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Impact of Azotobacter and Nitrogen on Growth and Productivity of Wheat (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To evaluate the effect of different nutrient management practices on growth, yield and yield attributes of wheat.
Study Design: Randomized Block Design (RBD).
Place and Duration of Study: The experiment was conducted during *Rabi* season 2016-17 at Instructional Farm of Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.)
Methodology: The experiment consisting of 10 treatments, T_1 Control (N-0,P-60,K-40Kg ha^{-1}); T_2 (*Azotobacter*); T_3 (60 kg Nitrogen ha^{-1}); T_4 (40 kg Nitrogen ha^{-1} + *Azotobacter*); T_5 (80 kg Nitrogen ha^{-1}); T_6 (60 kg Nitrogen + *Azotobacter*); T_7 (100 kg Nitrogen ha^{-1}); T_8 (80 kg Nitrogen ha^{-1} + *Azotobacter*); T_9 (120 kg Nitrogen ha^{-1}); T_{10} (100 kg Nitrogen ha^{-1}+ *Azotobacter)* were laid down in triplicate plots in Randomized block design (RBD).Wheat variety PBW-343 was taken as test crop.

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Results: The results revealed that the application of chemical fertilizers @ 100 kg Nitrogen ha^{-1}+ *Azotobacter* (T_{10}) recorded the highest growth attributes *viz.* Plant height, dry matter accumulations, and yield attributes *viz.* number of grains per spike, weight of spike, test weight, grain yield, straw yield and harvest index.

Keywords: Azotobacter; nitrogen; growth attributes; yield attributes.

1. INTRODUCTION

"Wheat (*Triticum aestivum L*.) is a staple food of the world and belong to family Poaceae (Gramineae). Wheat is the single most important cereal crop that has been considered as integral component of the food security system of the several nations. It has been described as the '**King of cereals**" because of the acreage and high productivity which also occupies a prominent position in the international food grain trade. Wheat provides nearly carbohydrates 78%, protein 14%, fat 2%, minerals 2.5%, and vitamins such as thiamine and vitamin B, as well as minerals such as zinc and iron, selenium, and magnesium make up a small percentage of the diet" [1]. "Unlike other cereals, wheat contains a high amount of gluten, the protein that provides the elasticity necessary for excellent bread making. Wheat rank first in the world among the cereals both in respect of area (219.42 million hectare) and production (758.38 million metric tonnes) with productivity of wheat 3.46 tonnes per hectare. In India, it's grown in an area of 30.79-million-hectare, production of 98.51 million metric tonnes with a productivity of 3.20 tonnes per hectare [2]. Plant growth may be stimulated by N-fixation, and nutrient supplementation" [3-5]. "Azotobacter, a Gamma proteobacteria member of the plant growth-promoting rhizobacteria "PGPR" group, can fix N from the atmosphere and thrive in N-free environments. They use N from the atmosphere to produce biological proteins. After the mineralization of the cellular protein, N availability is linked to cell death" [6]. "Furthermore, azotobacter strains have been shown to improve plant growth, production, and N use efficiency for horticultural crops" [7]. "There were significant increases in lettuce plant height, number of leaves, and fresh weight when the plants were treated with biofertilizers such as the *Azotobacter chroococcum* and *Azospirillum lipoferum"* [8]. Nitrogen is the most important plant nutrient and influences plant growth and production. It is a structural constituent of cell. It is an essential component of amino acids, prophyrins, flavins, purines and pyrimidine ne, nucleotides, flavin nucleotides enzymes, co-enzymes and alkaloids. It is therefore, a basic constituent of life. Consequently, to get more crop production, nitrogen application is essential in the form of chemical fertilizer. Hence, we aimed in this investigation to examine the role of the individual and combined applications of N and azotobacter on growth and yield parameters of wheat crop.

