Original Research Article

Effect of Nitrogen and Foliar Applied Boron on Yield and Economics of Barley(*Hordeum vulgare* L.)

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 30 cm × 5 cm to a seed rate of 100 kg/ha. Consisting of three nitrogen levels (45, 60 and 75 kg N/ha) on different Concentration of Boron *viz.*, 1, 1.5 and 3 % foliar spray. The experimental result reveals that yield attributes *viz.*, seed yield (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 to be were significantly higher with treatment 9 (75 kg N/ha + 3% boron).

Key words: Barley, Nitrogen, Boron, Yield, Economics.

Introduction

Barley *(Hordeum vulgare* L.) is an ancient cereal grain, which upon domestication has evolved largely a food and 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 **(Vangool and Vernon 2006)**. 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 **(FAO, 2002)**. 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 **(IIWBR 20-21)**. Its cultivation in India was 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 **(Rajasthan Agriculture Statistics at a Glance, 2015-16)** 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 pou1try 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 g folateμmg calcium, 6.0 mg iron, 0.31 mg vitamin B1, 0.10 mg vitamin B2 and 50 **(Vaughan *et al.*, 2006)**.

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 s eparation 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 **(Verma *et al.*, 2003)**.

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 *et al.*, 2003)** reported yields of barley under N and P stresses are individually less than 50% of those of the respective non-stressed environments **(Abourached *et al.*, 2008)**. 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 **(Shaban, 2013)**.

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 **(Saleem *et al.*, 2011)**. 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. 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 **(Reid *et al.*, 2007)**. Accordingly, a reduced growth of shoots and roots is typical of plants exposed to high boron levels **(Nable *et al.*, 1990)**. Different plant species respond differently to different levels of boron. B-deficiency reduced photosynthetic efficiency of sunflower leaves **(El-Shintinawy, 1999)**. 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 **(Li and Liang, 1997)**. Effects of foliar applications of B to soybean included increased yield and larger seed size **(Gascho and Mc Pherson, 1997)**. Although the emergence of pea was affected by excess boron, the plant height and the number of nodes were reduced **(Bagheri *et al.*, 1992)**.

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 analysed 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 are followed in order in the crop period. "Experimental data collected was subjected to statistical analysis by adopting Fisher's method of analysis of variance (ANOVA) as outlined by **(Gomez and Gomez, 1984)**. Critical Difference (CD) values were calculated wherever the 'F' test was found significant at 5 percent level".

Result and Discussion

Yield and yield attributes

Seed yield (t/ha):

At harvest, Treatment 9 [Nitrogen (75 kg/ha) + Boron (3%)] was recorded significant and Seed yield (4.81 t/ha) which was superior over all other treatments. However, the treatment 8

(4.37 t/ha) [Nitrogen (75kg/ha) + Boron (1.5%)], was found to be statistically at par with treatment 9.

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.*, 2018)**.

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. However, the treatment 8 (6.13 t/ha) [Nitrogen (75 kg/ha) + Boron (1.5%)], was found to be statistically at par with the treatment 9.

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. **(Ahmad *et al.*, 2021)**.

ECONOMICS

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.

Net return (INR/ha)

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

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 2013)**.

Conclusion

It is concluded that the treatment T_9 with the combination of Nitrogen (75 kg/ha) + Boron (3% foliar spray) It is also recorded that maximum Benefit cost ratio (2.87) as compared to other treatment combinations.

