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Impact of Fertility Levels and Bio-Fertilizers on Growth, Yield and Economics of Basmati Rice

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A B S T R A C T

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 growth, yield attributes, yield and economics of 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 thrice. Increasing NPK levels up to 100% RDF improved growth parameters, yield attributes, grain yield, straw yield and net return over the rest of fertility levels. Combined application of BGA + PSB proved significantly superior over alone application of BGA or PSB for the traits studied. However, BGA and PSB were observed at par with each other regarding growth characters, yield attributes and yield. Integration of 100% RDF along with BGA + PSB performed best in achieving higher growth, productivity and profitability under eastern U.P. conditions.

Introduction

Rice (*Oryza sativa* L.) is the prime food crop for more than 65 per cent of the people and provides livelihood security to 70 per cent of Indian population (Kulkarni *et al.*, 2015). Rice occupies 43.9 million hectare with production of 106.5 million tonnes and average productivity of 2424 kg ha^{-1} (Anonymous, 2014). With the advent of ever increasing demand, future projections for rice production is to be 170-180 million tonnes with an average productivity of 4030 kg ha^{-1} by the year 2020 (Mishra *et al.*, 2006). As the land area decreasing with time, increasing land use intensity with inadequate and imbalanced use of chemical fertilizers with little or no use of organic manure have caused severe fertility deterioration resulting in stagnating or even declining crop productivity (Shormy *et al.*, 2013). Integrated use of inorganic fertilizers, bio-fertilizers and farmyard manure seem to be the practicable alternative to the present malady of unsustainable agriculture. Farmyard manure is easily available, cheap, proven source of nutrition to agricultural crops and has been used by the farmers traditionally. Besides supplying major and micronutrients it also improves the physical, chemical and biological properties of soil. Use of farmyard manure also augments the response of the bio-inoculants, supplies essential nutrients, improves soil health and enhances yield on

sustained basis (Jobe, 2003). Application of BGA inoculants could be the cheapest and easiest way to increase rice yield because of their capacity to fix atmospheric nitrogen in wetland rice (Begum *et al.,* 1994). Blue green algae has vital role in soil fertility improvement and consequently increasing growth and yield as a natural fertilizer (Song *et al.,* 2005). Phosphate solubilising bacteria (PSB) has the capacity to solubilise and mineralize the residual or fixed phosphorous, increases phosphorus availability in the soil, produces growth substances like indole acetic acid, and gibberellins thus, increases the overall phosphate use efficiency (Chhonkar and Tilak, 1997; Gull *et al.,* 2004). 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 this study was to assess the effect of NPK levels and bio-fertilizers on growth, yield and economics of basmati rice under wetland condition of eastern Uttar Pradesh.

Materials and Methods

A field experiment was carried out during *kharif* season of 2015 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh to study the effect of NPK levels and bio-fertilizers on growth, yield and economics of basmati rice cv. HUBR 10-9. Treatments consisted of four NPK levels i.e. control, 50% RDF, 75% RDF and 100% RDF and three bio-fertilizers levels viz. BGA, PSB and BGA + PSB with 12 treatment combinations replicated thrice in factorial RCBD. The soil of the experimental field was sandy clay loam in texture, neutral in reaction (pH 7.55) (Jackson, 1973), low in organic carbon (0.38%) (Walkley and Blak, 1934), medium in available nitrogen (288.17 kg ha^{-1}) (Subbiah and Asija, 1956), low in available P_2O_5 (18.40 kg ha^{-1}) (Olsen *et al.,* 1954) and medium in available K_2O (184.40 kg ha^{-1}) (Jackson, 1973). 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. 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). 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. Recommended dose of fertilizer (RDF) N-P_2O_5-K_2O (120-60-60 kg ha^{-1}) was used for the experimental crop. Well decomposed FYM @ 2 tonnes ha^{-1} applied two days prior to transplanting uniformly to all the treatments. BGA was applied one week after transplanting @10 kg ha^{-1} in the respective treatments. Liquid PSB culture diluted 10 times in distilled water and seedling roots were dipped in solution for about twenty minutes 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).

Results and Discussion

Growth parameters

In the present investigation, remarkable effect of NPK levels was noticed on growth parameters viz. plant height, number of tillers $hill^{-1}$ and dry matter production $hill^{-1}$ at

harvest (Table 1). Increasing NPK levels significantly increased plant height and number of tillers hill^{-1} at harvest from control to 100% RDF which registered maximum value. However, dry matter production hill^{-1} significantly improved up to 75% RDF and further increment in NPK level i.e. 100% RDF has produced the maximum value but could not produce difference with 75% RDF. Plants supplied with adequate amount of nutrients (100% RDF) produced more leaves and prolific roots which brought about greater accumulation of photosynthates, yielding more plant height, number of tillers hill^{-1} and dry matter production hill^{-1}. The results are in conformity with earlier reports (Nanda *et al.*, 2016). Growth parameters viz. plant height, number of tillers hill^{-1} and dry matter production hill^{-1} were significantly affected by bio-fertilizers.

Combined application of BGA + PSB recorded significantly higher growth parameters compared to sole application of BGA and PSB. Blue green algae excrete growth-promoting substances such as hormones (auxin, gibberellin), vitamins, amino acids (Rodriguez *et al.,* 2006). Phosphate solubilizing bacteria (PSB) solubilizes and mineralize the residual or fixed phosphorus, increases the phosphorus availability in soil, produces growth promoting substances and increases the overall phosphate use efficiency (Gull *et al.*, 2004). In present study, the cumulative effect of BGA + PSB was noticeable and this combined application maintained higher availability of nitrogen, phosphorus and other nutrients in soil. The results are in conformity with findings of Meena *et al.,* 2015.