2. MATERIALS AND METHODS

An experiment was conducted during *Rabi* season 2016-17 at Instructional Farm of Acharya Narendra, Deva University of Agriculture & Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) to evaluate the effect of different nutrient management practices on growth and yield attributes of wheat. The soil was partially reclaimed sodic soil with silt loam texture slightly alkaline in reaction (pH 8.90) with low available nitrogen (159.0 kg ha^{-1}), medium in available phosphorus (12.60 kg ha^{-1}), and high in available potassium (245.80 kg ha^{-1}). The experiment consisting of 10 treatments, T_1 Control (N-0,P-60,K-40Kg/ha^{-1}); T_2 (*Azotobacter*); T_3 (60 kg Nitrogen ha^{-1}); T_4 (40 kg Nitrogen ha^{-1} + *Azotobacter*); T_5 (80 kg Nitrogen ha^{-1}); T_6 (60 kg Nitrogen + *Azotobacter*); T_7 (100 kg Nitrogen ha^{-1}); T_8 (80 kg Nitrogen ha^{-1} + *Azotobacter*); T_9 (120 kg Nitrogen ha^{-1}); T_{10} (100 kg Nitrogen ha^{-1}+ *Azotobacter)* were laid down in triplicate plots in Randomized block design (RBD).Wheat variety PBW-343 was taken as test crop. At the time of sowing, the soil was again mixed thoroughly. Nitrogen was applied as urea. Uniform doses of Phosphorus and Potassium at the rate of 60 and 40 kg ha^{-1}, respectively, were applied in all the plots for wheat and rice. The fertilizers were applied in rows along-side the seed at time of sowing of wheat. Nitrogen was applied in three splits. The seed rate of wheat used was 100 kg ha^{-1}, whereas, rice seedlings were transplanted at a spacing of 22.5 cm. All the standard cultural practices were followed during wheat periods. In each year, wheat was given three irrigations, *viz.* first at crown root initiation, second at late jointing and third at late flowering stage. The plant height (cm) and no. of tiller were recorded at 40 80, (days post sowing) and at harvest as presented in the form of tables. The yield attributes viz., number of spikes per m^2, no. of grains per spike, grain weight per spike (g) and 1000-grain weight were recorded at harvest. Grain yield was recorded from the net plot size and expressed as q ha^{-1}. Straw yield was calculated by subtracting the grain yield from biological yield. Harvest index was calculated by dividing the grain yield with biological yield (grain + straw) [9]. Statistical analysis was done as per randomized block design [10] and treatment means were compared at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

Plant height increased with increasing doses of nitrogen upto 120 kg ha^{-1} showing the value of 44.81 cm, 90.63 cm and 96.97 cm over $plant^{-1}$ as against 28.21 cm, 74.51 cm and 80.94 cm $plant^{-1}$ in control at 40 DAS 80 DAS and at harvest. (Table 1). Increase in plant height due to nitrogen application was also reported by Liaquat et al. [11]. Seed inoculation with *Azotobacter* significantly increased the plant height. *Azotobacter* showed the highest as 30.42 cm, 76.45 cm and 82.63 cm $plant^{-1}$as against the mean value of 28.21 cm, 74.51 cm and 80.94 cm $plant^{-1}$ in un-inoculation at40 DAS, 80 DAS and harvest stage. Significant increase in plant height due to seed inoculation with *Azotobacter* also has been reported by Rubiek et al. [12] and Tiwana et al. [13]. Highest plant height was recorded with the treatment combination (100 kg N ha^{-1} + *Azotobacter*) showing the value of 46.89 cm, 92.80 cm and 98.65 cm at 40 DAS,80 DAS and harvest stages of crop. More increase in plant height due to nitrogen combined with Azotobacter was also reported by Jaychandran et al. [14].

Number of leaves significantly increased upto the level of 120 kg N ha^{-1}. *Azotobacter* also increased number of leaves per plant significantly over un-inoculation (Table 2). From statistical point of view, the interaction of nitrogen levels and *Azotobacter* with regard to number of leaves per plant was significant. However, the maximum mean number of leaves per plant was noted as 4.53, 6.12 and 6.07 cm with the treatment combination of 100 kg N ha^{-1} + *Azotobacter*.

Application of nitrogen increased number of tillers $plant^{-1}$ with increasing levels of nitrogen upto 120 kg N ha^{-1} which showed the mean value of 7.67, 13.67 and 13.0 $plant^{-1}$ N-control as 4.53, 9.67and 9.27 $plant^{-1}$ at 40 DAS, 80 DAS and harvest stage (Table 3). Increase in total number of tillers $plant^{-1}$due to nitrogen application was also reported by Khosta and Raghu [15], Bharti [16], Mishra et al. [17], Pandey et al. [18] and Liaquat et al. [11]. *Azotobacter* inoculation significantly increased the number of $tillers^{-1}$ plant. Better tillering with value of 4.93, 10.27 and 9.87 $plant^{-1}$ was noted with mixed *Azotobacter* over un-inoculated control as 4.53, 9.67 and 9.27 $plant^{-1}$ at 40 DAS, 80 DAS and harvest stage. The increase in total number of tillers $plant^{-1}$ due to *Azotobacter* inoculation was also reported by Zambre and Kande [19]. Rubiek et al. (1989), Tiwana et al. [13] and Idris, M. (2003). The highest number of tillers $plant^{-1}$ was recorded with the treatment combination of T_{10} (100 kg N ha^{-1}+ *Azotobacter*) to the level of 8.13, 14.27and 13.33 $plant^{-1}$at 40 DAS, 80DAS and harvest stage of crop respectively.

