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Response of biofertilizers and phosphorus levels on growth and yield of wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was carried out during *Rabi*, 2020 at crop research farm of SHUATS, Prayagraj to study about the response of biofertilizers and phosphorus levels on growth and yield of Wheat (*Triticum aestivum* L.) The experiment was laid out in randomized block design. using two factors, Biofertilizers *i.e.*, *Azotobacter* and *Azospirillum* and Phosphorus levels *i.e.*, P_1 - (50 kg/ha), P_2 – (60 kg/ha) and P_3 – (70 kg/ha) which was replicated three times. Results revealed with that the treatment of *Azospirillum* + 70 kg/ha Phosphorus recorded significantly highest in plant height (83.84 cm), number of tillers per m^2 (248.00), dry matter accumulation (614 g/m^2), effective tillers per m^2 (229.33), number of grains per spike (44.62), test weight (33.22 g), grain yield (4.02 t/ha) and stover yield (5.16 t/ha). However, maximum Net returns (72002.50 INR/ha) and B:C ratio (2.52) were also obtained with the application of *Azospirillum* + 70 kg/ha Phosphorus. Therefore, concluded that *Azospirillum* + 70 kg/ha Phosphorus recorded significantly higher compared to other treatments.

Keywords: Azospirillum, azotobacter, biofertilizers, phosphorus, wheat and yield

Introduction

Wheat is second most important staple crop after rice in country, which contributes nearly one third of the total food grain production. It is consumed mostly in the form of bread as "chapati". Wheat is grown all over India from the sea level up to an elevation of 3500 m in the Himalaya. The common bread wheat occupies more than 90% of the total wheat area and along with 10% area under (*Triticum durum*). Its cultivation is common under rainfed condition only, on account of higher susceptibility to rusts. In India wheat crop is cultivated in *Rabi* season. It is normally sown during November and harvested between March and April. The cultivated area under wheat at national level has shown increasing trend, from 29.04 million hectares to 30.54 million hectares with a magnitude of 1.5-million-hectare (5%) net gain in terms of area. Uttar Pradesh has largest share in area with 9.75 (32%), followed by Madhya Pradesh (18.75%), Punjab (11.48%), Rajasthan (13%). The production of wheat has also showed an increasing trend, from 87.39 to 94.57 million tonnes from 2012-2013 to 2017-2018 with a magnitude of 7.18 million tonnes (8.22%). The national productivity trend for wheat showed a marginal improvement, which has increased from 3009 kg/ha to 3100 kg/ha from 2012-2013 to 2017-2018. The rise in productivity is due to adoption of high-yielding varieties coupled with other inputs (Sendhil *et al.*,2019) [24]

Bio-fertilizers are known as microbial inoculants and consist of artificially multiplied cultures of certain soil micro-organisms that can improve soil fertility and crop productivity. There utilization might also reduce the chemical fertilizers use (Mahdi and Ismail, 2015) [14].

Azotobacter is a free-living N-fixing bacterium. It can successfully grow in the rhizospheric zone of wheat, maize, rice, sorghum, sugarcane, cotton, potato; tomato; brinjal, cabbage and many others and fix 10-20N kg/ha cropping season. Another important characteristic of *Azotobacter* association with crop improvement is excretion of ammonia in the rhizosphere in the presence of root exudates; which helps in modification of nutrient uptake by the plants. Azotobacter has the ability to produce antifungal antibiotics and fungistatic compounds against pathogens like Fusarium, Alternaria, Trichoderma (Wani *et al*, 1988) [30].

Azospirillum inoculation of cereals should result in an average increased yield of 10-15% in fertilized areas and up to 20% under less developed agricultural practices. However, this is difficult to predict as long as basic features of the plant-bacteria interaction are unknown (Yoav Bashan, 1993) [5]. *Azospirillum brasilense* is a free-living soil bacterium, which colonizes the roots of many economically important crops including wheat, rice and corn. It is a member of the alpha subdivision of proteobacteria and it may enhance plant growth

(Greer-Phillips *et al*., 2004) [7]. *A. brasilense* is an aerophilic bacterium, which has an oxidative type of metabolism and can use nitrate as an alternative electron acceptor (Alexandre *et al*., 2000) [1]. *Azospirillum spp*. are diazotrophs that fix nitrogen as free-living organisms (Ramos *et al*., 2002) [21]. The bacterium obtains the nutrients necessary to replicate and survive from the plant and the plant benefits from the association with the bacterium because the bacteria produce hormones that increase the volume of the roots bulk thereby leading to improved plant nutrition. The beneficial effects of *Azospirillum* on plant growth have been applied in agricultural practices and inoculants containing *A. brasilense* have been used as biofertilizer for cereals all over the world.