Table.1 Effect of NPK levels and bio-fertilizers on growth characters of basmati rice at harvest stage

Treatments	Plant height (cm)	Number of tillers hill^{-1}	Dry matter production (g hill^{-1})
NPK levels (% RDF)			
0	86.20	8.28	24.11
50	95.11	9.71	28.14
75	99.91	10.41	30.45
100	103.35	10.93	32.03
SEm±	0.79	0.15	0.58
CD (*P*=0.05)	2.33	0.43	1.70
Bio-fertilizers			
BGA	95.33	9.32	28.10
PSB	95.47	9.67	28.17
BGA+PSB	97.63	9.99	29.76
SEm±	0.69	0.13	0.50
CD (*P*=0.05)	2.02	0.38	1.48

Table.2 Effect of NPK levels and bio-fertilizers on yield attributes and yield of basmati rice

Treatments	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	1000-grain weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
NPK levels (% RDF)					
0	98.88	32.95	19.98	36.90	54.36
50	121.98	25.78	21.58	47.85	70.48
75	133.60	23.23	22.46	53.03	78.13
100	142.89	21.44	22.97	57.16	84.18
SEm±	2.82	0.65	0.19	0.90	1.33
CD (*P*=0.05)	8.29	1.90	0.56	2.65	3.91
Bio-fertilizers					
BGA	120.86	26.63	21.52	47.57	70.02
PSB	122.12	26.44	21.57	48.09	70.91
BGA+PSB	130.03	24.48	22.12	50.55	74.43
SEm±	2.44	0.56	0.16	0.78	1.16
CD(*P*=0.05)	7.18	1.64	0.48	2.29	3.39

Table.3 Effect of NPK levels and bio-fertilizers on the economics of basmati rice

Treatments	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
NPK levels (%RDF)				
0	29277.51	67139.07	37861.38	1.30
50	32900.03	87037.86	54137.28	1.64
75	34471.75	96462.28	61990.53	1.80
100	36043.17	103969.80	67926.40	1.88
SEm±	-	1639.46	1400.73	0.04
CD (*P*=0.05)	-	4808.68	4108.45	0.10
Bio-fertilizers				
BGA	33013.12	86489.81	53476.29	1.60
PSB	32973.12	87450.02	54460.12	1.63
BGA + PSB	33533.12	92016.89	58500.29	1.74
SEm±	-	1419.82	1213.07	0.03
CD (*P*=0.05)	-	4164.44	3558.03	0.09

Yield attributes and yield

The NPK levels exerted significant effect on number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, 1000-grain weight, grain and straw yields of rice (Table 2). The maximum number of filled grains panicles^{-1}, minimum number of unfilled grains panicles^{-1}, maximum 1000-grain weight, grain and straw yields were recorded with 100% RDF where increasing NPK levels significantly increased the above traits and grain yield up to 100% RDF. NPK levels tried in the study differed significantly among themselves for all yield attributes except for 1000-grain weight and number of unfilled grain panicle^{-1} where 100% RDF and 75% RDF could not produce the difference. Continuous supply of

nutrients in balanced quantity throughout the growth stages assisted the plants to assimilate adequate photosynthates and their effective translocation to reproductive parts increased the yield attributes and yield of rice. These findings are in close agreement with reports of (Patel *et al.*, 2015; Nanda *et al.*, 2016). Application of bio-fertilizers had noticeable influence on filled grains panicle^{-1}, unfilled grains panicle^{-1}, 1000-grain weight, grain and straw yields of rice. The 1000-grain weight, grain and straw yield registered their maximum values with combined application of BGA + PSB which was significantly higher than application of BGA and PSB alone. Addition of BGA along with PSB significantly increased the yield attributes, grain and straw yield than sole application of PSB. Conversion of insoluble phosphorus to soluble form due to acidification, chelation and several other mechanisms coupled with additional N released after mineralization of dead algal cells and increased phosphorus availability in soil led to better matching between nutrient demand by crop and its supply by soil. So, higher dry matter accumulation and translocation to reproductive pats hence had a favorable effect on yield attributes and yield of rice. These results are in close conformity with the earlier findings (Meena *et al.*, 2014; Patel *et al.*, 2015).

Economics

Economics (cost of cultivation, gross return, net return and B: C ratio) was influenced due to different NPK levels and bio-fertilizers (Table 3). Among the NPK levels Maximum gross return (₹103969.80 ha^{-1}) and net return (₹ 67926.40 ha^{-1}) recorded with 100% RDF which was significantly superior over all the NPK levels and maximum B: C ratio (1.88) was recorded with 100% RDF which was significantly at par with 75% RDF. These results are in close conformity with the findings of Singh *et al.*, 2014. Among the bio-fertilizers tested, application of BGA + PSB recorded maximum gross return, net return and benefit: cost ratio. Maximum gross return (₹ 92016.89 ha^{-1}), net return (₹ 58500.29 ha^{-1}) and B: C ratio (1.74) was recorded with combined application of BGA + PSB which was found significantly better than sole application of BGA and PSB. This finding has been closely confirmed by (Nanda *et al.*, 2016).

On the basis of above findings it may be concluded that integration of highest NPK level (100% RDF) along with combined application of BGA and PSB proved better for achieving higher productivity and net return of basmati rice cv. HUBR 10-9 for Varanasi region.

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