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

Vishal [a++*], Rajesh Singh [a#] and Akankhya Pradhan [a†]

[a] Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj – 211 007, Uttar Pradesh, India.

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 entitled "Influence of Biofertilizers and Nitrogen on Yield and Economics 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 treatment consisted of three level of Biofertilizers [*Azotobacter*, *Azospirillum* and *Azotobacter* + *Azospirillum*], 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

[++] *M.Sc. Scholar;*
[#] *Associate professor;*
[†] *Ph.D. Scholar;*
**Corresponding author: E-mail: Vjaat431@gmail.com;*

Available K (240.7 kg/ha). Application of *Azotobacter* + *Azospirillum* and N 100 kg/ha produces higher Grain yield (4.34 t/ha), Straw yield (5.34 t/ha), Gross return (101977.56 INR/ha), Net return (74074.56 INR/ha) and B:C (2.65).

Keywords: Barley; biofertilizers; nitrogen; economics and yield.

1. INTRODUCTION

Barley (*Hordeum vulgare* L.) is the world's fourth most important cereal after wheat, rice and maize. The major use of barley is in brewing industries for manufacturing malt. Both barley grains and straw are highly digestible compared to wheat because they do not contain gluten. Barley ranks next to wheat both in acreage and production among *Rabi* cereals in India. 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 [1]. It is a Rabi cereal crop in India and commonly used as food for human beings and feed for animals and poultry birds [2].

In order to find out some alternative for fertilizer nitrogen economy, the use of diazotrophic bacteria has been evaluated. *Azotobacter* is a well known free-living heterotrophic bacterium which plays a beneficial role in crop production. *Rhizobium* and *Azotobacter* have mostly been emphasised in studies on biological nitrogen fixing. *Azospirillum*, however, now forms an associative symbiosis with wheat as a result of the discovery of free-living N_2-fixing bacteria. It has been proposed that either enhanced hormone production by these bacteria or improved nutrient uptake by inoculated roots may be responsible for the plant's response in terms of growth. In general, soils with high levels of organic matter have shown yield gains for a variety of crops. However, nitrogen fertiliser and organic matter are more expensive, making it impossible for India's small-scale and marginal farmers to employ them more extensively. Therefore, it was deemed crucial to determine the proper and suitable level of nitrogen fertiliser for these inoculations in the production of barley [3]. 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 [4]. 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 ecofriendly 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 [5]. Barley grain largest use as animal feed in all over the world and in India also. In world, about 70% of barley is used for animal feed, 20% for malting and 5% for direct food use [6]. Nitrogen is considered one of the most important factors affecting crop morphology [7], crop growth rate and grain yield [8] in Northwest Pakistan.

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. 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). 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 [9] and economic data analysis by mathematical method.

3. RESULTS AND DISCUSSION

3.1 Grain Yield (t/ha)

At harvest, Treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha], was 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 the treatment 10.

The significant and maximum grain yield was observed with the application of Biofertilizers (20g/kg seed) might be due increase levels of biofertilizers application increased yield attributes of barley might be due to release of growth hormones by various biofertilizers. Similar findings for yield attributes were reported by Diman and Dubey [10].

3.2 Straw Yield (t/ha)

At harvest, Treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha], was recorded significantly maximum Straw yield (5.51t/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 the treatment 10.

3.3 Harvest Index (%)

At harvest, highest harvest index (44.66%) was recorded treatment 6 [*Azospirillum*+ Nitrogen 80 kg/ha], though there was no significant difference among the treatments.

3.4 Cost of Production (INR/ha)

Cost of production (27923.00 INR) was found to be highest in treatment 7 [*Azospirillum*+ Nitrogen 100 kg/ha] as compared to other treatment.

3.5 Gross Return (INR/ha)

Gross return (101977.56) was found to be highest in treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha] as compared to other treatment.

