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Research Communication

Effect of nitrogen, compost and plant growth promoting rhizobactria on yield and nutrient uptake by rice (*Oryza sativa*)

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ABSTRACT

A field experiment was conducted in wet season of 2011 at New Delhi to study the effects of plant growth promoting rhizobacteria (PGPR) inoculation in different combinations with N-levels through urea and compost on yield and nutrient uptake by *basmati* rice cv. 'Pusa Basmati 1401'. Results showed that highest grain (5.02 t/ha) and straw (8.87 t/ha) yield was obtained with the application of 2/3N (80 kg N/ha) + bacterial inoculant (BI) + cyanobacteria inoculant (CI) + compost (5.0 t/ha). The uptake of N in grain (69.1 kg/ha) and straw (60.5 kg/ha) were the highest with the application of 2/3 N + BI + CI + compost (5.0 t/ha). Protein content in grain varied between 6.84% (N_0) and 8.20% (2/3 N + CI + BI + compost). Highest uptake of P, K, Fe, Zn and Cu in rice grain and straw were recorded with 2/3N + BI + CI + compost (5.0 t/ha). The nutrients uptake was significantly higher in integrated application than single inoculation of bio-inoculants.

Key words : *Basmati* rice, Micronutrient uptake, NPK uptake, PGPR

Microbial inoculants are promising components for integrated solutions to agro-environmental problems because they possess the capacity to promote plant growth, enhance nutrient availability and uptake and support the health of plants by active participation in almost every chemical transformation taking place in soil (Adesemoye *et al*., 2008). Plant growth-promoting rhizobacteria (PGPR) are beneficial bacteria that colonize plant roots and enhance plant growth by a wide variety of mechanisms. Plant-PGPR interactions have shown to increase root growth, yield, nutrient uptake and protein content (Bakker *et al.*, 2007). PGPR strains enhance phosphorus availability (Rodriguez and Fraga, 1999) and iron sequestration for plants by production of siderophores (Bakker *et al.*, 2007). Cyanobacteria have been widely employed as inoculants for enhancing soil fertility and improving soil structure, besides enhancing rice yield (Singh *et al.*, 2011). However, the information on effect of PGPR on nutrient concentration and uptake of rice crop are generally lacking. Therefore, field investigation was conducted to evaluate the influence of PGPR inoculation in combination with inorganic N-levels and compost on yield and nutrient uptake in rice.

The experiment was conducted during wet season of 2011 at Indian Agricultural Research Institute, New Delhi. The soil of experimental field had 145.3 kg/ha alkaline permanganate oxidizable N, 15.37 kg/ha available P, 254.2 kg/ha 1 N ammonium acetate exchangeable K, 0.52% soil organic carbon and 7.7 pH. The experiment was laid out in randomized block design with twelve treatments replicated thrice. The treatments included: T_1: N_0; T_2: 2/3 N(80 kg/ha) through urea; T_3: N_{120} (recommended dose of N @ 120 kg/ha through urea); T_4: 2/3 N + compost at 5.0 t/ha; T_5: 2/3 N + bacterial inoculants(BI); T_6: 2/3 N + BI + compost at 5.0 t/ha; T_7: 2/3 N + cyanobacterial inoculants (CI); T_8: 2/3N + CI + compost at 5.0 t/ha; T_9: 2/3N + CI + BI; T_{10}: 2/3N + BI + CI + compost at 5.0 t/ha; T_{11}: 2/3N + *Multani mitti* based blue green algae (BGA) biofertilizer and T_{12}: 2/3N+ compost at 5.0 t/ha + *Multani mitti* based BGA biofertilizer. Urea was the source of N for N application. In this study, one bacterial (*Providencia* sp. PW5), one cyanobacterial strain (*Anabaena* sp. CR3) and *Multani mitti* based BGA biofertilizer (composite culture of *Anabaena, Nostoc, Tolypothrix* and *Aulosira sp.*) were applied at 2.0 kg/ha. After puddling 21 days old seedlings of rice cv. 'Pusa Basmati 1401' were transplanted at 20 cm × 10 cm spacing keeping 2 seedlings/hill. Recommended dose of P and K was applied in all the

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treatments. Concentrations and uptake of NPK and micronutrients (Fe, Zn and Cu) in grain and straw of rice samples were determined by standard procedure.

