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Yield and nutrient removal of basmati rice as influenced by NPK levels and Bio-fertilizers

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Abstract
A field experiment was conducted at Agricultural Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh during *kharif* season, 2015 to evaluate the effect of different NPK levels and bio-fertilizers on yield attributes, yield, nutrient content and removal by basmati rice cv. HUBR 10-9. Factorial experiment was laid out in randomized complete block design involving two factors i.e. four NPK levels (control, 50% RDF, 75% RDF and 100% RDF) and three bio-fertilizer levels (BGA, PSB and BGA + PSB), replicated three times. Results revealed that increasing NPK levels up to 100% RDF (120-60-60 kg ha^{-1}) significantly improved yield attributes, grain yield and straw yield as well as nutrient content and removal by grain and straw. Combined application of BGA + PSB proved significantly superior to both BGA and PSB in respect of grain yield, straw yield, NPK content and removal. However, sole application of either BGA or PSB produced comparable results regarding yield attributes and yield. Integration of 100% RDF along with BGA + PSB performed best in achieving higher productivity. Hence, the study suggests that higher fertilizer dose when integrated with bio-fertilizers resulted in better performance of the crop.

Keywords: BGA, FYM, NPK Levels, PSB, Rice

Introduction
Rice is the prime food for about 2.7 billion people, mainly belongs to Asia (Hussain *et al*., 2008) [7]. Applying inorganic fertilizers even in balanced amount cannot sustain soil fertility and crop productivity under diversified cropping / mono cropping as a result agriculture is now facing lot of stresses (Kundu *et al.*, 2010) [10]. Improvement in nutrient use efficiency and there by stabilizing productivity and profitability are the issues of prime concern. Such issues may be addressed efficiently by adopting integrated nutrient management which emphasizes use of inorganic fertilizers, farmyard manure and bio-fertilizers to increase the productivity in a sustainable manner. Use of farmyard manure also augments the response of the bio-fertilizers, supplies essential nutrients, improves soil health and enhances yield on sustained basis (Jobe, 2003) [9]. Blue Green Algae (BGA) are alternative source of nitrogen to the chemical fertilizers and are eco-friendly and cost effective. Blue green algae can contribute up to 20-25 kg N ha^{-1} to rice crop and increases the yield to the extent of 10-12 per cent (Hedge and Dwivedi, 1993) [6]. BGA also liberate growth promoting substances like auxin and amino acids which is helpful for rice growth. It also adds organic matter and improves aeration to paddy roots. Phosphate solubilising bacteria (PSB) as a bio-fertilizer, has the capacity to solubilise and mineralize the residual or fixed phosphorous, increases the availability of phosphorus in the soil, produces growth substances like indole acetic acid and gibberellins thus, increases the overall phosphate use efficiency and increase rice yield (Chhonkar and Tilak, 1997; Gull *et al.*, 2004) [3, 5]. Indian farmers are resource poor and cannot afford chemical fertilizers due to escalating prices. However, it is imperative to use technologies in an integrated manner so that the potential of wetland rice could be realized on sustained basis.
The objective of the present study was to investigate the effect of NPK levels and bio-fertilizers on yield attributes, yield, NPK content and removal by basmati rice under wetland condition of eastern Uttar Pradesh.

Materials and methods
The experiment is planned with 2 factors consisting four NPK levels i.e. control, 50% RDF, 75% RDF and 100% RDF and three levels of bio-fertilizers viz. BGA, PSB and BGA + PSB with 12 treatment combinations in a factorial randomized block design with three replications at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University,

