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Effect of Nitrogen and Foliar Applied Boron on Yield and economics of Barlyaey (*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 entitled "Effect of Nitrogen and Foliar Applied Boron on Yield and Economics of Barley (*Hordeum vulgare* L.)" was conducted Response of during the *rabi* season of 2022 in Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.). The experiment was laid out in a Randomized Block Design with ten treatment combinations, The soil in the experimental area was sandy loam with pH (7.6), EC (0.305 d S/m), organic carbon (0.23%), available N (184.8 kg/ha), available P (16.45 kg/ha) and available K (187.64 kg/ha). Seeds are sown at a spacing of 23 cm × 5 cm with a seed rate of 100 kg/ha. Consisting of three nitrogen levels (45, 60 and 75 kg N/ha) and different Concentration of Boron *viz.,* 1, 1.5 and 3% foliar spray. The experimental result reveals that yield attributes *viz.,* seed yield

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(4.81 t/ha), straw yield (6.48 t/ha) and economics *viz.,* cost of cultivation (29911.98 INR/ha), gross return (115842.62 INR/ha), net return (85944.62 INR/ha) and benefit cost ratio (2.87) recorded were significantly higher with treatment 9 (75 kg N/ha + 3% boron).

Keywords: Barley; nitrogen; boron; yield; economics.

1. INTRODUCTION

"Barley *(Hordeum vulgare* L.) is an ancient cereal grain, which upon domestication has evolved largely as a food and a malting grain. Barley grains are used by Hindus in their social and religious ceremonies which also illustrates the antiquity of this crop. It can be grown in a wide range of environments than any other cereal crop, including extremes of latitude, longitude and high altitude" [1]. "It is frequently being described as the most cosmopolitan of the crops and also considered as poor man's crop because of the low input requirement and better adaptability to drought, salinity, alkalinity and marginal land" [2]. "Barley is a member of the grass family. It is a self-pollinating, diploid species with 14 chromosomes. The wild ancestor of domesticated barley, *Hordeum vulgare*, subsp. *spontaneous*, is abundant in grasslands and woodlands throughout the Fertile Crescent and is abundant in disturbed habitats, roadsides and orchards. The wild barley is less commonly occurred and is usually found in disturbed habitats. During the same reference year in India, it is grown in about 6.09 lakh hectare areas with the production of nearly 18.20 lakh tonnes grain and productivity of 2988 kg/ha. It is mainly grown in the northern plains and concentrated in the states of Uttar Pradesh, Rajasthan, Madhya Pradesh, Bihar, Haryana and Punjab. It is cultivated on about 3.12 lakh hectares area in Rajasthan with an annual production of 10.59 lakh tonnes grain and productivity of 3388 kg/ha" [3]. Its cultivation in India suffered during green revolution period due to replacement of barley from marginal land and rainfed areas by more remunerative oilseed and pulses. The average yield of this crop in the agro-climatic zone IV a was 2194 kg ha-1 which was far below than its potential yield [4]. Its cultivation in India suffered during green revolution period due to replacement from marginal land and rainfed areas by more remunerative oilseed and pulses. However, during early nineties, due to economic liberalization, the industrial demand for barley increased and presently 25-30% of total barley produced is used in the manufacturing of malt extract, which is further utilized for brewing, distillation, baby foods, coca malt drinks and medicinal syrups.

"Barley is usually used as food for human beings and feed for livestock and poultry and is also a valuable input for industries for extracting malt to be utilized in brewing, distillation, baby foods, cocoa malt drinks and ayurvedic medicines. Each 100 g of barley grain comprise 10.6 g protein, 2.1 g fat, 64 g carbohydrate, 50 mg calcium, 6 mg iron, 31 mg vitamin B_1, 0.1 mg vitamin B_2 and 50 µg folate" [5]. "Barley is preferred over other cereals for malting purpose because its glumes and hulls are firmly cemented to the kernel, which remain attached to the grain after threshing. Hull protects the coleoptile from damage during processing, as coleoptile grows and elongates under the hull. Hull acts as a filter for separation of soluble materials. Processing of barley grain for malting largely depends upon several factors *viz*; protein content of the grain, time taken for germination, uniformity in grain size, husk content, 1000-kernel weight and kernel plumpness etc. High protein content in grain is undesirable because malt extract is inversely related to protein content" [6].