Results showed that grain and straw yields of *basmati* rice significantly increased due to the inoculation of PGPR and BGA with compost at 5.0 t/ha and chemical N fertilizer (120 and 80 kg N/ha through urea) over N control (Table 1). Highest grain yield (5.02 t/ha) was obtained with the application of 2/3N + BI + CI + compost at 5.0 t/ha and this was at par with N_{120} and 2/3 N + compost (C) + BGA and significantly different from other treatments. Highest straw yield (8.87 t/ha) was obtained with the application of 2/3 N + BI + CI + compost at 5.0 t/ha and it was at par with N_{120}, 2/3 N + BI + compost at 5.0 t/ha, 2/3 N + CI + compost at 5.0 t/ha, 2/3 N + BI + CI, 2/3 N + BGA and 2/3 N + C + BGA and significantly different from other treatments. Response of combined inoculation of bacterial and cyanobacterial was better when these were inoculated with compost compared to without compost inoculation. Singh *et al.* (2011) also found significantly increased rice yield due to inoculation with BGA. Khan and Zaidi (2007) reported 133% higher yield of wheat due to combined inoculation with *Bacillus* sp. (PGPR) and *Glomus fasciculatum* (AMF) over their single application.

The uptake of N in grain and straw of *basmati* rice increased significantly due to the integrated application of bacterial and cyanobacterial PGPR with compost at 5.0 t/ha, BGA and chemical N fertilizer (80 and 120 kg N/ha) over N_0 control (Table 1). Highest uptake of N in grain (69 kg/ha) and straw (61 kg/ha) was found due to the combined inoculation of 2/3 N + BI + CI + compost at 5.0 t/ha followed by 2/3 N + compost + BGA, 2/3 N + CI + BI, 2/3 N + CI + compost at 5.0 t/ ha, 2/3 N + BI + compost at 5.0 t/ha in that order and these uptake were significantly higher than single inoculation of bio-inoculants. Adesemoye *et al.* (2008) confirmed that inoculation with mixed strains were more consistent than single strain inoculations. In addition to improvement of plant growth and yield, PGPR are directly involved in increasing concentration and uptake of nitrogen, synthesis of phytohormones and solubilization of minerals such as phosphorus and production of siderophores that chelate iron and make it available to the plant root (Bowen and Rovira, 1999). Choudhary *et al.* (2010) found significant effect of PGPR on N concentration in grain and straw of rice. Singh *et al.* (2011) reported significantly increased N concentration and uptake in grain and straw of rice due to the application of BGA.

Uptake of P and K in grain and straw of rice increased due to the integrated application of bacterial and cyanobacterial PGPR, compost, BGA and chemical N fertilizer (80 and 120 kg N/ha) over N_0 (Table 1). But the

Table 1. Effect of PGPR on yield, protein content in grains and uptake of N, P, K, Fe, Zn and Cu in grain and straw of *basmati* rice.

