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Influence of Biofertilizers and Nitrogen on the Growth and Yield of Barley (*Hordeum vulgare* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The field experiment entitled "Influence of Biofertilizers and Nitrogen on the Growth and Yield of Barley (*Hordeum vulgare* L.)" was conducted during *Rabi* season, 2022 at Crop Research Farm in the Department of agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj Uttar Pradesh. The study included biofertilizers and three levels of Nitrogen (60, 80 and 100 kg/ha) and control. The experiment was layout in Randomized Block Design (RBD) with 10 treatments and replicated thrice. The soil in the experimental area was sandy loam with pH (8.0), EC (0.56 dS/m), Organic Carbon (0.62%), Available N (225 kg/ha), Available P (38.2 kg/ha), and Available K (240.7 kg/ha). Application of *Azotobacter* + *Azospirillum* and N 100 kg/ha produces higher plant height (95.10 cm), maximum number of tillers/running row meter (72.00) and higher dry weight (25.53g), maximum number of effective tillers/m^2 (201.33), maximum number of grains/spike (51.20), higher grain yield (4.34 t/ha), straw yield (5.34 t/ha).

Keywords: Barley; biofertilizers; nitrogen; growth; yield.

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1. INTRODUCTION

"Barley (*Hordeum vulgare* L.) is the world's 4th most essential cereal crop after wheat, rice and maize with a share of about 7% of the global cereals production and 15% of coarse grains consumption. Barley is grown throughout the temperate, tropical and subtropical regions of the world and can be successfully grown in adverse climatic conditions of drought, salinity and alkalinity due to its wider adaptability" [1].

"Barley is generally grown on marginal and sub-marginal land because of its low inputs requirement. Barley grain is also valued for smothering and cooling effect on the body for easy digestion and as a source of vitamin B complex. Besides these conventional uses, it is an important industrial crop used as raw material for beer, whisky and brewing industries. Each 100 g of barley grain comprise 10.6 g protein, 2.1 g fat, 64.0 g carbohydrate, 50.0 mg calcium, 6.0 mg iron, 31.0 mg vitamin B_1, 0.1 mg vitamin B_2 and 50.0 µg folate" [2]. "In India, barley is mainly grown in the northern plains and concentrated in the states of Utter Pradesh, Haryana and Rajasthan. In India, barley was cultivated on 609 thousand ha area with 1818 thousand tonnes of production at an average productivity of 29.88 q/ha. In India, Rajasthan is the largest state having more than 52 % in production and 46% area followed by Uttar Pradesh. In Uttar Pradesh, barley was cultivated on 159.0 thousand ha area with 498.0 thousand tonnes of production at an average productivity of 31.32 q/ha" [3].

"Due to climate change, increased population pressure and detrimental environmental impacts on agriculture fields and continuous use of chemicals leads to decrease in organic carbon, reduction in microbial flora of soil, increasing acidity and alkalinity and hardening of soil are constantly facing many detrimental effects which finally lead to scarcity of food production. To overcome the situation, new mechanism must be developed to meet the increased food demands with sustainable food production that has the potentiality to provide adequate food nutrition without hampering the fields" [2]. One such mechanism that is used to meet the agricultural need is "Biofertilizer".

"Azotobacter are abiotic, free living soil microbes which play an important role in the nitrogen cycle in nature and binding atmospheric nitrogen which is inaccessible to plants. Inoculation with Azotobacter has been found to reduce the requirement of chemical fertilizer up to 50 per cent" [4]. *Azotobacter* is most common free-living heterotrophic bacterium having valuable role in case of crop production.

"Bio-fertilizer normally contains microorganisms which are having particular function such as N_2 fixation by *Azospirillum* and phosphorus solubilisation by P solubilizing bacteria from the soil and fertilizer which are to be available for plants" [5].

"Nitrogen is one of the most important mineral nutrients for plants influencing growth, development, yield and protein content of grains" [6]. "It promotes shoot elongation, tillering and regeneration after defoliation and governs to considerable degree, the utilization of phosphorus, potassium and other elements in the plant. Nitrogen is the most limiting factor for high crop productivity but its use efficiency is low. Secondly, the application of increased doses of N increases cost of production. Nitrogen also plays an important role in maintaining the yield attributes in barley" [7]. Another important function of nitrogen that can impact barley production is regarding its acceptability for malting status in relation to grain protein content [8,9].

