatments increased the dry biomass yield of crop up to harvest. Among the fodder maize cultivars, African tall recorded highest dry biomass yield 4.81 t/ha at harvest which was followed by sole J-1006 (4.62 t/ha) and sole local variety 4.55t/ha. Whereas, dry biomass of sole cowpea was recorded 3.63 t/ha which was lower to all fodder maize cultivars. Cultivar African tall produced higher dry biomass yield which might be due to more growth as indicated by its greater height. In the intercropping systems the dry biomass yield were found highest for

CONCLUSION

Based on the one year study it can be safely concluded that intercropping is more productive as compare than sole cropping. Cultivar African tall intercropped with cowpea in 2:1 row ratio as well as 2:1 seed mix proved to be the more remunerative under J&K conditions. However, under limited labour supply, African tall intercropped with cowpea in 2:1 seed mix can be adopted.

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Effect of rice establishment methods on growth and yield of different rice (*Oryza sativa*) hybrids in lateritic zone of West Bengal

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Rice is the most important staple food crop of the world, cultivated in about 163.2 million ha with a production of 719.7 million tons of grains. India is the second most populous nation and the largest producer of rice in the world after China. Establishment techniques need to be standardized to achieve the reported yield potential of rice under different rice hybrids in various environments. Because of the need for hybrids and to develop appropriate crop establishment methods to improve rice yield, this study was undertaken to assess the effect of different hybrids in different establishment methods on rice productivity.

METHODOLOGY

A field experiment was carried out during *boro* season of 2014 at Institute of Agriculture (Palli Siksha Bhavana), Visva-Bharati, Sriniketan, West Bengal to evaluate the productivity of different rice (*Oryza sativa* L.) hybrids in different methods of rice establishment. The experiment was laid out in a factorial randomized block design with three replications. The treatment structure consisted of four hybrids -Tej (V_1), NK6203 (V_2), Rajalaxshmi (V_3) and Ajoy (V_4) and two establishment methods -SRI(S) and Traditional transplanting (T). Fourteen days old seedlings were transplanted with a spacing of 25 x 25 cm in SRI and in traditional method of transplanting twenty four days old seedlings were transplanted with spacing of 20 x15 cm.

RESULTS

System of Rice Establishment (SRI) influenced the plant height and dry matter production of all the hybrids over traditional method of transplanting. Under SRI method of establishment, the highest plant height was recorded in the hybrid Raja laxshmi and highest dry matter productions were recorded with Tej hybrid under SRI system of establishment method. There was a progressive increase in plant height and dry matter production under SRI system of planting when compared to traditional method of transplanting. The transplanting of younger seedlings in SRI method which might have established quickly in the field and started growing at a faster rate might be attributed to higher plant height. Optimum

Table 1. Plant height, dry matter accumulation, spikelets/panicle, filled grains/panicle and grain yield of different establishment methods of hybrid rice.

Treatments	Plant height (cm)	Dry matter Accumulation at harvest (g)	Spikelets/ panicle	Filled grains/panicle	Grain yield t/ha
SRI					
V_1	96.8	1432	159	114	6.72
V_2	107.4	1399	156	107	6.64
V_3	108.6	1420	151	112	6.60
V_4	108.5	1389	158	113	6.26
Traditional method of transplanting					
V_1	89.7	1221	155	101	5.94
V_2	100.5	1172	149	104	6.06
V_3	99.7	1259	143	98	5.95
V_4	103.2	1174	153	105	6.00
SEm±	5.59	71.68	2.11	2.00	1.45
CD (P=0.05)	19.37	24.8	7.30	6.92	5.04

plant population and geometry under SRI system led to availability of more resources to the plants that resulted in increased plant height and higher dry matter accumulation. Planting in square method with wider spacing might have resulted in profuse tillering under SRI cultivation, which might have facilitated better utilization of the resources. SRI system of planting had significantly influenced the yield characters and yield (Table 1). SRI establishment method recorded significantly better yield characters over traditional method of transplanting. Among the different rice hybrids, the highest yield characters viz., number of panicles m^{-2}, total number of grains per panicle and number of filled grains per panicle were recorded with hybrid Tej under SRI establishment method. The least yield characters *viz*., number of panicles m^{-2} and numbers of filled grains per panicle were recorded with hybrid Raja laxshmi in traditional transplanting method. SRI method of establishment recorded higher grain yields over all the hybrids in traditional method of planting. Though all the hybrids in SRI recorded at par yields, the hybrid Tej recorded the higher grain yield. The lowest grain yield was noticed in Raja laxshmi in case of traditional method of transplanting. The hybrids viz. Tej, NK6302, Raja laxshmi and Ajoy obtained 11.2%, 11.0%, 11.3% and 11.2% yield advantage in SRI establishment method over traditional method of transplanting. Kumar (2012) obtained 7-20% more yields in SRI over normal method, irrespective of soils and locations across the years in the country. Increased grain yield under SRI is mainly due to the synergistic effects of modification in the cultivation practices such as use of young limited irrigation and frequent loosening of the top soil to stimulate aerobic soil conditions. Bhowmick *et al*. (2013), obtained comparatively lower yields under normal transplanting due to gradual degeneration of rice roots with the progress of crop growth stages due to continuous submergence. The higher yield realized with SRI method might be due to the use of younger seedlings, which preserved a potential for more tillering and rooting. The increase in the grain yield of SRI method was attributed to large root volume, profuse and strong tillers with big panicles, more and well filled spikelets with higher grain weight. Similar findings were recorded by Jayadeva *et al.* (2008).

CONCLUSION

It can be concluded that SRI establishment method recorded significantly better yield characters over traditional method of transplanting. Among the different rice hybrids, the highest number of panicles m^{-2}, total number of grains per panicle and number of filled grains per panicle were recorded with hybrid Tej under SRI establishment method. Though all the hybrids in SRI recorded at par yields, the hybrid Tej recorded the higher grain yield. The lowest grain yield was noticed in Raja laxshmi in case of traditional method of transplanting. The hybrids viz. Tej, NK6302, Raja laxshmi and Ajoy obtained 11.2%, 11.0%, 11.3% and 11.2% yield advantage in SRI establishment method over traditional method of transplanting.

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Efficacy of seaweed (*Kappaphycus alvarezii*) extract on productivity of wheat

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Productivity of wheat in Indian situation reach to its plateau ,in this situation use of seaweed sap is an alternative way to boost up the productivity as it is rich in macro and micronutrients beside containing high level of organic matter, vitamins, fatty acids, and growth regulators (Crouch and Van Staden, 1993), which promotes yield attributes and increased yield. Unlike, chemical fertilizer, seaweed extracts are biodegradable, non polluting, non toxic and non hazardous to humans, animals and birds.

METHODOLOGY

The present investigation was undertaken at Birsa Agricultural University, farm, Kanke, Ranchi, Jharkhand, India, during *Rabi* season of 2013-15on sandy-loam soil , moderately acidic in nature (pH 5.5), having low organic carbon (30 g/kg), low in available nitrogen (175.6 kg/ha), high in available phosphorus (26.8 kg/ha) and medium in exchangeable potassium (171.3 kg/ha), to find out the "Efficacy of seaweed (*Kappaphycus alvarezii*) extract on productivity of wheat". The experiment was laid out in a randomized block design (RBD) with 12 treatments, replicated thrice. Treatment consists of 6 concentration of seaweed *Kappaphycus alvarezii* extract. (0.0, 2.5, 5.0, 7.5, 10.0 and 15.0% in combination with 50 and 100% recommended dose of fertilizer (120:60:40 kg N: P2O5:K2O/ha). Seaweed sap was sprayed on the foliage of wheat as per treatment, thrice at 25 (CRI), 45 (maximum tillering) and 65 DAS (boot stage). Crop was fertilized as per treatment through urea, di-ammonium phosphate (DAP) and muriate of potash (MOP). Half of nitrogen, full dose of phosphorus and potassium was applied as basal and rest of nitrogen was top dressed equally in two splits at crown root initiation and maximum tillering stage.

RESULTS

Crop fertilized with 100% RDF produced 24.6, 18.4 and 6.79 % more effective tillers (351.1), grains/spike (35.9) and 1000 grain weight (44g),respectively, over 50% RDF, and consequently, produced 25.75 % higher grain yield (4.15 /ha) over 50%RDF. Application of seaweed extract significantly increased the yield and yield contributing character of wheat with increasing sap concentration up to 7.5% K sap, thereafter it gradually decreased. Crop sprayed with 7.5% K sap produced significantly 22.34, 20.86 and 8.57% higher no. of spikes/m^2 (352.1),grains/spike (36.5) and 1000 grain weight (44.3g) respectively, over control producing 17.68 %. Higher grain yield (4.06 t/ha). Interaction of seaweed sap and chemical fertilizer was not significant. However, comparison of simple treatment effect reveals that 7.5% K sap at 100%RDF produced significantly higher spikes/m^2 (388.5), grains/spike (39.8), 1000 grain wt.(45.8 g) and grain yield (4.54 t/ha) than all other combination of sap concentration and fertilizer level. However, similar spikes/m^2 (315.7), grains/spike (33.3), 1000 grain weight (42.8g) and grain yield (3.62 t/ha) with application of 7.5% seaweed sap, at 50%RDF,with that of control (water spray) at 100%RDF, indicating that 50% fertilizer requirement of wheat can be substitute by spraying of 7.5% sea weed extract.

CONCLUSION

Spraying of 7.5% Seaweed extract (*Kappaphycus alvarezii*) is an eco-friendly approaches for increasing wheat productivity. It can also replace 50% fertilizer requirement of wheat.

