D-6037
[1-6]

RESEARCH ARTICLE Agricultural Science Digest, Volume Issue : ()

Optimum Nitrogen Dose and Malt Quality of Barley Varieties under Saline Water Irrigation

Amandeep Kaur[1], Satyavan[2], Anil Kumar Yadav[3], Ram Prakash[4], Vikram Singh[2]

10.18805/ag.D-6037

ABSTRACT

Background: A field experiment was conducted during *rabi* 2017-18 and 2018-19 at Research Farm of Department of Soil Science, CCS Haryana Agricultural University, Hisar to find out the optimum dose of nitrogen and to evaluate malt quality parameters of different barley varieties under saline water irrigation.

Methods: The experiment was laid out in split plot design by keeping four varieties (BH 902, BH 946, BH 885 and DWRB 101) in main plots and four nitrogen levels (0, 30, 60 and 90 kg/ha) in sub plots with four replications.

Result: On an average, variety BH 946 produced maximum grain yield of 5151 kg/ha which was 5.1, 7.3 and 14.7% higher as compared to DWRB 101, BH 902 and BH 885, respectively. Under saline water irrigation, the optimum dose of nitrogen for variety BH 902, BH 946, BH 885, DWRB 101 was found as 74.5, 74.9, 71.8, 69.2 kg/ha and economic optimum dose as 72.9, 73.2, 70.0, 67.7 kg/ha, respectively. Diastatic power, α-amylase activity and protein content were significantly higher in 6-row barley varieties BH 902 and BH 946, whereas hectolitre weight, starch content and malt recovery were significantly higher in 2-row barley varieties BH 885 and DWRB 101. Nitrogen application significantly enhanced the hectolitre weight, protein content in grain, á-amylase activity and diastatic power, while starch content and malt recovery were significantly decreased under various nitrogen levels.

Key words: Barley varieties, Grain and malt quality, Optimum nitrogen dose.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is fourth important cereal crop after rice, wheat and pearl millet in India. Rajasthan, Uttar Pradesh, Haryana, Punjab and Madhya Pradesh are the major barley growing states. Due to uncertainty of rainfall and scarcity of water, farmers of Haryana often irrigate the crops with poor quality water and this situation is likely to become more alarming with the depleting water resources. Keeping such emerging problems in view, the present study signifies the importance of barley cultivation which is most salt tolerant crop and can be adopted in a condition where the irrigation quality of water is saline in nature. As compared to all other cereal crops, barley is considered better for malting purposes because its glumes and hulls are cemented to kernel, which remain attached to the grain after threshing. Kernel texture of steeped barley is also firmer and its amylase activity makes it unique for malt recovery. Therefore, barley grains are more suitable for malt purpose and its quality depends on the traits like test weight, grain plumpness, husk content, grain protein content, α- amylase activity and diastatic power. Barley is mostly utilised for malting in the brewing business. In order to cope with the heightened competitiveness in the brewing sector, it is necessary to optimise the utilisation of raw materials. Barley serves as the fundamental primary ingredient for the process of brewing. The chemical composition significantly influences both the quality of the beer and the economic efficiency of the brewing process. Several criteria have played a crucial role in determining the quality of malting. The endosperm's texture plays a crucial role in the malt modification process as it impacts the absorption of water and the creation of enzymes within the endosperm Mekonnen (2021). In India, barley is now becoming more and more important as a commercial crop for industrial raw materials particularly with respect to malting and brewing. Barley varieties generally differ in their yield potential and malt quality parameters. Kassie and Tesfaye (2019) reported 17.7% higher grain yield in variety Miscal-21 as compared to Holker. Variety Miscal-21 recorded higher protein content in grain, while hectolitre weight was more in variety Holker. Grain protein and kernel plumpness are two most important quality parameters of malt barley which are strongly related to nitrogen application. Barley crop has also been found to respond significantly to varying levels to nitrogen fertilization.

[1]Department of Agronomy, Lovely Professional University, Phagwara-144 411, Punjab, India.
[2]Department of Agronomy, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India.
[3]Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India.
[4]Department of Soil Science, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India.

Corresponding Author: Amandeep Kaur, Department of Agronomy, Lovely Professional University, Phagwara-144 411, Punjab, India. Email: amugorsian@gmail.com

How to cite this article: Kaur, A., Satyavan, Yadav, A.K., Prakash, R. and Singh, V. (2024). Optimum Nitrogen Dose and Malt Quality of Barley Varieties under Saline Water Irrigation. Agricultural Science Digest. DOI: 10.18805/ag.D-6037.

