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Effect of integrated nutrient management on growth, yield and mineral composition of rice (Oryza sativa L.) in an Inceptisol

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Abstract

A field experiment was conducted during 2005-06 at Sahara India Agricultural Research Institute, Lucknow with 13 treatments in RBD taking rice (var. saryu-52) to evaluate the effect of integrated nutrient management on growth, yield and mineral composition of rice (var. saryu-52). Highest grain yield 4.45 tonnes ha^{-1} (pooled) was recorded with 100 % NPK which was at par with 75 % NPK+10 tonnes ha^{-1} vermicompost. Among organic treatments, highest yield 2.48 tonnes ha^{-1} was recorded with 10 tonnes/ha vermicompost followed by 10 tonnes ha^{-1} farm yard manure and 3 tonnes ha^{-1} blue green algae (2.21 tonnes ha^{-1}). The integrated nutrient management improved the organic carbon, available N, P, K and S status of post harvest soil. Application of recommended dose of 100 % NPK or 75 % NPK along with 10 tonnes/ha vermicompost were equally beneficial for obtaining higher yields and sustaining soil fertility.

Key words- Integrated nutrient management, vermicompost, soil fertility, farm yard manure, and blue green algae

Introduction

Cultivation of crops that rely on the use of high rates of inorganic fertilizers, continuous for several years often lead to unsustainability in production and also pose a threat to the environment. The major concerns are the development of multinutrient deficiency and fertilizer related environmental pollution. Similarly, increased prices, energy crises and limited availability of fertilizer entail search of organic manure as an alternative source to supplement the nutrient requirement of different crops. Fertilizers along with available quantities of manure are now commonly used to maintain optimum soil fertility and to attain

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described level of yield. Rice (*Oryza sativa* L.) is a main cereal crop in Eastern Uttar Pradesh due to it is palatable and medium nutritive value. Rice requires high amount of nutrients, organics alone cannot meet its nutrient requirement. Under such situation, integrated nutrient management is a practical alternative, which holds great promise not only for securing high productivity but also against deterioration of soil environment (Paikaray *et al*. 2002). Further, long-term studies being carried out at several locations is India indicated that application of all the needy nutrients through chemical fertilizers have deleterious effect on soil health leading to unsustainable yields (Swarup, 2002). Therefore, to increase productivity under rain-fed conditions, balanced fertilization would be essential and inevitable; there is urgent need to educate farmers about the importance of balanced use of fertilizers in increasing yield and projects in rain-fed rice ecology.

Materials and Methods

The present study was carried out at the research farm of the Sahara India Agricultural Research Institute, Lucknow, Uttar Pradesh (India). The sandy loam soil had pH (1:2) 8.0, EC 0.19 dSm^{-1}, Organic carbon 0.41 % in the 0-15 cm layer. These soils are poorly permeable and the average water infiltration rate was 23 mm day^{-1}. In general water stands on the surface following irrigation rainfall. The water table at the experimental site remained below 6 meter during the growth period and did not fluctuate much. The rice cultivar saryu-52 (30 days old seedling) was transplanted in standing water on second week of July in 5 X 3 meter plot size during 2005 and 2006 at a spacing of 20 cm between rows and 15 cm between plants. The treatment consisted of control i.e. with no inorganic fertilizer and organic sources T_1; 10 tonnes farm yard manure ha^{-1}, T_2; 10 tonnes vermicompost ha^{-1}, T_3; 3 tonnes blue green algae ha^{-1}, T_4; 120 kg N ha^{-1}, 60 kg P ha^{-1} and 40 kg K ha^{-1} i.e. 100 % NPK recommended dose, T_5; 90 kg N ha^{-1}, 45 kg P ha^{-1} and 30 kg K ha^{-1} i.e. 75 % NPK recommended dose, T_6; 60 kg N ha^{-1}, 30 kg P ha^{-1} and 20 kg K ha^{-1} i.e. 50 % NPK recommended dose, T_7; 75 % NPK recommended dose with 10 tonnes farm yard manure ha^{-1} , T_8; 50 % NPK recommended dose plus 10 tonnes farm yard manure ha^{-1} , T_9; 75 % NPK recommended dose with 10 tonnes vermicompost ha^{-1} , T_{10}; 50 % NPK recommended dose with 10 tonnes vermicompost ha^{-1} , T_{11}; 75 % NPK recommended dose with 3 tonnes blue green algae ha^{-1}, T_{12}; 50 % NPK recommended dose with 3 tonnes blue green algae ha^{-1}, T_{13}. Fertilizer application consisted of 120 kg N ha^{-1} (through urea), 60 kg P_2O_5 ha^{-1} (through single super phosphate) and 40 kg K_2O ha^{-1} (through muriate of potash) in Randomized Block Design with four replications. One third of the N was applied at the time of sowing and rest of the N was applied three and six weeks after transplanting. Full dose of P and K was applied at the time of transplanting of the rice.

