The Pharma Innovation Journal 2021; 10(10): 1979-1982

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(10): 1979-1982

www.thepharmajournal.com
Received: 18-08-2021
Accepted: 29-09-2021

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Effect of bio-fertilizers and nitrogen levels on growth and yield of wheat (*Triticum aestivum* L.)

Kammara Sharath Sainath Achari, Shikha Singh and Shahazad Ahmed Khan

Abstract
A field experiment was conducted during *Rabi* 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U. P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The treatments which are T_1: control, T_2: *Azotobacter* + 100 kg/ha N, T_3: *Azotobacter* + 120 kg/ha N, T_4: *Azotobacter* + 140 kg/ha N, T_5: *Azospirillum* + 100 kg/ha N, T_6: *Azospirillum* + 120 kg/ha N, T_7: *Azospirillum* + 140 kg/ha N, T_8: *Azotobacter* + *Azospirillum* + 100 kg/ha N, T_9: *Azotobacter* + *Azospirillum* + 120 kg/ha N, T_{10}: *Azotobacter* + *Azospirillum* + 140 kg/ha N used. The experiment was laid out in Randomized Block Design with ten treatments each replicated trice. The results showed that application of *Azotobacter* + *Azospirillum* + 140 kg/ha N was recorded significantly higher plant height (86.07 cm), number of tillers/plant (6.34), dry weight (19.58 g/plant), number of effective tillers/m^2 (296.16), length of the spike (11.25 cm), test weight (46.93 g), number of grains/spike (58.11), grain yield (5.63 t/ha) and straw yield (13.20 t/ha), whereas harvest index (33.1%) was recorded maximum with *Azotobacter* + 120 kg/ha N.

Keywords: Wheat, bio fertilizers, nitrogen, *Azotobacter, Azospirillum*

Introduction
Wheat (*Triticum aestivum* L.) is an important staple food crop, which grown ancient time in the world and known as 'king of cereal' belongs to the family 'Poaceae'. It is the first important and strategic cereal crop for majority of world's population. It is the most staple food of about two billion people (36% of the world's population). Wheat is world's most widely cultivated food crop after rice and it is utilized in various forms by more than billion people in the world, being a staple food for large population contributing about 20% of humans' daily dietary calorie and protein intake (Shiferaw *et al*. 2013) [14]. It 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. A larger area has come in Punjab under irrigated condition due to high yielding varieties developed to obtaining the foreign exchange. Wheat grain is rich in food value containing 12% protein, 1.72% fat, 69.60% carbohydrate and 27.20% minerals (BARI, 2016) [3]. Measured either by cultivated area (211.06 million ha) or by the production (566.8 million t) achieved (Jagshoran *et al*., 2004) [7]. It is grown throughout the temperate, tropical and sub-tropical region in the world. It constitutes the staple food in at least 43 countries.
Biofertilizers play vital role to enhance the growth as well as the yield of crop plants. They involve in various biotic activities and sustainable for crop production (Amjed *et al*., 2011) [2]. Biofertilizers play an important role in the growth of plants as well as they bring down the cost of chemical fertilizers E.g. phosphorous, nitrogen and potassium. Biofertilizers contains microscopic microorganisms which are used as fertilizers for the growth of plants e.g Azospirillum sp. and Azotobacter sp. Biofertilizers due to its renewable, cheap and eco-friendly nature has gained increasing popularity in the past one decade in the field of agriculture and food production.
Nitrogen is one the most important mineral nutrients for poaceae plants influencing growth, development, yield, and protein content of grains. Wheat yields in the semiarid regions are not only limited by inadequate water supply, but also by nitrogen shortage late in the cropping season. Nitrogen plays a vital role in all living tissues of the plant. No other element has such an effect on promoting vigorous plant growth.

Abundant protein tends to increase number of the leaves, and accordingly, to bring about an increase in carbohydrate synthesis. Nitrogen plays a vital role in increasing the yield of the crop. Application of proper amount of nitrogen is considered key to obtain bumper crop of wheat. Nitrogen comprises 7% of total dry matter of plants and is a constituent of many fundamental cell components such as nucleic acids, amino acids, enzymes, and photosynthetic pigments. Generally, nitrogen (N) fertilization at sowing increases wheat grain yield, and late fertilization enhances grain protein concentration (Bishnupriya Patra and Pratik Kumar Ray, 2018) [8].