Submitted: 29-4-2024 **Accepted:** 01-07-2024 **Online:** 18-07-2024

Insufficient nitrogen can reduce grain yield and quality below acceptable levels, while excess nitrogen usually enhances undesirable high protein levels. A linear increase in grain yield and protein content with increasing nitrogen levels was observed by Dubey *et al.* (2018). However, Kassie and Tesfaye (2019) reported significant increase in grain yield of malt barley up to 92 kg N ha^{-1} but the grain protein content at this level exceeds the highest acceptable limit (11.5%) for malting. They concluded 48 kg N ha^{-1} as optimum dose for acceptable grain quality for malt barley that gave highest net returns. Therefore, appropriate dose of nitrogen need to be applied for malt barley to achieve a balance between optimum grain yield and protein concentration. However, information on the effect of nitrogen levels on grain yield and malt quality parameters of different barley varieties particularly under saline water irrigation is not available in India. Keeping the above aspects in view, the present study was undertaken.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2017-18 and 2018-19 at Research Farm of Department of Soil Science, CCS Haryana Agricultural University Hisar, which is situated in semi-arid, sub-tropics at 29°8´N latitude, 75°70´E longitude and elevation of 215.2 meters above mean sea level. It is characterized by semi-arid and sub-tropical type of climate with an average annual rainfall is 450 mm. Total rainfall of 15.9 mm and 28.6 mm and pan evaporation of 47.1 mm and 41.8 mm was received during 2017-18 and 2018-19, respectively. The soil of experimental site was sandy loam in texture with pH of 8.3, available nitrogen 175.0 kg/ha, phosphorus 17.0 kg/ha and potassium 320.0 kg/ha. The experiment was laid out in split plot design by keeping four varieties (BH 902, BH 946, BH 885 and DWRB 101) in main plots and four nitrogen levels (0, 30, 60 and 90 kg/ha) in sub plots with four replications.

The crop was sown on 22.11.2017 and 26.11.2018 by *pora* method using 90 kg/ha seed rate and row spacing of 22 cm. Half dose of nitrogen as per treatment and full dose of phosphorus (P_2O_5) and potassium (K_2O) was applied in the form of urea, single super phosphate and muriate of potash fertilizers at sowing. The remaining half dose of nitrogen was top dressed after 1st irrigation as per treatment. The crop was irrigated twice in each growing season with saline water having EC_{iw} 8.0 dS/m, pH 7.52 and SAR of 15.21 me/l. The soluble ions in the saline irrigated water were Naz 55.10, K^+ 0.36, Ca^2z 7.52, Mg^2z 18.51, CO_3^{2-} nil, HCO_3^- 1.62, Cl^- 48.2 and SO_4^{2} 13.7 me/l. Harvesting of the crop was done manually on 6.4.2018 and 8.4.2019.

The quadratic model was applied to calculate optimum and economic optimum dose of N as under:

$$Y= a+bx+cx^2$$

Where:
Y= Grain yield of barley in kg/ha for a given level of x,
x= Unit of nitrogen in kg/ha,
a, b and c = Constants of the quadratic model.

Optimum dose of nitrogen (N) was calculated as following:

$$\text{Optimum dose of N} = -b/ 2c$$

Where, b and c are the constants from the response curve according to Gomez and Gomez (1984).
The formula for calculating economic optimum dose of N was as following:

$$\text{Economic optimum dose of N} = 1/ 2c \times (Pf/Py-b)$$

Where,
Pf= Price of nitrogen per kg.
Py= Price of barley per kg.
b and c = Constants from the response curve according to Gomez and Gomez (1984).

Moisture content, protein content and starch content were determined by using instrument Infratech grain analyzer. Malt from the grains of different varieties was prepared ant diastatic power of malted grain was analyzed as per procedure suggested by AOAC (1990). The α-amylase activity was determined with the help of Rapid Visco Analyzer using stirring number method and Hegberg Falling Number apparatus. Malt recovery was calculated by using following formula:

$$\text{Malt recovery (\%)} = \frac{\text{Malt weight}}{\text{Sample weight}} \times 100$$

Data were statistically analyzed by using the technique of analysis of variance (ANOVA) described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Grain yield of barley varieties

The grain yield is a principle criterion for evaluating efficiency of various treatments. Variety BH 946 recorded maximum grain yield of 5151 kg/ha which was 5.1, 7.3 and 14.7% higher as compared to DWRB 101, BH 902 and BH 885, respectively (Table 1). Higher yield in variety BH 946 was attributed to its better genetic growth parameters which intercepted higher solar radiation and synthesized more photosynthates and resulted in higher grain yield. Kassie and Tesfaye (2019) reported that variety Miscal-21 recorded 17.7% more grain yield as compared to variety Holker.