Varanasi, Uttar Pradesh during the rainy season, 2015. The soil of the experimental field was sandy clay loam in texture, neutral in reaction (pH 7.55) (Jackson, 1973) [8], low in organic carbon (0.38%) (Walkley and Blak, 1934) [19], medium in available nitrogen (288.17 kg ha^{-1}) (Subbiah and Asija, 1956) [18], low in available P_2O_5 (18.40 kg ha^{-1}) (Olsen *et al*., 1954) [14] and medium in available K_2O (184.40 kg ha^{-1}) (Jackson, 1973) [8]. Well decomposed FYM @ 2 tonnes ha^{-1} applied two days prior to transplanting uniformly to all the treatments. Recommended dose of fertilizer (RDF) N-P_2O_5-K_2O (120-60-60 kg ha^{-1}) was used for the experimental crop. The sources of fertilizers for NPK were urea (46% N), di-ammonium phosphate (18% N and 46% P_2O_5) and muriate of potash (60% K_2O). One third of the recommended dose of nitrogen was applied at planting and the remaining two third was applied in two equal splits at active tillering and panicle initiation stages. Full dose of phosphorus and potassium were applied as basal as per treatments to their respective plots. Four week old seedlings of rice were transplanted on the puddled field keeping two seedlings hill^{-1} at a spacing of 20 cm × 15 cm. BGA was applied one week after transplanting @10 kg ha^{-1} in the respective treatments. Liquid PSB culture was applied by dipping the seedling roots in solution for about twenty minutes and thereafter transplanted immediately to their respective plots. Experimental crop received 871.5 mm rainfall throughout the crop period, and about ± 5 cm water level was continuously maintained till flowering. Recommended agronomic practices were followed to raise the experimental crop. The data recorded were analyzed following standard statistical analysis of variance procedure as suggested by Gomez and Gomez (1984) [4].

Results and discussion

Yield attributes and yield

Increasing NPK levels significantly increased panicle length, panicle weight and 1000-grain weight up to 75% RDF. Further increment in NPK level (100% RDF) though increased the values but remained at par with 75% RDF. Number of panicles m^{-2}, grain and straw yield increased significantly with each increment in the NPK level up to the highest level of 100% RDF which registered maximum grain yield (5716 kg ha^{-1}) and straw yield (8418 kg ha^{-1}). Continuous supply of nutrients in balanced amount throughout the growth period augmented production of sufficient photosynthates and their effective translocation from source to sink resulted in better yield attributes, grain and straw yield. Similar findings were also reported by Singh *et al.* (2014) [16] and Patel *et al.* (2015) [15]. Various bio-fertilizers significantly affected number of panicles m^{-2}, length and weight of panicle, 1000-grain weight, grain and straw yield. The maximum value for these parameters was found associated with combined use of BGA + PSB which was significantly higher than the sole application of BGA and PSB. However, sole application of BGA produced lowest number of panicles m^{-2}, panicle length and weight, 1000-grain weight, grain and straw yield which is statistically at par with sole application of PSB. Yield enhancement due to combined application of BGA + PSB was due to balanced nutrient supply, N fixation or phosphate solubilisation, and also because of several other factors such as release of growth promoting substances, control of plant pathogens and proliferation of beneficial organisms in the rhizosphere. Increased values of yield attributes, grain and straw yield may be ascribed to combined application of bio-fertilizers which might enhance soil microbial population resulting better root proliferation, nutrients availability and their uptake, ultimately led to the better dry matter production and its distribution in the crop. The result substantiates the findings of Meena *et al.* (2015) [11] and Nanda *et al*. (2016a) [13].

Table 1: Effect of NPK levels and bio-fertilizers on yield attributes and yield of basmati rice

Treatments	Number of panicles m^{-2}	Panicle length (cm)	Panicle weight (g)	1000-grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
NPK levels (% RDF)						
0	268.79	21.68	2.56	19.98	3690	5436
50	303.72	23.38	3.08	21.58	4785	7048
75	319.83	24.19	3.31	22.46	5303	7813
100	330.67	24.69	3.45	22.97	5716	8418
SEm±	3.36	0.18	0.06	0.19	90	133
CD (*P*=0.05)	9.88	0.53	0.18	0.56	265	391
Bio-fertilizers						
BGA	299.72	23.27	3.01	21.52	4757	7002
PSB	302.14	23.34	3.04	21.57	4809	7091
BGA+PSB	315.40	23.84	3.26	22.12	5055	7443
SEm±	2.91	0.16	0.05	0.16	78	116
CD (*P*=0.05)	8.56	0.45	0.16	0.48	229	339

NPK content

NPK content in grain and straw is affected due to different NPK levels and bio-fertilizers. Maximum NPK content in grain and straw recorded with 100% RDF. Nitrogen content increased with increase in the levels of NPK up to the maximum dose of 100% RDF. Application of NPK up to 75% RDF significantly increased the nitrogen content in grain and straw. However, 75% and 100% RDF were statistically comparable and both proved significance to 50% RDF and control treatment. Maximum phosphorus content in grain and straw was found under application of highest NPK level (100% RDF) which exhibited its significance over other treatments. Higher potassium content in grain and straw was found under application of highest NPK level (100% RDF) which could not differ with 75% NPK and both of them were superior to other levels tried. The increase in the nutrient content with the increasing doses of NPK may be due to better availability of these nutrients because of added supply and prolific root system developed by the balanced application of nutrients, resulting in better absorption of nutrients (Brar *et al.*, 1995) [2]. Among the bio-fertilizers, combined use of BGA + PSB recorded maximum N, P and K in grain and straw. Nitrogen content in grain and straw was maximum with combined use of BGA + PSB being at par with BGA alone, was significantly superior over sole application of PSB. However, in case of phosphorus content

