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EFFECT OF PHOSPHORUS LEVELS AND BIO-ORGANIC SOURCES ON GRAIN QUALITY, NUTRIENT REMOVAL AND ECONOMICS OF WETLAND RICE (*ORYZA SATIVA* L.)

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ABSTRACT
A field experiment was conducted during *kharif* season of 2013 at Agricultural Research Farm of Institute of Agricultural Sciences at Varanasi to evaluate the effect of phosphorus levels and bio-organic sources on grain quality, nutrient removal and economics of rice. Factorial experiment was laid out in Randomized Complete Block Design involving four levels of phosphorus *viz.*, control, 50 per cent RDP, 75 per cent RDP and 100 per cent RDP and three bio-organic sources *i.e.* PSB, PSB + BGA and PSB + BGA + FYM (5 t ha^{-1}) replicated thrice. Results revealed that maximum grain yield (50.97 q ha^{-1}), grain protein content (9.18%) and protein yield (471.36 kg ha^{-1}), gross return (₹82324.12), net return (₹44645.29) and higher removal of NPK by grain (75.42, 11.79 & 15.57 kg ha^{-1}) and straw (41.38, 8.98 & 96.44 kg ha^{-1}) of rice were recorded with application of 100% RDP (60 kg P_2O_5 ha^{-1}). Higher benefit: cost ratio (1.20) was obtained with 75% RDP. Among bio-organics, combined use of PSB+BGA+FYM (5 t ha^{-1}) recorded maximum net return (₹ 43085.03 ha^{-1}) and benefit: cost ratio (1.16), grain yield, protein content, protein yield and removal of NPK by grain and straw. Combined application of bio-organics increased N in grain (30.31%) and straw (17.54%), P uptake in grain (38.21%) and straw (49.76%) and K uptake in grain (14.74%) and straw (16.81%) and protein content (19.30%) and protein yield (30.32%) over use of PSB alone.

KEY WORDS: Phosphorus levels, Bio-organics, NPK removal, Protein content.

INTRODUCTION

Rice (*Oryza sativa* L.) is the premier food crop not only of India but also of the world. Presently, rice is grown in an area of 43.9 million hectare with a total production of 104.80 million tonnes and average productivity of 2390 kg ha^{-1} (Anonymous, 2015). In India, the average productivity of rice is far below the other rice-growing countries. Improvement in nutrient use efficiency and their by stabilizing yield and farmer's income are the issues of prime concern. Thus, it is necessary to search out ways and means to develop a phosphorus management system by nutrient supply through conjunctive use of chemical fertilizers, organic manure and biofertilizers is essential to produce crops in line with the observed global standards of quantity and quality. Amongst the non-renewable inputs of modern agriculture, phosphatic fertilizers occupy an important place as about 98% of the Indian soil has insufficient supply of available phosphorus primarily due to phosphorus fixation by soil. Thus, the efficiency of major nutrients use may be raised by the combined use of chemical fertilizers and organic sources like FYM and bio-fertilizers not only act as the source of nutrients but also modify soil-physical behaviour and found to sustain large-scale productivity goals (Pandey *et al.*, 2007).

Phosphorus solubilizing bacteria (PSB) solubilise the fixed soil phosphorus and increase the efficiency of applied phosphate resulting in higher rice yield (Gull *et al.*, 2004). FYM helps in improving soil organic matter content, water-holding capacity, and nutrient exchange, provides food for soil microorganisms and maintains soil health (Tadesse *et al.*, 2013). Application of cyanobacterial inoculants could be the cheapest and easiest way to increase rice yield because of their capacity to fix atmospheric nitrogen and solubilization of insoluble phosphorus in wetland rice. Among various organic sources, FYM and use of blue green algae (BGA) in wetland rice are the common practices (Begum *et al.*, 2009).

The high cost of chemical fertilizer and low purchasing power of Indian farmers restricts its use on proper amounts, hampering crop production. With a view to, reduce the use of chemical fertilizer by enhancing the use of organic sources of nutrients, *viz.* FYM, biofertilizers etc. is inevitable. Although, the use of phosphate solubilizing microorganisms, farmyard manure and blue green algae are commonly recommended and found suitable for rice crop under integrated nutrient management strategy. Keeping these facts in to consideration an experiment was conducted to evaluate the comparative performance of phosphorus levels and bio-organic sources on grain quality, uptake of primary nutrients and economics of wetland rice under eastern Uttar Pradesh conditions.