Optimum and economic optimum dose of nitrogen

The response curve, regression equations and regression coefficients for determining optimum and economic optimum dose of nitrogen for various varieties are presented in Fig 1.

Based on the regression equations and regression coefficients, the optimum dose of nitrogen for variety BH 902, BH 946, BH 885 and DWRB 101 was found as 74.5, 74.9, 71.8 and 69.2 kg/ha and economic optimum dose as 72.9, 73.2, 70.0 and 67.7 kg/ha, respectively under saline irrigation water (Table 1). Nitrogen application at 30, 60 and 90 kg/ha enhanced the grain yield by 25.3, 34.0 and 34.7%, respectively over control. Improvement in grain yield with

increased N dose was due to better growth and yield contributing characters. as reflected from significantly more plant height, DMA, LAI, LAD, PAR interception, effective tillers per meter row length, number of grains per spike and test weight. These results corroborate the findings of Dubey *et al.* (2018). Contrary to the above findings, Ejigu *et al.* (2015) observed that varieties Holker and Beka exhibited increasing trend in grain yield with increase in nitrogen level up to 50 kg/ha but grain yield decreased in varieties Miscal-21 and EH-1293 when nitrogen was applied beyond 30 kg/ha.

Grain quality parameters

Moisture content in grain

The present study showed no significant variation among different varieties and nitrogen levels with respect to moisture content in grain, however it varied between 10.27 to 11.43% among different treatments (Table 2). Yousif and Evans (2018) reported that malt barley grains need generally a moisture content level of 10-12%. Therefore, different varieties in the present investigation showed moisture content in grain within the desired limit.

Hectolitre weight

The data showed that variety DWRB 101 and BH 885 recorded statistically similar but significantly more hectolitre weight as compared to BH 902 and BH 946 (Table 2). Maximum hectolitre weight (67.15 kg/hl) was attained by variety DWRB 101 which was 0.5, 9.1 and 11.0% higher in comparison to BH 885, BH 902 and BH 946, respectively. Higher hectolitre weight in variety DWRB 101 was due to the fact that the grains of this variety were denser, uniform in size and of the desired shape which decreased the inter-grain spaces. Terefe *et al.* (2018) also reported that variety HB 1963 recorded higher hectolitre weight than other varieties. Application of N at 30, 60 and 90 kg/ha increased the hectolitre weight by 1.6, 2.5 and 2.8%, respectively over control. Higher hectolitre weight with nitrogen application might be due to large and bold grains. Contrary to the above findings, Kassie and Tesfaye (2019) reported that different

Table 1: Grain yield (pooled data of two years), optimum dose and economic optimum dose of nitrogen for different barley varieties.

Barley varieties	Grain yield (kg/ha)					Optimum nitrogen dose (kg/ha)	Economic optimum nitrogen dose (kg/ha)
	N_0	N_{30}	N_{60}	N_{90}	Mean		
BH 902	3832	4795	5224	5241	4773	74.5	72.9
BH 946	4214	5197	5566	5625	5151	74.9	73.2
BH 885	3576	4464	4754	4773	4392	71.8	70.0
DWRB 101	3924	5033	5293	5307	4889	69.2	67.7
Mean	3887	4872	5209	5237			

