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Effect of long-term organic and inorganic nutrients on transplanted rice under rice-wheat cropping system

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ABSTRACT

A field experiment was carried out during wet season of 2003 in calcareous soil at RAU, Pusa, Samastipur to find out the yield, nutrient uptake and fertility buildup in upland transplanted rice as influenced by organic and inorganic fertilizers. Integrated use of chemical fertilizer with organic manure and crop residue could substitute 50 percent of the recommended dose of NPK. The grain yield of rice (33.4) with 150 percent NPK alone increased the grain yield to 42.3 q ha^{-1} with 150 percent NPK + compost + crop residue. Integrated effect of chemical fertilizers with organic manure and crop residue also augmented N, P and K uptake over control. Long-term application of compost and crop residues increased the organic content of soil. The combined use of compost, crop residues with chemical fertilizers significantly increased the availability of N, P and K in soil over chemical fertilizer alone.

Key words: *rice, long term, organic, inorganic, nutrient effect*

Organic manures play a vital role in sustaining higher productivity in intensive agriculture and irrigated rice in particular. The availability of organic manures like compost, farm yard manure, green manure, crop residue is, however, a major limiting factor for their use. Complementary use of organic and biological source of plant nutrient along with chemical fertilizer is of great importance for the maintenance of soil health and productivity (Prasad, 1999).

Indiscriminate use of high analysis chemical fertilizers results in the deficiency of nutrients other than the ones applied and cause decline in the organic carbon content (Singh *et al*., 1999). An attempt was made to study the long-term effect of organic and inorganic fertilizers application on yield uptake and nutrient availability of transplanted rice under rice-wheat cropping system in calcareous soil.

MATERIALS AND METHODS

A long-term experiment effect of organic and inorganic nutrients on irce is in progress since dry season 1988, at Pusa farm in Rajendra Agricultural University, Bihar. The general properties of surface soil are pH 8.4, EC 0.36 dSm^{-1}, organic carbon 5.0 g kg^{-1}, free $CaCO_3$ 34.2%, available N 236.1 kg ha^{-1}, available P_2O_5 19.7 kg ha^{-1} and available K_2O 100.0 kg ha^{-1}. Four levels of NPK fertilizers based on soil test value viz No NPK (F_0), 50% NPK (F_1), 100% NPK (F_2) and 150% NPK (F_3) were used as treatments in the main plots. Each main plot was divided into 4 sub-plots in which the sub-treatments with no crop residue or no compost (M_0), compost @ 10 t ha^{-1} (M_1), 100% crop residue (M_2) and 10 t ha^{-1} compost + 100% crop residue (M_3) were superimposed over NPK levels. The experiment was conducted in split plot design with three replications, plot size was 10 m^2. The crop reported in this experiment was the 30^{th} crop, rice (cv. Rajshree) in wet season (2003) with continuous application of compost @ 10 t ha^{-1} and 100% crop residues of respective plot alone or in combination with different levels of NPK viz 0, 50, 100 and 150 percent of recommended dose of fertilizer. The residue of wheat before rice transplanting and residue of rice before wheat sowing were incorporated in the soil. 100% NPK referred to 100 kg N ha^{-1}, 26.7 kg P_2O_5 ha^{-1} and 32.2 kg K_2O ha^{-1}. Nitrogen, phosphorus and potash were supplied in the form of urea, single super phosphate and murate of potash, respectively. Half the dose of nitrogen and entire dose of P and K were applied at the time of transplanting of rice and remaining N fertilizer was applied in equal splits at tillering and flower initiation stage. Composite surface (0-15 cm) soil samples from each plot of the field experiment were collected during 2003 wet season. Soil samples were air dried and pulverized to pass through 2 mm sieve. Available N (alkaline $KMnO_4$), Olsen's P and 1N NH_4OAc-K, pH and organic carbon were determined (Jackson, 1973).

RESULTS AND DISCUSSION

Grain and straw yield increased significantly with increasing level of fertilizers up to 100 percent NPK (Table 1). Grain yield of rice varied from 2.94 to 4.28 t ha^{-1} with different nutrient levels. Increase in grain yield over control was 30.2, 44.9 and 45.1 percent with the application of 50, 100 and 150 percent NPK, respectively. Among the NPK treatments maximum grain yield (4.28 t ha^{-1}) and straw yield (7.15 t ha^{-1}) were obtained with 150 percent NPK. This may be due to the luxury consumption of nutrients in the plots receiving higher dose (150%) of inorganic fertilizer which caused lodging before harvesting.