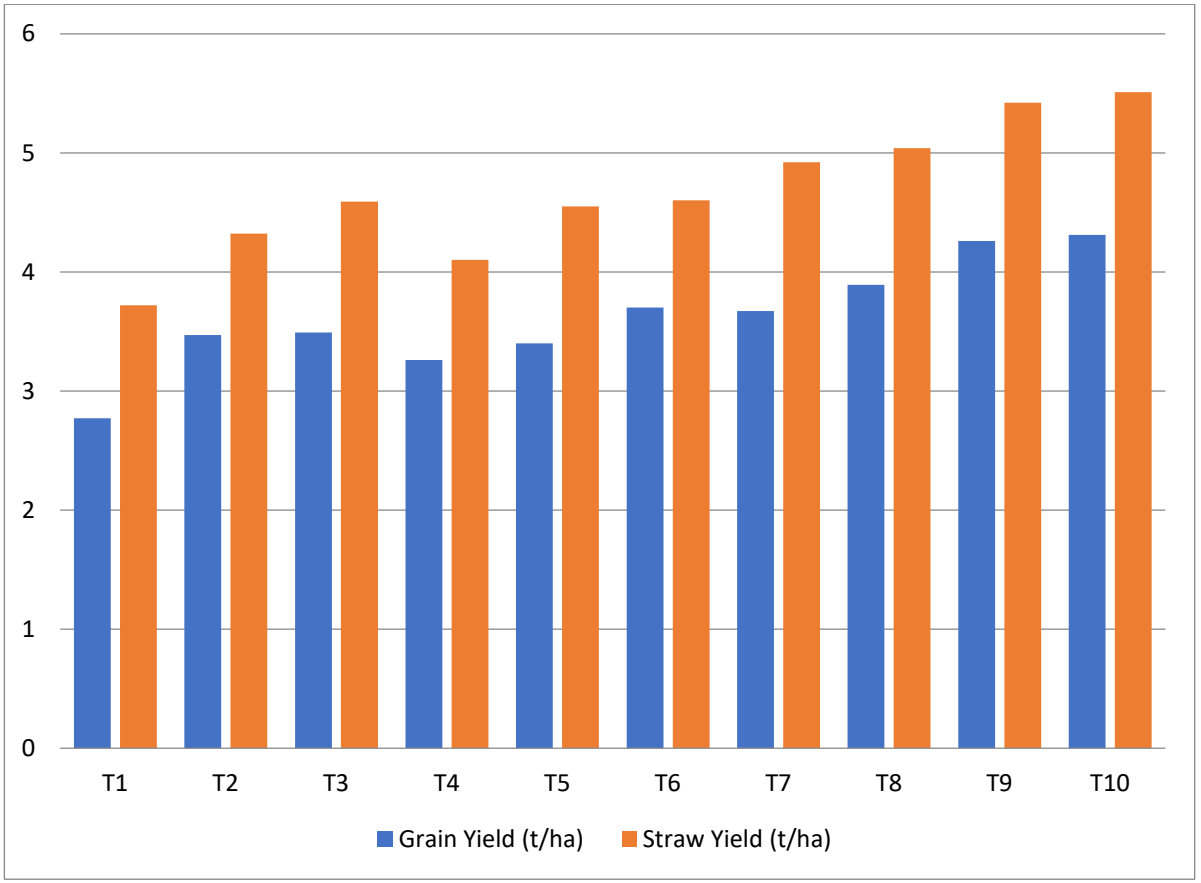

Fig. 1. Response of biofertilizers and nitrogen on yield of barley

Table 1. Response of biofertilizers and nitrogen on yield of barley

S.No.		Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
1	Control (NPK 80-30-20 Kg/ha)	2.77	3.72	42.76
2	*Azotobacter* + Nitrogen 60 kg/ha	3.47	4.32	44.60
3	*Azotobacter* + Nitrogen 80 kg/ha	3.49	4.59	43.50
4	*Azotobacter* + Nitrogen 100 kg/ha	3.26	4.10	44.27
5	*Azospirillum*+ Nitrogen 60 kg/ha	3.40	4.55	42.03
6	*Azospirillum*+ Nitrogen 80 kg/ha	3.70	4.60	44.66
7	*Azospirillum*+ Nitrogen 100 kg/ha	3.67	4.92	42.79
8	*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha	3.89	5.04	43.66
9	*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha	4.26	5.42	43.96
10	*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha	4.31	5.51	43.90
	F-test	S	S	NS
	SEm(±)	0.22	0.21	1.49
	CD (p=0.05)	0.65	0.64	-

Table 2. Response of biofertilizers and nitrogen on economics of barley

S.No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C
1	Control (NPK 80-30-20 kg/ha)	26500	65895.38	39395.38	1.49
2	*Azotobacter* + Nitrogen 60 kg/ha	27410	80813.18	53403.18	1.95
3	*Azotobacter* + Nitrogen 80 kg/ha	27647	82527.77	54880.77	1.99
4	*Azotobacter* + Nitrogen 100 kg/ha	27883	76203.20	48320.20	1.73
5	*Azospirillum*+ Nitrogen 60 kg/ha	27450	80726.20	53276.20	1.94
6	*Azospirillum*+ Nitrogen 80 kg/ha	27687	86276.92	58589.92	2.12
7	*Azospirillum*+ Nitrogen 100 kg/ha	27923	87227.64	59304.64	2.12
8	*Azotobacter* + *Azospirillum* + Nitrogen 60 kg/ha	27430	91739.37	64309.37	2.34
9	*Azotobacter* + *Azospirillum* + Nitrogen 80 kg/ha	27667	99560.22	71893.22	2.60
10	*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha	27903	101977.56	74074.56	2.65