Plant parameters

Plant height was observed 40 and 60 days after transplanting (DAT) and at harvesting by observing five randomly selected plants in each plot. At 30 DAT and harvest, numbers of fertile tiller/hill and number of ears/hill, length of ears (cm) were recorded from five locations in each plot. The rice crop was harvested on 20.10.2005 (2005) and 15.10.2006 (2006). Grain and straw yields were recorded on an air dry basis. The data were statistically analyses at 5 % level of significance.

Mineral composition

Plant samples were collected at harvesting stage. The samples were washed in distilled water, dried in the air and then in an oven at 60^0C to constant weight. Grain and straw samples were ground to pass a 1 mm sieve, whereas the intact grain and straw were taken as such for chemical analysis (Jackson, 1967). The samples were digested in a mixture of HNO_3:$HClO_4$ (3:1). After proper dilution of the digested materials analysis were carried out for P, K and S by following standard methods (Jackson, 1967). For N determination, plant material was digested separately and analyses by Kjeltec Auto 1030 Analyser.

Physico-chemical properties

The soil samples were air dried and ground to pass through 2 mm sieve and were analysed for particle size following: International pipette method (Piper, 1966). The pH of soils was measured with Backman glass electrode in (1:2): soil:water suspention. Electrical conductivity in (1:2): soil: water suspention was determined in saturation extracts with digital EC meter (Richards, 1954). The organic carbon in soil was anlysed by method outlined (Walkley and Black, 1934), available nitrogen (Subhiah and Asija, 1956); available phosphorus 0.5M $NaHCO_3$ solution buffered at pH 8.5 and determined by spectrophotometer at wavelength 780 nm using blue color method (Olsen, *et al.,* 1954), available potassium by extraction with 1N ammonium acetate at pH 7.0 (Jackson, 1967) and available sulphur by turbidimetric method (Chesnin and Yien, 1950) sited by Jackson(1967).

Results and Discussion

Growth characters-In general plant height (cm) increased with the advancement in crop age and reached to the maximum at maturity (Table 1). The varying fertility levels significantly influenced the plant height at 40, 60 DAT and at harvest. During both the years of study, treatment T_5 recorded highest plant height at 40, 60 DAT and at harvest and it was at par with T_{10}. Higher plant height in T_5 and T_{10} might be due to higher availability of nutrients in these treatments. Similar results were observed by (Singh and Verma, 1999; Narwal and Sindhu, 2001 and Satheesh and Balasubramanian, 2003). The results indicated tillers per hill, number of ears per hill and length of ear (cm) were higher to the tune of 76 %, 85 % and 33 %, respectively in

T_5 (100 % NPK) over the control (Table 2). Also reported similar findings (Jain and Poonia, 2003).

Yield and yield components

Higher grain and straw yield of rice were recorded in T_5 during first and second year of experiment respectively. T_5 (4.26 tonnes/ha) and 4.64 tonnes/ha) during first and second year recorded 103 % and 113 % higher grain yield over the control, respectively. From the pooled data of two years presented in table 3, it is clear that highest yield was obtained in T_5 (4.45 tonnes/ha) and significantly better over the rest of treatments. Similarly straw yield was also higher in T_5 during first and second year of study respectively. The pooled data depicted higher straw yield in T_5 closely followed by T_{10}. The Higher grain yield of rice obtained in T_5 could be ascribed to their favorable effect on growth and yield attributes (Table 1 and 2). Highest number of tillers per hill, number of ears per hill and length of ear (cm) and plant height with application of 100 % NPK (recommended dose) of fertilizers resulted because of higher content of nutrients due to release of higher content of nutrients and sufficient level that in turn produce higher yields (Patashetti, *et al*., 2002; Sankhyan, *et al*., 2003 and Hattab, *et al*., 2000).