Materials and Methods

This experimental trial was carried out during *Rabi* 2020 at Crop Research Farm (CRF), Department of Agronomy, Sam Higginbottom University of Agriculture, Technology & Sciences (SHUATS), Prayagraj (U. P) located at 25˚39”42” North latitude, 81˚67”56” East longitude and 98 m altitude above the mean sea level. The experiment laid out in Randomized Block Design consisting of ten treatments which are T_1: control, T_2: *Azotobacter* + 100 kg/ha N, T_3: *Azotobacter* + 120 kg/ha N, T_4: *Azotobacter* + 140 kg/ha N, T_5: *Azospirillum* + 100 kg/ha N, T_6: *Azospirillum* + 120 kg/ha N, T_7: *Azospirillum* + 140 kg/ha N, T_8: *Azotobacter* + *Azospirillum* + 100 kg/ha N, T_9: *Azotobacter* + *Azospirillum* + 120 kg/ha N, T_{10}: *Azotobacter* + *Azospirillum* + 140 kg/ha N replicated thrice to determine the effect of Bio-fertilizers and Nitrogen on Growth and Yield of Wheat. The soil of trial plot was sandy loam in texture nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The nutrient sources used in the research plot were urea, DAP and MOP to fulfill the requirements of nitrogen, phosphorous and potassium. The recommended dose of 60 kg P/ha and 60 kg K/ha were applied. Whereas, Nitrogen is applied according to the treatment details and the seeds were treated with the biofertilizers i.e. *Azotobacter* and *Azospirillum* as per the treatment combinations. 15 days after sowing thinning and hand weeding were done. Four irrigations were given at CRI stage, tillering stage, booting stage and flowering stage. Between the period of germination to harvest several plant growth parameters were recorded at equal intervals and after harvest several yield parameters were recorded. In growth parameters plant height (cm), dry weight (g) per plant and number of tillers/hill were recorded and yield parameters like number of spikes/m^2, spike length (cm), number of grains per spike, test weight (g), grain yield (t/ha), straw yield (t/ha) and harvest index (%)were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez, K. A. and Gomez, A. A. 1984).

Results and Discussion

Effect on growth of wheat

The statistical data regarding growth parameters is presented in Table 1.

Plant height (cm)

Significantly higher plant height (86.07 cm) was observed in treatment *Azotobacter* + *Azospirillum* + 140 kg/ha N. Whereas, plant height 83.97 cm with treatment *Azospirillum* + 140kg/ha N and 83.30 cm with treatment *Azotobacter* + *Azospirillum* + 120kg/ha N were found to be statistically at par with treatment *Azotobacter* + *Azospirillum* + 140kg/ha N compared to other treatments. The increase in plant height in response to application of N fertilizers is probably due to enhanced availability of nitrogen (Indra chaturvedi, 2006) [6] and inoculation of bacterial preparation accelerate plant growth provide biologically fixed nitrogen to the inoculated plant and also stimulate plant growth by excreting plant growth promoting substances like auxins, kinetins, vitamins and gibberellins as similarly observed by Malik *et al*., 2005 [9].

Dry weight (g)/plant

Significantly higher dry weight (19.58 g) was observed in treatment *Azotobacter* + *Azospirillum* + 140kg/ha N. However, treatment *Azospirillum* + 140kg/ha N with 17.20 g and *Azotobacter* + *Azospirillum* + 120kg/ha N with 16.06 g found to be statistically at par with *Azotobacter* + *Azospirillum* + 140kg/ha N compared to other treatments. The adequate supply of Nitrogen allowed the plant tissue to grow large and increase the chlorophyll formation and stimulated rapid rate of photosynthetic activity, consequently recorded more dry matter accumulation in comparison to its lower level as stated by Singh *et al*., (2019) [15]. Inoculation of biofertilizers stimulates activation of hormones which helps in shoot and root elongation and high dry matter production, similar results were observed by Akhthar *et al*., (2018) [1].