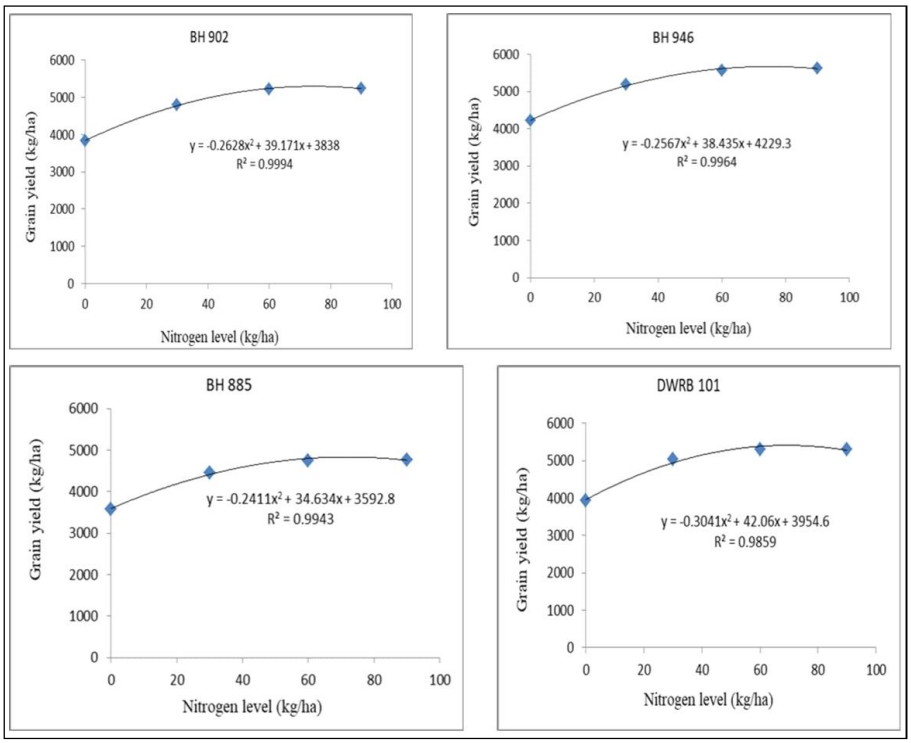

Fig 1: Response curve for computation of optimum dose and economic optimum dose of N for different barley varieties.

nitrogen levels did not show any significant effect on hectolitre weight.

Protein content: Protein content in grain is an important parameter for evaluating recovery and quality of malt. Lower the values of protein content, better is the grain quality. The present study showed that both 2-row barley varieties BH 885 and DWRB 101 produced significantly lower protein content as compared to 6-row barley varieties BH 902 and BH 946 (Table 2), thus indicating better grain quality in 2-row barley varieties. Reduction in protein content under 2-row barley varieties might be due to lower N uptake by their grains. Similarly, Terefe *et al.* (2018) reported that variety Holker recorded highest protein content in grain which was followed by variety Ibon174/03 and variety HB-1963, while lowest protein content in grain was observed in variety Explorer. Variation in grain protein content of malt barley due to various genotypes was also reported by Bera *et al*. (2018). However, Kassie and Tesfaye (2019) suggested that growers should grow varieties with low protein content for malt purpose. The data showed that highest protein content (10.33 %) was obtained with N application at 90 kg/ ha and it showed its significant superiority over 60 kg/ha (10.01 %), 30 kg/ha (9.60 %) and control (9.02 %). Increase in grain protein content with increase in N doses was due to more nitrogen uptake by the plants and more translocation of nitrogen towards the grain resulting in higher grain protein content accordingly. However, Terefe *et al.* (2018) observed that protein content improved with each increment in N level up to 54 kg/ha, but the acceptable quality for malt barley production was obtained with application of 36 kg/ha.

Starch content

Starch accounts for 85-90% of the malt extract, out of which 70% is fermented in brewing. The data showed that variety BH 885 being statistically at par with DWRB 101 produced significantly more starch content in comparison to varieties BH 902 and BH 946 (Table 2). Results indicated that 2-row barley varieties BH 885 and DWRB 101 produced higher starch content as compared to 6-row barley varieties BH 902 and BH 946. Higher starch content in 2-rowed barley varieties was mainly due to lower protein content in their grains. The variation in starch content among different varieties was due to their different genetic constitution. Kumar *et al.* (2014) also reported that two-row cultivars have better grain quality parameters as compared to six-row cultivars. Among nitrogen levels, maximum starch content in grains (64.74%) was recorded under control treatment and it was significantly higher in comparison to all other nitrogen levels. Nitrogen application at 30, 60 and 90 kg/ha decreased the starch content in grains by 0.92, 1.76 and 2.81%, respectively as compared to control. Reduced starch content with nitrogen application might be due to increased protein content in grains because starch and protein content in grains are inversely proportional to each other. However, Singh *et al.* (2012) reported that starch content in barley was not significantly affected by N levels.

Malt quality parameters

Diastatic power

It is the ability to produce enzymes which convert starch of the grain into fermentable sugars during brewing and malting process and thus influences alcohol production. The data given in table 2 revealed that maximum diastatic power of malted grain was recorded in variety BH 902 which was statistically similar with BH 946 but was significantly higher than BH 885 and DWRB 101. Both 6-row barley varieties BH 902 and BH 946 produced significantly higher diastatic power (106.3 °L and 105.6 °L) as compared to 2-row barley varieties BH 885 and DWRB 101 (101.4 °L and 102.3 °L). Higher diastatic power of both 6-row barley varieties was

Table 2: The grain and malt quality parameters of barley varieties as influenced by different nitrogen levels (pooled data of two years).

