Influence of Biofertilizers and Zinc on the Growth and Yield of Barley

ABSTRACT

The field experiment entitled "Influence of Biofertilizers and Zinc on the Growth and Yield of Barley" 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 treatment consisted of Biofertilizers [*Azotobacter*, PSB and *Azotobacter* + PSB], Zn (20, 25 and 30 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), 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* + PSB and Zn 30 kg/ha recorded growth parameters and yield attributes like, highest plant height (107.63 cm), maximum number of tillers/running row meter (66.32), higher Plant dry weight (22.31 g), maximum number of effective tillers/m^2 (278.85), maximum number of grains/spike (52.27), higher grain yield (4.29 t/ha) and straw yield (6.72 t/ha).

Keywords: Barley, Biofertilizers, Zinc, *Azotobacter*, PSB, Growth and Yield attributes.

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" **(Neelam *et al*., 2018)**.

"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" **(Vaughan *et al*., 2006)**. "In India, barley is mainly grown in the northern plains and concentrated in the states of Uttar Pradesh, Haryana and Rajasthan. In India, barley was cultivated on 609 thousand ha area with 1818 thousand t 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" **(IIWBR, 2020-21)**.

Climate change, growing population pressure, negative environmental effects on agricultural areas, and continued chemical use reduce organic carbon, reduce soil microbial flora, raise acidity and alkalinity, and harden the soil. hese negative effects eventually lead to a decrease in 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. "Biofertilizer" is one such method for addressing agricultural needs". [19]

Azotobacter are abiotic, naturally occurring soil microorganisms that bind atmospheric nitrogen that is unavailable to plants and play a significant role in the nitrogen cycle in nature. Inoculation with *Azotobacter* has been found to reduce the requirement of chemical fertilizer up to 50% shown to lower the need for chemical fertilizer by up to 50%. **(Soleimanzadeh and Gooshchi, 2013)**. The most prevalent heterotrophic free-living bacterium, Azotobacter, is important for 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 **(Saraswati and Sumarno, 2008)**.

"Several enzyme systems that control different metabolic processes in plants depend on zinc. It contributes to the synthesis of auxins, which are plant growth regulators. Zinc is also vital for the oxidation processes in plant cells and helps in the transformation of carbohydrates and regulates sugar in plants" . [20] "Zinc helped to increase leaf area, chlorophyll content in leaves, uptake of total Zinc availability in soil agronomic efficiency, grain and stover yield of sorghum" **(Jakhad *et al*., 2023).**

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 Which consisted of ten treatments with T_1 – *Azotobacter* + Zn 20 kg/ha, T_2 – *Azotobacter* + Zn 25 kg/ha, T_3 – *Azotobacter* + Zn 30 kg/ha, T_4 - PSB + Zn 20 kg/ha, T_5 - PSB + Zn 25 kg/ha, T_6 - PSB + Zn 30 kg/ha, T_7 - *Azotobacter* + PSB + Zn 20 kg/ha, T_8 - *Azotobacter* + PSB + Zn 25 kg/ha, T_9 - *Azotobacter* + PSB + Zn 30 kg/ha, T_{10} - Control (NPK 80-30-20 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) in the form of Urea, DAP and MOP, respectively and Biofertilizer and zinc were applied as per the treatments. Data recorded on different aspects of the crop, *viz.*, growth, yield attributes were subjected to statistically analysis by analysis of variance method". (**Gomez and Gomez, 1976)** and economic data analysis mathematical method.

RESULT AND DISCUSSION:

Growth parameters

Plant height (cm)

"The data revealed that a significantly and higher plant height (107.68 cm) was recorded in treatment 9 [*Azotobacter* + PSB + Zn 30 kg/ha]. However, treatment 8 [*Azotobacter* + PSB + Zn 25 kg/ha] (106.00 cm), treatment 7 [*Azotobacter* + PSB + Zn 20 kg/ha] (103.70 cm), were found to be statistically at par with treatment 9. The significant and higher plant height found with zinc treatment could be attributed to zinc's involvement in the manufacture of indole acetic acid (IAA), which aids in the development of growth characteristics". [20] Similar result was reported by **(Ganapathy *et al*. 2006).** Further increase in plant height observed with the application of biofertilizers (20g/kg seed) might be due increase levels of biofertilizers application to improve growth by increasing the supply or availability of primary nutrients to the host plant. Crop development may have been aided by the higher endogenous nitrogen content brought on by inoculation. These results were supported by

Aechra *et al*. (2020).