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Enhancement of betelvine production through integrated crop management practices

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Betel vine (*Piper betle* L.) crop occupied an area about 4000 ha in Bihar which covered 23 districts. The major betel vine growing districts of Bihar are Bhagalpur, Purnea, Samstipur, Vaishali, East Champaran, Darbhanga and Madhubani. These districts contribute 60% of total acreage of the state (Kumar and Pandey, 2014). Magahi pan is a high quality paan which is grown only in Central Bihar (Nalanda, Nawada, Gaya and Aurangabad districts) and earns better market price than other pan. Biotic stresses likes pests and diseases; and others abiotic factors i.e. unfavourable rainfall, wind speed and temperature causes greater losses to betel growers in the state. The betelvine crop is attacked by a number of fungal and bacterial pathogens. Thus, betel vine cultivation is an extremely delicate job, requiring an intimate knowledge with respect to temperature humidity, shade support and its nutritional requirements. Being a commercial crop, the betel vine crop must preferably be grown with organic sources of nutrient, which are easily available at domestic level. Production of healthy, broad, succulent, tasty with good shelf life of leaves might be possible due to adoption of ICM package in betel vine cultivation (Das and Mohan, 2011). Fresh leaves of betel vine are recognized as green ATM for the growers yet it is neglected due to lack of improved technology transfer in farmer fields (Das *et al*., 2014). Therefore integrated crop management practices of betel vine were tested at farmer's fields for dissemination of technology and enhancement of betel leaf production.

METHODOLOGY

The demonstration trial of ICM practices on Magahi pan cultivation were conducted under AICRP on MAP &Betel vine in 15 farmer's field at 10 villages (Location) of four districts (Nalanda, Nawada, Gaya, and Aurangabad) in Bihar during 2013-14 as per the following details (Table 1).

RESULTS

The comparative study of crop performance under ICM and farmers practice (Table 2) revealed that the ICM practices resulted better yield performances (36.6 to 49.2 lakh marketable leaves/ha) at all the locations than farmer's fields (30.5 to 41.0 lakh marketable leaves/ha). The crop under ICM practices have low incidence of foot–rot (4.0-16.0%) as comparison to farmers practices (14.0 to 45.0%). Similarly ICM practices produces better leaves quality with highest fresh weight of 100 leaves ranged from118.8-143.0 g whereas, farmer's practices recorded lower fresh weight of 100 leaves (112.0 to 137.8 g). Thus, betel growers can increase their marketable leaves per hectare and fresh weight of 100 leaves with lower incidences of diseases like foot-rot by adopting ICM practices and gets higher market price.

CONCLUSION

Overall, it was observed from the demonstration trial that ICM practices proved to be an effective and viable technology for enhancement of betelvine production though increase of

Table 1. Technology used under the farmers and ICM practices for betel vine cultivation

Technology Followed	Farmers Practices	ICM Practices
Variety	Magahi pan	Magahi pan
Seed Treatment	Nil	*TrichodermaViridi*
Plant Population	1.25Lakh vines/ha	1.5 Lakh vines/ha
Fertilizer	Imbalanced use of chemical fertilizer	Organic as Vermicompost@ 10 t/ha
Biofertliser	Nil	Azatobactor or Phosphobactor @10 kg/ha
Integrated Disease management	Chemical Control	Sanitation & soil drenching with 1% BM at pre-monsoon & 60 DAP+ *Trichodermaviridi*at 30 DAP
Growth Promoter	Mustard Cake	Mustard Cake

Table 2. Comparative performance of ICM over farmers practices for Magahi pan cultivation

S. No.	Location (Village)	District	Marketable Leaves (Lakh/ha)		Fresh Weight of100 leaves (g)		Foot-rot incidence(%)	
			Farmer Practice	ICM	Farmer Practice	ICM	Farmer Practice	ICM
1.	Arjun–Sarathua	Nalanda	38.5	46.2	128.5	134.4	19.0	7.0
2.	Bauridih	Nalanda	32.0	38.4	119.4	125.8	14.0	4.0
3.	Baurisarai	Nalanda	35.5	42.6	130.8	134.4	24.0	10.0
4.	Duhai-suhai	Nalanda	31.7	38.1	119.2	129.2	20.0	8.0
5.	Duhai-suhai	Nalanda	34.7	41.7	113.6	118.8	15.0	6.0
6.	Duhai-suhai	Nalanda	33.5	40.2	121.5	128.2	26.0	11.0
7.	Dola	Nawada	41.0	49.2	137.8	143.0	20.0	10.0
8.	Debri	Nawada	32.7	39.3	126.3	132.4	25.0	9.0
9.	Debri	Nawada	34.2	41.10	115.0	122.8	30.0	12.0
10.	Harsinghra	Gaya	34.1	40.8	119.5	125.2	26.0	9.0
11.	Harsinghra	Gaya	36.0	43.2	117.3	123.0	19.0	8.0
12.	Harsinghra	Gaya	31.0	37.2	119.4	125.0	29.0	13.0
13.	Aerora	Aurangabad	32.0	38.4	123.1	129.2	45.0	16.0
14.	Batthubigha	Aurangabad	33.5	40.2	112.0	122.0	33.0	14.0
15.	Jodhpur	Aurangabad	30.5	36.6	119.0	125.0	40.0	15.0

marketable betel leaves/ha and fresh weight of hundred leaves with lower incidence of phytophthora foot rot.

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Effect of date of planting on performance of potato variety kufri surya

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Potato is the third most important food crop globally after rice and wheat in terms of human consumption and has high a high nutritional value (CIP, 2013). Predicted fluctuations in weather during the next 50 years include frequent extreme temperatures in a number of important crop production regions (Jaggard *et al*., 2010). Potato has been thermo-sensitive and was productive only under long day conditions in temperate climate. But development of heat tolerant cultivars and adjustment in production system management has made it possible to have very high productivity in subtropical and warmer climate. Temperature controls the plant growth, development and yield. To address the adverse impacts of climate change on productivity and quality of crops we need to develop sound adaptation strategies and altering the date of planting is one of these. Hence, experiment was conducted to assess the effect of date of planting on potato productivity.

METHODOLOGY

A field experiment was conducted to study adaptation of potato to climate aberrations at ICAR-Central Potato Re-

Table 1. Yield attributes and yield of potato as influenced by planting windows (mean data for three years).

Planting windows	Number of tubers ('000/ha)				Yield of tubers (t/ha)				NUE (kg tuber/ kg N)	WUE (kg tuber/mm water)
	Small (< 25 g)	Medium (25-75 g)	Large (>75g)	Total (all size)	Small size tubers	Medium size tubers	large size tubers	Total		
15th September	71	81	139	291	1.0	5.0	19.0	25.0	139	62
30th September	134	125	152	397	1.8	7.6	18.0	27.4	152	69
15th October	129	116	183	391	1.5	7.1	24.3	32.9	183	82
30th October	189	149	188	459	3.1	10.6	18.9	32.6	188	85
MSE±	25	10	6.1	25	0.3	0.8	1.7	2.0	6.1	8.2
CD (P=0.05)	61	25	15	61	0.8	1.9	4.2	4.9	15	20

search Station, Gwalior, India which is located in Central Plains at 26^{0}N and 78^{0}E and 207 m above mean sea level. Heat tolerant potato cultivar Kufri Surya was planted with four planting windows (planting dates) *viz.*15th September, 30th September, 15th October and 30th October for three consecutive years during 2009-10, 2010-11 and 2011-12, replicated four times. The soil of the experimental site was silty clay loam, low in organic carbon (0.33%), available N (149) and P (9.97) and medium in available K (280 kg/ha) with pH of 6.7 The quantification of irrigation water applied was done using depth –interval method. All the standard cultural and plant protection practices were followed as per recommended schedules to raise a stress free crop. Destructive plant sampling and computations of total fresh weights were done at 10 days interval starting from 25 DAP to 90 DAP. At each sampling fresh weight of leaves, stems and easily recoverable roots were recorded from 5 plants per plot. Dehaulming was done manually at 90 days after planting (DAP) as per treatments and harvesting was done two weeks later after skin suberization.

RESULTS

The total as well as graded tuber numbers were highest with 30th October planting date. The number of small and medium size tubers recorded with 30th October planted crop was significantly higher over 15th September planted crop but on par with other planting windows. Number of large size tubers (157,000/ha) recorded with 15th October planted crop was statistically at par with 30th October planted crop only. Lower number of tubers in 15th and 30th September planted crop could be due to high temperature stress to potato crop which resulted in decreased tuberization and tuber production. High temperature results in reduction of tuber yield or even failure of tuberization. Highest yield of small and medium size tubers was recorded with 30th October planting window which was significantly higher over other planting windows. Highest production of large size tubers (24.3 t/ha) was recorded with 15th October window which was significantly higher over all other windows. The total tuber yield (32.9 t/ha) was highest with 15th October planted crop, significantly higher over 15th September and 30th September but statistically on par with 30th October planting window. Comparatively higher N uptake (167 kg/ha) was recorded with 30thOctober planted crop which was significantly higher over all other planting windows. Higher uptake of N was attributed to favourable climatic condition resulting in higher tuber yield. Highest N use efficiency (188 kg tuber/kg N applied) was recorded with 30th October planted crop which was higher than all other planting windows. Similarly higher P uptake (17 kg/ha) was recorded with 30th October planted crop which was significantly higher over all other planting windows except 15th October planted crop. K uptake (134 kg/ha) was highest with 30th October planted crop which was significantly higher over all other planting windows. Results are in conformity with Singh *et al.* (2012). Highest water use efficiency (85 kg tuber/mm of applied water) was recorded with 30th October planted crop which was higher than all other planting windows. A considerable increase in water application without significant increase in yield is known to reduce the water use efficiency (Singh and Lal, 2013).

CONCLUSION

Early planting at higher temperature delayed tuberization, reduced tuber number (2,91,000/ha) and finally there was drastic reduction in tuber yields (25.0 t/ha).Thus, 30th October planting window was found to be most suitable date for planting for ware crop of heat tolerant potato in the region.

