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Influence of Biofertilizer and Zinc on Yield and Economics of Barley (*Hordeum vulgare* 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

The field experiment "Influence of Biofertilizer and Zinc on Yield and Economics of Barley" was carried out during the *Rabi* season of 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 designed using Randomized Block Design (RBD) and reproduced three times. The soil in the experimental area was sandy loam with a pH of 8.0, 0.62% organic carbon, 225 kg/ha available nitrogen, 38.2 kg/ha available phosphorus, and 240.7 kg/ha available potassium. *Azotobacter* + PSB + Zn 30 kg/ha increases grain production (4.29 t/ha), straw yield (6.72 t/ha), gross return (108675 INR/ha), net return (78555 INR/ha) and B:C (2.61).

Keywords: Barley; biofertilizer; zinc; yield; economics.

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1. INTRODUCTION

After wheat, rice, and maize, barley (*Hordeum vulgare* L.) is the fourth most significant cereal in the world. Brewing industries use barley primarily for the production of malt. When opposed to wheat, barley grains and straw are more digestible because they don't contain gluten. When it comes to production and acreage among Rabi cereals in India, barley comes in second place to wheat. Barley is farmed largely in India's northern plains, notably Uttar Pradesh, Haryana, and Rajasthan. "On 609000 ha. barley was grown with an average productivity of 29.88 q/ha, yielding 1818000 tonnes. Rajasthan is India's largest state, followed by Uttar Pradesh, which accounts for 46% of the country's total land area and more than 52% of the nation's production. Barley was grown in Uttar Pradesh on 159.0 thousand ha, producing 498.0 thousand tonnes at an average productivity of 31.32 q/ha" [1].

Azotobacter are abiotic, naturally occurring soil microbes that play an important part in the nitrogen cycle by binding atmospheric nitrogen that plants cannot use. It has been discovered that *Azotobacter* vaccination can cut the need for chemical fertilizer by up to 50 [2]. "*Azotobacter*, the most common heterotrophic free-living bacterium, plays an important role in crop production. Bio-fertilizer often contains microorganisms with specialized functions, such as N_2 fixation by *Azospirillum* and phosphorus solubilization by P solubilizing bacteria from the soil, in order for fertilizer to be available to plants" [3]

Sandy soils and soils high in calcium carbonate are linked to several zinc deficiency issues around the world. Zinc deficiencies occur all over the world on a variety of soil types, but semi-arid locations with calcareous soils, tropical regions with heavily worn soils, and soils with a sandy texture tend to be the most severely affected [4]. Acidic, calcareous, and weathering soils can all exhibit zinc shortage. In calcareous soils, zinc insufficiency frequently coexists with iron deficit. The adsorption of aqueous zinc in these soils by clay and limestone particles is a contributing factor to zinc insufficiency. Zinc insufficiency in degraded soils is brought on by a lack of organic matter [5].

2. MATERIALS AND METHODS

This experiment was carried out at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj (U.P.) during the *Rabi* season of 2022. The crop research farm is located at 250 39" 42" North latitude, 810 67" 56" East longitude, and 98 m above mean sea level. The experiment was laid out in Randomized Block Design Which consisted of ten treatments with T1 - *Azotobacter* + Zn 20 kg/ha, T2 - *Azotobacter* + Zn 25 kg/ha, T3 - *Azotobacter* + Zn 30 kg/ha, T4 - PSB + Zn 20 kg/ha, T5 - PSB + Zn 25 kg/ha, T6 - PSB + Zn 30 kg/ha, T7 - *Azotobacter* + PSB + Zn 20 kg/ha, T8 - *Azotobacter* + PSB + Zn 25 kg/ha, T9 - *Azotobacter* + PSB + Zn 30 kg/ha, T10 - Control (NPK 80-30-20 Kg/ha). Seeds are sown at a seed rate of 100 kg/ha with a spacing of 23 cm 5 cm. The treatments included the application of the recommended doses of nitrogen (80 kg/ha), phosphorus (30 kg/ha), and potassium (20 kg/ha) in the form of Urea, DAP, and MOP, as well as Biofertilizer and zinc. Data collected on several elements of the crop, such as growth and yield variables, were statistically analyzed using the analysis of variance approach [6] and a mathematical method for analyzing economic data.

3. RESULTS AND DISCUSSION

3.1 Grain Yield (t/ha)

At harvest, Treatment 9 [*Azotobacter* + PSB + Zinc 30 kg/ha] produced the highest seed yield (4.29 t/ha), outperforming all other treatments. Treatments 8 [*Azotobacter* + PSB + Zinc 25 kg/ha] (4.20 t/ha), 7 [*Azotobacter* + PSB + Zn 20 kg/ha] (4.11 t/ha), and 6 [PSB + Zn 30 kg/ha] (4.06 t/ha) were shown to be statistically equivalent to treatment 9.

