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EFFECT OF AZOTOBACTOR, PHOSPHATE SOLUBILIZING BACTERIA AND DIFFERENT LEVELS OF PHOSPHORUS ON THE GROWTH AND YIELD OF WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract

A field experiment was conducted at Agronomy Research Farm of Allahabad Agricultural Institute - Deemed University, Allahabad during *Rabi* seasons of 2004-05 and 2005-06 to study the "Effect of Azotobactor Phosphate Solubilizing Bacteria and different levels of Phosphorus on the growth and yield of Wheat (*Triticum aestivum* L.). The treatments consisted of four levels of phosphorus (0, 40, 60 and 80 kg ha^{-1}), two levels of phosphate solubilizing Bacteria inoculation (No inoculation and seed inoculation) and two levels of Azotobactor inoculation (No inoculation and seed inoculation) were replicated thrice in a factorial randomized block design. Growth and yield components of wheat were significantly influenced by Phosphorus levels and seed inoculation with bio-fertilizers. The number of effective tillers m^{-2}, number of grains ear^{-1}, test weight (g), grain yield (q/ha^{-1}) and straw yield (q/ha^{-1}) were significantly improved by the application of 60 kg P_2O_5 ha^{-1}, all these characters were significantly increased owing to combined inoculation with Azotobactor and Phosphate Solubilizing Bacteria. The interaction effect showed that seed inoculation with Azotobactor and Phosphate Solubilizing Bacteria + 60 Kg P_2O_5 ha^{-1}, registered significantly higher grain yield of wheat.

Key words : Wheat, azotobactor, phosphate solubilizing bacteria, phosphorus levels, interaction effect.

Introduction

Wheat being a major food crop of India is a subject of great interest and concern also. The enormous pressure to produce more food from less land with shrinking natural resources is tough task. This calls for special efforts to manage the key inputs without eroding the ecological assets and sound knowledge base to increase agricultural productivity on sustainable basis. The Indian soils are generally low to medium in available phosphorus and not more than 30 percent of applied phosphate is available to current crop, and the remaining part gets converted into relatively unavailable forms. In this context, use of efficient phosphate solubilizing bacteria as inoculant for improving the solubility of insoluble phosphatic compounds resulting in improved phosphorus use efficiency is of vital significance is sustainable crop production (Singh and Rai, 2002). Azotobactor is known to fix atmospheric nitrogen and synthesize growth promoting substances and antifungal antibiotics. The present investigation was conducted to know the effect of Azotobactor, phosphate solubilizing bacteria and different levels of phosphorus on the growth and yield of wheat (*Triticul aestivum* L.).

Materials and Methods

A field experiment was conducted at Agronomy Research Farm of Allahabad Agricultural Institute – Deemed University, Allahabad during *Rabi* seasons of 2004-05 and 2005-06. The soil of the experimental field was sandy loam in texture, low in organic carbon and available nitrogen. The status of the available phosphorus was low to medium with high exchangeable potassium. The experimental treatments consisting of four levels of phosphorus (0, 40, 60 and 80 Kg ha^{-1}), two levels of phosphate solubilizing bacteria inoculation (No inoculation and seed inoculation) and two levels of Azotobacter inoculation (No inoculation and sub inoculation) were replicated thrice in a factorial randomized block design. Phosphorus as per treatments was drilled manually in the farm of SSP prior to sowing at a depth of 10 cm in furrows and biofertilizers *i.e.* Azotobacter and PSB inoculation were done to wheat seed (Variety 'PBW-343').

Results and Discussion

Phosphorus

Phosphorus application significantly improved the yield contributing characters of wheat (table 1). All the yield attributing characters studied *viz.* number of effective tillers, grains per ear, test weight were positively influenced by the increasing levels of phosphorus. The cumulative effect of high doses of phosphorus on the yield attributes ultimately resulted in higher grain and straw yields.