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Intercropping of groundnut with minor millets on alfisols of Northern transition zone of Karnataka

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The field experiment was conducted at Saidapur farm, main Agriculture Research Station, Dharwad of *Alfisols* during *kharif* season of 2014 to study the effect of intercropping of groundnut with minor millets vic., foxtail millet, finger millet and little millet under different row proportions. Millets were intercropped with groundnut with groundnut at different row proportions (2:1 and 4:2) along with three sole treatments of millets and groundnut. Growth parameters of groundnut viz., leaf area, LAI, total dry matter production and yield attributing characters viz., number of pods/plant, pods weight/ plant and test weight were significantly higher in 4:2 row ratios of groundnut + millets intercropping systems compared to respective sole cropping. Sole groundnut recorded significantly higher pod yield (3047 kg/ha) and haulm yield (4147 kg/ha) over intercropping systems. Yield components such as number of tillers, grain weight/panicle, number of panicles and test weight were significantly higher in groundnut + millets intercropping treatments in 4:2 row ratios. Sole finger millet recorded significantly higher yield attributing characters, grain yield (2628 kg/ha) and haulm yield (3028 kg/ha) than other cropping systems. The highest Groundnut Pod Equivalent Yield (GPEY) Land Equivalent Ratio (LER) and Area Equivalent Ratio (ATER) were recorded with ground nut + finger millet (2916 kg/ha. 1.22 and 1.17 respectively) followed by foxtail millet (2792 kg/ha 1.21 and 1.13 respectively) in 4:2 row ratio. Gross and net returns were significantly higher with sole groundnut (Rs.1,26,857/ha and 83,778/ ha). However it is on par with 4:2 row ratios of groundnut + finger millet (Gross and net returns were Rs. 1,21,584/ha and Rs. 80,497/ha respectively) maximum benefit : cost ratio was realized with groundnut + finger millet in 4:2 row ratio (2.96) whereas, it was on par with sole groundnut (2.94).

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Effect of sulphydryl compounds on productivity and profitability of *summer* green gram (*Vigna radiata*) under moisture stress in north Gujarat conditions

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A field experiment was conducted at S.K. Nagar Dantiwada Agricultural University, Sardarkrushinagar during summer 2011 on loamy sand soil. Sixteen treatment combinations comprising of two moisture stress treatments viz., M_1- No moisture stress (irrigation at all growth stages) and M_2 – Moisture stress at vegetative stage (missing irrigation at vegetative stage) with eight treatments of SH-compounds viz., S_1 – control, S_2 – water spray, S_3 – Thiourea 250 ppm, S_4 - Thiourea 500 ppm, S_5 – Thiourea 750 ppm, S_6 – Thioglycolic acid 100 ppm, S_7 - Thioglycolic acid 200 ppm and S_8 - Thioglycolic acid 300 ppm were tested on summer green gram cv. GM 4. Both the SH compounds and water spray was performed twice i.e., at 25 and 45 DAS. Seed yield was not influenced but stover yield was significantly reduced due to imposing of moisture stress at vegetative stage (M_2). Crop without moisture stress (M_1) produced higher net return and cost benefit ratio (CBR). Use of Thiourea 500 ppm (S_4) increased seed and stover yield by 58 and 84% respectively over control (S_1). Net return and CBR was highest with Thiourea 500 ppm. Among the combinations use of thiourea @ 500 ppm without moisture stress (M_1S_4) earned maximum while moisture stress with control (M_2S_1) recorded the lowest net return and CBR. Foliar spray of thiourea@ 500 ppm twice at 25 and 45 DAS proved most effective to get higher yield and net return from summer greengram.

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Use of PGR's to minimize lodging and enhancing yield and quality of wheat

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In tall and semi-dwarf varieties it is primarily a problem of high productivity situations. Fields with productivity potential below 4 tons/ha lodge only under sever conditions while those above 5 tons/ha are at higher risk even under milder situations. The agronomists who recommended PGRs generally reported higher yields for wheat (4.0 t/ha) than those who did not recommend PGRs (3.1 t/ha) Berry *et al.,* 2000. Reduction in yield- depending on extent, type and time of lodging the yield losses may range from negligible to 75%. High yield losses are recorded when lodging occurs at ear emergence as also when there is stem breakage. The most widely evidenced mode of action in the scientific literature for PGRs is in the reduction of plant height when these are applied at early stem elongation in cereals (Berry *et al.,* 2004). Shorter plant height increases crop resistance to lodging and can improve harvest ability and possibly grain quality if lodging is associated with increased sprouting (Tripathi *et al.* 2004). Some improvement in yield has been reported in response to PGRs used on wheat (Berry and Spink, 2009). PGR's have been successfully used in Britain & France where average productivity is above 7 tones/ha. and are being considered in Australia for high productivity environments. Use of plant growth regulator (PGRs) appears to be a possible immediate option.

METHODOLOGY

A field experiment was conducted during rabi season 2014-15 at the experimental farm of Indian Agricultural Research Institute, New Delhi to study the minimize lodging by reducing plant height and enhancement of wheat productivity through foliar application of PGR. The soil of the experimental field was sandy loam having pH 7.86, EC 0.48 dS/m, organic carbon 0.55%, available Nitrogen 185 kg/ha, available phosphorus 26.1 kg/ha and available potassium 283 kg/ha. Wheat variety C 306, was grown in the second week of November. The treatment combinations involving viz. (i) T0-Control, T1-Lihosin @ 0.2% at GS 31, T2 = Kirpan @ 0.2% at GS 31, T3- Lihosin @0.2% + Folicur@0.1% at GS 31, T4-T1- Lihosin @ 0.2% at GS 31 + Kirpan @ 0.2% at GS 39, T5- Lihosin @ 0.2% +Folicur at GS 31 & GS 39. The stages for PGR application were GS 31 (Above ground appearance of 1st. Node) & GS 39 (Complete emergence of flag leaf) were evaluated in randomized block design with four replications. The recommended dose of inorganic fertilizers @ 60 kg N/ha+40 kg P_2O_5 was applied at the time of sowing.

RESULTS

Treatment differences were highly significant for plant height, yield and its components as also lodging score. The treatment lihocin with combination of folicur applied at vegetative stage reduced 26.67 percent plant height over control while these applied at two times (vegetative + flag leaf stage) with kirpan plant height reduced up to 45 percent in present investigation. Similarly combination of lihicin + folicur also reduced more than 50 percent second internode and peducle length. Yield and its components significantly increased over control with lohicin application. The studied showed variable responses but adverse effects were observed with the use of Kripon. The maximum seed yield (2.93 t/ha) and biological yield (7.74 t/ha) was recorded with Lihicin + Folicur sprayed at vegetative stage and flag leaf stage. The increase in grains and straw yield may be attributed mainly to grain number per spike, grain weight/spike and test weight which was highly

Table 1. Effect of plant growth regulators on growth, yield and lodging of wheat

Treatment	Plant height (cm)	Iind inter node length (cm)	Panicle length (cm)	Ear length (cm)	No of grains/ spike	Seed wt/ spike
Control	108.33	19.00	42.67	9.30	43.33	1.84
Lihocin GS 31	83.33	13.83	32.33	9.97	48.33	2.05
Kirpan GS 31	91.67	17.67	31.67	10.00	36.33	1.64
Lihocin+Folicur (GS31)	79.33	8.50	27.33	10.30	51.00	2.24
Lihocin+Kirpan (GS31+GS39)	85.00	12.33	23.83	9.57	43.00	1.85
Lihocin+Folicur+Kirpan (GS31+GS39)	59.33	7.33	20.00	9.60	40.67	1.49
CD (P=0.05)	10.11	1.70	1.95	0.63	3.36	0.17

Treatment	Yield/ plant	1000 seed wt	Seed yield (t/ha)	Biomass (t/ha)	HI (%)	Lodging %
Control	5.55	40.43	2.64	6.33	41.66	98.50
Lihocin GS 31	5.99	40.73	2.76	7.08	39.09	66.50
Kirpan GS 31	4.48	41.40	2.10	6.21	33.94	60.50
Lihocin+Folicur (GS31)	6.95	43.13	2.93	7.74	37.87	45.50
Lihocin+Kirpan (GS31+GS39)	5.76	33.20	2.32	7.28	31.97	25.55
Lihocin+Folicur+Kirpan (GS31+GS39)	5.05	33.40	2.17	5.87	36.94	10.56
CD (P=0.05)	1.26	3.13	0.31	0.454	4.60	-

favored under Lihocin + folicar spary at both the stages. PGR spray at two growth stages magnified the response and more effectively reduced lodging. Lihosen+Folicur sprayed at vegetative stage and flag leaf stage performed best in reducing incidence of lodging.

CONCLUSION

On the basis of our investigation it could be concluded that PGR spray at two growth stages magnified the response and more effectively reduced lodging. Lihosen+Folicur sprayed at vegetative stage and flag leaf stage performed best in reducing incidence of lodging and enhanced the yield and quality of wheat seed.

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System of root intensification (SRI) in oilseed *Brassica*

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India being the third largest cultivator and producer of rapeseed- mustard after Canada and China (DRMR, 2014) accounts for about 19.3% and 11.1% rapeseed – mustard area and production (2013-14) in world, respectively. In most cropping system, due to late harvest of *kharif* crops the sowing of rapeseed- mustard gets delay which hamper the yield significantly due to reduction in its vegetative and reproductive phases. Moreover, the productivity of the *Brassica* cultivars have almost been stagnant under conventional planting system, which could be made agile by adopting suitable agronomic practices and genotypes. Transplanting of *Brassica* seedlings under optimum spacing could be one of such agronomic practice in irrigated condition of India.

METHODOLOGY

A field experiment was conducted during *rabi* season of 2014-15 at N. E. Borlaug Crop Research Centre of GBPUA & Technology, Pantnagar. The experimental site had silty clay loam soil with pH 7.2, organic carbon 0.81% and 261, 21.3 and 231 kg/ha of N, P_2O_5 and K_2O, respectively. The experiment was laid out in Split Plot Design with three replications taking four planting geometry (90 cm × 60 cm, 75 cm × 75 cm and 60 cm × 60 cm for transplanting and the conventional sowing) as main plot treatments and three genotypes {*Brassica juncea* cv. 'Kranti', *Brassica carinata* cv. 'RP-09' and *Brassica rapa* ssp. yellow *sarson* cv. 'Pant Shweta') as sub-plot treatment. Seedlings were raised in polythene bags and transplanted at 15 days stage. The experimental plot was fertilized uniformly with 120:40:20 kg/ha of N, P and K, respectively. The seedlings were transplanted manually at the desired spacing after the basal application of fertilizers.

