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Productivity and Phosphorus Use Efficiency of Wheat (*Triticum aestivum* L.) as Influenced by Biofertilizers and Phosphorus under Subtropical Conditions of UP

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Abstract

A field experiment was conduct during the *rabi* season of the year 2002-2003 and 2003-04 to study the effect of biofertilizers and phosphorus on productivity and phosphorus use efficiency of PBW 373 wheat (*Triticum aestivum* L.). Biofertilizers and various levels of phosphorus exerted significant effect on various yield attributes viz. effective spikelets/spike, number of grains/ spike, weight of grains/spike and 1,000-grain weight (g). Crop dry matter production, P-uptake and yield followed similar pattern as they increased with increase in P-levels upto 45 kg P_2O_5/ha. The treatment B_2P_3 (PSB and 45 kg P_2O_5 /ha) proved best in terms of their positive influence on major parameters especially on crop growth and yield. Crop stand per meter row length and dry matter trends were similar and supported the crop yield trends. With increase in the P fertility level beyond 45 kg P_2O_5/ha decrease in maximum yield attributing factors was recorded. Hence, the application of phosphorus at 45 kg P_2O_5/ha along with PSB can save up to 15 kg P_2O_5/ha. The treatment B_1P_3 (VAM and 45 kg P_2O_5/ha) gave the second highest result in almost all attributes. The treatment combinations B_2 (PSB) and B_1 (VAM) was therefore, found most remunerative at 45 kg P_2O_5/ha (P_3 level). However, maximum benefit was recorded with treatment B_2P_3 (PSB and 45 kg P_2O_5/ha). Therefore this particular treatment combination could be recommended for profitable cultivation of wheat under subtropical conditions.

Key words : Biofertilizer, Nutrient uptake, Phosphorus, Wheat, Yield.

For a sustainable agriculture, it is imperative to utilize renewable inputs which can maximize the ecological benefits and minimize the environmental hazards. One possible way of achieving this is to decrease dependence on use of chemical phosphate fertilizers by solubilizing and mobilizing the native and applied phosphorus through biological processes. An integrated approach for use of biofertilizers with chemical fertilizers is considered as the need of hour, as biofertilizers are not replacement of fertilizers but can supplement their requirement. Therefore, its efficient use in the cultivable crops, mainly to wheat, whic is heavy feeder of nitrogen and phosphorus, is much more relevant. The increase in eco-friendly production of wheat can be made possible by wide-spread adoption of improved technologies of which fertilizer management particularly that of nitrogen and phosphorus through biofertilizers can play a key role. Hence present investigation was carried out to study the effect of biofertilizers and phosphorus on productivity and phosphorus use efficiency of wheat.

Methods

The experiment was carried out at research farm of Shri F. H. (PG) College of agricultural and sciences, Nidholi Kalan, Etah, UP, during the winter season 2002-2003 and 2003-04 in alluvial soil. The available nutrients N,P and K in soil were 270, 13.4 and 309 kg/ ha, respectively, with pH 6.8. The experiment was laid out in split plot design with three replications, comprising three levels of biofertilizer, B_0 (control), B_1(VAM), and B_2 (PSB), and four levels of phosphorus, P_1(15), P_1 (30), P_1 (45) and P_1 (60) kg/ha. For inoculation, 10% sugar solution was prepared by dissolving 100g sugar in 1 liter of water and heated for 20—25 minutes. The solution was cooled at room temperature and mixed with cultures treatment-wise. The

Table 1. Growth and yield attributes and grain and straw yield of wheat as influenced by biofertilizers and phosphorus levels (pooled data of 2 years).

Treatments	Plant height (cm)	Dry matter accu-mulation at harvest (q/ha)	Effective ear heads/m	Length of spike (cm)	No. of effective spikelets/ spike	No. of grains/ spike	Test weight (g)	Straw yield (q/ha)	Grain yield (q/ha)	Harvest index (%)
					Biofertilizers					
B_0 (Control)	89.38	77.97	62.91	7.12	12.50	51.75	37.37	87.77	38.25	30.09
B_1 (VAM)	90.35	83.25	65.75	9.97	14.00	55.25	40.87	94.87	40.54	29.73
B_2 (PSB)	91.78	89.19	67.66	10.60	14.75	56.75	43.37	96.83	46.00	32.12
SE	0.09	1.16	3.56	0.10	0.48	0.55	0.25	1.68	0.95	0.59
CD (5%)	0.19	2.46	NS	0.23	1.03	1.17	0.53	3.55	2.01	1.25
					Phosphorus (kg/ha)					
P_1	90.0	75.97	61.63	6.55	9.33	48.66	36.33	86.19	33.83	28.06
P_2	90.35	82.06	64.55	8.66	12.66	52.66	39.50	92.38	40.05	30.15
P_3	90.68	86.45	67.00	10.99	16.00	58.00	42.66	97.08	46.16	32.10
P_4	90.98	89.41	68.88	10.72	17.00	59.00	42.33	96.97	46.33	32.28
SE	2.23	2.90	2.50	0.14	1.64	2.68	2.74	0.97	1.13	0.54
CD (5%)	NS	6.09	5.25	0.29	3.46	5.63	5.77	2.03	2.38	1.14

