Hindawi
Advances in Agriculture
Volume 2021, Article ID 5566381, 5 pages
https://doi.org/10.1155/2021/5566381

Research Article

Performance Evaluation of Malt Barley (*Hordeum vulgare* L.) Varieties for Yield and Quality Traits in Eastern Amhara Regional State, Ethiopia

Abebe Assefa, Getawey Girmay, Tesfaye Alemayehu, and Alemu Lakew

Sekota Dry Land Agricltural Research Center, P.O. Box 62, Sekota, Ethiopia

Correspondence should be addressed to Abebe Assefa; assefaabebe1921@gmail.com

Received 30 January 2021; Revised 20 May 2021; Accepted 14 June 2021; Published 21 June 2021

Academic Editor: İbrahim Kahramanoğlu

Barley (*Hordeum vulgare* L.) is an annual cereal crop that belongs to the grass family Poaceae of the tribe Triticeae. Due to the establishment and production capacity of malt and beer factories in Ethiopia, malt barley production demand increased from time to time. Eight released malt barley varieties were evaluated in four environments in Wag-himra and Lasta districts in the main production season for two years (2016 and 2017). The objective of the trial was to identify a high yielder and standard-quality malting barley variety for production. The trial was conducted using a randomized complete block design with three replications on a plot size of 1.2 m width with that of 2.5 m length. The results revealed that there was a highly significant difference in grain yield and quality traits ($p < 0.05$). The kernel protein and starch content of the varieties ranged from 9.85 to 11 and 63–65%. The thousand kernel weight of the varieties was in the range of 32.5 to 46.4 g. EH1847 (3340 kg ha^{-1}), IBON174/03 (3351 kg ha^{-1}), and Bahati (3220 kg ha^{-1}) were the first three best performing high yielder and best varieties that fulfilled quality parameter requirements set by the National Standard Authority for malting barley. Therefore, these varieties are recommended for production in the Wag-himra and Lasta agroecologies for their high yield, kernel size, and kernel protein content. Further study is required on agronomic practices and brewing quality attributes in malt barley.

1. Introduction

Barley (*Hordeum vulgare* spp. *vulgare* L.) is one of the oldest crops cultivated in the world. Archaeological evidence from the Fertile Crescent indicates that about 10,000 years ago, the crop was domesticated from its wild relative (*Hordeuum spontaneum* C. Koch). The crop is an important feed, malt, and food crop in Russia, Canada, Australia, Ukraine, Turkey, Spain, Morocco, Germany, Kazakhstan, Iran, Syria, USA, France, Polland, Ethiopia, and UK [1].

In Ethiopia, barley is an important crop that is mainly grown by subsistence farmers in a wide range of environments with an altitude range of 1500 to 3500 m.a.s.l. [2, 3]. It is the fifth most important cereal crop after teff, wheat, maize, and sorghum in area coverage in the country [4]. The crop is predominantly categorized as food and malting barley based on their uses [5]. The share of malting barley production is quite low as compared to food barley in Ethiopia [2] despite the country having favorable environment and potential market opportunity. As a result, domestic breweries are still forced to import malt from abroad. For example, the Asela malt factory imported 15,609 tons of malting barley from 1999/00 to 2000/01 [6].

Because of urbanization, population growth, and increasing of beer industry in Ethiopia, malt barley production is increased [7]. In Ethiopia, malt barely covers an area of 950742.01 hectares of land with the production of 23780102.92 in quintals on the productivity of 25.2 q ha^{-1}. In Amhara Region, it also covers 32515.21 with a production of 7512996.98 in quintals and productivity of 23.3 q ha^{-1}. In Wag-himra, it covers 17437.02 hectares of land with production 213401.13 in quintals with the productivity of 12.25 q ha^{-1} [8].

The low productivity of malt barely in Amhara region, particularly in Wag-Lasta (12.25 q ha^{-1}), compared to the

national (25 q ha^{-1}) and regional average (23.3 q ha^{-1}) is due to use of low-yielding local variety, less rainfall amount and distribution in the area (late coming and early set of rainfall), low soil fertility, poor agronomic practice such as intercrop with legume and lack of crop rotation with pulse crop, disease, insect pest, and late maturing malt barely variety.

Important malting barley quality characteristics include kernel size, kernel protein content, malt extract, and diastatic power [9]. Generally, malt barley protein content within the range of 9–12.5% can be used by malt factories to meet brewers' need [10]. Malt barley genotypes with high grain protein content result in low extract for the brewers, while genotypes with low protein level result in lack of enzymes necessary to modify the barley kernel and to break down the starch during brewing [11]. Low protein also impairs the brewing performance due to poor yeast amino acid nutrition [12]. These malt barely quality traits are inherited quantitatively, and their performance depends on both genetic and environmental conditions [13].