RESULTS

The root density, yield attributes and seed yield were significantly influenced by the planting geometry and the *Brassica* genotypes (Table 1). Root density was found significantly more in transplanted crop over the conventionally sown crop. Transplanting at 60 × 60 cm resulted in maximum root density however it remained on a par with the other transplanting geometries. Among the different genotypes, *Brassica carinata* "RP-09' resulted in more root density which remained significantly superior over *B. juncea* 'Kranti' and *B. rapa* 'Pant Shweta'. Yield attributing characters viz. branches and siliquae/plant; and 1,000- seed weight were observed more under transplanted crop. Significantly higher numberof branches/plant and thus siliquae/plant were observed in transplanted crop over the conventionally sown crop. Among the different genotypes, 'RP 09' (*Brassica carinata*) produced more number of branches and siliquae /plant remaining statistically superior over the other two genotypes. Weight of 1,000 seeds did not differ significantly in terms of planting geometries but was significantly influenced by different genotypes. 'RP-09' produced more weight of 1,000 seeds and was statistically superior over the other two. Transplanting of *Brassica* species with 60 cm × 60 cm spacing yielded the maximum being significantly superior over the other planting geom-

Table 1. Effect of planting geometry and genotypes on root density, yield attributes and yield of oilseed *Brassica*

Treatment	Root density (kg/m^3)	Branches/ plant	Siliquae/ plant	1000-seed weight (g)	Seed yield (kg/ha)
Planting geometry					
90 cm x 60 cm Transplanting	1.99	209	1493	4.09	1,612
60 cm x 60 cm Transplanting	2.11	210	1491	4.08	2,419
75 cm x 75 cm Transplanting	2.05	207	1500	4.10	1,595
Conventional	0.65	32	291	3.96	1,183
SEm±	0.04	2.5	26	0.04	37
CD (P = 0.05)	0.15	8.7	91	NS	125
Genotype					
B. juncea 'Kranti'	1.83	123	1344	4.00	1,652
B. carinata 'RP-09'	2.53	334	1910	4.25	2,247
B. rapa 'Pant Shweta'	0.66	35	326	3.92	1,207
SEm±	0.02	2	21	0.02	32
CD (P = 0.05)	0.07	6	65	0.06	96

Table 2. Interaction effect of planting geometry and genotypes on seed yield of oilseed *Brassica*

Parameter Planting geometry Genotypes	Seed yield (kg/ha)		
	B. juncea 'Kranti'	*B. carinata* 'RP-09'	*B. rapa* 'Pant Shweta'
90 cm × 60 cm Transplanting	1,505	2,284	1,046
60 cm × 60 cm Transplanting	2,310	3,128	1,820
75 cm × 75 cm Transplanting	1,522	2,240	1,023
Conventional	1,273	1,334	941
To compare two levels of genotypes at same level of planting geometry	193		
To compare two levels of planting geometry at same or different levels of genotypes	201		

etries. *Brassica carinata* out yielded the other two species being significantly superior in terms of seed yield. Interaction between planting geometry and genotypes on seed yield was found to be significant (Table 2). Transplanting of *Brassica carinata* 'RP-09' at 60 cm × 60 cm stood out to be significantly superior among all the combinations of Brassica species and planting geometries producing the maximum seed yield.

CONCLUSION

Thus it could be concluded that the transplanting of *Brassica carinata* (RP-09) at 60 × 60 cm spacing could be beneficial in the *tarai* region of Uttarakhand.

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Best management practices for maintaining soil health and sustainable production in inceptisols with rice-rice cropping system

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Rice is one of the most important staple foods for most of the south Asian population and rice-rice cropping system is one of the major cropping systems particularly in the irrigated areas of eastern India. Productivity of the rice-rice cropping system is low and it continues to decline because continuous submergence changes in soil environment and subsequent deterioration of soil health. Therefore, it is needed to find out the best management practices for maintaining soil health and sustainable production. This study was undertaken using a 23-year-old long-term fertility experiment in Inceptisols with rice-rice cropping system with the objective to find out the effects of use of NPK and their different combinations with and without organics on the productivity of continuous rice-rice system in relation to the changes in fertility status of the soil.

METHODOLOGY

The management practices included in this study were control, 100% recommended dose (RD) of NPK, 75% RD of N and 100% PK + 25 % N through FYM, 75% RD of N and 100% PK + 25% N through crop stubble, 75 % RD of N and 100 % PK + 25 % N through Azolla and a fallow, where no cultivation was done since the initiation of the experiment. Soil samples were collected after the harvest of *kharif* rice and a part of sample was stored in refrigerator at 4^{o}C at field moisture for analysis of biological and biochemical parameters. Soil health was assessed analyzing a large number of physical (soil texture, bulk density, hydraulic conductivity, aggregate stability and structural indices), chemical (soil pH, cation exchange capacity, pools of organic C, available N, P, K, S, Fe, Mn, Zn, Cu and B, exchangable Ca and Mg, total organic C and N) and biological (mineralizable C and N, microbial biomass C and N, dehydrogenase, fluorescein diacetate, â-glucosidase, urease, acid and alkaline phosphatase and aryl sulphatase activity, population of fungi, total bacteria, actinomycetes, non-symbiotic N-fixing, phosphate solubilizing and cellulolytic bacteria) attributes of soil following standard protocol. The data of soil analysis was analysed statistically by folling Duncan's multiple range test (DMRT) (Gomez and Gomez, 1984) and software namely SPSS (17.0). Soil health index was calculated using all the above-mentioned soil attributes following Andrews *et al*. (2001) method.

RESULTS

Results showed that among the treatments, soils with NPK+FYM had highest values of available N , P and K, cation exchange capacity (CEC) and microbial biomass C (MBC) followed by NPK+crop stubble and NPK+azolla treatment. Principal component analysis (PCA) showed that microbial biomass C, cation exchange capacity and available

Table 1. Effect of best management practices on soil health

Treatment	Available N kg/ha	Available P kg/ha	Available K kg/ha	CEC C mol (p+)/kg	MBC (µg TPF/g soil/24h)	Yield t/ha
Fallow	115.4^{bc}	10.5^{c}	55.2^{c}	6.4^{bc}	430.4^{e}	-
Control	109.6^{c}	7.7^{d}	45.4^{c}	5.4^{c}	409.5^{f}	2.91^{d}
NPK	122.5^{a}	13.3^{b}	61.8^{b}	5.9^{c}	572.2^{d}	5.10^{c}
NPK+FYM	140.7^{a}	16.9^{a}	69.8^{ab}	8.3^{a}	691.8^{a}	5.50^{a}
NPK+crop stubble	137.2^{b}	16.3^{a}	67.5^{bc}	7.3^{bc}	628.5^{b}	5.49^{a}
NPK+azolla	127.8^{b}	14.3^{b}	64.3^{bc}	7.8^{ab}	601.6^{c}	5.29^{b}

P were selected as the key soil health indicators. Microbial biomass usually makes up less than 5% of soil organic matter (Dalal, 2000); it is both a source and sink for nutrients and participates in the C, N, P and S transformations. Soil test for cation exchange capacity (CEC) can be used as an indication of the potential pattern of crop response to fertilizer application and soil management practices. As soil was acidic availability of P was reduced by the fixation of P by Fe and Al. Thus the key indicators have a considerable role to play in influencing various soil functions and in turn the functional goals of the experimental soils.

The soil health index varied from a lowest of 0.57 in control to a highest of 0.94 in NPK +FYM treatment. The soil health index values under different treatments were as follows: NPK+FYM > NPK+crop stubble > NPK+azolla > NPK > fallow > control.

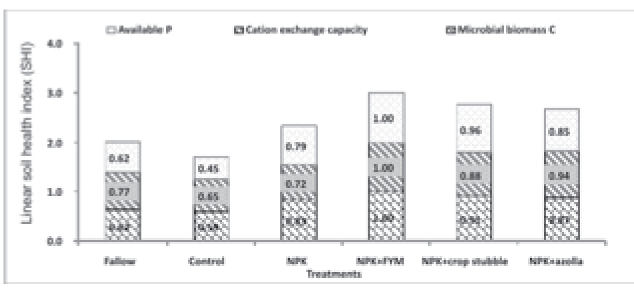

Fig. 1. Soil Health Index under different treatments

CONCLUSION

Among the different combination of organics compared, NPK+FYM maintained better soil as well as highest soil health index value than NPK+crop stubble and NPK+azolla. Integrated use of inorganic fertilizer and organics was thus necessary for maintaining better soil health as well as sustainable crop production.

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Fungal inoculant for improving phosphorus availability of mustard soil

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Low availability of phosphorus (P) in most of the Indian soil is a matter of great concern due to its adverse effect on crop productivity. Increasing the P availability is of utmost importance if we want to provide food security to the projected population during the next century. The primary approach to enhance the cited nutrient availability should focus on scavenging the native or fixed P using natural resources. Microorganisms play a fundamental role in releasing inorganic P (Pi) from native P sources present in soil or added exogenously. The phosphorus dissolving fungi have the higher potential to mediate the process at a relatively low cost. Due to their non specificity for plant and soil association, members of genera *Aspergillus* and *Penicillium* can be exploited as inoculants for a range of plant production systems. The soil P contains different P fractions and that may change with crop management practices. Accurately characterizing P forms is important for evaluation of its availability status in soil. Fractionation of soil P is also important to overcome the limited information that total P analysis provides. With this background we studied the interactive effects of co-application of P fertilizer and seed inoculation with different rates of *Penicillium* sp. on changes in soil inorganic P fractions under mustard crop.