MATERIALS & METHODS

A field experiment was conducted during kharif season of 2013 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to evaluate the effect of phosphorus levels and bio-organic sources on grain quality, nutrient removal and economics

of wetland rice. Soil samples (0-15 cm depth) were collected from experimental site and analyzed for mechanical and physico-chemical properties. The soil was sandy clay loam in texture with pH 7.35, Electrical conductivity (dSm^{-1} at 25^{o} C) is 0.15, available organic carbon 0.39%, available N, P, K content in soil was 198.03 kg ha^{-1}, 23.7 kg ha^{-1} and 188.32 kg ha^{-1} respectively. Factorial experiment was laid out in Randomized Complete Block Design assigning four levels of phosphorus viz. control, 50%, 75% and 100% recommended dose of fertilizers (RDP) and three bio-organic sources *i.e.* PSB, PSB + BGA and PSB + BGA + FYM (5 t ha^{-1}) replicated thrice. Recommended dose of fertilizers used was N_2-P_2O_5-K_2O (120-60-60 kg ha^{-1}). The N, P and K were supplied through urea, diammonium phosphate (DAP) and muriate of potash respectively. Half of the recommended dose of nitrogen and full dose of potassium were applied as basal application and remaining half nitrogen was applied in two equal splits at active tillering and panicle initiation stages uniformly to all the treatments. Variable rates of phosphorus were applied as per treatment. The experimental area was ploughed twice with tractor drawn cultivator and puddled with cage wheel and leveled. Four week old seedling of rice cv. HUR-105 was transplanted on the puddled field keeping two seedling $hill^{-1}$ at a spacing of 20 cm × 15 cm. After 10 days of transplanting, BGA was applied at the rate of 10 kg ha^{-1} in their respective treatments. Before transplanting, inoculants suspension liquid PSB culture (*Bacillus polymyxa*) prepared with water in ratio of 1:10 and seedling roots were dipped in solution for about 30 minutes under shade and transplanted immediately to their respective plots. Well decomposed FYM was applied basally as per treatment. Throughout the crop period, experimental crop received 825.0 mm. rainfall and about ± 5 cm water level was continuously maintained till flowering then after field was kept under saturated condition. Recommended agronomic practices were followed to raise the experimental crop. The crop was harvested at proper physiological maturity. The economics was computed using the prices of inputs and outputs as per prevailing market rates. The N content in grain and straw was analysed by micro Kjeldahl method. Phosphorus was determined by Vanado molybdo phosphoric acid yellow colour method and potassium by Flame photometer (Jackson, 1973). Nutrient removal by grain and straw for individual treatment was calculated by multiplying grain and straw yield with respective nutrient content. Protein content (%) in grain was worked out by multiplying the nitrogen content in grain by the factor 6.25 (A.O.A.C., 1970). Protein yield (kg ha^{-1}) was calculated by multiplying grain yield with protein content. The data recorded were analyzed following standard statistical analysis of variance procedure as suggested by Gomez and Gomez (1984).

RESULTS & DISCUSSION

Grain yield

The highest grain yield (50.97 q ha^{-1}) was recorded with the application of 100% RDP which exhibited a superiority of 19.67, 13.11, and 2.12 per cent over 0, 50 and 75% RDP, respectively. Addition of 100% RDP and 75% RDP recorded grain yield at par to each other but both were significantly superior over 50% RDP and control treatment. Phosphorus is a constituent of nucleic acid, phytin, phospholipids and essential in laying down the primordial for the reproductive parts of the plants hence its increased uptake finally resulting into increased yield. Similar observations were opined by Yosef Tabar, 2011).

Combined application of PSB + BGA + FYM (5 t ha^{-1}) recorded the maximum grain yield (49.27 q ha^{-1}) which was significantly superior to PSB + BGA and PSB alone. However, difference between PSB + BGA and PSB alone was not significant. Increase in grain yield might be due to higher photosynthetic activity because of increased leaf area index, which ultimately promoted dry matter production resulting higher grain yield. Quyen and Sharma, 2003 also reported similar results.

Protein content and Protein yield

Data revealed that maximum grain protein content (9.18%) and protein yield (471.36 kg ha^{-1}) was recorded with the highest phosphorus level (100% RDP) applied which was significantly superior over all other lower phosphorus levels. However, phosphorus levels i.e. control, 50% RDP and 75% RDP remained statistically at par with each other in case of protein content and protein yield in grain. The application of 100% RDP increased the protein content (37.63%) over control. The results are in accordance with findings of Singh *et al.* (2006)

Among bio-organics, maximum protein content and protein yield recorded in rice grain with combined use of PSB+BGA+FYM proved significantly higher over use of PSB alone but observed at par with the application of PSB+BGA. Application of PSB+BGA+FYM increased the protein content (19.30%) and protein yield (30.32%) over use of PSB alone. Integration of bio-organic sources might have increased the removal of phosphorus and other nutrient to the plant which ultimately influenced the protein yield favourably. The results substantiates the finding of Dixit and Gupta *et al.* (2000).

Economics

Among phosphorus levels, cost of cultivation was minimum (₹34373.95) with application of 0% RDP and increased with increase in levels of phosphorus up to 100% RDP (₹ 37678.83). Maximum gross return (₹ 82324.12) and net return (₹44645.29) was recorded with application of 100% RDP followed by 75%, 50% RDP and control treatment. However, the difference between 75% and 100% RDP in respect of gross return, net return and benefit: cost ratio remained statistically at par. Higher benefit: cost ratio (1.20) was obtained with 75% RDP.

