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Effect of fortified and unfortified rice-straw compost with NPK fertilizers on productivity, nutrient uptake and economics of rice *(Oryza sativa)*

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ABSTRACT

A field experiment was conducted during the rainy seasons *(kharif)* of 2002 and 2003 at the Research Farm of the institute at Varanasi to study the effect of superimposition of fortified and unfortified rice-straw compost @ 6 t/ha over recommended NPK (120 kg N, 60 kg P_2O_5, 60 kg K_2O/ha) on growth, yield and nutrient uptake by rice *(Oryza sativa* L.). Among the different cellulo-azoto-bacterio compost treatments, rice-straw compost @ 6 t/ha inoculated with *Azotobacter* + phosphous solublizing bacteria (PSB) along with NPK registered significantly higher plant height, leaf-area index and yield attributes (panicles, panicle length, grains/panicle and test weight), and gave 21.17% increase in grain and 15.36% in straw yields compared with NPK (120 kg N, 60 kg P_2O_5, 60 kg K_2O/ha). This treatment also gave the highest net returns (Rs 18,946/ha). Application of rice-straw compost inoculated with cellulolytic fungi + *Azotobacter* + PSB along with NPK was also equally effective as rice-straw compost inocluated with *Azotobacter* + PSB (cellulo-azoto-bacterio compost) along with NPK in terms of leaf-area index, number of panicles, grains/panicle, test weight and K uptake by rice. Fortified compost with *Azotoacter* and PSB + NPK also maintained soil fertility, as indicated by higher contents of organic carbon, available nitrogen, phosphorus and potassium. However, values of these parameters showed declining trend with recommended level of NPK (control).

Key words : Fortified, Soil fertility, Compost, Rice yield, Nutrient uptake.

Rice *(Oryza sativa* L.) is the premier food crop not only of India but also of the world. India is its second largest producer, covering 45 millions ha area with 89.5 million tonnes production, contributing 45% of the total cereal production. Of the several productivity factors, fertilizer has been recognized as the most important. The high annual plant-nutrient removal by the crops and cropping systems than the added amount through the fertilizers has resulted in a negative nutrient balance (Yadav *et al.*, 2000). Recently the decline in yield was found to be related to soil properties effected by prolonged soil wetness or soil-nutrient depletion (Dawe *et al.*, 2000). Therefore there is need to supplement these with organic sources, more particularly biofertilizers as these are cheaper, eco-friendly and renewable (Mukherjee and Rai, 2000). The integrated approach of nutrient supply through conjunctive use of organic, enriched and unenriched rice-straw compost along with inorganics may not only reduce the dependence on chemical fertilizers but also improve the soil structure, encourage the growth and activity of mycorrhizae and other beneficial organisms in the soil, alleviate the deficiency of secondary and micronutrients, sustaining higher crop productivity due to improved soil health. Hence the present experiment was conducted to study the effect of fortified and non-fortified rice-straw composts in combination with NPK on the growth, yield and nutrient uptake by rice.

MATERIALS AND METHODS

The field experiment was conducted during the rainy season of 2002 and 2003 on same piece of land (fixed plot) on sandy clay-loam soils of the Research Farm, at Varanasi. The soil was slightly alkaline, having pH 7.2; organic carbon 0.46%, and the available N 180.2, phosphorus 19.3 and K 206.3 kg/ha. There were 10 treatments, viz. T_1, NPK + rice-straw compost (RSC); T_2, NPK + cellulo-compost; T_3, NPK + azoto-compost; T_4, NPK + bacterio-compost; T_5, NPK + cellulo-compost + azoto-compost; T_6, NPK + cellulo-compst + bacterio-compost; T_7, NPK + azo + bacterio-compost; T_8, NPK + cellulo-compost + azoto-compost + bacterio-compost; T_9, NPK + enriched RSC with synthetic fertilizers; and T_{10}, NPK alone. These treatments were laid out in randomized block design replicated thrice. Rice variety 'Samba Mahsuri' ('BPT 5204') was taken as the test crop. Seedlings at 27-28 days were transplanted in puddled field at

20 × 10 cm spacing. Half the amount of nitrogen (60 kg N/ha) in the form of urea was applied basal and the remaining was applied in two equal splits at tillering (30 kg N/ha) and panicle-initiation (30 kg N/ha) stages. The full quantity of P through diammonium phosphate and K through muriate of potash were applied basal. The rice-straw compost, treated with different bio-inoculants, to enrich its fertiliser value, was applied @ 6 t/ha as per treatment a month before transplanting. Rice-straw compost, rice-straw compost enriched with synthetic fertilizers and bio-inocluants were prepared as suggested by Singh (2001) and Gaur (1999) respectively. Rice straw was brought from threshing floor in bundles of convenient weight (10-15 kg) to composting pits. These pits were irrigated frequently to maintain moisture level of 80-100 per cent.

In the pits (3 m length × 2 m breadth × 1 m height) rice straw was spread layer after layer, each having a thickness of 15 cm. On each layer, urea solution (1 kg urea for 1,000 litres water) was spread maintaining 80-100 per cent moisture. The material was turned thrice during the entire composting period; the first two turnings were given at interval of 15 days and the third after 30 days. At each turning the material was moistened with water and again placed in the pit.