The basic reason of increase in grain yield due to phosphorus application was an adequate supply of phosphorus in the early vegetative growth stages of the crop considered essential for the development of its reproductive phases. Therefore, the number of effective tillers were higher in case of 60 Kg P_2O_5/ha (312.17 and 304.08 in first and second year, respectively) as compared to 40 Kg P_2O_5/ha or no phosphorus, which significantly contributed towards higher grain yield (table 1).

Phosphorus fertilization resulted in increased the number of grains per ear over the control. Further 60 Kg P_2O_5/ha produced significantly more grains per ear (36.42 and 39.38 in first and second year respectively) over 40 Kg P_2O_5/ha. A positive relationship was observed between number of grains per ear and grain yield per hectare. While 80 Kg P_2O_5/ha did not bring significant increase in yield attributes. These observations further confirmed the findings of Chakravarty and Gogoi (1991).

The grains in phosphorus fertilized plots might have attained their full capacity of sink size and manifested into bold and heavier grains as observed in the present study. This may probably be the reason for significant higher test weight in case of 60 Kg P_2O_5/ha as compared to other levels of phosphorus. The overall effect of phosphorus was remarkable significantly higher yield was recorded at 60 Kg P_2O_5/ha, which was 5.08 and 6.59 percent higher over 0 Kg P_2O_5/ha in respective years. The integration of all favourable yield components such as number of effective tillers, number of grains per year and test weight with 60 Kg P_2O_5/ha registered higher grain yield over 40 Kg P_2O_5/ha and more conspicuously than zero level of phosphorus application. The reduction in grain yield, in the absence of phosphorus fertilization was due to reduced sink size consequently resulting in poor development of yield components. Thus, increase in grain yield as well as straw yield might have been the result of increased phosphorus availability.

Therefore, phosphorus was directly related to the vegetative and reproductive phase of the crop and attribute complex phenomenon of phosphorus utilization in plant metabolism. Since, this element enters into the oxidative disintegration process of carboyhydrate to yield hexose phosphate which further transformed due to development of meristemic tissues, cell division, leaf area development and grain filling. It also have helped in the efficient absorption and utilization of the other required plant nutrients, which ultimately increased the grain and straw yield which confirms the findings of Tell and Khattari (1989), Modak (1992) and Ravi (1993).

Azotobacter

The Azotobacter micro-organism significantly influenced the yield components as compared to no inoculation (table 1). The results were consistent in both years of experimentation. The seed inoculation with Azotobacter enhanced the grain and straw yield of wheat as compared to no inoculation. The seed inoculation with Azotobacter registered maximum grain yield, being 16.61 and 16.85 per cent higher over no inoculation in successive years, respectively (table 1).

Among the yield parameters, number of grains per ear and test weight were closely associated with the grain yield. Significantly higher values of yield attributes were recorded due to seed inoculation with Azotobacter compared to no-inoculation. The higher values of various yield attributes viz. number of effective tillers (309.13 and 31.29 m^{-2}) number of grains per ear (39.42 and 42.23) and test weight (42.54 and 42.49 gm) due to seed inoculation with Azotobacter micro-organism consequently resulted in higher grain yield in both the years of experimentation. Such increases in yields due to Azotobacter inoculation have been attributed to Nitrogen fixation, development of better root system, production of plant growth hormones, enhancement in uptake of NO_3^- , NH_4^+, H_2PO_4, K and Fe, improvement of plant water status and increase in nitrate reductase activity (Wani *et al*., 1988).

The significant increase in number of effective tillers is attributed to profuse root growth by due to secretion of different growth regulators like B vitamins, nicotinic acid pentothenic acid, biotin, heteroauxin, gibberellins etc. by Azotobacter (Rao, 1986).

Phosphate Solubilizing Bacteria

The phosphate solubilizing bacteria treatment significantly influenced the yield and yield components compared to no inoculation. The seed inoculation with phosphate solubilizing bacteria registered maximum grain yield being 11.64 and 9.49 per cent higher over no

Table 1 : Effect of phosphorus levels, azotobacter and phosphate solubilizing bacteria on yield and yield attributes of wheat.