wheat seeds were inoculated (1 kg + 10g culture) with the solution and then dried under shade before sowing. The VAM was applied by 'inoculation in furrows' method. Wheat PBW 373 was sown on 14 and 16 December of 2001 and 2002, respectively, at 125kg/ha between 20 cm apart rows at a depth of 4 cm from the top of the soil in lines using *kera* method of sowing by opening furrows through a liner. The half dose of recommended nitrogen was applied at the time of sowing as basal dose and rest N at two equal splits, at crown-root initiation and ear initiation stage, phosphorus (P_2O_5) based on treatment was applied at the time of sowing along with full recommended dose of potassium (K_2O). The total rainfall received during the crop season was 87.7 mm and 77 mm during 2001-2002 and 2002-03 respectively. Wheat crop was harvested in the third week of April in both the years.

Results and Discussion

Biofertilizers

Plant height, crop stand/m row length and dry matter accumulation, spike length, number of grains/ spike and test weight significantly increased by the treatment of B_2 (PSB) over B_1 (VAM) and B_0 (control) at all crop growth stages (Table 1). However, in number of effective spike lets/ spike, the treatment B_2 was at par with B_1, however, both $B_1$and B_2 were statistically significant over control. This might be partly owing to their additive effect of phosphorus solubilization and its mobilization and synthesis of biologically active substances like vitamins, auxins and gibberellins etc.,which in turn might have stimulated the plant growth parameters. Singh and Kapoor (1) and Hazara (2) have observed the similar results.

The biofertilizer inoculation has significantly influenced the yield parameters and harvest index. The variations in grain, straw yield and harvest index were found statistically significant with treatment B_2 over B_1 and B_0. But in straw yield, the treatment B_2 found at par with B_1, however, both the treatments proved statistically significant over B_0 and in case of harvest index the treatment B_1 remained at par with B_0 (Table 1). The magnitude of increase in grain, straw yield and harvest index with treatment B_2 recorded 5.46 and 7.75 (q/ha), 1.96 and 9.06 (q/ha) and 2.39 and 2.03 (%) over B_1 and B_0 respectively.

These increments are similar as the findings of Gaur (3) and Singh and Kapoor (1). The nitrogen content and its uptake were quite marginal and thus were

Table 2. Nitrogen content, its uptake and phosphorus content, its uptake in grain and straw as affected by various treatments (Average data of 2002-03 and 2003-04).

Treatments	N content (%) in grains	N content (%) in straw	N uptake by grain (kg/ha)	N uptake by straw (kg/ha)	P content (%) in grains	P content (%) in straw	P uptake by grain (kg/ha)	P uptake by straw (kg/ha)
				Biofertilizers				
B_0 (Control)	1.66	0.58	65.34	51.69	0.42	0.05	16.90	4.48
B_1 (VAM)	1.74	0.68	71.02	64.92	0.42	0.06	17.34	5.75
B_2 (PSB)	1.89	0.59	87.38	57.52	0.43	0.07	20.12	6.84
SE	0.18	0.08	8.90	5.25	0.008	0.00	0.89	0.10
CD (5%)	NS	NS	NS	NS	NS	0.00	1.89	0.22
				Phosphorus (kg/ha)				
P_1	1.46	0.43	50.06	37.82	0.26	0.03	9.02	2.89
P_2	1.83	0.61	73.83	57.08	0.42	0.06	16.99	5.93
P_3	1.96	0.71	91.04	69.73	0.50	0.073	23.49	7.18
P_4	1.79	0.69	83.38	67.54	0.49	0.070	23.09	6.76
SE	0.30	0.19	19.55	14.31	0.01	0.003	1.03	0.35
CD (5%)	NS	NS	NS	NS	0.03	0.008	2.17	0.74

statistically non -significant (Table 2). However, the phosphorus content and its uptake were highest with B_2 treatment, followed by B_1 and B_0. Both the biofertilizers showed significant result over B_0 (control). The increase in P content and its uptake might be due to enhanced P solubilization by PSBs and its mobilization by effectively developed root system, increasing the availability of P from non-labile sources.