For enrichment of rice-straw compost with synthetic fertilizer, the composition of salt solution used was gypsum 12 kg, single superphosphate (SSP) 6 kg, magnesium sulphate 4 kg, iron sulphate 500 g, zinc sulphate 200 g, magnesium chloride 15 g, copper sulphate 7 g, boric acid 70 g, ammonium molybdate 5 g and cobalt sulphate 7 g for 1 tonne composting biomass. These were dissolved in 1,000 litres water and sprayed on composting mass as single dose at 30 days stage after initiation of composting process.

For enrichment of rice-straw compost with bio-inoculants, the rice-straw compost was treated with suitable culture of nitrogen-fixing bacteria *(Azotobacter chroococcum),* phosphorus-solubilizing fungi (PSF : *Trichoderma viridae)* and phosphorus-solubilizing bacteria (PSB; *Bacillus polymyxa)* to obtain the enriched quality compost (Gaur, 1999). Rice straw was collected and chopped to 5-6 cm size and brought to the composting pit. Low-grade rock phosphate (1%) was added to organic residues to narrow down the C:P ratio and to improve the phosphorus content of the compost. The most effective celluloytic fungal culture of *Trichoderma viridae* was then inoculated @ 300 g/t and *Bacillus polymyxa* @ 500 g/t of raw material. Carrier-based inoculants of *Azotobacter* was applied to raise their number to 100 × 06/ 100 kg organic material. The celluloytic fungi were inocluated at the start of composting, whereas the nitrogen fixers and phosphate solublizers were given 30 days after initial composting. After every 15 days, the composting mass was turned upside down for proper aeration and decomposition at optimum moisture level of 80-100%. The fully decomposed compost was removed from the pit for application.

Factor productivity was worked out as suggested by Cassman *et al.*(1996). After the harvest of rice crop, commercial wheat crop was taken in winter *(rabi)* season.

RESULTS AND DISCUSSION

Growth, yield attributes and yield

Growth parameters were significantly influenced by different fortified and non-fortified rice-straw composts superimposed over NPK compared with the control (NPK only). The treatments comprising rice-straw compost inocluated with *Azotobacter* and PSB along with NPK significantly increased the plant height over other treatments (Table 1). The former (T_7) also proved superior in leaf-area index to others except NPK + cellulo- + azoto-compost + bacterio-compost and NPK + cellulo-bacterio compost (T_8) and NPK + cellulo-compost +azoto-compost (T_6), NPK (T_{10}) alone was significantly inferior to others in respect of these traits. The favourable effect of rice-straw compost treated with bio-activators on growth parameters might be attributed to decomposition of rice-straw compost, liberating carbon that might have increased the activities of heterotrophic bacteria and fungi in the soil, which in turn increased the activity of soil enzymes responsible for the conversion of unavailable from of nutrients to available forms. *Azotobacter* and PSB not only provided nitrogen and phosphate but also produced amino acids, vitamins and growth-promoting substances like indole acetic acid (IAA) and gibberellic acid (GA), which might have promoted crop growth (Bardiya and Gaur, 1974; Chonkar and Tilak, 1997).

Fortified and non-fortified rice-straw compost superimposed over NPK showed significant variation in the yield-attributing characters and the grain and straw yields of rice (Table 1). Incorporation of rice-straw compost inoculated with *Azotobacter* + PSB in combination with NPK proved significantly superior to other treatments except NPK + cellulo-compost + azoto-compost + bacterio-compost for number of panicles/m^2 and grains/panicle. Moreover, the former was significantly superior to others for panicle length, but it failed to improve the test weight over T_8, T_6 and T_5. Superimposition of rice-straw compost inoculated with bio-activators showed marked effect on grain and straw yields of rice. Maximum yield was obtained with application of rice-straw compost inoculaed with

Azotobacter + PSB along with NPK, which was significantly higher than other treatments as well as NPK alone. Similarly, NPK + cellulo-compost + bacterio-compost was significantly superior to others, except NPK + cellulo-compost + bacterio-compost for grain yield; and NPK + cellulo-compost + bacterio-compost over NPK + cellulo-compost + azoto-compost compost for straw yield. The increase in grain yield was attributed to significant improvement in panicles/m^2, grains/panicle and test weight. The efficient supply of nurients delayed the senescence and increased the life-cycle of the plant, which resulted in higher economic yield (Singh *et al.*, 2005). Singh (2001) also obtained enhanced grain and straw production with addition of straw compost, *Azotobacter chroococum, Bacillus polymixa* (PSB) and *Trichoderma.* Improved yield due to superimposition of fortified rice-straw compost with bio-activators over NPK may be attributed to improved status of NPK, as a result of enhanced microbial activity, leading to improved nitrogen fixation, phosphate solubilization and availability of micronutrients (Fe, Mn, Zn, Cu) as well as improved soil condition (Gaur, 1999).