On the other hand, incorporation of organic sources of nutrition, the grain yield of control (3.34 t ha^{-1}) significantly, increased to the tune of 0.60, 0.47 and 0.89 t ha^{-1} with compost, crop residue and compost+crop residue, respectively. Compost or crop residue resulted in a small increase in grain yield but their combination was superior to either of them. Similar results were also reported by Sharma and Bali (2001). Even though the interaction was found to be significant, the integrated effects of fertilizer and manure/crop residue were noted to be more beneficial than the use of chemical fertilizer alone. Additional increase in grain and straw yield was registered due to the integrated effect of compost, crop residue and compost + crop residue with inorganic fertilizer. 100 percent NPK + compost +crop residue produced the highest grain yield (4.65 t ha^{-1}). Grain yield with 50 percent NPK + compost + crop residue was significantly higher than the yield obtained at 100 percent NPK alone. This indicates that more than half of the nutrients in fertilizer could be substituted with compost + crop residue to get the higher yield.

A significant effect of integrated use of inorganic fertilizers with compost, crop residue and compost + crop residue were recorded. N uptake by rice increased from 32.1 to 86.1 kg ha^{-1} with increasing levels of NPK from 0 to 150%. Nitrogen uptake by rice increased over control (54.3 kg N ha^{-1}) at 12.6 kg N ha^{-1}, 6.8 kg N ha^{-1} and 19.6 kg N ha^{-1} with the application of NPK + compost, NPK + crop residue and NPK + compost + crop residue, respectively (Table 2). The direct effect of compost and crop residue on nitrogen uptake by rice was found in the order : compost + crop residue > compost > crop residue > no manure. The efficiency of compost in augmenting nutrient uptake by rice was higher than that of crop

Table 1. Effect of long term application of organic and inorganic fertilizer on rice (30th crop) yield under rice-wheat cropping system.

Treatment	Grain yield (t ha^{-1})					Straw yield (t ha^{-1})				
	No manure	Compost	Crop residue	Compost + crop residue	Mean	No manure	Compost	Crop residue	Compost + crop residue	Mean
No NPK	2.04	3.19	2.99	3.56	2.94	3.13	4.63	3.38	5.53	4.17
50% NPK	3.66	3.93	3.76	4.28	3.83	4.88	6.35	5.93	7.29	6.11
100% NPK	3.89	4.22	4.21	4.65	4.27	6.07	6.73	6.65	7.63	6.77
150% NPK	4.06	4.34	4.26	4.43	4.28	6.34	7.22	7.48	7.56	7.15
Mean	3.34	3.94	3.81	4.23		5.05	6.30	5.60	7.00	
Source		CD (P = 0.05)				CD (P = 0.05)				
Fertilizer (F)		2.97				2.07				
Manure (M)		1.32				1.91				
F x M		2.64				3.83				

residue. The benefit derived from organic manure and crop residue by addition of chemical fertilizer might be due to applied nutrients and release of nutrients as a result of decomposition process finally enhanced their availability to crops. .

The P uptake by rice under the NPK treatment was 11.6 kg ha^{-1} which increased to 14.5, 13.7 and 16.2 kg ha^{-1}, respectively with the treatments of compost, crop residue and compost + crop residue incorporation (Table 2). Phosphorus uptake increased from 9.7 to 16.7 kg ha^{-1} with increase in the level of NPK from 0 to 150%. At the optimum level of fertilizer (150% NPK), phosphorus uptake increased to 15.0, 12.9 and 27.2% with compost, crop residue and compost + crop residue incorporation, respectively. The increase in uptake of P and K may be also to more availability of these nutrients from the added fertilizers and the solubilising action of organic acids produced during degradation of compost and crop residue.

The highest pooled mean K uptake by rice was recorded under the treatment 150% NPK + compost + crop residue and it was the lowest when only mineral fertilizers were added (Table 2). At the optimum dose of fertilizers, K uptake by rice increased by 22.8, 19.7 and 43.9% under the treatments comprising of incorporation of compost, crop residue and compost + crop residue, respectvely. The increased uptake of K by rice may be ascribed to the release of K from the K-bearing minerals by complexing agents and organic acids produced during decomposition.