Phosphorus

The various levels of phosphorus did not show any significant effect on crop stand/m and shoot height. However, treatment P_3 (45 kg P_2O_5/ha) showed improvement in crop stand, while in terms of shoot height only numerical increase were shown but none of the treatment could cross the level of statistical significance (Table 1). Earlier workers working under different agro-climatic conditions have also reported the same influence of phosphorus on crop stand and shoot height (4—7).The dry matter accumulation recorded maximum with treatment P_4 (60 kg P_2O_5 /ha) was statistically significant over treatment P_2 (30 kg P_2O_5/ha) and P_1 (15 kg P_2O_5/ha) but remained at par with treatment P_3 (45 kg P_2O_5/ha). Phosphorus being strongly related with leaf expansion, leaf surface area and also number of leaves and efficiency per unit chlorophyll. Thus efficient P might have attributed to accumulation of more photosynthates and resultant dry matter production. A positive influence of phosphorus application on dry matter yield was also observed by Sharma and Parmar (8). The yield attributing parameters were significantly influenced by various levels of phosphorus and the treatment P_4 (60 kg P_2O_5/ha) showed significant variation in effective ear head/meter, number of effective spike lets/spike and 1000-grain weight and found to be statistically significant over P_2 (30 kg P_2O_5/ha) and P_1 (15 kg P_2O_5/ha) (Table 1). Similar trend has been observed with treatment P_3 (45 kg P_2O_5/ha) and both the treatments P_3 and P_4 were at par with preceding one (P_2). However, in spike length (cm) the maximum variation has been observed with treatment P_3 and found to be statistically significant over treatment P_2 and P_1 and also slight decrease in variation were noticed with treatment P_4.The probable reason for the appreciable enhancement in all yield attributing characters could be that phosphate being one of the most important constituents of RNA and DNA, played a vital role in energy translocation in various metabolic processes like photosynthesis, glycolysis and respiration. This enhanced the various growth parameters and result-

Table 3. Interaction effect of biofertilizers and phosphorus on grain yield.

Treat-ments	P_1	P_2	P_3	P_4	Total	Mean
B_0	30.16	36.33	41.50	45.00	153.00	38.25
B_1	32.16	38.33	46.66	45.00	162.16	40.54
B_2	39.16	45.50	50.33	49.01	184.00	46.00
Total	101.49	120.16	138.49	139.01		
Mean	33.38	40.05	46.16	46.33		
SE	1.78					
CD (5%)	3.75					

ant yield attributes. The results are in close agreement with the findings of Bhendia (9), and Singh et al. (10).

In terms of yield, the highest grain and straw yield and harvest index (physiological efficiency) (Table 1) were recorded with the application of P_2O_5 at 45 kg/ha (P_3) and were statistically significant over treatment P_1 and P_2 but remained at par with P_4. As grain and straw yield is the product of yield attributes, increase in their values resulted in the increased grain and straw yields. Similar results were reported by Singh et al. (10), Rai and Sinha (11). Maximum N content N uptake was associated with the treatment P_3 and decreased with treatment P_4 in grain and straw. The total N uptake was more with treatment P_3 and found statistically significant over P_2 and P_1 but remained at par with treatment P_4 (Table 2). This might be attributed to beneficial influence of P on the root growth and development, biological nitrogen fixation and uptake of other essential nutrients, translocation of photosynthates to sink and reproductive activities in plant, which in turn have increased the N uptake and thereby content. The results are in accordance with the findings of Schilling et al. (12) and Sharma and Parmar (8). Similar trends were also observed with P content and its uptake in grain and straw, where treatment P_3 registered significantly higher values over P_2 and P_1 and remained at par with treatment P_4.

Interaction Effect of Bio-Fertilizers and Phosphorus on Grain Yield

The interaction indicates that interaction B_0P_1 (no biofertilizer + P_2O_5 @ 15kg/ha) gave lowest grain yield, while as B_2P_3 (PSB + P_2O_5@ 45 kg/ha) gave highest grain yield and also proved to be significantly better than other treatment interactions under test but remained at par with B_2P_4 (PSB + P_2O_5 @ 60 kg/ha) (Table 3). The interaction data also reveals that P fertility level beyond 45 kg/ha had no significant effect on grain yield which might be due to inhibitory effect of higher P fertility level on activities of PSB and VAM. These results are in accordance with the findings of Majjigudda and Sreenivasa (13).

Conclusion

Thus it can be concluded that use of bio-fertilizers (PSB and VAM) along with 45 kg P_2O_5/ha may help to sustain higher grain and straw yield of wheat under western conditions of Uttar Pradesh against the general recommendation of 60 kg P_2O_5 /ha or more. Thus 15—30 kg P_2O_5/ha can be saved, if bio-fertilizers are incorporated in cultivation of wheat.

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