The maximum dry matter accumulation was recorded 38.39, 195.59 and 276.67 (g) at 40 DAS , 80 DAS and harvest stage value which was recorded with application of 100 kg Nitrogen + *Azotobacter* (Table 4). The lowest dry matter accumulation was recorded 22.84, 171.24 and 251.33(g) at 40 DAS, 80 DAS and harvest stages control condition. More dry matter accumulation on the inoculation over un-inoculate control. Increase in the dry matter accumulation due to nitrogen application was also reported by Singh and Anderson [20].

3.2 Yield and Yield Attributes

Data depicted in the Table 4 shows that yield attributes of wheat was significantly affected by nitrogen application upto 120 kg N ha^{-1}, while the maximum yield attributes *viz.* Number of spike (286.33 m^{-2}), Number of grains $spike^{-1}$ (49.00) Test weight (43.95 g) was recorded under the treatment applying 100 kg Nitrogen + *Azotobacter* (T_{10}) which was at par with the treatment consisting T_9-120 kg Nitrogen ha^{-1}. Results fall in the conformity with the report of other workers [15,21]. Seed inoculation of *Azotobacter* significantly increased the yield attributes.

Application of nitrogen was responsible for general improvement in the growth and development of her plant, which had an overall favorable effect on grain and straw yields. It was evident that increasing doses of nitrogen significantly increased the grain yield upto 120 kg

N ha^{-1}. Data depicted in the Table 5 shows that Maximum yield of 45.7q ha^{-1} was recorded at 120 kg N ha^{-1}while minimum yield to the level of 38.1 q $ha^{-1}$was recorded in control in the same order Similar trend of result was noted in case of straw yield also. Significant increase in the grain

Table 1. Plant height (cm) of wheat as influenced by *Azotobacter* and nitrogen

S. No.	Treatments	Plant height (cm)		
		40 DAS	**80 DAS**	**At harvest**
T_1	Control (N-0,P-60,K-40Kg ha^{-1})	28.21	74.51	80.94
T_2	*Azotobacter*	30.42	76.45	82.63
T_3	60 kg Nitrogen ha^{-1}	32.33	78.35	84.39
T_4	40 kg Nitrogen ha^{-1} + *Azotobacter*	34.58	80.30	86.04
T_5	80 kg Nitrogen ha^{-1}	36.08	82.62	88.36
T_6	60 kg Nitrogen + *Azotobacter*	38.45	84.75	90.32
T_7	100 kg Nitrogen ha^{-1}	40.49	86.20	92.95
T_8	80 kg Nitrogen ha^{-1} + *Azotobacter*	42.49	88.71	94.91
T_9	120 kg Nitrogen ha^{-1}	44.81	90.63	96.97
T_{10}	100 kg Nitrogen ha^{-1}+ *Azotobacter*	46.89	92.80	98.65
SEm+		1.48	3.29	1.98
CD at 5 %		4.40	9.78	5.88

Table 2. Number of leaves plant^{-1} of wheat as influenced by *Azotobacter* and nitrogen

S. No.	Treatments	Number of leaves plant^{-1}		
		40 DAS	**80 DAS**	**At harvest**
T_1	Control (N-0, P-60, K-40 Kg ha^{-1})	3.20	3.65	3.53
T_2	*Azotobacter*	3.47	4.13	4.06
T_3	60 kg Nitrogen ha^{-1}	3.73	4.27	4.26
T_4	40 kg Nitrogen ha^{-1} + A*zotobacter*	4.13	4.33	4.20
T_5	80 kg Nitrogen ha^{-1}	4.27	4.60	4.53
T_6	60 kg Nitrogen ha^{-1} + *Azotobacter*	4.33	5.07	5.13
T_7	100 kg Nitrogen ha^{-1}	4.34	5.33	5.22
T_8	80 kg Nitrogen ha^{-1} + *Azotobacter*	4.47	5.73	5.41
T_9	120 kg Nitrogen ha^{-1}	4.48	5.80	5.67
T_{10}	100 kg Nitrogen ha^{-1}+ *Azotobacter*	4.53	6.12	6.07
SEm±		0.27	0.49	0.30
CD at 5%		0.80	1.45	0.88

Table 3. Dry matter accumulation (g)/m^2 of wheat as influenced by *Azotobacter* and nitrogen