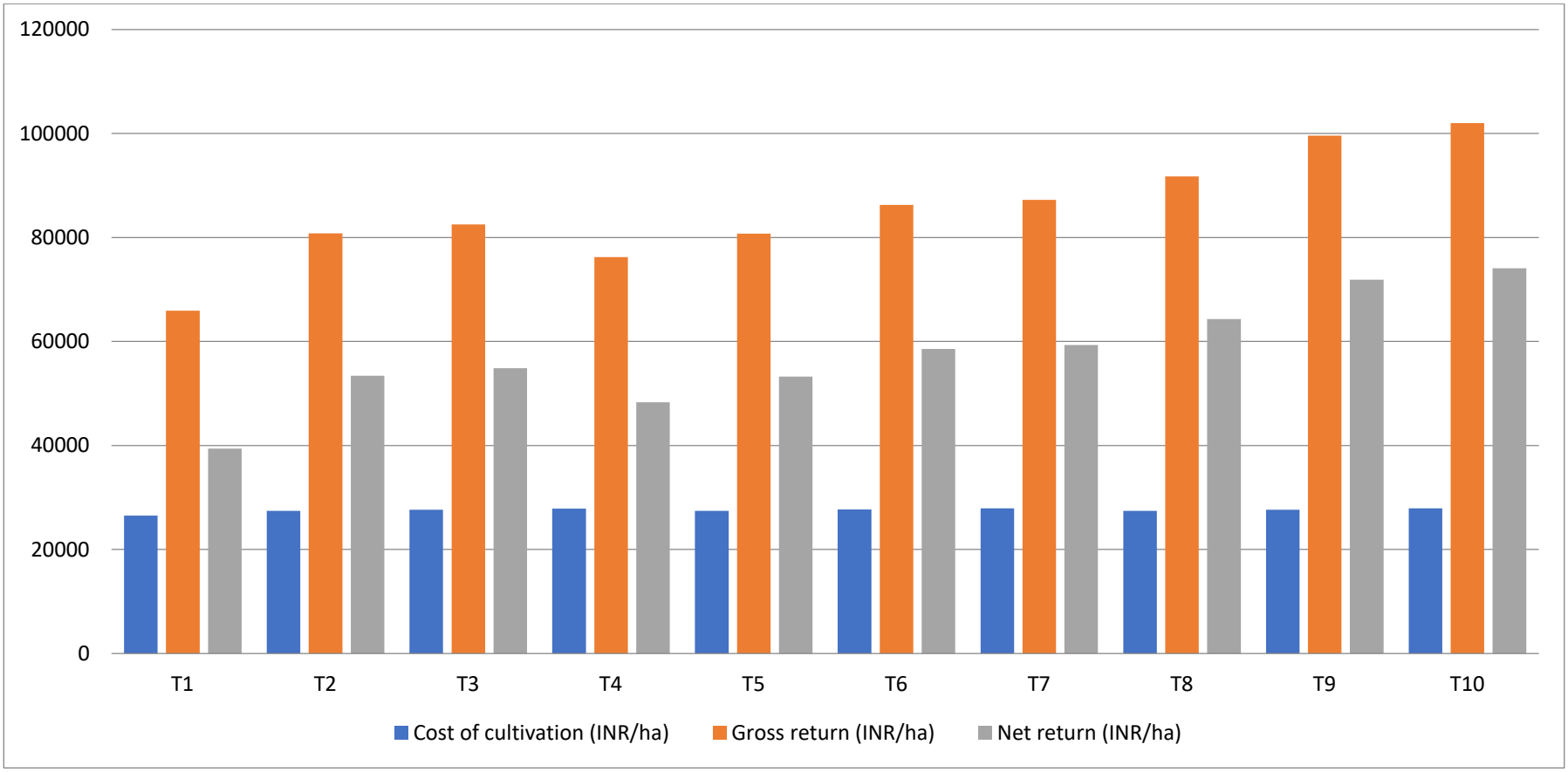

Fig. 2. Response of biofertilizers and nitrogen on economics of barley

3.6 Net Return (INR/ha)

Net return (74074.56) was found to be highest in treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha] as compared to other treatment.

3.7 B: C Ratio

Benefit Cost Ratio (2.65) was found to be highest in treatment 10 [*Azotobacter* + *Azospirillum* + Nitrogen 100 kg/ha] as compared to other treatment.

Higher B:C ratio in biofertilizer seed treatment is because of very less increase in cost of cultivation as compared to the control. Similar results were reported by Yadav et al. [11].

4. CONCLUSION

It is concluded that in barley with the seed inoculation with *Azotobacter* and *Azospirillum* along with the application of Nitrogen 100 kg/ha (Treatment 10) observed highest seed yield, straw yield, gross return, net return and benefit-cost ratio.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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