Number of tillers/plant

Significantly higher number of tillers/plant (6.34) was observed in treatment *Azotobacter* + *Azospirillum* + 140kg/ha N. However, treatments *Azospirillum* + 140kg/ha N, *Azotobacter* + *Azospirillum* + 120kg/ha N and *Azotobacter* + 140 kg/ha N were statistically at par with *Azotobacter* + *Azospirillum* + 140kg/ha N compared to other treatments. The number of tillers was increased due to the greater availability of nutrients in soil due to increasing application of Nitrogen doses might have enhanced multiplication and elongation of cells leading to increased number of tillers reported by Maurya *et al*., (2019) [10]. MeCarty *et al*., (2017) [11] stated that inoculation of Azotobacter and PSB solubilization of inorganic insoluble phosphates by microorganisms to the production of organic acids, chelating oxoacids from sugars, and exchange reactions in growth environment.

Table 1: Effect of Bio-fertilizers and Nitrogen levels on growth parameters of Wheat.

	Treatments	Plant height (cm)	Dry weight (g/plant)	No. of tillers/ plant
1	Control	70.03	10.44	5.14
2	*Azotobacter*+100kg/ha N	73.53	12.63	5.29
3	*Azotobacter*+120kg/ha N	76.07	13.74	5.28
4	*Azotobacter*+140kg/ha N	81.27	15.52	6.02
5	*Azospirillum*+100kg/ha N	75.03	13.83	5.46
6	*Azospirillum*+120kg/ha N	78.23	15.27	5.84
7	*Azospirillum*+140kg/ha N	83.97	17.20	6.23
8	*Azotobacter*+*Azospirillum*+100kg/ha N	77.30	15.07	5.66
9	*Azotobacter*+*Azospirillum*+120kg/ha N	83.30	16.06	6.11
	Azotobacter+*Azospirillum*+140kg/ha N	86.07	19.58	6.34
	S. EM (±)	1.53	1.35	0.12
	CD (5%)	4.53	4.02	0.36

Effect on yield and yield attributes of wheat

The statistical data representing yield and yield attributes is presented in Table 2.

Number of Spikes/m^2

Azotobacter + *Azospirillum* + 140kg/ha N was recorded with maximum number of spikes/m^2 (296.16) over all the treatments. However, *Azotobacter* + *Azospirillum* + 120kg/ha N and *Azospirillum* + 140kg/ha N were statistically at par to *Azotobacter* + *Azospirillum* + 140kg/ha N as compared to all the treatments. The probable reason might be due to the enhanced early vegetative growth in terms of higher leaf area, dry matter accumulation and vigorous root system resulted in more spikes which consequently increased the number of spikes bearing tillers significantly. Similar findings were observed by Devi *et al*., (2011) [5]

Length of the spike

The non-significant results were obtained in case of spike length, maximum spike length (11.25 cm) was recorded with *Azotobacter* + *Azospirillum* + 140kg/ha N, whereas the minimum length of the spike (9.92 cm) was recorded with control plot.

Number of grains/spike

Treatment *Azotobacter* + *Azospirillum* + 140kg/ha N was recorded significantly maximum number of grains/spike (58.11) over all the treatments. However, *Azotobacter* + *Azospirillum* + 120kg/ha N, *Azotobacter* + *Azospirillum* + 100kg/ha N, *Azospirillum* + 140kg/ha N, *Azospirillum* + 120kg/ha N, *Azotobacter* + 140kg/ha N, were statistically at par with *Azotobacter* + *Azospirillum* + 140kg/ha N over all the treatments. Significant increase in number of grains /spike is due to increase in higher doses of Nitrogen by which more spikelets are produced due to increased rates of spikelets primordial production, similar results were found by Bhatta *et al*., (2020) [4].

Test weight (g)

Azotobacter + *Azospirillum* + 140kg/ha N was recorded significantly highest Test weight (46.93 g). Whereas, *Azospirillum* + 140kg/ha N was statistically at par with *Azotobacter* + *Azospirillum* + 140kg/ha N.