Phosphorus (P) is an essential nutrient for plant growth and development. It is second largest limiting element for plant growth. It plays a vital role in virtually every plant process like photosynthesis, energy storage and transfer, stimulating root development and growth, giving plant rapid and vigorous start leading to better tillering in wheat, and encouraging earlier maturity and seed formation. It utilizes sugar and starch and involved in transfer of energy. Application of phosphorus enhances drought tolerance in plant. It also has a significant role in sustaining and building up of soil fertility. (Sharma *et al*. 2011) [25].

Materials and Method

The experiment was carried out during *Rabi* season of 2020, at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The Crop Research Farm is situated at 25º24‘41.27” N latitude, 81°50‘56” E longitude (Google, 2021) and 98 m altitude above the mean sea level. This area is situated on the right side of the river Yamuna and south east side of Prayagraj city during *Rabi* season 2020on sandy loam soil, having nearly neutral in soil reaction (pH 7.4), organic carbon (0.306%), EC (0.247 ds/m), available nitrogen (145.75 kg/ha), available phosphorus (13.9 kg/ha) and available potassium (243.5 kg/ha). The climate of the region is sub-humid, sub-tropical climate. Treatments comprised of T_1 –Control + Phosphorus 50kg/ha, T_2 - *Azotobacter* + Phosphorus 50kg/ha, T_3 - *Azospirillum* + Phosphorus 50kg/ha, T_4 - Control + Phosphorus-60 kg/ha, T_5 - *Azotobacter* + Phosphorus-60 kg/ha, T_6 - *Azospirillum* + Phosphorus-60 kg/ha, T_7 - Control + Phosphorus-70 kg/ha, T_8 - *Azotobacter* + Phosphorus-70 kg/ha and T_9 - *Azospirillum* + Phosphorus-70 kg/ha. These were replicated thrice in Randomized Block Design. The recommended dose of fertilizer is 120-60-60 kg/ha NPK. Recommended dose of fertilizer was applied at the time of sowing in the form of Urea, SSP and MOP.

Chemical analysis of soil

Composite soil samples are collected before layout of the experiment to determine the initial soil properties. The soil samples are collected from 0-15 cm depth and were dried under shade, powdered with wooden pestle and mortar, passed through 2 mm sieve and were analysed for organic carbon by rapid titration method by Nelson (1975) [16]. Available nitrogen was estimated by alkaline permanganate method by Subbiah and Asija (1956) [27], available phosphorus by Olsen’s method as outlined by Jackson (1967), available potassium was determined by using the flame photometer normal ammonium acetate solution and estimating by using flame photometer (ELICO Model) as outlined by Jackson (1973) [9] and available $ZnSO_4$ was estimated by Atomic Absorption Spectrophotometer method as outlined by Lindsay and Norvell (1978).

Statistical analysis

The data recorded were different characteristics were subjected to statistical analysis by adopting Fishers the method of analysis of variance (ANOVA) as described by Gomez and Gomez (2010). Critical difference (CD) values were calculated the ‘F’ test was found significant at 5% level.

Results and Discussion

Plant height (cm)

Observations regarding the plant height of wheat are given in Table 1. The analysis on plant height was significantly higher in all the different growth intervals with the levels of Biofertilizers and Phosphorus. At harvest, maximum plant height (83.84 cm) was recorded with application of (T_9) *Azospirillum* + Phosphorus 70kg/ha which was significantly superior over all other treatments however (T_5) *Azotobacter* + Phosphorus 60 kg/ha (82.9 cm) was found statistically at par to (T_9) *Azospirillum* + Phosphorus 70kg/ha. Increased in plant height might be due to application of phosphorus increased photosynthesis activity of plant and helps to develop a more extensive root system and thus enables the plant to extract more water and nutrient from soil depth, resulting in better development of plant growth. Similar results are in accordance with the findings of Patel *et al*. (2000) [18], Sarma *et al*. (2000) [23] and Kumar and Singh (2003) [11]. Azospirillum inoculation have suggested that Nitrogen fixation was major mechanism of plant growth. This increase in the soil nutrient level was responsible for plant growth and development. These findings are in harmony with those obtained by Kundu (1988) [12] and Lima *et al.* (1987) [13].