Table 1 Effect of different treatments on plant height (cm) of rice crop

Treatments	40-DAT			60-DAT			At Harvesting		
	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
T_1	51.7	52.2	51.9	63.3	63.5	63.4	73.6	74.7	74.2
T_2	53.8	54.2	54.0	65.3	69.6	67.4	77.2	78.7	77.9
T_3	54.9	55.7	55.3	70.2	72.2	71.2	80.9	82.4	81.7
T_4	52.4	53.9	53.1	68.3	67.2	67.8	76.3	77.6	76.9
T_5	75. 4	76.1	75.8	94.6	96.1	95.3	94.6	96.6	95.6
T_6	62.7	64.3	63.5	86.7	87.9	87.3	85.3	87.1	86.2
T_7	62.3	63.6	62.9	85.7	86.9	86.3	84.5	86.5	85.5
T_8	65.4	66.5	65.9	90.7	91.8	91.3	91.5	93.9	92.7
T_9	64.1	65.5	64.8	88.2	89.4	88.8	90.6	92.9	91.7
T_{10}	70.7	72.3	71.5	92.4	92.7	92.5	92.9	95.0	93.7
T_{11}	68.5	69.5	69.0	91.4	92.6	92.0	91.9	93.6	92.8
T_{12}	63.9	65.1	64.5	87.3	89.2	88.2	88.3	90.9	89.6
T_{13}	63.6	64.7	64.1	86.3	88.8	87.6	86.6	87.8	88.2
CD (P=0.05)	2.27	0.51	1.39	1.65	0.56	1.10	1.15	0.89	1.02

DAT- Days after transplanting.

Mineral composition

The higher nitrogen, phosphorus, potassium and sulphur uptake in grain and straw were observed T_5 as compared to other treatments in both the years. T_5 treatment recorded nitrogen, phosphorus, potassium and sulphur uptake in grain to the order of 77.1, 20.2, 19.0 and 7.2 kg ha^{-1}, respectively during 2005 and 86.1, 22.3, 20.8 and 8.2 kg ha^{-1}, respectively during 2006 presented in table 4. T_5 treatment recorded nitrogen, phosphorus, potassium and sulphur uptake in straw to the order of 21.2, 1.8, 99.6 and 6.0 kg ha^{-1}, respectively during 2005 and 25.9, 1.99, 108.6 and 6.8 kg ha^{-1}, respectively during 2006. The highest uptake might be due to developed by root system under balanced nutrient application resulting in better absorption of water and nutrients. The increases in nutrients uptake with recommended dose of fertilizers can be explained on the basis that application of nutrients is known to increase root cation exchange capacity which enhances absorption of nutrients (Elgababy, 1962) and (Datt, *et al*., 2003; and Sharma, *et al*., 2003 b).The nutrient uptake by the crop is determined by its nutrient content and yield and was also evident that yields were more deciding factors for the uptake of nutrients by the crop (Brar, *et al*., 2000 and Khalil, *et al*., 2000).

Effect on physico-chemical properties

The pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium and sulphur in soil were varied significantly due to varying fertility levels presented in table 5. The soil pH and electrical conductivity however remained nearly at par with the initial value in treatment (T_2). In general 75 % recommended dose of inorganic fertilizers with 10 tonnes vermicompost were recorded to have more organic carbon, nitrogen, phosphorus, potassium and sulphur in soil compared to other treatments. Available nutrients content in all treatments are in the order of $T_5<T_{10}<T_8<T_{11}<_{12}<T_9<T_{13}<T_6<T_7<T_4<T_3<T_2<T_1$. The fertility levels of 75 % NPK with 10 tonnes ha^{-1} vermicompost treatment left the maximum organic carbon content in soil might be due high organic matter content of the vermicompost.