Treatments	Effective tillers (m^2)		No. of grains (ear^{-1})		Test weight (g)		Grain yield (q/ha^{-1})		Straw yield (q/ha^{-1})	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Phosphorus (Kg/ha^{-1})										
0	274.50	290.33	32.70	35.50	41.24	41.50	40.87	39.27	60.60	60.12
40	292.33	294.83	34.03	36.28	41.70	41.89	41.65	40.54	62.90	62.41
60	312.17	304.08	36.42	39.38	42.38	42.17	42.95	41.86	64.42	65.20
80	302.00	298.33	35.68	38.50	41.86	41.94	42.49	41.23	63.72	62.98
S.Ed (±)	1.72	3.86	0.10	0.32	0.11	0.10	0.13	0.23	0.21	0.15
C.D. (P = 0.05)	3.52	7.83	0.21	0.65	0.22	0.21	0.26	0.47	0.43	0.32
Azotobacter										
Uninoculated	281.38	278.50	29.99	32.60	41.05	41.26	38.77	37.56	55.83	55.64
Inoculated	309.13	315.29	39.42	42.23	42.54	42.49	45.21	43.89	69.99	69.72
S.Ed (±)	1.2	2.73	0.07	0.22	0.08	0.07	0.09	0.16	0.15	0.11
CD (P = 0.05)	2.49	5.57	0.15	0.46	0.16	0.15	0.18	0.33	0.31	0.22
PSB										
Uninoculated	289.42	288.50	32.27	34.63	41.41	41.39	39.68	38.88	58.50	59.53
Inoculated	301.08	305.29	37.15	40.20	42.19	42.36	44.30	42.57	42.57	65.83
S.Ed (±)	1.22	2.73	0.07	0.22	0.08	0.07	0.09	0.16	0.15	0.11
CD (P = 0.05)	2.49	5.57	0.15	0.46	0.16	0.15	0.18	0.33	0.31	0.22

Table – 2 : Interaction Effect of Treatments on Grain Yield (q/ha^{-1}) of Wheat

Treatments	Phosphorus Level (Kg/ha^{-1})							
	2004 – 05				2005 – 06			
	0	40	60	80	0	40	60	80
No Inoculation	32.72	34.68	36.92	35.83	33.18	34.50	37.05	35.84
PSB Inoculation	34.10	42.24	42.86	42.80	38.63	39.71	41.30	40.24
Azotobacter Inoculation	34.07	43.73	45.35	45.15	41.65	42.87	43.03	42.29
Azotobacter + PSB Inoculation	38.60	44.95	46.65	46.18	42.61	45.06	46.06	45.91
S.Ed (±)	0.25				0.46			
C.D. at 5%	0.51				0.94			

inoculation is successive year, respectively (table 1). The increase in grain yield was obviously due to phosphate solubilizing activity of bacteria resulting in increased availability of phosphorus.

Among the yield parameters, number of effective tillers, grains number of per year and test weight were closely associated with the grain yield. Significantly higher values of yield attributes were recorded due to inoculation comparison to no inoculation. The significant increase in number of effective tillers is attributed to profuse root growth due to enhanced availability to phosphorus. Similarly the increase in number of grains per ear due to inoculation with phosphate solubilizing bacteria was because of more phosphorus availability which led to efficient translocation of phosphates to reproductive parts resulting in retention of more number of flowers. Similarly higher test weight was recorded due to increased availability and uptake of phosphorus which plays a crucial role in proper development of seed.

The higher values of various yield attributes viz. Number of effective tillers (301.08 and 305.29 m^2), number of grains per ear (37.15 and 40.20) and test weight (42.19 and 42.36) due to seed inoculation with Phosphate Solubilizing Bacteria Consequently resulted in higher grain yield in both years of experimentation. These differences in various yield components due to Phosphate Solubilizing Bacteria may be largely because of difference in dry matter production and its accumulation in reproductive parts. The higher dry matter was mainly due to growth promoting substance produced by phosphate solubilizing bacteria as well as increase in the availability of native and applied phosphorus by their solubilization. These observations further confirm the results of Tiwari *et al.* (1995) and Whitelaw (2000).