in grain and straw, combined use of BGA + PSB resulted in maximum value which was at par with the sole application of PSB which was significantly superior over BGA alone. Potassium content in grain and straw was recorded maximum with the application of BGA + PSB which was significantly superior over others. Increased NPK content is due to positive and combined effect of BGA and PSB that increased NPK availability to plant resulted higher NPK content in grain and straw. Similar findings have been reported by Bhat *et al.* (2005) [1].

Table 2: Effect of NPK levels and bio-fertilizers on nutrient content of basmati rice

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
NPK levels (% RDF)						
0	1.11	0.33	0.294	0.050	0.261	1.18
50	1.28	0.42	0.349	0.076	0.299	1.35
75	1.36	0.47	0.364	0.088	0.323	1.45
100	1.41	0.50	0.372	0.094	0.335	1.51
SEm±	0.02	0.01	0.002	0.001	0.005	0.02
CD (*P*=0.05)	0.05	0.03	0.006	0.004	0.015	0.07
Bio-fertilizers						
BGA	1.30	0.43	0.335	0.073	0.303	1.36
PSB	1.26	0.40	0.348	0.078	0.296	1.33
BGA+PSB	1.32	0.44	0.351	0.080	0.316	1.42
SEm±	0.01	0.01	0.002	0.001	0.004	0.02
CD(*P*=0.05)	0.03	0.02	0.005	0.003	0.013	0.06

NPK removal

Maximum NPK removal by grain and straw was recorded with 100% RDF while the minimum removal was noticed with the control treatment. Increasing NPK levels up to 100% RDF resulted significantly increase in NPK removal by grain and straw over all the treatments. The increase in the uptake of nutrients with increasing dose of NPK seems because of greater availability of these nutrients and prolific root system developed due to balanced and timely application of nutrients, resulting better absorption of nutrients (Brar *et al.*, 1995) [2] which found similar to the findings of Srivastava *et al.* (2014) [17]. Among bio-fertilizers, combined use of BGA + PSB removed higher N, P and K by grain and straw. However nitrogen removal by combined use of BGA + PSB being at par with BGA alone, was significantly superior over PSB. Whereas, in case of phosphorus removal the combined use of BGA + PSB was at par with the sole application of PSB which was significantly superior over BGA alone. The potassium uptake by both grain and straw recorded highest with the application of BGA + PSB which was however, significantly superior over others. This might be due to the cumulative and synergistic effect of bio-fertilizer sources resulting increased uptake of nutrients. These findings are in close conformity with Nanda *et al.* (2016b) [12].

Conclusions may be drawn on the basis of results of the present investigation that integration of highest NPK level (100% RDF) along with BGA+PSB gave most remunerative for achieving higher growth attributes, grain yield, straw yield and higher content and removal of NPK in grain and straw.

Table 3: Effect of NPK levels and bio-fertilizers on nutrient removal of basmati rice

Treatments	Nitrogen removal (kg ha^{-1})		Phosphorus removal (kg ha^{-1})		Potassium removal (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
NPK levels (% RDF)						
0	41.45	17.60	10.90	2.70	9.72	64.65
50	61.67	30.23	16.75	5.37	14.34	95.03
75	72.06	36.50	19.36	6.86	17.10	113.46
100	79.60	41.77	21.37	7.93	19.12	126.61
SEm±	1.37	1.06	0.34	0.15	0.37	3.00
CD (*P*=0.05)	4.01	3.12	0.99	0.44	1.09	8.80
Bio-fertilizers						
BGA	63.92	32.13	16.21	5.13	14.64	97.17
PSB	60.08	29.01	17.16	5.74	14.44	95.82
BGA+PSB	67.07	33.44	17.91	6.08	16.12	106.82
SEm±	1.18	0.92	0.29	0.13	0.32	2.60
CD(*P*=0.05)	3.47	2.70	0.86	0.38	0.94	7.62

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