Number of tillers/running row meter

The data revealed that a significantly and maximum number of tillers/running row meter (66.32) was recorded in treatment 9 [*Azotobacter* + PSB + Zn 30 kg/ha]. However, treatment 8 [*Azotobacter* + PSB + Zn 25 kg/ha] (64.93), treatment 7 [*Azotobacter* + PSB + Zn 20 kg/ha] (63.46) were found to be statistically at par with treatment 9. The application of biofertilizers resulted in the substantial and highest number of tillers/running row meter, which may be attributable to the higher amount of biofertilizer application that has been shown to boost cereal tiller output, initially determined by rate of auxiliary bud growth and later on growth of individual tiller. Which is heavily controlled by environmental factors such as temperature, photoperiod, and the availability of mineral nutrients and photosynthates. The results are in close conformity with the findings of **Kekatpure *et al*., (2021).**

Plant dry weight (g)

The data revealed that a significantly and maximum plant dry weight (22.31 g) was recorded in treatment 9 [*Azotobacter* + PSB + Zn 30 kg/ha]. However, treatment 8 [*Azotobacter* + PSB + Zn 25 kg/ha] (21.65 g), treatment 7 [*Azotobacter* + PSB + Zn 20 kg/ha] (21.25 g), were found to be statistically at par with treatment 9. Zinc in the soil and its participation in numerous enzymatic activities, as well as its role as a catalyst in various development processes and hormone production, may be the cause of the significant and increased plant dry weight found with zinc (30 kg/ha) application and protein synthesis, which results in increased growth. Similar results were reported by **(Shekhawat *et al*., 2017).** Further increase in dry weight observed with the application of biofertilizers (20 g/kg seed) might be due to 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).**

B. Post-harvest observation

Number of effective tillers/m^2

The data revealed that Treatment 9 [*Azotobacter* + PSB + Zn 30 kg/ha] was recorded significant and maximum of effective tillers/m^2 (278.85) which was superior over all other treatments. However, treatment 8 [*Azotobacter* + PSB + Zn 25 kg/ha] (249.63), treatment 7 [*Azotobacter* + PSB + Zn 20 kg/ha] (238.10), treatment 6 [PSB + Zn 30 kg/ha] (236.98), treatment 5 [PSB + Zn 25 kg/ha] (234.85) was found to be statistically at par with the treatment 9. The use of biofertilizers (20 g/kg seed) resulted in a considerable and maximum number of effective tillers/m^2, which could be attributed to improved nitrogen availability for plant absorption. This growth promotion of plant characteristics, such as increased tillering, led to an increase in the number of effective tillers. These can be corroborated by similar findings by **Yadav *et al.* (2011).**

Number of grains/spike

The data revealed that Treatment 9 [*Azotobacter* + PSB + Zn 30 kg/ha] was recorded a significant and maximum number of grain/spike (52.27) which was superior over all other treatments. However, treatment 8 [*Azotobacter* + PSB + Zn 25 kg/ha] (51.48), treatment 7 [*Azotobacter* + PSB + Zn 20 kg/ha] (50.62), treatment 6 [PSB + Zn 30 kg/ha] (50.04), treatment 5 [PSB + Zn 25 kg/ha] (49.37), treatment 4 [PSB + Zn 20 kg/ha] (48.86) was found to be statistically at par with the treatment 9. Significant increase in number of grains/spike is due to increase in the availability of *Azotobacter* and PSB bio fertilizer inoculation by which more seeds were produced due to increased rate of production, similar results were found by (**Joshi and Chilwal 2018)**.

Grain Yield (t/ha):

The data revealed that a Treatment 9 [*Azotobacter* + PSB + Zn 30 kg/ha], was recorded significantly maximum Grain yield (4.29 t/ha) which was superior over all other treatments. However, treatment 8 [*Azotobacter* + PSB + Zn 25 kg/ha] (4.20 t/ha), treatment 7 [*Azotobacter* + PSB + Zn 20 kg/ha] (4.11 t/ha), treatment 6 [PSB + Zn 30 kg/ha] (4.06 t/ha), treatment 5 [PSB + Zn 25 kg/ha] (4.09 t/ha), was found to be statistically at par with the treatment 9. The significant and highest seed yield recorded with the application of Biofertilizers (20 g/kg seed) could be attributed to increased levels of biofertilizers application increased yield attributes of barley could be due to release of growth hormones by various biofertilizers. Similar findings for yield attributes were reported by **Diman and Dubey (2017)**. "Significant and higher seed yield obtained with the application of zinc (25 kg/ha) might be due to zinc improves the source and sink relationship due to increased translocation of photosynthates towards reproductive system" **(Sammuauria *et al*., 2010).**