Organic carbon content of the surface soil increased significantly with incorporation of compost, crop residue and compost + crop residue with fertilizer over control (Table 3). Compost, crop residue and compost + crop residue increased the 12.5, 10.4 and 18.7%, respectively over control and increased the available N by 24.1, 15.5 and 30.2%, respectively over control after harvest of rice. The increase in available nitrogen due to incorporation of organic materials might be also attributed to the enhanced multiplication of microbes by the incorporation of crop residue and compost for the conversion of organically bound N to inorganic form (Kumar and Prasad, 2008). The favourable soil conditions under compost and crop residue might have helped in the mineralization of soil N leading to the build up of higher available N (Bhat *et al.*, 1991; Sharma *et al.*, 2000). Significant buildup of

Table 2. Influence of long term use of organic and inorganic fertilizer on N, P and K uptake by rice (30th crop) under rice-wheat cropping system.

Treatment	N uptake (kg ha^{-1})					P uptake (kg ha^{-1})					K uptake (kg ha^{-1})				
	No manure	Compost	Crop residue	Compost + crop residue	Mean	No manure	Compost	Crop residue	Compost + crop residue	Mean	No manure	Compost	Crop residue	Compost + crop residue	Mean
No NPK	32.0	45.0	38.4	52.9	42.1	7.3	10.3	9.1	12.0	9.7	40.2	49.8	44.8	64.1	49.7
50% NPK	49.9	65.4	57.6	74.7	61.7	10.7	14.6	13.0	15.8	13.5	51.1	64.7	59.5	80.2	63.9
100%NPK	63.6	75.0	68.2	82.1	72.2	13.6	16.2	16.0	18.3	15.9	62.6	77.9	72.3	95.3	77.0
150% NPK	71.7	82.4	80.0	86.1	80.0	14.7	16.9	16.6	18.7	16.7	67.9	83.4	81.3	97.7	82.6
Mean	54.3	66.9	61.0	73.9		11.6	14.5	13.7	16.2		55.4	68.9	64.5	84.3	
Source		CD (P = 0.05)					CD (P = 0.05)					CD (P = 0.05)			
Fertilizer (F)		3.96					4.82					3.56			
Manure (M)		3.82					3.68					4.92			
F x M		NS					NS					NS			

Table 3. Influence of long term use of organic and inorganic fertilizers on organic carbon, pH and available nutrients of rice under rice-wheat cropping system in calciorthents.

Treatments	Organic carbon ($g\ kg^{-1}$)	pH (1:2)	Available N ($kg\ ha^{-1}$)	Available P ($kg\ ha^{-1}$)	Available K ($kg\ ha^{-1}$)
No NPK	5.0	8.5	261	26.5	99.9
50% NPK	5.2	8.4	308	37.2	108.2
100% NPK	5.4	8.3	330	45.4	111.6
150% NPK	5.5	8.3	345	45.7	118.1
Mean	5.3	8.3	311	38.7	109.4
CD (P=0.05)	0.01	0.11	18.1	3.0	2.4
No manure	4.8	8.6	265	35.1	103.5
Compost	5.4	8.2	329	38.6	111.1
Crop residue	5.3	8.2	306	38.2	109.7
Compost + Crop residue	5.7	8.1	345	42.8	113.5
Mean	5.3	8.2	311.2	38.7	109.4
CD (P=0.05)	0.01	0.07	14.3	2.8	2.1

available P and K was recorded with graded levels of fertilizers and also with compost, crop residue and compost + crop residue. Compost, crop residue and compost + crop residue augmented the available P content by 38.6, 38.2 and 42.8 kg ha^{-1}, respectively. It also increased K uptake. Larger build up in available P with green manure and crop residue may be attributed to the influence of organic manure in increasing the labile P in soil through complexation of cations like Ca^{2+} and Mg^{2+} which are mainly responsible for the fixation of phosphorus in calcareous soil (Yashpal *et al*., 1993; Tolanur and Badanur, 2003).

The integrated effect of compost and crop residue with fertilizers at any level of NPK resulted in maximum yield. Integrated effect of chemical fertilizers with organic manure and crop residue also augmented N, P and K uptake over control. There was build up of available N, P and K with conjoint use of chemical fertilizers with compost and crop residue incorporation in soil. Addition of different organic materials increased the organic carbon and slightly decreased in soil pH.

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