Table 1. Effect of forified and unfortified rice-straw compost with NPK fertilizer treatments on growth, yield parameters, yield net return and factor productivity of rice (pooled daa of 2 years)

Treatment	Growth parameter		Yield attribute				Yield (t/ha)		Factor productivity (kg grain/ kg NPK)	Net return (Rs/ha)
	Plant height (cm) at harvest	Leaf-area index at 100 DAT	Panicles/ m^2	Panicle length (cm)	Grains/ panicle	Test weight (g)	Grain	Straw		
T_1 NPK + rice-straw compost	97.8	4.21	401.8	18.79	124.7	20.30	4.54	7.47	13.4	12,898
T_2 NPK + cellulo-compost	98.7	4.33	403.4	18.86	135.9	20.58	4.57	7.53	13.5	13,026
T_3 NPK + azoto-compost	99.6	4.45	410.8	19.09	147.3	21.02	5.00	7.66	14.7	15,283
T_4 NPK + bacterio-compost	101.2	4.58	412.4	19.33	147.4	21.15	5.06	7.85	14.9	15,724
T_5 NPK + cellulo-compost + azoto-compost	102.0	4.72	415.5	19.53	149.9	21.30	5.15	7.94	15.2	16,157
T_6 NPK + cellulo-compost + bacterio-compost	102.1	4.99	421.7	19.77	155.8	21.43	5.29	8.00	15.6	16,927
T_7 NPK + azoto-compost + bacterio-compost	102.4	5.27	425.7	22.07	167.0	22.22	5.62	8.62	16.5	18,946
T_8 NPK + cellulo-compost + azoto-compost + bacterio-compost	102.1	5.09	422.1	20.51	165.0	21.60	5.39	8.15	15.8	17,435
T_9 NPK + enriched RSC with synthetic fertilizer	99.0	4.36	406.0	18.96	147.1	21.01	4.93	7.60	14.5	14,770
T_{10} NPK alone	95.9	3.68	396.2	18.31	125.4	19.13	4.43	7.30	20.1	14,022
CD (P=0.05)	2.1	0.30	3.9	1.25	6.6	1.03	0.21	0.32	-	1,694

Table 2. Effect of fortified and unfortified rice-straw compost with NPK fertilizer treatments on nutrient status of soil after rice harvest and NPK uptake by rice (pooled data of 2 years)

Treatment	Nutrient status of soil				Total nutrient uptake		
	Organic C (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	N	P	K
T_1	0.49	181.43	20.10	213.53	68.23	13.22	109.52
T_2	0.50	182.22	20.27	215.34	69.67	14.37	110.23
T_3	0.51	185.18	20.78	220.77	75.26	15.53	114.18
T_4	0.51	186.65	20.95	222.58	78.31	14.82	117.82
T_5	0.52	188.16	21.12	224.39	79.74	15.04	120.90
T_6	0.52	189.65	21.29	226.45	83.56	17.06	124.40
T_7	0.57	194.83	22.63	234.52	90.75	18.07	139.20
T_8	0.53	190.14	21.46	228.01	85.73	16.93	130.70
T_9	0.50	183.59	20.61	218.96	73.65	14.53	112.60
T_{10}	0.48	180.34	19.59	210.49	67.05	13.18	106.23
CD (P=0.05)	0.04	NS	NS	NS	3.81	0.97	10.15
Initial value	0.46	180.0	19.30	206.30			

Note: Details of treatments are given with Table 1

Nutrient uptake

The differences in uptake of NPK by the crop were statistically significant due to different treatments (Table 2). Application of rice-straw compost (RSC) inoculated with *Azotobacter* + PSB along with NPK caused significant improvement in total N, P and K uptake by rice over other treatments. However, differences in K uptake due to rice-straw compost inoculated with *Azotobacter* + PSB along with NPK and RSC inoculated with fungi + *Azotobacter* + PSB in combination with NPK were at par. However, the former was significantly superior to others. The later also proved significantly superior to others except NPK + cellulo-compost + azoto-compost (T_6) in this respect. The increase in total nitrogen and phosphorus uptake was ascribed to increase in the available N, P and K contents in the soil, resulting from increased availability of nutrients and improvement in soil structure, texture and tilth, creating better environment for higher uptake of nutrients.

Soil fertility

There was a marginal change in the organic carbon and the available N, P and K of soil after rice harvest (Table 2). The fortified RSC improved he chemical status of soil, which was maximum with RSC inocluated with *Azotobacter* + PSB along with NPK for the organic carbon and the available N, P and K in soil, whereas chemical status of the soil declined marginally with NPK application alone.

Economics

Superimposition of rice-straw compost and rice-straw compost prepared with cellulo-compost or azoto-compost or bacterio-compost did not show much effect compared with NPK alone. Superimposition of either two or three of cellulo-compost, azoto-compost and bacterio-compost in combination with NPK increased the net returns. The highest net returns were observed with the treatment having superimposition of azoto-bacterio compost over NPK. However, the response of cellulo-compost or azoto-compost or bacterio-compost was statistically on a par with the treatment having cellulo-compost, azoto-compost and bacerio-compost over NPK.

Superimposition of composts prepared through bio-inoculants did not affect factor productivity.

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