Straw yield (t/ha):

"The data revealed that a Treatment 9 [*Azotobacter* + PSB + Zn 30 kg/ha] was recorded significantly maximum Straw yield (6.72t/ha) which was superior over all other treatments. However, the treatment 8 [*Azotobacter* + PSB + Zn 25 kg/ha] (6.38 t/ha), treatment 7 [*Azotobacter* + PSB + Zn 20 kg/ha] (6.22 t/ha) was found to be statistically at par with the treatment 9. Significant and higher Stover yield was obtained with the application of Zinc (25 kg/ha), which could be attributed to the Zinc increase in yields being attributed to the fact that because of the favourable nutritional environment in the rhizosphere and higher absorption of nutrients by the plant, leading to increased photosynthetic efficiency and assimilate production". **Khan *et al*., 2010**. Application of *Azotobactor* (20 g/kg) resulted in an even higher maximum straw yield. Significant Application of biofertilizer, which increases grain and straw yield, was the cause of the increase in straw yield. Similar results were reported by **(Patel *et al*. 2017)**.

CONCULSION

Based on the finding it is concluded that seed inoculation with *Azotobacter* and PSB along with the application of Zn (30 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.

ACKNOWLEDGEMENT

I express my gratitude to my advisor Dr. RAJESH SINGH for constant support, guidance and for his valuable suggestions for improving the quality of this Research work and to all the faculty members of Department of Agronomy, SHUATS, Prayagraj, Uttar Pradesh, India for providing necessary facilities, for their cooperation, encouragement and support.

Table: 1 Effect of Biofertilizers and Zinc on growth of Barley.

Treatment combinations	**At 120 DAS**		
	Plant height (cm)	**Number of tillers/running row meter**	**Dry weight (g/plant)**
Azotobacter + Zn 20 kg/ha	90.77	53.87	18.72
Azotobacter + Zn 25 kg/ha	92.80	56.23	19.25
Azotobacter + Zn 30 kg/ha	98.00	58.58	19.73
PSB+ Zn 20 kg/ha	99.10	60.43	20.15
PSB+ Zn 25 kg/ha	100.70	61.11	20.53
PSB+ Zn 30 kg/ha	102.67	62.36	20.89
Azotobacter + PSB + Zn 20 kg/ha	103.70	63.46	21.25
Azotobacter + PSB + Zn 25 kg/ha	106.00	64.93	21.65
Azotobacter + PSB + Zn 30 kg/ha	107.63	66.32	22.31
Control	88.27	50.25	18.15
F-test	S	S	S
SEm(±)	3.48	2.07	0.78
CD (p=0.05)	10.36	6.16	2.34

Table: 2 Effect of Biofertilizers and Zinc on yield attributes and yield of Barley.

Treatment combination	Number of effective tillers/m^2	Number of grains/spike	Grain Yield (t/ha)	Straw Yield (t/ha)
Azotobacter + Zn 20 kg/ha	204.86	45.51	3.77	4.99
Azotobacter + Zn 25 kg/ha	207.75	46.35	3.87	5.64
Azotobacter + Zn 30 kg/ha	213.16	47.78	3.90	5.74
PSB+ Zn 20 kg/ha	224.51	48.86	3.77	5.82
PSB+ Zn 25 kg/ha	234.85	49.37	4.09	5.92
PSB+ Zn 30 kg/ha	236.98	50.04	4.06	6.06
Azotobacter + PSB + Zn 20 kg/ha	238.10	50.62	4.11	6.22
Azotobacter + PSB + Zn 25 kg/ha	249.63	51.48	4.20	6.38
Azotobacter + PSB + Zn 30 kg/ha	278.85	52.27	4.29	6.72
Control (RDF)	188.25	42.49	3.58	4.78
F-test	S	S	S	S
SEm(±)	15.84	1.54	0.12	0.21
CD (p=0.05)	47.07	4.59	0.36	0.64

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