Treatment	Yield (t/ha)		Protein content	N–uptake (kg/ha)		P–uptake (kg/ha)		K–uptake (kg/ha)		Fe–uptake (g/ha)		Zn–uptake (g/ha)		Cu–uptake (g/ha)	
	Grain	Straw	(%)	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
N_0	2.64	5.39	6.84	30.3	25.4	3.6	5.4	7.6	78.9	182	1,816	37	467	23	176
2/3 N(80 kg/ ha)	4.18	7.94	7.05	49.6	44.9	5.9	8.4	12.5	118.1	299	2,760	62	761	41	298
N_{120}	4.79	8.71	8.00	64.3	57.3	6.9	9.5	15.0	130.5	396	3,596	100	1,028	61	337
2/3 N + C	4.54	8.34	7.59	58.0	49.8	6.7	9.3	14.6	124.7	356	3,084	76	851	48	320
2/3 N + BI	4.23	8.26	7.34	52.1	47.3	6.1	10.1	13.1	125.2	317	3,020	73	804	46	315
2/3 N + BI + C	4.66	8.62	7.65	60.0	52.9	6.7	10.7	15.0	132.8	411	3,449	106	1,006	53	360
2/3 N + CI	4.35	8.42	7.43	54.3	51.3	6.3	9.4	14.0	128.3	349	3,089	96	838	45	310
2/3 N + CI + C	4.69	8.63	7.73	60.9	53.9	7.0	10.8	15.4	132.2	410.0	3,312	96	985	54	339
2/3 N + CI + BI	4.58	8.56	7.74	59.5	51.1	6.7	10.6	14.7	131.7	368	3,201	89	911	50	327
2/3 N + BI + CI + C	5.02	8.87	8.20	69.1	60.5	7.7	11.6	18.3	139.0	457	3,818	121	1,078	65	406
2/3 N + BGA	4.53	8.57	7.65	58.2	49.8	6.7	10.4	14.6	131.0	375	3,153	84	885	49	343
2/3 N + C +BGA	4.78	8.65	7.80	62.6	56.0	7.2	10.9	15.9	132.7	412	3,379	92	978	54	362
SEm±	0.10	0.12	0.26	2.08	2.26	0.22	0.53	0.47	2.07	14.5	135.8	9.0	25.9	4.7	18.8
CD (P=0.05)	0.28	0.36	0.78	6.10	6.70	0.63	1.56	1.40	6.10	42.5	398.3	26.3	76.1	13.6	55.0

C: Compost @ 5.0 t/ha; BGA: BGA biofertilizer @ 2.0 kg/ha; BI: Bacterial inoculation; CI: Cyanobacterial inoculation

response of PGPR on P and K was lower compared to N. Uptake of P and K in grain and straw was the highest in treatment having application of 2/3 N + BI + CI + compost at 5.0 t/ha. Singh *et al.* (2011) also found significant effect of BGA application on concentration and uptake of P and K in grain and straw of rice. Choudhary *et al.* (2010) reported that inoculation of rice with PGPR was beneficial with respect to P and K concentration in grain and straw over non-inoculated control. Biswas *et al*. (2000) reported significantly increased P uptake in rice due to rhizobial inoculation compared to control.

Uptake of Fe, Zn and Cu in grain and straw of rice increased significantly due to the integrated application of PGPR, compost, BGA and chemical N fertilizer (80 and 120 kg N/ha) over N_0 (Table 1). The highest Fe uptake in grain (457 g/ha) and straw (3818 g/ha) was recorded with inoculation of 2/3N + BI + CI + compost at 5.0 t/ha and this uptake was significantly higher than all other treatments. Inoculation with 2/3N + BGA biofertilizer, 2/3N + CI + BI, 2/3N + CI + compost at 5.0 t/ha, 2/3 N + CI, 2/3 N + BI, 2/3 N also showed higher Fe uptake compared to 2/3N and N_o. The highest total Fe uptake (4,275 g/ha) was recorded with the 2/3 N + BI + CI + compost at 5.0 t/ha. Uptake of Zn and Cu in grain and straw at N_{120} was significantly higher than N_{80} and N_0. Highest uptake of Zn and Cu were recorded with the inoculation of 2/3 N + BI + CI + compost at 5.0 t/ha. But the response of PGPR on Zn and Cu uptake was lower compared to Fe uptake. Singh *et al.* (2011) also found significant effect of BGA application on Fe and Zn concentration and uptake in grain and straw of rice.

It is concluded that yield and uptake of N, P, K, Fe, Zn and Cu in grain and straw of rice increased significantly due to the integrated application of bacterial and cyanobacterial PGPR with compost and 2/3 N (80 kg N/ha) through fertilizer. So, PGPR can be used to enhance the productivity and quality of rice.

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