2. MATERIALS AND METHODS

This experiment was laid out during the *Rabi* season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U. P.). The crop research farm is situated at 25^0 39" 42" N latitude, 81^0 67" 56" E longitude and at an altitude of 98 m above mean sea level. The experiment was laid out in Randomized Block Design (RBD) which consisting of ten treatments; T_1 – Control (NPK 80-30-20 Kg/ha), T_2 – *Azotobacter* + Nitrogen 60 kg/ha, T_3 – *Azotobacter* + Nitrogen 80 kg/ha, T_4 - *Azotobacter* + Nitrogen 100 kg/ha, T_5 - *Azospirillum* + Nitrogen 60 kg/ha, T_6 - *Azospirillum* + Nitrogen 80 kg/ha, T_7 - *Azospirillum* + Nitrogen 100 kg/ha, T_8 - *Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha, T_9 - *Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha, T_{10} - *Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha. Seeds are sown at a spacing of 23 cm × 5 cm to a seed rate of 100 kg/ha. The recommended dose of nitrogen (80 kg/ha), phosphorus (30 kg/ha) and potassium (20 kg/ha). Data recorded on different aspects of crop, *viz.,*

growth, yield attributes were subjected to statistical analysis by analysis of variance (ANOVA) method" [10] and economic data analysis by mathematical method.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

The data revealed that significantly and higher plant height (95.10 cm) recorded in treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha]. However, the treatment 9 [*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha] (93.15 cm), treatment 8 [*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha] (92.02 cm), were found to be statistically at par with treatment 10.

"The significant and higher plant height was observed with the application of N (100 kg/ha) might be due to increased level of N application increased availability of nitrogen leading to better nutritional environment in the root zone for growth and development. As nitrogen is one of the major essential plant nutrients required for growth and its uptake by plants might have enhanced rapid cell division, cell enlargement and cell multiplication leading to better vertical growth" [11]. "Further increase in plant height observed with the application of biofertilizers might be due to increase levels of biofertilizers application improve growth by increasing the supply or availability of primary nutrients to the host plant. The increased endogenous nitrogen content due to inoculation might have promoted crop growth" [12].

3.1.2 Number of tillers/running row meter

The data revealed that significantly and maximum number of tillers/running row meter (72.00) recorded in treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha]. However, treatment 9 [*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha] (70.33), treatment 8 [*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha] (70.00), treatment 7 [*Azospirillum* + Nitrogen 100 kg/ha] (68.33), were found to be statistically at par with treatment 10.

"The significant and maximum number of tillers/running row meter was observed with the application of biofertilizers might be due to increases level of biofertilizers application documented that tiller production in cereals, initially determined by rate of auxiliary bud growth and later on growth of individual tiller, which is markedly influenced by environmental factors (temperature, photoperiod etc.) as well as availability of mineral nutrients and photosynthates" [13].

3.1.3 Plant dry weight (g/plant)

The data revealed that significantly and maximum plant dry weight (25.53 g) recorded in treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha]. However, treatment 9 [*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha] (24.94 g), treatment 8 [*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha] (23.77 g), treatment 7 [*Azospirillum*+ Nitrogen 100 kg/ha] (23.46 g), were found to be statistically at par with treatment 10.

"The significant and higher plant dry weight (g) was observed with the application of Nitrogen (100 kg/ha) might be due increase levels of N adequate supply of Nitrogen which resulted in plant tissue growth 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" [14]. "Further increase in dry weight observed with the application of biofertilizers might be due to biofertilizers stimulates activation of hormones which helps in shoot and root elongation and high dry matter production" [15].

3.1.4 Post harvest observations

Number of effective tillers/m^2: The data revealed that Treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha] recorded significant and maximum effective tillers/m^2 (201.33) which was superior over all other treatments. However, the treatment 9 [*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha] (200.33), treatment 8 [*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha] (195.00), treatment 7 [*Azospirillum*+ Nitrogen 100 kg/ha] (193.00), treatment 6 [*Azospirillum*+ Nitrogen 80 kg/ha] (191.33), treatment 5 [*Azospirillum*+ Nitrogen 60 kg/ha] (190.00), treatment 3 [*Azotobacter* + Nitrogen 80 kg/ha] (189.33), treatment 2