As regard the bio-organic sources, application of PSB+BGA+FYM recorded the highest cost of cultivation than the PSB+BGA and PSB alone, while application of PSB+BGA+FYM recorded maximum gross return (₹ 80020.73 ha^{-1}), net return (₹43085.03 ha^{-1}) and benefit: cost ratio (1.16) because of higher yield under this treatment. This might be due to favourable effect of FYM which was helpful in release of nutrients in adequate amount and it also accelerate the algal growth which provide atmospheric nitrogen as compared to application of PSB+BGA or PSB alone. Findings are in close conformity with Davari and Sharma (2010).

TABLE 1: Effect of phosphorus levels and bio-organics on grain yield, protein content, protein yield and economics of rice

Treatments	Grain yield (q ha^{-1})	Grain protein content (%)	Protein yield (kg ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
P levels (% RDP)							
0	42.59	6.67	284.34	34373.95	70170.19	35796.24	1.04
50	45.06	7.21	325.29	35987.29	74260.14	38272.85	1.06
75	49.91	7.69	383.71	36763.95	80750.44	43986.49	1.20
100	50.97	9.18	471.36	37678.83	82324.12	44645.29	1.18
SEm±	0.93	0.35	20.06	-	931.40	931.40	0.04
CD (*P*=0.05)	2.73	1.04	58.72	-	2720.60	2720.60	0.11
Bio-organics							
PSB	45.37	6.94	316.49	35599.12	74200.40	38601.28	1.08
PSB+BGA	46.76	7.84	369.65	36068.20	76407.55	40339.35	1.12
PSB+BGA+FYM	49.27	8.28	412.45	36935.70	80020.73	43085.03	1.16
SEm±	0.81	0.31	17.37	-	806.62	806.62	0.03
CD (*P*=0.05)	2.37	0.90	50.85	-	2361.31	2361.31	NS
Interaction	NS	NS	NS	NS	NS	NS	NS

RDP: Recommended dose of phosphorus (60 kg ha^{-1}), **PSB** (Phosphate Solubilizing Bacteria), **BGA** (Blue Green Algae), **FYM** (Farmyard manure) @ 5 tonne ha^{-1}

TABLE 2: Effect of phosphorus levels and bio-organics on N, P and K content and removal by rice grain and straw

Treatments	N content (%)		N removal (kg ha^{-1})		P content (%)		P removal (kg ha^{-1})		K content (%)		K removal (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
P levels (% RDP)												
0	1.07	0.34	45.51	19.82	0.14	0.05	6.12	3.06	0.26	1.17	11.16	69.39
50	1.15	0.42	52.05	25.87	0.16	0.06	7.28	4.03	0.27	1.28	12.06	79.79
75	1.23	0.53	61.39	32.56	0.17	0.08	8.37	4.90	0.29	1.34	14.24	84.02
100	1.47	0.66	75.42	41.38	0.23	0.14	11.79	8.98	0.30	1.49	15.57	96.44
SEm±	0.06	0.01	3.21	0.84	0.01	0.01	0.41	0.55	0.01	0.03	0.54	2.04
CD (*P*=0.05)	0.17	0.03	9.40	2.41	0.02	0.02	1.21	1.60	0.03	0.08	1.54	5.97
Bio-organics												
PSB	1.11	0.46	50.64	27.53	0.15	0.07	6.96	4.20	0.27	1.26	12.41	76.29
PSB+BGA	1.26	0.49	59.14	29.84	0.18	0.08	8.60	5.23	0.28	1.32	13.12	81.82
PSB+BGA+FYM	1.33	0.52	65.99	32.36	0.19	0.10	9.62	6.29	0.29	1.38	14.24	89.12
SEm±	0.05	0.01	2.78	0.73	0.01	0.01	0.36	0.47	0.01	0.02	0.47	1.77
CD (*P*=0.05)	0.14	0.02	8.14	2.14	0.02	0.02	1.05	1.39	NS	0.07	1.38	5.17
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

RDP: Recommended dose of phosphorus (60 kg ha^{-1}), **PSB** (Phosphate Solubilizing Bacteria), **BGA** (Blue Green Algae), **FYM** (Farmyard manure) @ 5 tonne ha^{-1}

Nutrient content and removal

Data in Table 2 show that remarkably higher content and removal of NPK in grain and straw of rice were recorded under100% RDP. Application of highest phosphorus level (100% RDP) claimed significantly higher content and removal of nitrogen, phosphorus and potassium uptake by grain and straw over its lower phosphorus levels. The application of 100% RDP recorded 120.98%, 83.4% and 56.51% more removal of phosphorus over 0, 50 and 75% RDP, respectively. The adequate supply of phosphorus played a vital role might be on account of better removal and translocation of nutrients resulting in higher uptake of NPK by rice crop (Tripathi *et al.*, 2007).

Among bio-organics, combined use of PSB + BGA + FYM recorded higher N, P and K content and removal by grain and straw. Minimum NPK content and removal observed by grain and straw with PSB alone and increased with addition of each bio-organic source (BGA + FYM) and reached to its maximum with use of PSB + BGA + FYM. This might be due to increased efficiency and cumulative effect of combined application of bio-organic sources resulting increased removal of nutrients. The potassium content in grain did not showed significant variation due to bio-organic sources. Similar findings are in close conformity with Maiti *et al.* (2006) and Yadav *et al.* (2013).

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