Nitrogen (N) levels and stage of nitrogen application greatly affect the grain and malt yield of barley. Nitrogen is the most important element for realizing potential yield of crops. It is an integral part of chlorophyll, which is the primary absorber of light energy, needed for reduction of carbon dioxide to produce assimilates by the process of photosynthesis. Assimilates are reflected in terms of yield. Nitrogen is the main constituent of amino acids which are precursor to protein. Moreover, high protein content in grain is undesirable, because malt extract is inversely related to grain protein content. Time of nitrogen application is an important cultural practice for realizing potential Nitrogen levels and stages of nitrogen application and production of barley yield of crop. Cantero-Martínez [7] reported yields of barley under N and P stresses are individually less than 50% of those of the respective non-stressed environments [8]. "Nitrogen and phosphorus are known to be essential nutrients for plant growth and

development. For taking highest seed yield in agriculture, addition of both nitrogen and phosphate fertilizer is very important" [9].

"Boron (B) is an essential nutrient for normal growth of higher plants and its availability in soil and irrigation water is an important determinant of agricultural production" [10]. "Boron deficiency causes different effects on very diverse processes in vascular plants such as root elongation, Indole Acetic Acid oxidase activity, sugar translocation, carbohydrate metabolism, nucleic acid synthesis and pollen tube growth" [10]. Foliar application of B significantly increased the yield and growth traits in barley. However, 2% foliar application of Boron showed the highest value for all studied traits including; plant height (5.6%), number of tillers/plant (2.4%), spike length (32%), weight gain/spike (6.2%), seed index (6%), grain yield (10%) and biological yield (4%). Based on these findings, it can be concluded that the foliar application of Boron at 2% can be used to improve the growth and yield in barley.

"Boron toxicity exerts different effects on vascular plants, such as reduced root cell division, lower photosynthetic rates and decreased lignin and suberin levels" [11]. "Accordingly, a reduced growth of shoots and roots is typical of plants exposed to high boron levels" [12]. "Different plant species respond differently to different levels of boron. B-deficiency reduced photosynthetic efficiency of sunflower leaves" [13]. "Boron application increased the rate of fruiting of grain crops and decreased the incidence of bare ears in maize and decreased empty pods of soybean and empty grains in rice" [14]. "Effects of foliar applications of B to soybean included increased yield and larger seed size" [15]. "Although the emergence of pea was affected by excess boron, the plant height and the number of nodes were reduced" [16].

2. MATERIALS AND METHODS

The experiment was conducted during the *Rabi season* of 2022 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Science (SHUATS), Prayagraj (UP). The Crop Research Farm is situated at 25.57^{o} N latitude, 87.19^{o} E longitude and at an altitude of 98 m above mean sea level. This area is situated on the right side of the river *Yamuna* and by the opposite side of Prayagraj City. All the facilities for crop cultivation were available. The experiment was laid out in Randomized Block Design and comprised of Nitrogen and Boron with ten treatments and each was replicated thrice *viz*., T1- Nitrogen (45 kg/ha) + Boron (1%), T2- Nitrogen (45 kg/ha) + Boron (1.5%), T3- Nitrogen (45 kg/ha) + Boron (3%), T4- Nitrogen (60 kg/ha) + Boron (1%), T5- Nitrogen (60 kg/ha) + Boron (1.5%), T6- Nitrogen (60 kg/ha) + Boron (3%), T7- Nitrogen (75 kg/ha) + Boron (1%), T8- Nitrogen (75 kg/ha) + Boron (1.5%), T9- Nitrogen (75 kg/ha) + Boron (3%), T10- Control (NPK 60-30-20 kg/ha). At harvesting maturity, the barley crop was harvested at 100 DAS, Seeds were harvested from each plot, dried under the sun for three days, winnowed and the seed yield per hectare was calculated and expressed in t/hectare. The straw production from each plot was measured and expressed in t/hectare after ten days of drying in the sun. The data was analyzed using statistical analysis. The B:C ratio was recalculated after replacing the seed value with straw and including the overall cost of crop cultivation. All agronomic practices were followed during the crop period. "Experimental data collected were treated using Fisher's method of analysis of variance (ANOVA) as outlined by Gomez and Gomez [17]. Critical Difference (CD) values were calculated wherever the 'F' test was found significant at 5 percent level".

3. RESULTS AND DISCUSSION

3.1 Yield and Yield Attributes

3.1.1 Seed yield (t/ha)

At harvest, Treatment 9 [Nitrogen (75 kg/ha) + Boron (3%)] was recorded significant with Seed yield (4.81 t/ha) which was superior over all other treatments. The application of 80 kg N/ha increased grain yield by 71.14, 47.69, 29.58 and 12.20% over 0, 20 and 60 kg N/ha respectively. The results obtained are in accordance with the results of Terefe et al., [18].