Number of tillers per m^2

Observations regarding the tillers of wheat are given in Table 1 and there was tillers progressively increased with advancement of crop during the crop growth and at the time of harvest tillers were decreased. At harvest, maximum recorded with the application of (T_9) *Azospirillum* + Phosphorus 70kg/ha (248.00) which was significantly superior over all other treatments however(T_5) *Azotobacter* + Phosphorus 60kg/ha (240.00), (T_2) *Azotobacter* + Phosphorus 50kg/ha (232.00) and (T_7) Control + Phosphorus 70kg/ha (224.00) was found statistically at par to (T_9) *Azospirillum* + Phosphorus 70kg/ha. It might be due to the production of higher number of effect tillers over control may probably be due to the fact that phosphorus application helped in secondary root and short developed, through its favourable effect on cell division and multiplication. Similar results have also been reported by Singh *et al.* (1987) [26]. Positive effects of Azospirillum inoculation were demonstrated in various root parameters including increased in number and length of root, root dry weight. Application of Azospirillum increased growth characters due to plant growth hormones such as auxins, gibberellins, cytokinins etc. Several investigators found that azospirillum may produce plant growth substances, mainly indole acetic acid, indole lactic acid, gibbrellin and cytokinins. They indicated that inoculation with azospirillum or pure hormone substances induce the proliferation of lateral roots and root hairs which increase nutrient absorbing surfaces and many more root tips available and result in significant positive influence in increasing no of tillers. These findings are in harmony with those obtained by Hadas and Okon (1987) [8], Vlassak and Reynders (1978) [29].

Dry matter accumulation (g/m^2)

Observations regarding the dry matter accumulation are given in table 1 and there was dry matter accumulation (g/m^2) had consecutively increased from 20 DAS to at harvest. At harvest, maximum dry matter accumulation (614 g/m^2) was recorded with application of (T_9) *Azospirillum* + Phosphorus 70 kg/ha which was significantly superior over all other treatments however (T_5) *Azotobacter* + Phosphorus 60kg/ha (582.4 g/m^2) was found statistically at par to (T_9) *Azospirillum* + Phosphorus 70 kg/ha. It might be due to the application of phosphorus might have increased interception, absorption and utilization of radiant energy which in turn increased photosynthesis and thereby higher dry matter accumulation was due combined effect of higher plant height. These findings are in harmony with those obtained by Arun Kumar *et al*. (2007) [3]. Azospirillum inoculation on wheat, sorghum and panicum, significantly increased the total shoot and root weight, plant and leaf length which were ultimately increased dry matter accumulation (Kapulnik *et al.*, 1981) [10] and in winter wheat (*Triticum aestivum*) inoculated with *Azospirillum brasilense* showed significantly increase in the number of fertile tillers, shoot and root dry weight and root to shoot ratio (Warembourg *et al.*, 1987) [31].

Table 1: Effect of Biofertilizers and Phosphorus Levels on Growth Attributes of Wheat