METHODOLOGY

The experiment was conducted during winter season of 2014-15 at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi, India situated at an latitude of 28°40' N and longitude of 77°12' E, altitude of 228.6 meters above mean sea level. The soil of experimental field had available N-140 kg/ha, available P-15.64 kg/ha, available K-283 kg/ha, organic carbon -0.56 % and pH -8.0.Mustard crop was grown on 10 sub-plot of 12 m^2each with three replicates, following randomized block design. The two rates of chemical P fertilizer included 100 % P (recommended dose of chemical P) and 50 % P (½ the recommended dose of chemical P). The un-inoculated control treatments included the application of recommended doseof chemical fertilizers ($N_{120}P_{60}K_{60}$) and ½ the recommended dose of P ($N_{120}P_{30}K_{60}$).Urea, single super phosphate and muriate of potash were applied at 120 kg N, 60 kg and 30 kg P_2O_5, and 60Kg K_2O /ha, respectively to meet the N, 100 % P and 50 % P and K needs of the test crops. The chemical fertilizers were evenly spread on the soil surface of each plot on the date of sowing. Mustard (var. Pusa M-30, seed rate- 4 kg /ha) seeds were treated with three rates of *P. billai* based fungal formulation. The soil samples were drawn at different stages of crop growth and analyzed for phosphorus fractions by the method of Hedley et al. (1982).

RESULTS

Analysis of soil at 60 d of crop growth revealed that un-inoculated treatment recorded the highest availability of water soluble P compared to fungal inoculated treatments. This indicated that a part of the easily available water soluble P must have been assimilated by fungal population for their cell growth. The lowest content of water soluble P in treatment receiving recommended dose of chemical P (100 % P) showed that higher the amount of soluble form of P added through chemical P fertilizer, more is its chemical fixation in soil. At 120 d mustard crop growth, availability of water soluble P remained at its peak values in un-inoculated treatments receiving 50% and 100% chemical P. At 60 d sampling, most available fraction of sodium bicarbonate (SB)-P was recorded in soil with 100 % P. However, at harvest the values were almost doubled in 50 % chemical P+ highest dose of fungal formulation and 100% chemical P+ highest dose of fungal formulation. Fungal formulation applied @ 10.604 g / kg seed + 100 % P /ha recorded 183.47mg P /kg soil, compared to 140.66 mg P /kg soil in its un-inoculated counterpart, thereby registering an increase of 30.43 % due to inoculation. Application of 100 % chemical P resulted in less availability of SB-P compared to ½ the recommended dose of chemical P emphasizing the role of phosphate dissolving inoculants in improving the availability of chemically fixed soil P. The decline in P with crop growth reflected the P removal by plants. More sodium hydroxide (SH)-P was extractable in treatments receiving 50 % recommended dose of P + fungal based product @5.302 g /kg seed. No effect of inoculation was observed for SH-P in treatments receiving 100% chemical P. The relationship between SH-P and pH showed that former was negatively related with pH of soil. The values for HCl-P ranged between 113 mg P /kg to 183.47 mg /kg, the lowest being in 5.302 g /kg seed +50 % chemical P and highest in un-inoculated control. The high values of HCl-P indicated the presence of Ca-containing minerals.

CONCLUSION

By separating soil P into different fractions characterized by their mode of extraction, it was possible to identify the soil P fractions that get altered by crop management practices. Under mustard grown soil, the recommended dose of P and high rate of fungal inoculation could improve the P availability by >30 % over un-inoculated control.

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Maximizing productivity of mustard by managing sowing time and planting geometry

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Among the *Brassicas,* Indian mustard is the premier crop which is predominantly cultivated in states of Rajasthan, UP, Haryana, Madhya Pradesh and Gujarat. The crop can be raised well under both irrigated and rainfed conditions. Among the different agronomic practices optimum sowing time plays an important role to fully exploit the genetic potentiality of a variety as it provides optimum crop growing environment such as temperature, humidity, light etc. Delayed sowing would adversely influence the crop performance. It requires developing suitable agro-techniques to augment the productivity of the crop. The optimum plant population density/unit area varies with the environment, the genotype, the seeding time and the season. Uniform distribution of crop plants over an area results in efficient use of nutrients, moisture and suppression of weeds leading to high yield. Keeping in view the inter-plant competition for optimum plant nutrients, sun light, moisture and aeration, the present study was planned to find out the optimum sowing time and planting geometry to achieve maximum yield from the latest released mustard variety (Giriraj) of zone-II comprising the states Haryana, Punjab, Delhi and parts of Rajasthan.

METHODOLOGY

An experiment was conducted during 2014-15 and 2015-16 to find out the optimum sowing time and planting geometry for latest released variety (Giriraj) at Research Farm of Oilseeds Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar (29°10'N; 75° 46' E) on a sandy loam soil. The experiment was conducted in split plot design with three sowing times (*viz*. mid-October, end October and early November) in main plot and 5 planting geometries (*viz*. 30x10 cm, 30x20 cm, 30x30 cm, 45x15 cm & 45x30 cm) in sub plots with three replications. The crop was sown with hand plough at a row to row spacing of 45 cm and 30 cm as per treatments on October 18 & 15, October 26 & 29 and November 5 & 7 during 2014 and 2015, respectively. Thinning was done after three weeks of sowing to maintain crop geometry of 30x10, 30x20, 30x30, 45x15 & 45x30 cm as per the treatments. Full dose of phosphorus was applied at sowing and nitrogen was applied in two splits i.e., half as basal dose and half at flowering. The crop received only one post-sown irrigation at flowering stage. All the other recommended package of practices was followed for raising the crop.

RESULTS

Maximum average seed yield (2202 kg/ha) was recorded when mustard variety was sown during mid-October, elucidating 8.6 and 30.1 % yield superiority over end-October and early November, respectively. The favourable weather conditions prevailed in early sown crop might be the possible reason for better vegetative infrastructure development resulting in significantly higher seed yield. Rushima *et al*. (2014) also reported reduction in seed yield of mustard with delayed sowing. Regarding the planting geometry, it was observed that maximum seed yield (2150 kg/ha) was recorded with crop sown at 30 cm x 20 cm, which was at par with spacing of 45 x 15 cm (2080 kg/ha). Mustard sown at other spacing produced significantly lower yield than that sown at a spacing of 30x20 or 45x15 cm. Kumar *et al*. (2004) also observed difference in seed yield with change in crop geometry and the crop geometry of 45 cm x 10 cm was found optimum. Interaction effect between sowing date and planting geometry was found

Table 1. Effect of sowing time and plant geometry on seed yield, oil content and oil yield of mustard variety Giriraj (Mean of 2014-15 and 2015-16)

Treatment	Seed yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)
Sowing date			
Mid October	2202	39.41	867
End October	2027	37.96	768
Early November	1693	37.74	639
CD (P=0.05)	102	0.44	41
Planting geometry			
30x15 cm	1870	38.41	719
30x20 cm	2150	38.31	824
30x30 cm	1911	38.34	733
45x15 cm	2080	38.33	799
45x30 cm	1858	38.47	716
CD (P=0.05)	126	NS	52

to be non-significant. Oil content decreased when crop was sown on end-October or early-November as compared to its sowing on mid-October, whereas, it was not influenced by planting geometry. Similar reduction in oil content with delayed sowing was also reported by Kumar *et al*. (2004). As oil yield is a product of seed yield and oil content, similar trend was observed in case of oil yield as that of seed yield.

CONCLUSION

The mustard variety Giriraj gave maximum seed and oil yield when sown in mid-October and at plating geometry of 30 x 20 cm or 45 x 15 cm.

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Intercropping of pulses in coconut for nutritional security and sustainability under island ecosystem

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Farming in Andaman and Nicobar islands (ANI) is spread on about 45, 000 ha, which is dominated by plantation crops of coconut (21,768 ha) and arecanut. Studies have indicated that in coconut plantation about 20 per cent of the soil and light are utilized. Thus, the inter spaces of coconut forms excellent avenues for intercropping especially pulses, as they enrich soil through N fixation. The pulse production of the islands (1155 tonnes) is far behind the requirement (6200 t/year). Hence to fill this huge demand and supply gap of pulses, intercropping in coconut was contemplated. The information on performance of pulses as intercrops of coconut plantation is lacking, hence the study was under taken.

METHODOLOGY

Field studies were conducted for two years (2013-15) at Sipighat farm, CIARI, Port Blair. The experimental soil was sandy loam with pH 5.2, organic carbon 0.6 %, E.C 0.3 dS/m, available N (205 kg/ ha), P (4.5 kg/ha) and K (95 kg/ha) at the start of the experiment in August, 2013. Rainfall (mm) received during red gram growth period was 1009 and 1316 mm and green/ black gram growth period was 260 and 386 mm in 2013-14 and 2014-15. Thus, the crops faced moisture stress in 2013-14. The treatments comprise of three pulse crops viz., red gram, green gram and black gram and their varieties (4 in red gram: Table 1; 6 each in green gram: Table. 2; and black gram: Table 3.) were tested in RBD with 4 (5 for red gram) replications. Red gram, black gram and green gram were sown in August and November, respectively and harvested February. The cost of cultivation was Rs.12,500 and 9,200/ha for red gram and green/black gram. The experiment was conducted on 36 years old coconut (Andaman tall) plantation in hilly slopes.

RESULTS

Under coconut, pulse crops registered about 60 % yield as compared to their open cultivation. The results indicated that red gram (Table 1), green gram (Table 2) and black gram (Table 3) recorded a mean seed yield of 503 and 606, 347 and 472 and 312 and 468 kg/ha, respectively in 2013 and 2014. Among the red gram varieties, ANP-12-2 recorded significantly higher seed yield in 2014, however, during 2013-14, it has at par yield as that of Co-6. In green gram, ANM-11-12 showed significantly superior performance in 2014-15, but it has at par yields as that of VBN-3 and ANM-11-08 in 2013-14. Among black gram varieties, ANU-11-19 recorded higher seed yield in 2014-15 but at par with VBN 6 and Uttara in 2013-14. The higher seed yield of pulses has resulted in higher net return (Table 1-3). All pulse crops besides their seed production, produced stover (excluding 4 t sticks, can be a fuel wood source) of 1.5 t in red gram and 2.7 t/ha in black

Table 1. Yield and economics of red gram under coconut plantation

Variety	Seed yield (kg/ha)		Mean stover yield (kg/ha)	Mean net return (Rs./ha)
	2013-14	2014-15		
Co 6	544	635	1540	14765
Bahar	479	582	1452	12036
ANP-11-21	459	515	1305	10024
ANP-12-02	528	691	1720	15710
Mean	503	606	1504	13146
SEm	5.24	5.18	-	-
CD (P=0.05)	60	58	-	-

Table 2. Yield and economics of green gram varieties under coconut plantation.