Interaction effect of Azotobacter, Phosphate Solubilizing Bacteria and different levels of Phosphorus on the grain yield of wheat

The Phosphate Solubilizing Bacteria had significant effect on growth and yield of wheat at lower levels of phosphorus. Seed inoculation with Azotobactor Phosphate Solubilizing Bacteria registered significantly higher yield upto 60 Kg P_2O_5 ha^{-1}. However, when 40 Kg Phosphorus ha–1 was applied with Phosphate Solubilizing Bacteria and Azotobactor in association resulted in statistically almost higher growth and yield. Thus 50% saving in phosphorus application could be possible with combined use of *Azotobactor, Phosphate Solubilizing Bacteria*. The favourable effect of Azotobactor, Phosphate Solubilizing Bacteria could be explained as these micro-organism created favourable condition for nitrogen and phosphorus availability to the plant, respectively. The higher nutrient uptake and its translocation had conducive effect on photosynthesis and accumulation of photosyntheates which contributed to the development of yield attributes. Besides, increasing the nitrogen and phosphorus availability, these micro-organisms also produced growth promoting substances like IAA, CA which enhance the plant growth. The increases in grain number with more availability of nitrogen and phosphorus might have been due to efficient translocation of photosynthates to reproductive parts and at the same time phosphorus might have played crucial role in proper development and maturity of seed which led to higher test weight. Such increases in yields due to Azotobactor inoculation have been attributed to nitrogen-fixation production of plant growth, hormones, increase in nitrate reductase activity and the Phosphate Solubilizing Bacteria increased phosphorus availability by solubilizing of native as well as applied phosphorus. This could be the possible reason for non-significant yield difference between 60 Kg P_2O_5 ha^{-1} and 40 Kg P_2O_5 ha^{-1} in combination with Azotobactor and Phosphate Solubilizing Bacteria (table 2). These observations further confirm the results of Gaur (1990) and Singh *et al.* (2002).

References

Chakravarty, A. and H. N. Gogoi (1991). Effect of source, level and time of application of phosphate on irrigated wheat (Triticum aestivum L.) *Indian J. Agron*., **36 (Supplement)** : 256 – 257.

Gaur, A. C. (1990). Phosphate solubilizing micro-organisms as biofertilizers. *Omega Scientific Publishers*, New Delhi.

Modak, S. B. (1992). Studies on phosphorus utilization in pigeonpea-wheat sequence using ^{32}P as a tracer. *Ph.D. Thesis*, *Indian Agricultural Research Institute*, New Delhi.

Rai, S. N. and A. C. Gaur (1988). Characterization of Azotobactor Spp. and effect of Azotobactor and Azospirillium as inoculated on the yield and N uptake of wheat crop. *Plant and Soil*, **109(1)** : 131 – 134.

Ravi, K. (1993). Relative efficiency of N and P utilization in Kharif legumes – wheat sequence using ^{15}N and ^{32}P tracers. *Ph.D. Thesis,* Indian Agricultural Research Institute, New Delhi.

Sharma, M. L. and V. K. Mishra (1986). Effect on inoculation and levels of nitrogen on growth, yield and quality of wheat (Narmada-4). *Madras Agricultural Journal*, **73(2)** : 96 – 100.

Singh, Vireshwar, R. P. Singh, K. S. Panwar and S. M. Singh (1993). Effect of inoculation with Azotobactor on wheat (*Triticum aestivum*). *Indian J. Agron*., **38(4)** : 648 – 650.

Tell, A. and S. Khattari (1989). Response of durum wheat cultivation to phosphate fertilizers under rainfed conditions. *Mesopotamia J. Agri*., **21** : 209 – 221.

Tiwari, V. N., A. N. Pathak and L. K. Lehri (1993). Rock phosphate-superphosphate in wheat in relation to inoculation with phosphate solubilizing micro-organism and organic waste. *Indian J. Agric. Res*., **27** : 137-145.

Whitelaw, M. A. (2000). Growth and plants inoculated with phosphate solubilizing fungi. *Adv. Agron*., **69** : 100 – 144.