Treatments	Plant height (cm)				Number of tillers per m^2				Dry matter accumulation (g/m^2)			
	40 DAS	60 DAS	80 DAS	At harvest	40 DAS	60 DAS	80 DAS	At harvest	40 DAS	60 DAS	80 DAS	At harvest
Control + Phosphorus 50kg/ha	11.62	58.98	76.70	78.30	69.33	149.33	229.33	208.00	63.06	154.13	466.80	452.53
Azotobacter + Phosphorus 50kg/ha	14.79	62.68	81.05	81.83	93.33	173.33	253.33	232.00	70.13	200.26	549.06	520.26
Azospirillum + Phosphorus 50kg/ha	9.25	53.54	73.22	74.55	61.33	141.33	221.33	202.66	56.66	108.93	380.40	381.60
Control + Phosphorus 60kg/ha	12.22	59.82	77.98	79.58	82.66	162.66	242.66	221.33	65.60	167.06	493.60	469.33
Azotobacter + Phosphorus 60kg/ha	16.92	66.23	81.56	82.90	101.33	181.33	261.33	240.00	77.86	229.46	565.20	582.40
Azospirillum + Phosphorus 60kg/ha	9.98	56.33	74.23	76.16	64.00	141.33	221.33	205.33	59.33	131.20	408.13	428.53
Control + Phosphorus 70kg/ha	13.36	61.07	79.00	80.50	85.33	165.33	245.33	224.00	67.86	190.13	515.73	481.60
Azotobacter + Phosphorus 70kg/ha	11.14	57.60	75.54	77..08	69.33	149.33	229.33	213.33	61.20	145.06	441.20	440.26
Azospirillum + Phosphorus 70kg/ha	17.57	67.40	82.34	83.84	109.33	189.33	269.33	248.00	79.73	240.13	580.00	614.00
SEm (±)	0.25	0.48	0.56	0.64	2.93	9.54	10.81	8.54	3.90	10.05	28.26	28.13
CD (0.05%)	0.74	1.44	1.67	1.92	8.70	28.35	32.12	25.40	11.60	29.86	83.97	83.59

Effect of biofertilizers and phosphorus levels on yield and economics of wheat

Yield

Treatment with application of (T_9)*Azospirillum* + phosphorus 70 kg/ha was recorded maximum Grain yield (4.02 t/ha) which was significantly superior over all other treatments however (T_5) *Azotobacter* + Phosphorus 60kg/ha (3.9 t/ha) was found statistically at par to (T_9) *Azospirillum* + Phosphorus 70 kg/ha. Treatment with application of (T_9) *Azospirillum* + Phosphorus 70 kg/ha was recorded maximum stover yield (5.16 t/ha) which was significantly superior over all other treatments and there is no statistically at par value. It might be due to the increase in number of grains per ear head may be because phosphorus plays an important role in grain formation, since it is an important constituent of DNA and some enzymes. Similar findings have been reported by Oliveira *et al.* (1986) [17], Malavia *et al.* (1987) [15] and Rana *et al.* (1982) [22]. Some azospirillum strains can solubilize inorganic phosphorus, making it readily available to the plants and resulting in higher yield (Turan *et al.* 2012) [28].

Economics

Maximum Gross returns (Rs. 1,00,500INR/ha), Net returns (Rs. 72,002.50 INR/ha) and B:C ratio (2.52) was obtainedwith application of *Azospirillum* + 70 kg/ha Phosphorus.

Table 2: Effect of Biofertilizer and Phosphorus Levels on Yield and Economics of Wheat

Treatments	Yield		Economics		
	Grain yield (t/ha)	Stover yield (t/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
Control + Phosphorus 50kg/ha	3.35	4.43	83,750	56,127.50	2.03
Azotobacter + Phosphorus 50kg/ha	3.74	4.86	93,500	65,877.50	2.38
Azospirillum + Phosphorus 50kg/ha	2.76	3.93	69,000	41,377.50	1.49
Control + Phosphorus 60kg/ha	3.48	4.56	87,000	58,940.00	2.10
Azotobacter + Phosphorus 60kg/ha	3.90	4.96	97,500	69,440.00	2.47
Azospirillum + Phosphorus 60kg/ha	2.83	4.08	70,750	42,690.00	1.52
Control + Phosphorus 70kg/ha	3.63	4.73	90,750	62,252.50	2.18
Azotobacter + Phosphorus 70kg/ha	3.19	4.22	79,750	51,252.50	1.79
Azospirillum + Phosphorus 70kg/ha	4.02	5.16	1,00,500	72,002.50	2.52
SEm(±)	0.06	0.04			
CD (p=0.05)	0.19	0.13			

Conclusion

On the basis of one season experimentation, it was concluded that with the application of (T_9) *Azospirillum* + Phosphorus 70 kg/ha and whereas (T_5) *Azotobacter* + Phosphorus 60 kg/ha is economically viable.

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