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

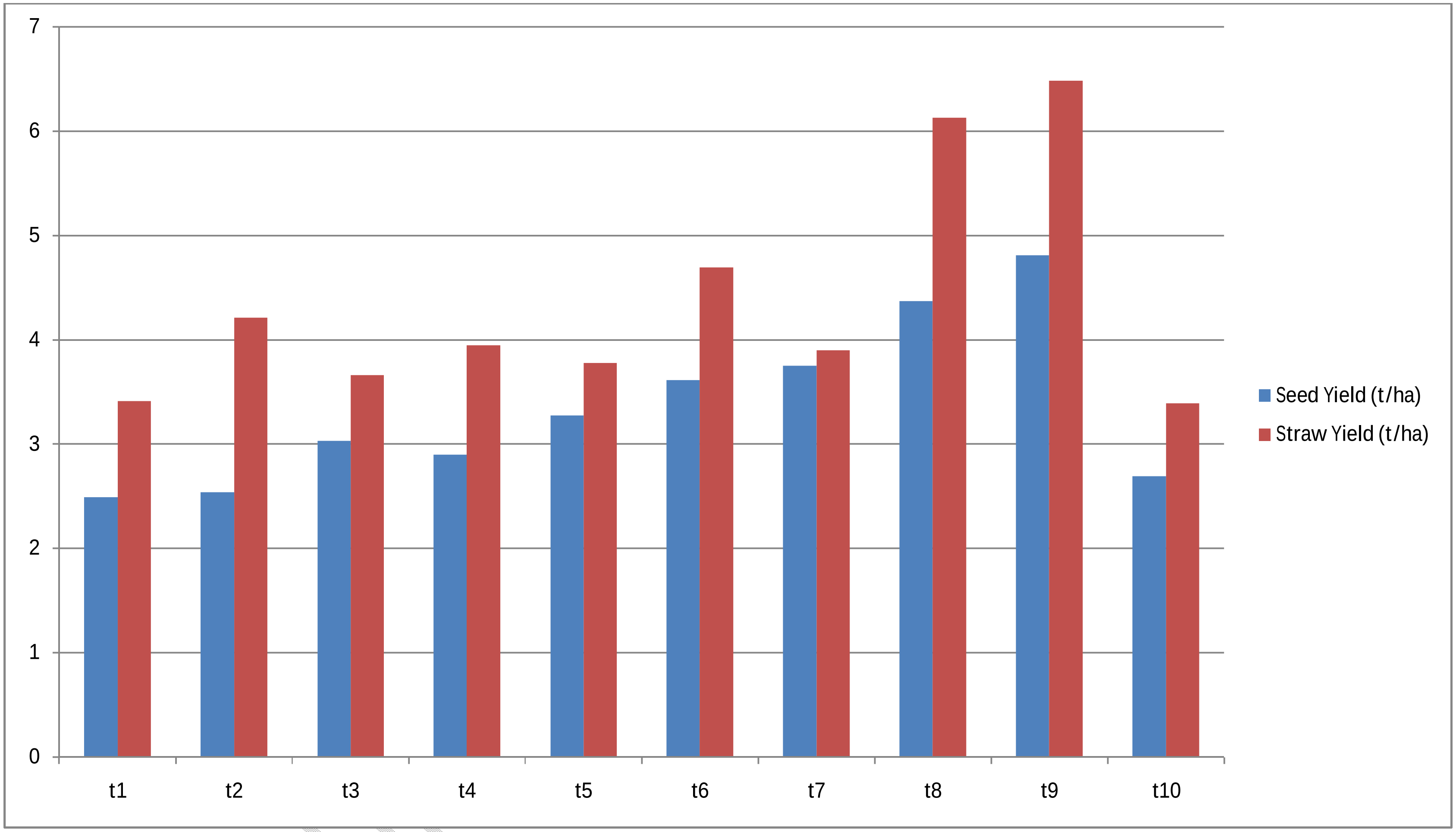

Fig. 1 Effect of Nitrogen and foliar applied Boron on Seed Yield and Straw Yield of Barley.