3.1.2 Straw yield (t/ha)

At harvest, Treatment 9 [Nitrogen (75 kg/ha) + Boron (3%)] was recorded significant and Straw yield (6.48 t/ha) which was superior over all other treatments. "Highest biological yield (7876.7 kg/ha), while minimum (7186.7 kg/ha) in non-sprayed treatment. The increase in the grain yield and biological yield was recorded at 8.9% and 9.6% by 2% foliar application of Boron respectively over control treatment" [19].

Table 1. Effect of nitrogen and foliar applied boron on yield attribute of barley

S. No.	Treatment combination	Seed yield (t/ha)	Straw yield (t/ha)
1.	Nitrogen (45 kg/ha) + Boron (1%)	2.49	3.41
2.	Nitrogen (45 kg/ha) + Boron (1.5%)	2.54	4.21
3.	Nitrogen (45 kg/ha) + Boron (3%)	3.03	3.66
4.	Nitrogen (60 kg/ha) + Boron (1%)	2.90	3.95
5.	Nitrogen (60 kg/ha) + Boron (1.5%)	3.27	3.78
6.	Nitrogen (60 kg/ha) + Boron (3%)	3.61	4.69
7.	Nitrogen (75 kg/ha) + Boron (1%)	3.75	3.90
8.	Nitrogen (75 kg/ha) + Boron (1.5%)	4.37	6.13
9.	Nitrogen (75 kg/ha) + Boron (3%)	4.81	6.48
10.	Control (NPK 60-30-20 kg/ha)	2.69	3.39
	F-test	S	S
	SEm(±)	0.17	0.17
	CD (p=0.05)	0.52	0.50

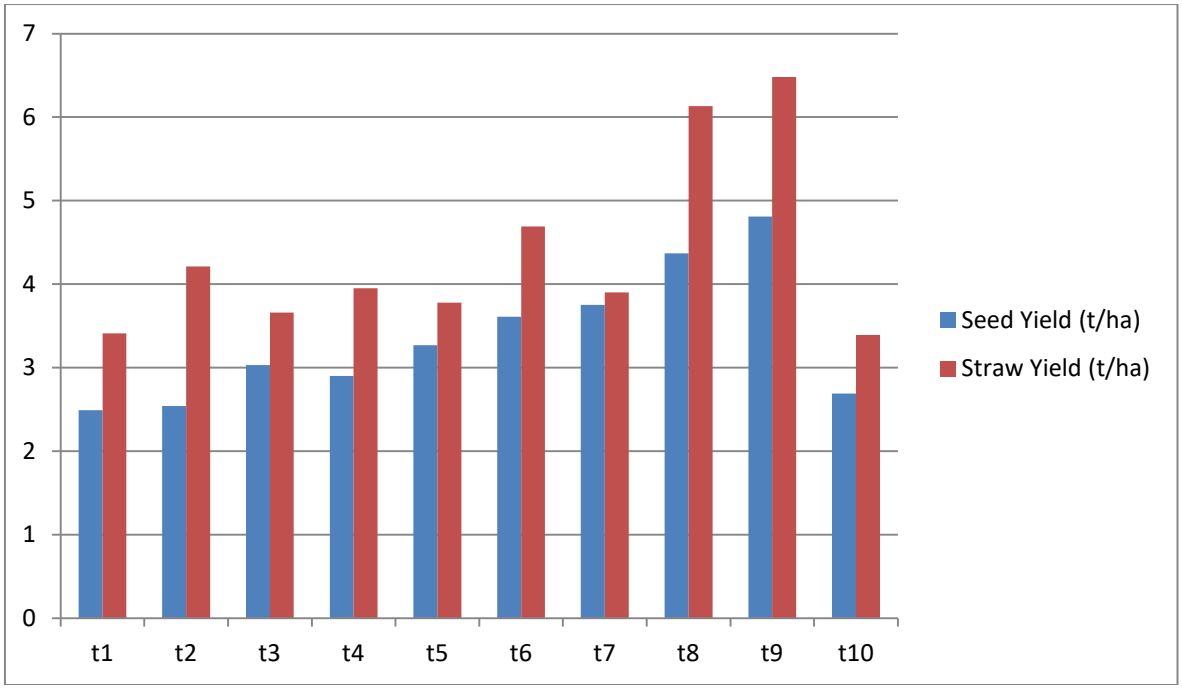

Fig. 1. Effect of nitrogen and foliar applied boron on seed yield and straw yield of barley