S. No.	Treatments	Dry matter accumulation (g)/m^2		
		40 DAS	**80 DAS**	**At harvest**
T_1	Control (N-0, P-60, K-40Kg ha^{-1})	22.84	171.24	251.33
T_2	*Azotobacter*	25.13	175.90	255.00
T_3	60 kg Nitrogen ha^{-1}	30.34	178.08	258.33
T_4	40 kg Nitrogen ha^{-1} + *Azotobacter*	29.88	180.28	261.73
T_5	80 kg Nitrogen ha^{-1}	32.10	183.30	263.83
T_6	60 kg Nitrogen ha^{-1}+ *Azotobacter*	32.79	185..16	266.67
T_7	100 kg Nitrogen ha^{-1}	34.23	188.94	268.67
T_8	80 kg Nitrogen ha^{-1} + *Azotobacter*	35.12	190.41	271.33
T_9	120 kg Nitrogen ha^{-1}	36.18	193.60	273.33
T_{10}	100 kg Nitrogen ha^{-1}+ *Azotobacter*	38.39	195.59	276.67
SEm±		1.48	4.03	8.46
CD at 5%		4.39	11.97	25.14

Table 4. Yield attributes of wheat as influenced by *Azotobacter* and nitrogen

S. No.	Treatments	Number of spike (m^2)	Number of grains spike^{-1}	Test Weight (g)
T_1	Control (N-0, P-60, K-40 Kg ha^{-1})	216.33	38.67	35.23
T_2	*Azotobacter*	238.00	42.67	39.56
T_3	60 kg Nitrogen ha^{-1}	238.67	44.00	40.49
T_4	40 kg Nitrogen ha^{-1} + *Azotobacter*	246.67	44.33	40.85
T_5	80 kg Nitrogen ha^{-1}	254.33	45.00	41.87
T_6	60 kg Nitrogen ha^{-1}+ *Azotobacter*	258.67	45.67	43.17
T_7	100 kg Nitrogen ha^{-1}	263.33	46.00	43.08
T_8	80 kg Nitrogen ha^{-1} + *Azotobacter*	264.33	46.67	43.92
T_9	120 kg Nitrogen ha^{-1}	284.00	47.67	43.95
T_{10}	100 kg Nitrogen ha^{-1}+ *Azotobacter*	286.33	49.00	44.81
SEm±		18.94	2.59	1.33
C.D. at 5%		56.27	7.69	3.96

Table 5. Yield and harvest index of wheat as influenced by Azotobacter and nitrogen

S. No.	Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1	Control (N-0, P-60, K-40 Kg ha^{-1})	38.1	64.37	37.2
T_2	*Azotobacter*	39.0	66.70	36.9
T_3	60 kg Nitrogen ha^{-1}	43.4	64.50	40.2
T_4	40 kg Nitrogen ha^{-1} + *Azotobacter*	44.0	66.83	39.7
T_5	80 kg Nitrogen ha^{-1}	45.1	68.07	39.9
T_6	60 kg Nitrogen ha^{-1}+ *Azotobacter*	45.5	67.27	40.3
T_7	100 kg Nitrogen ha^{-1}	45.3	68.80	39.7
T_8	80 kg Nitrogen ha^{-1} + *Azotobacter*	46.5	68.43	40.4
T_9	120 kg Nitrogen ha^{-1}	45.7	69.03	39.8
T_{10}	100 kg Nitrogen ha^{-1}+ *Azotobacter*	47.9	69.73	40.7
SEm±		1.20	1.71	NS
C.D.at 5%		3.56	5.07	NS

and straw yield due to nitrogen in the study corroborates the findings of Singh and Singh (1989), and Pandey et al*.* [18]. *Azotobacter* inoculation significantly increased the grain and straw yield over un-inoculate control. Although inoculation of *Azotobacter* along with 39.0 q ha^{-1} as compared to 38.1in un-inoculated control. Similar trend was noted in case of straw yield also. Increase in grain and straw yield of wheat due to *Azotobacter* inoculation was also reported by Maskey [22], Poi and Kabi [23] and Singh et al. (2000). Interaction of nitrogen levels and *Azotobacter* in relation to wheat yield (grain and straw) was significant. However apparently, the inoculation response at higher dose of nitrogen was lower as compared to no or lower dose of nitrogen. Maximum gain yield (47.9 q ha^{-1}) was noted in the treatment combination of 100 kg N ha^{-1} + Azotobacter inoculation. Higher crop yields due to combined use of nitrogen and Azotobacter has also been reported by Shivankar et al. (1993), Soliman et al. [24] and Tomar et al. [25]. Nitrogen economy through *Azotobacter* inoculation ranging from 24 to 30 kg ha^{-1} has been reported by Raut et al. [26,27-30].

4. CONCLUSION

The integrated use of organic sources (viz. bio-fertilizer) along with inorganic fertilizers positively affected the growth, and yield of wheat crop. The potential yield of wheat crop could be achieved by adopting treatment as T_{10} (100 kg ha^{-1} Nitrogen + Azotobacter) and considered to be the most effective treatment for sustainable wheat production.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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