Table 1. Effect of biofertilizers and nitrogen on growth of barley

S. No.	Treatment combinations	At 120 DAS		
		Plant height (cm)	Number of tillers/running row meter	Dry weight (g/plant)
1.	Control (NPK 80-30-20 Kg/ha)	81.30	58.33	20.06
2.	*Azotobacter* + Nitrogen 60 kg/ha	87.33	62.00	20.74
3.	*Azotobacter* + Nitrogen 80 kg/ha	84.59	61.33	22.27
4.	*Azotobacter* + Nitrogen 100 kg/ha	84.46	61.33	21.44
5.	*Azospirillum*+ Nitrogen 60 kg/ha	81.03	59.33	21.94
6.	*Azospirillum*+ Nitrogen 80 kg/ha	85.49	64.33	22.03
7.	*Azospirillum*+ Nitrogen 100 kg/ha	84.79	68.33	23.46
8.	*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha	92.02	70.00	23.77
9.	*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha	93.15	70.33	24.94
10.	*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha	95.10	72.00	25.53
	F-test	S	S	S
	SEm(±)	2.60	2.35	0.78
	CD (p=0.05)	7.71	6.97	2.32

Table 2. Effect of biofertilizers and nitrogen on yield attributes and yield of barley

S. No.	Treatment combination	Number of effective tillers/m^2	Number of grains/spike	Grain Yield (t/ha)	Straw Yield (t/ha)
1.	Control (NPK 80-30-20 Kg/ha)	171.33	44.53	2.77	3.72
2.	*Azotobacter* + Nitrogen 60 kg/ha	189.67	44.93	3.47	4.32
3.	*Azotobacter* + Nitrogen 80 kg/ha	189.33	47.13	3.49	4.59
4.	*Azotobacter* + Nitrogen 100 kg/ha	175.33	46.07	3.26	4.10
5.	*Azospirillum*+ Nitrogen 60 kg/ha	190.00	45.67	3.40	4.55
6.	*Azospirillum*+ Nitrogen 80 kg/ha	191.33	47.27	3.70	4.60
7.	*Azospirillum*+ Nitrogen 100 kg/ha	193.00	48.87	3.67	4.92
8.	*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha	195.00	49.47	3.89	5.04
9.	*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha	200.33	50.53	4.26	5.42
10.	*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha	201.33	51.20	4.31	5.51
	F-test	S	S	S	S
	SEm(±)	5.90	1.41	0.22	0.21
	CD (p=0.05)	17.54	4.19	0.65	0.64

[*Azotobacter* + Nitrogen 60 kg/ha] (189.67) were found to be statistically at par with treatment 10.

The significant and maximum number of effective tillers/m^2 was observed with the application of biofertilizers might be due to increase levels of biofertilizers application increased in availability of nitrogen for plant uptake that resulted in growth promotion of plant attributes such as increased tillering, thus resulting in an increased number of effective tillers [16].

Number of grains/spike: The data revealed that Treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha] recorded significant and maximum number grain/spike (51.20) which was superior over all other treatments. However, the treatment 9 [*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha] (50.53), treatment 8 [*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha] (49.47), treatment 7 [*Azospirillum*+ Nitrogen 100 kg/ha] (48.87), treatment 6 [*Azospirillum*+ Nitrogen 80 kg/ha] (47.27), treatment 3 [*Azotobacter* + Nitrogen 80 kg/ha] (47.13) was found to be statistically at par with treatment 10.

Grain yield (t/ha): The data revealed that Treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha] recorded significantly maximum grain yield (4.31 t/ha) which was superior over all other treatments. However, the treatment 9 [*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha] (4.26 t/ha), treatment 8 [*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha] (3.89 t/ha), treatment 7 [*Azospirillum*+ Nitrogen 100 kg/ha] (3.67 t/ha), treatment 6 [*Azospirillum*+ Nitrogen 80 kg/ha] (3.70 t/ha), was found to be statistically at par with treatment 10.

"The significant and maximum grain yield was observed with the application of Biofertilizers might be due to increase levels of biofertilizers application increased yield attributes of barley might be due to release of growth hormones by various biofertilizers" [17].

Straw yield (t/ha): The data revealed that Treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha] recorded significantly maximum Straw yield (5.51 t/ha) which was superior over all other treatments. However, the treatment 9 [*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha] (5.42 t/ha), treatment 8 [*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha] (5.04 t/ha), treatment 7 [*Azospirillum*+ Nitrogen 100 kg/ha] (4.92 t/ha), was found to be statistically at par with treatment 10.

4. CONCULSION

Based on the finding it is concluded that seed inoculation with *Azotobacter* and *Azospirillum* along with application of Nitrogen (100 kg/ha) produce significantly higher plant height, dry weight, number of tillers/running row meter, number of effective tillers/m^2, number of grains/spike, grain yield and straw yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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