Table 2 Effect of different treatments on number of tillers $hill^{-1}$, number of ears $hill^{-1}$ and length of ears of rice crop

Treatments	Number of tillers $hill^{-1}$			Number of ears $hill^{-1}$			Length of ears (cm)		
	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
T_1	6.5	7.7	7.1	5.8	6.4	6.1	18.5	19.4	18.9
T_2	7.5	8.4	7.9	6.5	7.8	7.1	19.6	20.6	20.1
T_3	9.1	10.1	9.6	6.7	7.9	7.3	20.3	21.6	20.9
T_4	7.2	8.1	7.6	6.2	7.6	6.9	19.0	20.1	19.6
T_5	11.9	13.1	12.5	10.7	11.8	11.3	24.6	25.9	25.3
T_6	9.2	9.9	9.6	9.3	10.5	9.9	21.2	22.4	21.8
T_7	9.0	10.0	9.5	7.1	9.3	8.2	20.2	21.2	20.7
T_8	9.8	10.9	10.4	8.9	10.0	9.5	22.6	23.5	23.1
T_9	9.6	10.7	10.1	8.1	9.8	8.9	21.6	22.5	22.1
T_{10}	10.7	11.9	11.3	10.2	11.2	10.7	23.6	24.8	24.2
T_{11}	10.2	11.1	10.6	9.5	10.7	10.1	23.0	24.2	23.6
T_{12}	9.7	10.8	10.3	7.9	9.1	8.6	21.6	22.8	22.2
T_{13}	9.5	10.5	10.0	7.1	8.4	7.8	21.2	22.3	21.8
CD (P=0.05)	0.72	0.30	0.51	0.99	0.29	0.64	1.28	0.32	0.80

Table 3 Effect of different treatments on grain and straw yield of rice crop

Treatments	Grain (t ha^{-1})			Straw (t ha^{-1})		
	2005	2006	Pooled	2005	2006	Pooled
T_1	2.09	2.18	2.14	1.80	1.87	1.84
T_2	2.26	2.38	2.32	1.86	2.01	1.94
T_3	2.31	2.65	2.48	2.06	2.24	2.15
T_4	2.15	2.26	2.21	1.85	1.95	1.90
T_5	4.26	4.64	4.45	3.94	4.26	4.10
T_6	3.66	4.13	3.90	3.82	4.12	3.97
T_7	3.52	3.65	3.59	3.01	3.11	3.06
T_8	4.19	4.40	4.30	3.65	3.95	3.80
T_9	4.10	4.24	4.17	3.45	3.82	3.64
T_{10}	4.26	4.44	4.35	3.84	4.11	3.98
T_{11}	3.97	4.47	4.22	3.60	3.90	3.75
T_{12}	4.14	4.41	4.23	3.40	3.62	3.51
T_{13}	3.93	4.21	4.07	3.15	3.57	3.36
CD (P=0.05)	0.115	0.022	0.069	0.067	0.420	0.243

Inspite of results organic carbon build up in soil provide huge available nitrogen, phosphorus, potassium and sulphur due to increased activity of micro-organisms leading to greater mineralization of applied and inherent nutrients (Tolessa, *et al*., 2001) in respect of organic carbon; and available nitrogen, phosphorus, potassium and sulphur, Yadhuvanshi, *et al*., (1985), in respect of available phosphorus confirmed the observed trend by Dixit and Gupta (2000).

Conclusions

The 100 % recommended dose of fertilizers, being statistically similar to T_{10} (75 % NPK with10 tonnes ha^{-1} vermicompost) recorded the higher number of tillers per hill, number of ears per hill and length of ear (cm) and plant height and grain and straw yield. The nitrogen, phosphorus, potassium and sulphur uptake in grain and straw of rice (*Oryza sativa* L.) were found the maximum with the recommended dose of fertilizer 100% NPK (T_5). The highest content of organic carbon and available nitrogen, phosphorus, potassium and sulphur contents were observed in 100 % recommended dose (T_5) treatment.

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Table 4. Effect of different treatments on nitrogen, phosphorus, potassium and sulphur uptake in grain and straw of rice crop