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

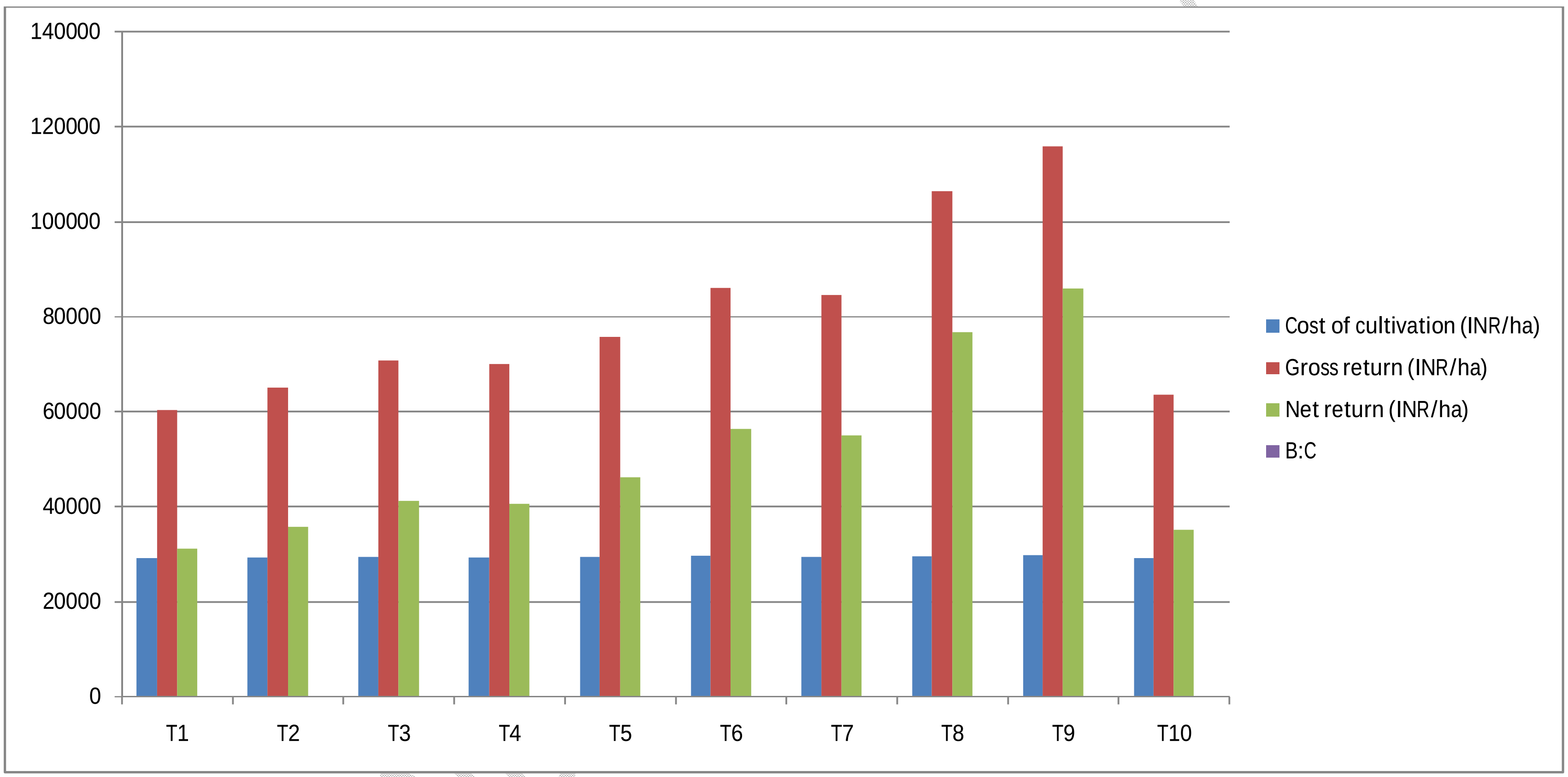

Fig. 2 Effect of Nitrogen and foliar applied Boron on Cost of cultivation, Gross return, Net return and Benefit cost ratio of Barley.

Reference

Abourached, C. G., Yau, S. K., Nimah, M. N. and Bashour, I. I. (2008). Deficit irrigation and split N fertilization on wheat and barley yields in a semi-arid Mediterranean area. *The Open Agriculture Journal*, **2**(1).

Ahmad, S., Raza, T., Imran, S. (2021). Foliar Application of Boron Improves the Growth and Yield in Barley (H*ordeum Vulgare* L.). *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca: Food Science and Technology*.