Grain yield (t/ha)

Significantly maximum grain yield (5.63 t/ha) was recorded with the treatment *Azotobacter* + *Azospirillum* + 140kg/ha N. However, 5.42 t/ha in *Azospirillum* + 140kg/ha N, 5.24 t/ha in *Azotobacter* + *Azospirillum* + 120kg/ha N, 5.20 t/ha in *Azotobacter* + 140kg/ha N and 5.18 t/ha in *Azospirillum* + 120kg/ha N which were statistically at par with *Azotobacter* + *Azospirillum* + 140kg/ha N as compared to other treatments. The increase in grain yield might be due to application of higher doses of nitrogen, which increases the photosynthetic activity and might have increased vegetative growth and yield attributes also improved ultimately increased grain yield. Similar findings have been observed by Pandey *et al*., (2018) [18]. Kaur *et al*., (2018) [8] observed that increase in yield attributes and yield through bio-fertilizer might be attributed to supply of more plant hormones (auxin, cytokinin, gibberellin etc.) by the microorganisms inoculated or by the root resulting from reaction to microbial population.

Straw yield (t/ha)

Significantly higher straw yield (13.20 t/ha) was recorded with the treatment *Azotobacter* + *Azospirillum* + 140kg/ha N. However, *Azospirillum* + 140kg/ha N, *Azotobacter* + *Azospirillum* + 120kg/ha N, *Azotobacter* + 140kg/ha N and *Azospirillum* + 120kg/ha N which were statistically at par with *Azotobacter* + *Azospirillum* + 140kg/ha N as compared to other treatments. Incorporation of bio-fertilizer not only increased the growth and yield attributing characters but also increased the straw yields of wheat, reported by Kaur *et al*., (2018) [8]. Bhatta *et al*., (2020) [4] observed that Straw yield is dependent on vegetative growth as use of balanced and optimum use of fertilizer increased plant height, green leaves per hill, and dry matter production, which finally resulted in higher straw yield.

Harvest index (%)

Significantly highest harvest index (33.1%) was recorded with the treatment *Azotobacter* + 120kg/ha N. However, *Azotobacter* + *Azospirillum* + 140kg/ha N, *Azospirillum* + 140kg/ha N, *Azotobacter* + *Azospirillum* + 120kg/ha N, *Azotobacter* + 140kg/ha N, *Azospirillum* + 120kg/ha N and *Azospirillum* +100 kg/ha N which were statistically at par with *Azotobacter* + 120kg/ha N as compared to other treatments.

Table 2: Effect of Bio-fertilizers and Nitrogen levels on yield and yield attributes of Wheat.

	Treatments	Spikes/ m^2	Grains/spike	Length of spike(cm)	Test weight(g)	Grain yield(t/ha)	Straw yield(t/ha)	Harvest Index (%)
1	Control	234.16	47.97	9.92	36.77	3.24	7.92	21.9
2	*Azotobacter*+100kg/ha N	243.20	48.22	10.20	38.35	4.31	8.91	32.6
3	*Azotobacter*+120kg/ha N	255.69	50.89	10.69	39.06	4.61	10.70	33.1
4	*Azotobacter*+140kg/ha N	276.00	55.33	10.78	42.32	5.20	12.25	29.8
5	*Azospirillum*+100kg/ha N	246.21	49.77	10.51	38.50	4.42	9.70	31.4
6	*Azospirillum*+120kg/ha N	264.28	53.11	10.77	40.39	5.18	12.09	30.0
7	*Azospirillum*+140kg/ha N	291.61	57.33	11.04	44.39	5.42	12.73	29.8
8	*Azotobacter*+*Azospirillum*+100kg/ha N	256.54	54.00	10.69	39.85	4.63	11.97	27.7
9	*Azotobacter*+*Azospirillum*+120kg/ha N	285.87	56.11	10.89	43.27	5.24	13.03	28.7
10	*Azotobacter*+*Azospirillum*+140kg/ha N	296.16	58.11	11.25	46.93	5.63	13.20	30.0
	S. EM (±)	3.70	2.28	0.34	1.04	0.32	0.40	1.74
	CD (P = 0.05)	10.98	6.77	1.00	3.10	0.94	1.19	5.18

Conclusion

Based on the findings of the investigation it may be concluded that *Azotobacter* + *Azospirillum* + 140 kg/ha N performed exceptionally in all growth and yield parameters and in obtaining maximum seed yield of wheat. Hence, *Azotobacter* + *Azospirillum* + 140 kg/ha N is beneficial under eastern Uttar Pradesh Conditions.

Acknowledgement

The authors are thankful to Department of Agronomy, Naini Agricultural institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj-211007,

Uttar Pradesh, India for providing us necessary facilities to undertake the studies.

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