Treatment	Moisture content (%)	Hectolitre weight (kg/hl)	Protein content (%)	Starch content (%)	Diastatic power (°L)	α-amylase activity (Falling No.)	Malt recovery (%)
Varieties							
BH 902	10.86	61.01	10.41	63.20	106.3	372.7	84.5
BH 946	10.84	59.78	10.03	62.30	105.6	371.4	84.4
BH 885	10.82	66.79	9.35	64.33	101.4	363.7	85.9
DWRB 101	10.82	67.15	9.16	63.64	102.3	365.9	86.4
SEm ±	0.8	0.20	0.14	0.31	0.2	0.9	0.2
CD (p=0.05)	NS	0.65	0.42	0.92	0.9	2.8	0.5
Nitrogen levels (kg/ha)							
Control	10.82	62.61	9.02	64.74	101.7	362.5	86.7
30	10.85	63.61	9.60	63.82	103.7	367.6	85.9
60	10.81	64.15	10.01	62.98	104.8	370.8	85.1
90	10.87	64.37	10.33	61.93	105.4	372.8	83.5
SEm ±	0.07	0.09	0.05	0.11	0.1	0.3	0.1
CD (p=0.05)	NS	0.26	0.15	0.30	0.4	1.0	0.2

Interaction- NS.

due to higher grain protein content under these varieties, as diastatic power and protein content has direct correlation with each other. Bera *et al.* (2018) reported that variety DWRB 92 had the highest value of diastatic power while DWRB 101 showed lowest diastatic power. Among nitrogen levels, significantly higher diastatic power (105.4°L) was recorded with N at 90 kg/ha in comparison to 60 kg/ha, 30 kg/ha and control treatments having diastatic power of 104.8°L, 103.7°L and 101.7°L, respectively. Increase in diastatic power under different nitrogen levels might be due to increased protein content in grain. The findings are in accordance with the results reported by Singh *et al.* (2012).

α-amylase activity

The α-amylase activity is responsible for conversion of starch into simple sugars during the process of malting. Maximum α-amylase activity in terms of falling number (372.7) was recorded in variety BH 902 which was statistically at par with BH 946 (371.4) but was significantly higher than DWRB 101 (365.9) and BH 885 (363.7). The results indicated that both 6-row barley varieties produced significantly higher α-amylase activity than 2-row barley varieties. The higher α-amylase activity in 6-row barley varieties may be attributed to higher protein content in their grain due to different genetic constitution. As this parameter is an indicator of enzymatic activity, an enzyme being protein increases with increase in protein content and this is also true in the present study. Bera *et al.* (2018) reported highest α-amylase activity in malted grains of variety DWRB 91 and the lowest in DWRB 92. The data indicated that á-amylase activity increased significantly with each incremental dose of N at 30 kg/ha. The maximum á-amylase activity (372.8 falling number) was recorded with N at 90 kg/ha and it was significantly higher as compared to 60 kg/ha (370.8), 30 kg/ha (367.6) and control (362.5). This was due to the fact that increased protein content in grain might be increased the α-amylase activity under different nitrogen levels.

Malt recovery

Variety DWRB 101 recorded highest malt recovery of 86.4% which was 0.5, 1.9 and 2.0% higher as compared to BH 885, BH 902 and BH 946, respectively (Table 2). The data showed that both 2-row barley varieties BH 885 and DWRB 101 recorded significantly higher malt recovery as compared to 6-row barley varieties BH 902 and BH 946. Higher malt recovery in varieties DWRB 101 and BH 885 was due to the fact that low protein content and higher starch content was recorded under varieties. Higher malt extract values are normally associated with low protein content in grain and this relation has truly been recorded in present study too. Varietal difference for malt recovery has also been observed by Kaur and Singh (2011). Malt recovery decreased significantly with increase in N level up to 90 kg/ha during both years of investigation. Nitrogen application at 30, 60 and 90 kg/ha caused reduction in the malt recovery by 0.7, 1.5 and 3.1%, respectively than control treatment. Reduction in malt recovery with nitrogen application was mainly due to increase in protein content and decrease in starch content under different nitrogen levels.