The significant and largest amount of seeds were produced when biofertilizers (20 g/kg seed) were applied, which may have been due to increased application rates or the release of growth hormones by different biofertilizers Diman and Dubey [7].

3.2 Straw Yield (t/ha)

"At harvest, Treatment 9 [*Azotobacter* + PSB + Zinc 30 kg/ha], was recorded significantly maximum Straw yield (6.72 t/ha) which was superior over all other treatments. However, treatment 8 [*Azotobacter* + PSB + Zn 25 kg/ha] (6.38 t/ha), treatment 7 [*Azotobacter* + PSB + Zn 20 kg/ha] (6.22 t/ha), treatment 6 [PSB + Zn 30 kg/ha] (6.06 t/ha), was found to be statistically at par with the treatment 9" [8].

Table 1. Response of biofertilizer and zinc on yield of barley

S.No.	Treatment combination	Grain Yield (t/ha)	Straw Yield (t/ha)	Harvest index (%)
1.	*Azotobacter* + Zn 20 kg/ha	3.77	4.99	43.01
2.	*Azotobacter* + Zn 25 kg/ha	3.87	5.64	40.69
3.	*Azotobacter* + Zn 30 kg/ha	3.90	5.74	40.48
4.	PSB+ Zn 20 kg/ha	3.77	5.82	39.33
5.	PSB+ Zn 25 kg/ha	4.09	5.92	40.87
6.	PSB+ Zn 30 kg/ha	4.06	6.06	40.09
7.	*Azotobacter* + PSB+ Zn 20 kg/ha	4.11	6.22	39.82
8.	*Azotobacter* + PSB+ Zn 25 kg/ha	4.20	6.38	39.69
9.	*Azotobacter* + PSB+ Zn 30 kg/ha	4.29	6.72	38.96
10.	Control (RDF)	3.58	4.78	42.80
	F-test	S	S	NS
	SEm(±)	0.12	0.21	1.43
	CD(p=0.05)	0.36	0.64	-

Table 2. Response of biofertilizer and zinc on economics of barley

S. No.	Treatment combination	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net Return (INR/ha)	B:C
1.	*Azotobacter* + Zn 20 kg/ha	29620.00	90925.00	61305.00	2.07
2.	*Azotobacter* + Zn 25 kg/ha	29870.00	95925.00	66055.00	2.21
3.	*Azotobacter* + Zn 30 kg/ha	30120.00	96950.00	66830.00	2.22
4.	PSB + Zn 20 kg/ha	29620.00	95075.00	65455.00	2.21
5.	PSB + Zn 25 kg/ha	29870.00	101175.00	71305.00	2.39
6.	PSB + Zn 30 kg/ha	30120.00	101350.00	71230.00	2.36
7.	*Azotobacter* + PSB + Zn 20 kg/ha	29620.00	103025.00	73405.00	2.48
8.	*Azotobacter* + PSB + Zn 25 kg/ha	29870.00	105400.00	75530.00	2.53
9.	*Azotobacter* + PSB + Zn 30 kg/ha	30120.00	108675.00	78555.00	2.61
10.	Control (RDF)	28300.00	86550.00	58250.00	2.06

It is possible to attribute the beneficial effects of applied Zn on these features to its stimulatory action on the majority of plant physiological and metabolic processes. Zinc application to the soil has a positive impact on crop yields of grain and straw [9].

3.3 Cost of Production (INR/ha)

Treatment 9 [*Azotobacter* + PSB + Zinc 30 kg/ha] had the greatest cost of production (30120.00 INR) when compared to the other treatments.

3.4 Gross Return (INR/ha)

When compared to other treatments, treatment 9 [*Azotobacter* + PSB + Zinc 30 kg/ha] yielded the best gross return (108675.00).

3.5 Net Return (INR/ha)

When compared to other treatments, treatment 9 [*Azotobacter* + PSB + Zinc 30 kg/ha] yield the highest net return (78555.00).

3.6 B: C Ratio

When compared to other treatments, treatment 9 [*Azotobacter* + PSB + Zinc30 kg/ha] had the highest benefit-cost ratio (2.61).

4. CONCLUSION

It is concluded that seed inoculation with *Azotobacter* and PSB, combined with the application of Zn 30 kg/ha, resulted in the maximum seed yield, straw yield, gross return, net return, and benefit-cost ratio in barley.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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