Variety	Seed yield (kg/ha)		Mean stover yield (kg/ha)	Mean net return (Rs/ha)
	2013-14	2014-15		
Samrat	315	412	2698	8380
HUM-16	332	431	2591	9253
ML-11-65	311	355	2675	6901
VBN-3	370	477	2794	11290
ANM-11-08	354	516	3081	11848
ANM-11-12	400	638	3109	15922
Mean	347	472	2725	10611
SEm	5.24	6.16	-	-
CD (P=0.05)	58.6	80.8	-	-

Table 3. Yield and economics of black gram varieties under coconut plantation

Variety	Seed yield (kg/ha)		Mean stover yield (kg/ha)	Mean net return (Rs/ha)
	2013-14	2014-15		
VBN-6	330	476	2760	9439
Uttara	324	490	2540	9624
ANU-11-10	291	416	2480	7150
VBN-4	296	434	2843	7682
VGB-10-19	277	412	2915	6733
ANU-11-19	354	581	3150	12422
Mean	312	468	2781	8838
SEm	4.80	5.92	-	-
CD (P=0.05)	48	74	-	-

and green gram that can serve as potential fodder to livestock. The productivity of coconut indicated a slight improvement (2 nuts/tree) under intercropping of pulses as compared no inter crop (55 nuts/tree). The N content of the soil at the end of 2 years study showed a depletion under monocropped coconut and buildup when intercropped with pulses. The buildup of available N was highest with red gram (29 kg/ha), followed by green gram (13 kg/ha) and was least after urd bean (8 kg/ha).

CONCLUSION

It can be concluded from the two-year study that red gram "ANP-12-2", green gram "ANM-11-12" and black gram "ANU-11-19" can be grown as intercrops under coconut plantation for meeting the pulse demand while improving soil N status in the islands. The stover of pulse crops can also support the feed requirement of animals. Further, red gram sticks produced can be used as household fuel wood. It is contemplated to transfer this technology for at least 25% of the coconut area in the coming years through On Farm Research (OFR).

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Fodder based cropping system to address fodder shortage in rainfed areas

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India has the world's largest population of livestock, but the productivity of the livestock is very low compared to many other countries. One of the constraints limiting livestock productivity is the scarcity of fodder and feed. As of 2013, the country had a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients. The demand of green and dry fodder is projected to reach 1012 and 631 million tonnes by the year 2050. At the current level of growth in forage resources, there will be 18.4% deficit in green fodder and 13.2% deficit in dry fodder in the year 2050. To meet out the deficit, green forage supply has to grow at 1.69% annually (IGFRI, 2013).Past research focused mainly on including a fodder crops into the existing cropping systems in such a way as to minimize loss of food crop production. Focus has also been given to develop dual purpose crops.Studies on integration of fodder legumes and grasses with rainfed crops and the effect of such systems on system productivity, and soil properties are scarce.An attempt was made to include multi-cut legume and grass fodder crops as permanent strips in existing dryland cropping systems. The study was initiated in 2015-16 toevaluate fodder based cropping systems, determine physical, chemical and biological changes in soil, and determines the nutritive value of the fodder crops and to monitor diversity in insect pests in different systems.

METHODOLOGY

The study was taken up in Gunegal Research Farm (17°5'3"N 78°40'1"E)of CRIDA in the year 2015-16 with the following seven treatments i.e. sorghum: fodder clusterbean - fodder cowpea - fodder horsegram, sorghum + pigeonpea: hedge lucerne, sorghum + pigeonpea: guinea grass, castor: hedge lucerne, castor: guinea grass, sole pigeonpea, and sole sorghum.The experiment was laid out in a randomized block design (RBD), wit 3 replications. The crops and fodder species were grown with recommended package of practices. Annual fodders were cut at flowering stage and green fodder yields were recorded. Sorghum, pigeonpea and castor were harvested at maturity and sorghum grain and fodder yield, pigeonpea seed yield and castor seed

Table 1. Fodder yield, grain yield and economics of fodder-based cropping systems

Cropping system	Fodder Yield (kg/ha)	Grain yield	Fodder (₹/ha)	Grain (₹/ha)	Total (₹/ha)	System Total (Gross) (₹/ha)
Sorghum - F. Clusterbean-	7525	2649	15050	41589	56639	68976
F. Cowpea- F. Horsegram	8016		20040		20040	
	19666		49165		49165	
	1873		4682.5		4682	
	3713		7426		7426	
Sorghum + Pigeonpea -Hedge lucerne	4352	1709	8704	26831	35535	44925
		1141		52780	52781	
	613.3		1533		1533	
Sorghum + Pigeonpea -Guinea grass	4549	1368	9098	21478	30576	38163
		767		35651	35652	
	10100		10100		10100	
Castor- Hedge lucerne		927		29667	29667	15454
	497		1242		1242	
Castor- Guinea grass		845		27027	27027	17814
	8600		8600		8600	
Sole Pigeonpea		1426		65953	65953	32976
Sole Sorghum-R	7101	2957	14202	46425	60627	36003
	5690		11380		11380	

yield were recorded. In sole sorghum and sorghum: fodder clusterbean - fodder cowpea - fodder horsegram treatments, sorghum stumps were allowed to ratoon and green fodder yield of ratoon was recorded at flowering. A single cut was taken from hedge Lucerne and guinea grass at the age of 6 months and green. Hedge Lucerne, Guinea grass and sorghum fodder samples were subjected to proximate analysis using standard procedures.

RESULTS

Sorghum based cropping systems viz., Sorghum + Pigeonpea - Hedge lucerne and Sorghum + Pigeonpea - Guinea grass were significantly higher in fodder yield as compared to castor based system (Table 1). The possibility of raising 5 annual fodder yielding crops including sorghum ratoon in the same piece of land within a period of 6 months was attempted with some success in the Sorghum: Fodder clusterbean - Fodder cowpea - Fodder horsegram system. Fodder cowpea produced the highest yield in this system (₹19666 kg/ha) followed by fodder cluster bean (8016 kg/ha) and sorghum (₹7525 kg/ha) indicating the feasibility of an intensive fodder production system in dryland areas. While comparing the annual and perennial fodder sorghum based systems, annual based fodder system recorded higher sorghum grain yield. Fodder yields from the perennial fodder species were low since the plants were still in establishment stage.

CONCLUSION

Inclusion of forage legumes or grasses in the existing cropping system can address the problem of fodder shortage in rainfed areas. They grow fast and cover the land surface quickly even under low rainfall situations and provide considerable amount of green fodder throughout the year.

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Effect of different sowing dates on growth and yield of chickpea under irrigated condition

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Chickpea is the dominant crop of *rabi* season grown on receding soil moisture largely in soybean based crop sequence could not seeded during first fortnight of October and also loose the getting advantage of stored soil moisture under rainfed cultivation resulting in failure to keep the optimal initial plant stand. In addition to this sowing executed after first fortnight of October requires pre-sowing irrigation for maintaining optimal initial plant stand. Therefore, sowing time plays an important role in optimal utilization of residual soil profile moisture. Keeping this in view, an investigation was undertaken to study the response of different dates of sowing in relation to different chickpea cultivars so as to provide wider sowing window to the farmer.

METHODOLOGY

A field experiment was conducted at Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (22^0 42' N latitude, 72^0 02' E longitude and at an altitude of 307.42 m above MSL) in Vidarbha region of Maharashtra during *rabi* seasons of 2011-12 to 2013-14, in factorial randomized block design with 10 treatments comprising of 5 date of sowing *viz.*, 30 October (44 MW) sowing was considered as normal growing condition, 15 November (46 MW) and 30 November (48 MW) and 15 December (50 MW) and 30 December (52 MW) and two cultivar *viz.*, Vijay and JAKI 9218, replicated three times. The soil of experimental field was Inceptisol, almost neutral in reaction (pH 8.07), low in organic carbon (0.45%), medium in available phosphorus (18.89 kg/ha) and medium in available potassium (344 kg/ha). The chickpea was sown at row spacing of 30 cm. Recommended basal dose of nitrogen (20 kg N/ha) and phosphorus (40 kg P_2O_5/ha) was applied through urea and di-ammonium phosphate.

RESULTS

The results indicated that the significantly higher ancillary parameters like number of pods/plant, grain weight/plant and grain yield (1913 kg/ha) were obtained with the crop sown on 30 October which was statistically on par with 15 November sowing, but significantly higher than recorded in the late sowing dates (Table 1). This may be due to the favourable weather conditions for growth and development of the 30 October and 15 November sown crop which resulted in higher dry matter accumulation. The reduction in seed yield continues with further delayed sowing (30 November, 15 December and 30

Table 1. Effect of sowing dates and cultivars of chickpea on yield and economics

Treatment	Seed yield (kg/ha)				COC	GMR	NMR	BCR
	2011-12	2012-13	2013-14	Pooled		(Rs/ha)	(Rs/ha)	
Sowing date								
30 Oct (44 MW)	2315	1846	1579	1913	24307	60748	36423	2.50
15 Nov (46 MW)	2267	1810	1586	1887	24322	59923	35606	2.46
30 Nov (48 MW)	1428	1097	905	1143	23947	36301	12346	1.52
15 Dec (50 MW)	837	667	1180	895	24777	28406	3630	1.15
30 Dec (52 MW)	520	415	847	594	24117	18860	-5254	0.78
CD (P=0.05)	163.3	170	190	80.2	–	1990	1990	–
Cultivar								
Vijay	1400	1100	1211	1237	24252	39275	15013	1.62
JAKI-9218	1547	1234	1227	1336	24335	42418	18087	1.74
CD (p=0.05)	120.68	NS	NS	NS	–	NS	NS	–
Interaction	251.1	228.4	225.1	113.4	–	–	–	–

Table 1a. Interaction effect of date of sowing and cultivar on seed yield of chickpea (Pooled of 3 years)

Date of sowing /Cultivar	30 October	15 November	30 November	15 December	30 December	Mean
Vijay	1771	1744	1060	864	745	1237
JAKI-9218	2055	2031	1226	925	444	1336
Mean	1913	1887	1143	895	594	
CD (P=0.05)	113.42					

December) was due to the shorter reproductive period and the reduction in seed yield perhaps due to unfavourable temperature conditions during reproductive period. The detrimental effect of heat at a later stage of crop development and earning in delayed sowing had an adverse effect on grain yield. The interaction effect between date of sowing and cultivars was found to be significant (Table 1a) and both the cultivars sown at different dates significantly improved the seed yield of chickpea. Cultivar sown at 30 October showed clear superiority over remaining sowing dates excluding sowing at 15 November with respect to seed yield of chickpea. This indicated that sowing of chickpea can be extended up to 15 November without any significant loss in seed yield. In terms of economics significantly higher gross, net return and BCR were recorded with 30 October and 15 November sown chickpea over further delayed in sowing.