Bagheri, A., Paull, J. G., Rathjen, A. J., Ali, S. M. and Moody, D. B. (1992). Genetic variation in the response of pea (*Pisum sativum* L.) to high soil concentrations of boron. *Plant and Soil,* **146**, 261-269.

Cantero-Martínez, C. (2003). Soil bulk density and penetration resistance under different tillage and crop management systems and their relationship with barley root growth. *Agronomy journal*, **95**(3), 526-536.

El-Shintinawy, F. A., Shaker, E. M. and Shams El-Din, H. A. (2012). Effect of elevated boron concentrations on the growth and yield of barley (*Hordeum vulgare* L.) and alleviation of its toxicity using different plant growth modulators. *Australian Journal of Crop Science*, **6**(12), 1687-1695.

FAO (2002). Food barley improvement. (http://www.fao.org/ag/AGP/AGPC/doc/field/other/act.htm).

Gascho, G. J. and Mc. Pherson, R. M. (1997). A foliar boron nutrition and insecticide program for soybean. In Boron in Soils and Plants: *Proceedings of the International Symposium on Boron in Soils and Plants held at Chiang Mai, Thailand,* **7–11**(pp. 11-15).

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for agricultural research. 2nd Ed. New York: John Wiley and Sons.680.

IIWBR. 2020-21. Progress Report, All India coordinated wheat and barley improvement project. Indian Institute of Wheat and Barley Research, Karnal, Haryana **6**: pp-1.1.

Li, Y. and Liang, H. (1997). Soil Boron Content and the Effects of Boron Application on Yields of Maize, Soybean, Rice and Sugarbeet in Heilongjiang Province, PR China. In *Boron in Soils and Plants: Proceedings of the International Symposium on Boron in Soils and Plants held at Chiang Mai, Thailand,* **7–11**(pp. 17-21).

Nable, R. O., Lance, R. C. And Cartwright, B. (1990). Uptake of boron and silicon by barley genotypes with differing susceptibilities to boron toxicity. *Annals of Botany*, **66**(1),

Rajasthan Agricultural Statistics at a Glance.2015-16. Commissionrate of Agriculture, Jaipur, Rajasthan.

Reid, R. (2007). Update on boron toxicity and tolerance in plants. *Advances in plant and animal boron nutrition*, **1**, 83-90.

Saleem, M. A., Tahir, M., Ahmad, T. and Tahir, M. N. (2020). Foliar application of boron improved the yield and quality of wheat (*Triticum aestivum* L.) in a calcareous field. *Soil and Environment*, **39**(1).

Shaban, Y. A., El Sayed, M. A., El Maradny, A. A., Al Farawati, R. K.and Al Zobidi, M. I. (2013). Photocatalytic degradation of phenol in natural seawater using visible light active carbon modified (CM)-n-TiO2 nanoparticles under UV light and natural sunlight illuminations. *Chemosphere*, **91**(3), 307-313.

Singh, J., Mahal, S. S. and Singh, A. (2013). Productivity and quality of malt Barley (*Hordeum vulgare*) as affected by sowing date, rate and stage of nitrogen application. *Indian Journal of Agronomy*, **58**(1), 72-80.

Terefe, D., Desalegn, T. and Ashagre, H. (2018). Effect of nitrogen fertilizer levels on grain yield and quality of malt barley (*Hordeum vulgare* L.) varieties at Wolmera District, Central Highland of Ethiopia. *International Journal of Research Studies in Agricultural Sciences*, **4**, 29-43.

Vangool, D. and Vernon, L. (2006). Potential impacts of climate change on agricultural land use suitability: Barley. Department of Agriculture, Western Australia.

Vaughan, J. G., Judd, P. A. and Bellamy, D. (2006) The oxford book of health foods. http://books.google.co.in/books p 37.

Verma, R. P. S, Sharma, R. K. and Nagarajan, S. (2003) Influence of nitrogen and irrigation malt and wort quality in barley. Cereal Res Commun 31: 437-44.