It may be concluded that optimum dose of nitrogen for variety BH 902, BH 946, BH 885 and DWRB 101 was found as 74.5, 74.9, 71.8 and 69.2 kg/ha, respectively under saline water irrigation. Diastatic power, á-amylase activity and protein content were significantly higher in 6-row barley varieties BH 902 and BH 946, whereas hectolitre weight, starch content and malt recovery were significantly higher in 2-row barley varieties BH 885 and DWRB 101.

CONCLUSION

Based on two years study, it was found that variety BH 946 produced maximum grain yield which was statistically similar with DWRB 101 and significantly more in comparison to BH 902 and BH 885. On an average, variety BH 946 recorded 5.1, 7.3 and 14.7% higher grain yield as compared to DWRB 101, BH 902 and BH 885, respectively. Both 2-row barley varieties BH 885 and DWRB 101 recorded significantly higher hectolitre weight, starch content and malt recovery as compared to 6-row barley varieties BH 902 and BH 946, whereas protein content, diastatic power and α-amylase activity were significantly higher in 6-row barley varieties.

Each incremental dose of nitrogen gave significantly more grain yield only up to 60 kg ha^{-1} and further increase in N dose up to 90 kg ha^{-1} did not significantly affect grain yield under saline irrigation water. Nitrogen application at 30, 60 and 90 kg ha^{-1} enhanced the grain yield by 25.3, 34.0 and 34.7%, respectively over control. Based on regression equations and regression coefficients, the optimum dose of nitrogen for variety BH 902, BH 946, BH 885 and DWRB 101 was found as 74.5, 74.9, 71.8, 69.2 kg ha^{-1}, respectively. Nitrogen application significantly enhanced the hectolitre weight, protein content in grains, α-amylase activity and diastatic power, while starch content and malt recovery were significantly decreased.

It may be concluded that grow BH 946 variety for getting higher productivity and DWRB 101 for better malt quality along with application of 74.9 and 69.2 kg N ha^{-1}, respectively.

ACKNOWLEDGEMENT

The author is highly thankful to CCS Haryana Agricultural University, Hisar and all other authors who provided valuable contribution to complete this research.

Conflict of interest

The authors have no conflicts of interest to declare.

REFERENCES

AOAC. (1990). Official Method of Analysis. Association of Official Analytical Chemists. Washington.

Bera, S., Sabikhi, L. and Singh, A.K. (2018). Assessment of malting characteristics of different Indian barley cultivars. Journal of Food Science and Technology 55(2): 704-711.

Dubey, S., Tiwari, A., Singh, V., Pandey, V.K. and Singh, G. (2018). Effect of nitrogen levels and its time of application on yield attributes, yield and economics of barley (*Hordeum vulgare* L.). International Journal of Current Microbiology and Applied Science 7(1): 1695-705.

Ejigu, D., Tana, T. and Eticha, F. (2015). Effect of nitrogen fertilizer levels on yield components and grain yield of malt barley (*Hordeum vulgare* L.) varieties at Kulumsa, Central Ethiopia. Journal of Crop Science and Technology 4(3): 11-21.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. IInd Ed., John Willey and Sons, New York.

Kassie, M. and Tesfaye, K. (2019). Malting barley grain quality and yield response to nitrogen fertilization in the Arsi highlands of Ethiopia. Journal of Crop Science and Biotechnology. 22(3): 225- 234.

Kaur K. and Singh H. (2011). Effect of levels and time of nitrogen application on grain and malt quality characteristics of barley varieties. Environment and Ecology. 29(2): 542-5.

Kumar. D., Narwal. S., Verma. R.P.S., Kumar. V., Kharab. A.S. and Sharma, I. (2014). Performance of barley varieties for malting quality parameters in north western plains of India. Journal of Wheat Research. 6: 132-137.

Mekonnen, G. (2021). Impact of malt barley varieties on malt quality: A review. Agricultural Reviews. 42(1): 116-119. doi: 10.188 05/ag.R-162.

Singh, J., Mahal, S.S. and Manhas, S.S. (2012). Effect of sowing methods, nitrogen levels and irrigation scheduling on yield and quality of malt barley (*Hordeum vulgare* L.). Indian Journal of Agronomy. 57(3): 259-64.

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 Agriculture Science 4(4): 29-43.

Yousif, A.M. and Evans, D.E. (2018). The impact of barley nitrogen fertilization rate on barley brewing using a commercial enzyme (Ondea Pro). Journal of the Institute of Brewing 124: 132-142.