CONCLUSION

Under irrigated condition sowing of *desi* chickpea cultivar (Vijay and JAKI 9218) can be extend up to 15 November without significant loss in grain yield.

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Effect of different treatments on growth functions of potato

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Potato is one of the most important crops of the world, ranking next to rice and wheat. It assumes greater significance for its ability to provide food security to millions of people across the globe, as it provides more dry matter content, proteins and calories from per unit area of land and time. It is a wholesome food which is rich in carbohydrates, phosphorus, calcium, vitamin C and vitamin A, minerals and is high yielding short duration crop with high protein calorie ratio. Potato is one of the unique crops grown in our country having high productivity and supplementing food needs (Gupta, 2006) .The non adoption of improved agro-techniques in a climate change scenario as irrigation scheduling, variable planting dates and use of mulch are the limiting factors for low productivity and poor in creation of favorable microclimatic conditions. Globally this climate change should also be addressed in eco-friendly manner. With this back ground in view, the present investigation was undertaken to know the AGR and CGR as Influenced by sowing windows in potato.

METHODOLOGY

The field trial of Potato (Variety) Kufri Pukhraj was conducted during both the seasons (2009-10 and 2010-11) on PGI Farm without changing randomization. The experiment was laid out split plot design in *Rabi* season with recommended dose of fertilizer. 120:60:120 NPK Kg ha-1. There were eighteen treatments comprised of nine main plot treatments, *viz*. I_1D_1- (0.8 IW/CPE) X (42 MW), I_1D_2- (0.8 IW/CPE) X (44 MW), I_1D_3-(0.8 IW/CPE) X (46 MW), I_2D_1- (1.0 IW/CPE) X (42 MW), I_2D_2 - (1.0 IW/CPE) X (44 MW), I_2D_3- (1.0 IW/CPE) X (46 MW), I_3D_1- (1.2 IW/CPE) X (42 MW),

I_3D_2- (1.2 IW/CPE) X (44 MW) and I_3D_3 - (1.2 IW/CPE) X (46 MW) and two sub-plot treatments, viz. with and without mulch. The absolute growth rate and crop growth rate were estimated with standard formulae.

RESULTS

The data pertaining to AGR, on the basis of pooled analysis study in potato revealed that all the growth functions *viz.,* mean AGR and CGR plant^{-1} were conspicuously increased from initial stage up to 56 DAP of crop. Moreover, numerically mean maximum values of all the growth functions were observed during grand growth and tuber development phase of crop. Irrigation scheduled at 1.2 IW/CPE and planting on 44th MW (I_3D_2) recorded numerically highest mean values of all these growth functions, whereas Irrigation scheduled at 0.8 IW/CPE and planting on at 46th MW (I_1D_3) treatment exhibited numerically lowest mean values of them throughout the stages of crop growth during both seasons. It might be due to sufficiently available soil moisture from initial growth stage up to maturity phase with high frequency irrigation level and planting on 44th MW. This might be due to the favourable climatic condition available during crop growth period that improved the leaf area and total dry matter of potato crop, which led to record maximum values of these growth functions under higher moisture regimes. It is observed from the data presented in Table 1 that on pooled basis, planting on 44th MW, the irrigation scheduled at 1.2 IW/CPE (I_3D_2) was comparable with 1.0 IW/CPE (I_2D_2) and exhibited and produced significantly higher mean values of the grade wise yield of tubers, total fresh tuber yield and haulm yield than rest of the treatments. The tuber production which reduced by the effect of water stress on stem growth and reduction in number of branches, as well to a limited extent it effect on the tubers themselves. In potato, increased tuber production was more phenomenal with adequate irrigation, since the percentage of bigger tubers was more in irrigated plants than in un-irrigated plants. The maximum tuber yield was recorded in 44th MW, which was decreased as delayed in planting, this might due to the favourable climatic conditions during the crop growth period of early planting during 56 to 84 days the minimum temperature was 8.7-9.7°C. The beneficial effect of early planting might be associated with the prevalence of low temperature during the tuber development stage. Water deficit affects crop growth depending on the stage of growth and the degree or intensity of water stress. Dry matter production is known to be affected significantly by soil moisture stress. Patel *et al.* (2000) noticed significant increase in CGR with successive increase in number of irrigations. It is observed from the data presented in Table 1 to 2 that during both the years of experimentation, of crop growth in respect of total dry matter accumulation/plant, while at all the days of observation regarding fresh tuber weight/plant, planting on 44th MW, the irrigation scheduled at 1.2 IW/CPE (I3D2) was comparable with 1.0 IW/CPE (I2D2) and produced significantly higher mean values of these attributes than rest of the treatments. Whereas, during the same period, irrigation scheduled at 0.8 IW/CPE and planting on 46th MW (I1D3) treatment recorded significantly the lowest mean total dry matter accumulation and fresh tuber weight/plant compared to other treatments. Thus, the taller but sturdy plants with higher spread and dry matter accumulation at higher soil moisture regimes produced more number of total dry matter accumulation/plant with higher fresh tuber weight resulting into higher yield. Similar trend was observed at 28, 56, 84 DAP and at harvest. Lowest total dry matter was recorded in 46 MW at all the days after planting.

CONCLUSION

Growth attributes study in respect of mean AGR, CGR, RGR, NAR, LAI, LAD revealed that during both the seasons at all the growth stages of potato, numerically higher mean values of each growth function were recorded with application of irrigation at 1.2 IW/CPE ratio and early planting on D_2 (44th MW), whereas numerically lower mean values of said parameters were recorded at application of irrigation at 0.8 IW/CPE ratio and late planting on D_3 (46th MW). More water stress imposed due to irrigation scheduling at 0.8 IW/CPE ratio (58.3 mm CPE) and late planting on 46th MW (I_1D_3) affecting the early tuber initiation stage, tuber bulking stages and tuber development stage recorded significantly less values as compared to other treatments.

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Weeds identification and herbarium preparation methodology

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Weed identification is important to weed science since identifying troublesome weed species is the foundation of sound weed management. Accurate identification of weeds is critical at the time of emergence of seedling for selecting an appropriate post emergence herbicide. Herbarium preparation is also an important part of taxonomy. It is simply a dried and pressed collection of plants arranged in an accepted sequence of classification (Lawrence 1951).They provide the comparative material that is essential for studies in taxonomy. Summer weed flora of Hyderabad was collected and taxonomic description and herbarium was prepared for accurate identification of weed species.

METHODOLOGY

One weed sample was used for making herbarium specimens and another sample was used for writing taxonomic description with the help of dissecting microscope. Morphological characters noted with the help of Lawrence (1951). The taxonomic description of each species was written and with the help of botanical keys (indented and bracketed keys) from different floras, the correct identification of weed species was done. Photographs were taken for different plant parts of each weed species and plates were prepared. Specimen longer than the herbarium sheets were folded in different shape viz. V, W, M and L and kept for drying under the press. Poisoning was done by dipping the whole plant or twig in standard solution of Mercuric Chloride (2 g in 1 litre of ethyl alcohol) in Ethyl Alcohol. Later on, Mountingon herbarium sheet and accessioning of specimens was done. The purpose of the accessioning is to provide a permanent reference number to each specimen.

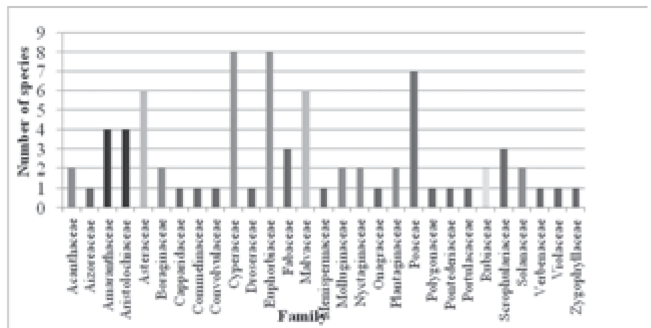

Fig. 1. Bar diagram between number of families and species

RESULTS

The description of all the 73 weeds along with its herbarium was prepared belonging to 29 families. The systematic enumerations of all families were arranged alphabetically. The accepted plants names and families were as per the plant list (2015). The genera under each family are arranged alphabetically. The maximum number species identified were from Cyperaceae and Euphorbiaceae with eight however, Poaceaehad seven and Asteraceae, Malvaceae had six species each respectively. A bar diagram was prepared using the families and number of species (Fig. 1).