Treat -ments	Nitrogen (kg ha^{-1})				Phosphorus (kg ha^{-1})				Potassium (kg ha^{-1})				Sulphur (kg ha^{-1})			
	Grain		Straw		Grain		Straw		Grain		Straw		Grain		Straw	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
T_1	20.5	21.9	6.1	6.4	4.6	4.9	0.55	0.58	6.3	6.6	31.2	32.8	2.1	2.4	1.4	1.8
T_2	28.9	31.4	7.6	8.6	8.4	9.0	0.74	0.81	8.6	9.1	36.6	40.0	2.4	2.9	1.6	2.0
T_3	31.5	37.2	8.7	10.3	8.9	10.4	0.84	0.92	8.9	10.3	41.4	45.6	2.7	3.4	2.1	2.5
T_4	26.2	28.8	7.4	8.4	7.7	8.2	0.73	0.77	7.9	8.5	33.4	35.7	2.1	2.5	1.7	1.8
T_5	77.1	86.1	21.2	25.9	20.2	22.3	1.82	1.99	19.0	20.8	99.6	108.6	7.2	8.2	6.0	6.8
T_6	56.9	66.0	17.0	20.0	15.1	17.3	1.60	1.74	14.4	16.8	80.4	87.6	4.8	5.5	4.2	4.8
T_7	51.9	55.2	12.9	14.5	14.0	14.8	1.25	1.30	13.8	14.4	61.5	64.1	4.3	4.3	3.0	3.1
T_8	73.1	78.6	18.6	21.7	19.5	20.8	1.65	1.80	18.1	19.1	88.1	95.8	6.2	7.0	4.4	5.1
T_9	65.8	71.2	16.5	20.1	17.8	19.2	1.51	1.69	16.6	17.8	78.6	88.2	5.2	5.8	3.8	4.7
T_{10}	75.9	75.2	20.3	23.8	20.1	19.7	1.75	1.90	18.8	18.3	95.5	103.5	6.7	6.9	5.4	5.6
T_{11}	69.8	77.6	17.7	21.3	18.6	20.5	1.60	1.76	17.4	19.1	84.9	93.7	6.2	7.0	4.7	4.9
T_{12}	67.3	73.4	16.0	18.7	18.2	19.2	1.47	1.58	17.0	17.8	76.7	82.7	5.6	6.3	4.1	4.5
T_{13}	58.9	65.7	14.2	18.2	16.8	18.2	1.33	1.54	15.9	16.7	66.6	77.2	4.9	5.8	3.5	3.9
CD (P=0.05)	1.92	1.27	0.29	0.24	0.47	0.17	0.02	0.02	0.44	0.12	1.63	1.38	0.7	0.8	0.6	0.8

Table 5 Effect of different treatments on physico-chemical properties in soil after harvesting of rice crop

Treat -ments	pH		EC (dSm^{-1})		Organic Carbon (%)		N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		S (kg ha^{-1})	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
T_1	8.00	8.00	0.18	0.19	0.40	0.42	180.9	181.8	22.0	23.0	291.8	292.0	10.7	10.9
T_2	8.10	8.10	0.19	0.20	0.59	0.61	205.3	206.3	22.7	23.3	308.9	309.9	11.5	12.3
T_3	8.10	8.23	0.18	0.20	0.66	0.69	213.6	214.3	23.2	24.5	315.6	316.8	12.4	13.1
T_4	8.20	8.10	0.19	0.19	0.55	0.57	205.1	206.2	22.5	23.8	300.5	301.6	11.2	12.2
T_5	8.38	8.23	0.24	0.25	0.94	0.96	250.6	252.8	27.7	29.1	340.4	341.9	14.2	15.7
T_6	8.20	8.23	0.29	0.21	0.74	0.76	235.4	236.5	24.8	26.2	322.1	323.2	12.2	12.8
T_7	8.10	8.20	0.20	0.22	0.69	0.71	232.6	233.7	23.7	24.6	320.6	321.5	11.4	12.7
T_8	8.23	8.30	0.22	0.23	0.88	0.91	245.5	246.4	27.4	28.8	335.4	336.6	12.6	13.9
T_9	8.18	8.20	0.22	0.22	0.78	0.80	235.5	36.8	26.8	27.4	333.2	334.5	12.1	12.7
T_{10}	8.30	8.23	0.24	0.25	0.91	0.93	246.1	247.9	28.5	29.7	337.5	338.8	13.4	14.9
T_{11}	8.30	8.28	0.23	0.24	0.87	0.89	240.3	242.0	26.5	27.6	330.0	331.2	12.8	13.6
T_{12}	8.10	8.20	0.22	0.23	0.80	0.82	239.3	240.9	26.5	27.6	329.8	330.8	12.1	13.4
T_{13}	8.20	8.20	0.21	0.21	0.76	0.78	228.4	229.6	25.0	26.2	326.6	327.5	12.0	13.2
CD (P=0.05)	0.14	0.26	0.29	0.01	0.21	0.02	1.7	0.5	0.26	0.29	1.1	0.2	0.4	0.4

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