Table 2. Effect of nitrogen and foliar applied Boron of economics on barley

S. No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C
1.	Nitrogen (45 kg/ha) + Boron (1%)	29207.19	60340.05	31141.05	1.07
2.	Nitrogen (45 kg/ha) + Boron (1.5%)	29294.69	65111.12	35824.12	1.22
3.	Nitrogen (45 kg/ha) + Boron (3%)	29557.19	70848.50	41299.50	1.40
4.	Nitrogen (60 kg/ha) + Boron (1%)	29384.59	69968.60	40594.60	1.38
5.	Nitrogen (60 kg/ha) + Boron (1.5%)	29472.09	75676.86	46214.86	1.57
6.	Nitrogen (60 kg/ha) + Boron (3%)	29734.59	86111.68	56387.68	1.90
7.	Nitrogen (75 kg/ha) + Boron (1%)	29561.98	84558.92	55010.92	1.86
8.	Nitrogen (75 kg/ha) + Boron (1.5%)	29649.48	106410.06	76774.06	2.59
9.	Nitrogen (75 kg/ha) + Boron (3%)	29911.98	115842.62	85944.62	2.87
10.	Control (NPK 60-30-20 kg/ha)	29209.59	63569.43	35069.43	1.23

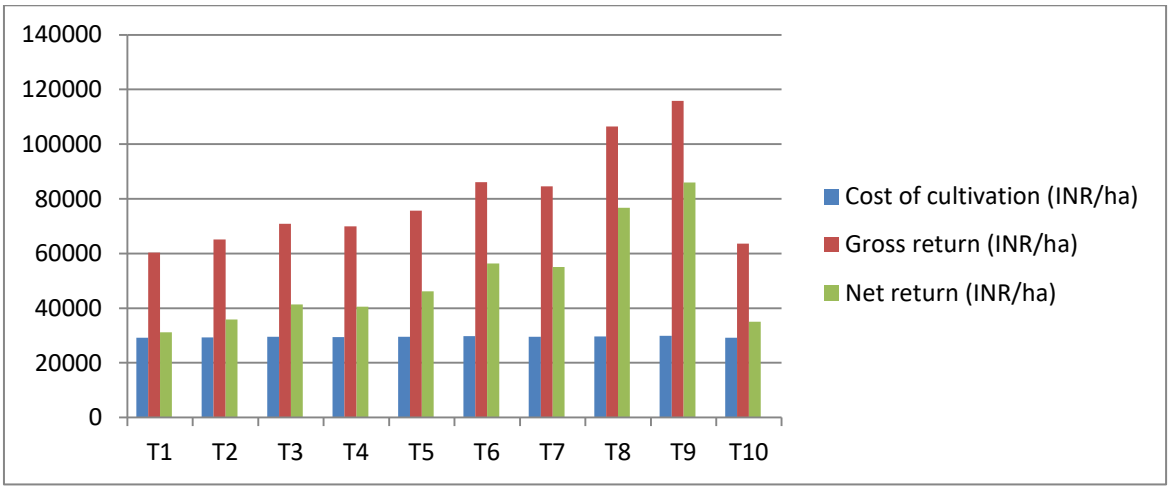

Fig. 2. Effect of nitrogen and foliar applied boron on cost of cultivation, gross return and net return of barley

3.2 Economics

3.2.1 Gross return (INR/ha)

Gross return (INR 115842.62/ha) was found to be highest in treatment 9 [Nitrogen (75 kg/ha) + Boron (3%)] as compared to other treatment.

3.2.2 Net return (INR/ha)

Net return (85944.62) was found to be highest in treatment 9 [Nitrogen (75 kg/ha) + Boron (3%)] as compared to other treatment.

3.2.3 B:C ratio

Benefit Cost Ratio (2.87) was found to be highest in treatment 9 [Nitrogen (75 kg/ha) + Boron (3%)] as compared to other treatment. The application of nitrogen led to more net return with each increment of 20 kg N/ha from 0 to 100 kg N/ha. The highest net return (55552 INR/ha) and B:C (2.16) was obtained with application of 100 kg N/ha. The net return obtained with application of 80 kg N /ha was 52674 INR/ha and B: C of 2.07. The application of 80 and 100 kg N/ha gave B:C above 2 and while loss of 1505 INR/ha was recorded with 0 kg N/ha with negative B C ratio. The increase in net return with increase in nitrogen levels are due to high grain and straw yield associated with the nitrogen. The results are in accordance with the findings of Singh [20].

4. CONCLUSION

It is concluded that the treatment T_9 with the combination of Nitrogen (75 kg/ha) + Boron (3% foliar spray) has given good yield of grain, straw with maximum Benefit cost ratio (2.87) as compared to other treatment combinations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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