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Productivity of maize-based cropping system in intermediate zone of Jammu and Kashmir

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The cropping system is defined as the combination of crops grown on a given area within a year. The forms of agriculture and cropping system found throughout the world are the results of variation in local climate, soil, economics and social structure. Water balance, radiation, temperature and soil conditions are the main determinants of the physical ability of crops to grow and cropping system to exist. Therefore, the cropping system varies from place to place in the world. An attractive strategy for increasing productivity and labour utilization per unit area of available land is to intensify land use. This can be increased by growing several crops simultaneously or in succession with each other in farms devoted to short maturing annual crops. Being a major crop of the district Rajouri, maize is grown in almost 80 % as rainfed agriculture and forms the major crop in any crop rotation in the region. Maize is the predominant crop in Rajouri District with an area of 43.04 thousand hectare and production and productivity of 136102.4 tonnes and 31.36 kg/ha respectively. A study was conducted to compare the various cropping systems prevalent in the Intermediate zone of Jammu division of Jammu and Kashmir. The studied crop rotations were Maize-wheat, Maize-oat, Maize-baron sarson, Maize-fallow both grain and stover yield of maize was maximum for the Maize-wheat rotation as compared with other rotations. This indicated that maize-wheat had a better potential than other cropping systems in the region owing to unique climate conditions, which are intermediate between temperate and sub-tropical type of climate.

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Validation and assessment of economic impact of medium range weather forecast for scarce rainfall zone of Andhra Pradesh

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The success or failure of agriculture crop production is mainly determined by the weather parameters. Out of the total annual crop losses, a substantial portion is because of aberrant weather. The loss could be minimized by making adjustment with coming weather through timely and accurate weather forecasting. Agricultural operations can be advanced or delayed with the help of advanced weather forecast from three to ten days. An agriculturally relevant forecast is not only useful for efficient management of farm inputs but also leads to precise impact assessment (Gadgil, 1989).The major crops are Groundnut, Rice, Castor, Cotton, short duration pulses and horticultural fruit and plantation crops. In addition to this dairy and poultry are the important activities in the region. The south west monsoon season is more important for crop production in this region and is highly useful to the small and marginal farmers. The India Meteorological Department

(IMD) is issuing medium range forecast on various weather parameters and the AAS Unit (AMFU-Ananthapuramu) in turn is issuing Agro advisory bulletins to the local farming community. In this paper an attempt has been made to verify the reliability and suitability of the medium range weather forecasts in Scare Rainfall Zone (Ananthapuramuand Kurnool) of Andhra Pradesh State.

METHODOLOGY

Medium range forecast (forecast given for the period of five days) was given by India Meteorological Department, New Delhi on amount of rainfall for the year 2015-16 for the Scare Rainfall Zone. Forecasted rainfall data was compared with the observed values of the respective rainfall recorded at the AWS and revenue rain gauges located in mandal head-quarters ofAnantapuramuand Kurnool district. Different verification methods were used to assess the reliability of forecast values of weather parameters. The forecast of rainfall have been verified by calculating the error structure. Initially, the error structure was used to categorize the forecast given as correct, usable or unusable based on the per cent deviation in the forecast values as compared to observed values as per the guidelines of National Centre for Medium Range Weather Forecasting (NCMRWF) (Anon., 1999). The correct and usable cases were summed up and the combined values indicate the per cent usability of the forecasts of various parameters to the total events occurred in respective parameter. The Ratio Score was also worked out for rainfall forecast and this score varied from 0 to 1, with 1 indicating perfect forecast (Anon., 1999). In addition, Hanssen and Kuiper's Score (H.K. Score) was also worked out for rainfall forecast which indicated the skill of the forecast given (Anon., 1999). It ranged between -1 to +1, with 0 indicating no skill. The verification of weather forecasts was done for 2015-16 as per the guidelines of NCMRWF (Anon., 1999).

RESULTS

The forecasted values of weather parameters with actual recorded weather parameters were verified for applicability/usability for the 63 mandals of the Ananthapuramu district and 54 mandals of the Kurnool district. The rainfall was verified with skill scores and RMSE and results are presented Table 1. The performance of rainfall was excellent in postmonsoon season as it was not rainy season for Ananthapuramu district. The lowest value of ratio score was calculated in chilmathur mandal (46.25 %)and highest value (73.2%) of ratio score was calculated in roddammandal. The HK score was found positive for almost all mandals in the district expect a very few mandals.The positive value of HK score in indicates that the reliability of forecasts is satisfactory. The highest 52.1% of correct rainfall was found in Kanekalmandal and lowest (37.9%) intanakalmandal and the average of correct rainfall was 45.8% (Table 1). The highest per cent (11.7%) of usable rainfall was found in chilamaturmandal and lowest (1.84%) in Kudairmandal and the average of correct rainfall was 5.86% (Table 1). Overall 51.86 % forecast was correct and useful indicates that only half of the forecast is successful in the Ananthapuramu district and helpful for the farmers make timely and effective planning of their operations based on the NCMRWF. The performance of rainfall was excellent in postmonsoon season as it was good in rainy season for Kurnool district. The lowest value of ratio score was calculated in Banaganapallimandal (54.6%) and highest value (71.6%) of ratio score was calculated in srisailammandal.T he HK score was found positive for all mandals in the district.The positive value of HK score in indicates that the reliability of forecasts is satisfactory. The highest per cent (93.3%) of correct rainfall was found in orvakalmandal and lowest (76.9%) inB.Atmakurmandal and the average of correct rainfall was 84.3% (Table 1). The highest per cent (8.6%) of usable rainfall was found in B. At makurmandal and lowest (0.6%) in Peapullymandal and the average of correct rainfall was 3.85% (Table 1). Overall 95.7 % forecast was correct and useful indicates that the NCMRWF forecast mostly helpful for the farmers make timely and effective planning of their operations.

Table 1. Mandal wise forecast verification averages for the Ananathapuramu and Kurnool district for 2015-16.

Mandal	RS	H.K.	RMSE	Correct	Usable	Unusable
Ananthapuramu district						
Kudair	59.47	0.07	6.63	46.25	1.84	51.91
Kanekal	48.88	0.09	7.00	52.18	6.39	42.00
Tanakal	55.54	-0.03	7.84	37.96	6.12	55.92
Roddam	73.29	0.08	6.84	42.15	4.05	53.80
Chailamathur	46.25	0.13	7.48	48.72	11.77	39.51
Average	57.19	0.11	7.56	45.80	5.16	48.98
Kurnool district						
Orvakal	54.6	0.0	5.7	93.3	0.0	0.0
B.Atmakur	65.9	0.1	6.5	76.9	8.6	14.4
Banaganapalli	54.6	0.0	5.7	93.3	0.0	0.0
Srisailam	71.6	0.1	6.8	79.9	3.5	16.6
Average	61.2	0.1	6.2	84.3	3.5	11.4

CONCLUSION

The results indicate that Rainfall forecast performance was good with respect to the Kurnool district. However in the Ananthapuramu district considering all seasons the performance is better but in monsoon season its performance was not so good.Further fine tuning of the model forecast can increase accuracy and prove more beneficial in reducing crop losses and cost of cultivation in different crops.

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Estimated yield and economic losses due to weeds in India

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Among the major biotic constraints, weeds are considered as the most substantial to agricultural production besides affecting agrobiodiversity and natural water bodies. Therefore, weed management is the major and important part of crop production. But, despite the development and adoption of various weed management technologies, the problem of weeds is increasing day by day due to the way we manage our crop lands and other non-cropped situations. Further, increasing globalization and unchecked import of seed materials and foodgrains from other countries in the past have led to invasion of alien weeds in the country. In view of this, yield loss caused due to weeds has become the major burning issue for discussion in the present weed management scenario. In past, very limited studies have been conducted to estimate the yield losses as well as economic losses due to weeds at farmers' level in India. Therefore, in the present study efforts have been made to estimate the potential and actual yield losses as well as economic losses due to weeds in different crops.

METHODOLOGY

A study was conducted to estimate the yield losses and economic losses due to weeds using the data from a total of 1821 On-Farm Research trials conducted by different centres of All India Coordinated Research Project on Weed Management (AICRP-WM) in 18 major crops in different districts of 18 states of India. Data on yield losses in three treatments viz. farmers' practice, weedy check and weed free (2 Hand Weedings) were used for the study. In order to calculate the economic losses caused by weeds, normal estimates of the production of different crops (average of 2008-09 to 2013-14) in different states and Minimum Support Price (MSP) of the crops (except fair and remunerative price for sugarcane) for the crop year 2014-15 were considered. It is computed using following formula:

RESULTS

For each selected state, the estimates of yield losses due to weeds for important crops were obtained using data from On-

Table 1. Potential and actual yield losses (%) due to weeds

Crop	Potential yield loss (%)	Actual yield loss (%)
Transplanted Rice	48.2*	13.8
Direct Seeded Rice		21.4
Wheat	30.3	18.6
Maize	43.4	25.3
Mustard	-	21.4
Soybean	62.5	31.4
Sunflower	-	31.7
Pigeonpea	33.6	23.9
Ragi	62.0	41.5
Groundnut	57.9	35.8
Chickpea	-	35.0
Sugarcane	67.8	21.9
Sorghum	42.3	25.1
Blackgram	50.9	30.7
Greengram	56.5	30.8
Sesame	58.0	23.7
Niger	61.3	37.5
Cotton	-	17.9
Pearlmillet	41.1	27.6

Farm Research (OFR) trails. Potential and actual yield losses are presented in Table 1 which shows the average yield losses due to weeds.

As far as economic loss is concerned, actual economic losses is highest as 36% (Rs. 28290.67 crore) of total loss in case of rice followed by wheat (21605.72 crore) and soybean (Rs. 9979.30 crore), respectively. Further analysis showed that foodgrains (cereals, pulses and millets) experienced more economic losses due to weeds (76.5%) followed by oilseed crops (16.5%) and cash crops viz. sugarcane and cotton (7%). All together total actual economic loss in these major crops in 18 states are estimated as Rs.78630.30 crore due to weeds alone.

CONCLUSION

Analysis of yield loss data showed that range of potential yield loss is very high in case of soybean (50-76%) followed by groundnut (45-71%). Depending upon the growth condition of crops and intensity of weeds, actual yield losses varied greatly among states. This variation is highest in case of maize (7-51%) followed by direct-seeded rice (6-49%). Actual yield loss is more in case of pulses and oilseeds as compared to cereal crops. Economic losses help in making policy decisions and taking appropriate remedy measures to decrease the losses due to this pest. It was realized that study underestimated the economic losses by including some of the crops only. It may be much higher than what is actually estimated from the data.

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