Genotypes differ in these characteristics, and they are also influenced by environmental factors [14]. Some genotypes may perform well in certain environments, but fail in several others. The phenotypic performance of a genotype is not necessarily the same under diverse agroecological conditions. So far, malt barley varieties have not been evaluated in Wag-himra and Lasta areas of eastern Amhara Regional State. The crop plays an important role in improving the livelihood of barley farmers in these areas, and it is one of the most important cereal crops in the area to get additional income to the farmers as it is one of the industrial crops and the demand of the crop (malt barely) in the area is increased as the Raya beer industry is located as the nearest. Therefore, the objective of this trial was to identify a high-yielder and early matured variety with malting quality for production in eastern Amhara Regional State, particularly in Wag-Lasta areas.

2. Materials and Methods

2.1. Description of Test Locations. The experiment was conducted during the main cropping seasons for two years (2016 and 2017) in Dehana and lasta districts. The experiment was conducted on experimental field stations in the main cropping season in Wag-Lasta, North Ethiopia, namely, at Lalibela district (medagai) and Dehana district (Amed worke). Wag-Lasta is one of the drought-affected areas in the country, and mostly it grows barely, sorghum, wheat, and teff as major crops and low-land pulse crops.

The area (Wag-Lasta) is characterized by a unimodal rainfall pattern that extends from June to late August or early September. Lalibela (medagai) is located in Lasta district, North Wollo Zone of Amhara Region and 637.5 km far from Addis Ababa (the capital of Ethiopia), and wheat, barely, teff, and low-land pulse crops such as mung bean, haircot bean, and cow pea are majorly growing crops. Amde Work a is located in Dehana district, North Wollo Zone of Wag-himra, Amhara Region, and 800 km far away from Addis Ababa (the capital of Ethiopia). Based on the long years metrological data collected from the nearby metrological stations, the annual rainfall of Wag-Lasta ranges from 180 millimeters (mm) (lowlands) to 970 mm (high lands).The dominant soil type is classified as Cambisol, and both of the testing sites are verti soil type.

2.2. Experimental Treatments, Design, and Management. Eight nationally and regionally released malting barley, namely, EH1847, Bahati, Holker, traveler, Bekoji, free gebse, sabini, and IBON174/03, varieties were tested in RCBD with three replications in each location. Descriptions of the malting barley varieties are presented in Table 2. The gross and the net harvest plot size for each variety was 3 m^2 and 2 m^{-2} having six rows spaced and 20 cm row spacing. Planting of the variety at both locations was in the first week of July (July1–6).

The seeds of each tested variety were collected from the research center (Adet Agricultural Research Center under the ARARI, Holtta, and Kulmssa Agricultural Research Center under the EARI), and the seed rate was adjusted for plot by using 125 kg ha^{-1} while fertilizer application rate was100 kg ha^{-1} for NPS and 30 kg ha^{-1} for urea as per the national recommendations. Urea was applied in spilt that is half at planting and half at the vegetative growth stage (before heading) for the reason of effective use of urea fertilizers as it is one of the most mobile element and all the NPSs were applied fully at planting. Two times hand weeding at the seedling and vegetative stage at each testing district was also carried out as per recommendation. One time chemical insecticide and fungicide was sparing to controlling barely insect pest and barely fungal disease at the seedling stage before heading. After full management of the trial, four middle rows were harvested, from the first week of October to the end of October in both testing years and locations and then cleaned, dried, and threshed for 1000 kernel weight and grain yield data.

2.3. Data Collection and Statistical Analysis. Data on plant and plot based were measured and recorded. Plot-based data such as days to 50% heading (DH) and days to 90% maturity (DM) using personal visualization, thousand grain weight (gr), dry weight of above ground biomass (kg ha^{-1}), and grain yield (kg ha^{-1}) were recorded on plots basis. Plant-based data such as plant height (PH, in cm), spike length (SPL, in cm), and number of seeds per spike (SPS in No.) were measured on five randomly sampled plants from the central four rows of each plot, and grain quality data such as protein, starch, and moisture content were measured, but moisture content is also for grain yield adjustment.

For quality data, samples were collected from the two testing sites, namely, Dehana and Lalibella (medagai), for different plots of malt quality data such as grain protein and starch and grain moisture content of the tested varieties. 500 g per sample was taken after manually cleaning the grain to remove broken grain and other inert matter. Then, the samples were packed into a low-density polyethylene bag (plastic bag). Quality traits were analyzed at the Amhara Agricultural Research Institute (ARARI) cereal quality laboratory using NIRS analysis instruments. NIRS spectroscopy is analysis using instruments and rapid tests on

Table 1: Some descriptions of the testing sites. The rainfall and the temperature were the average of the two years (2016 and 2017).

Variable	Testing site	
	Dehana	Lalibela (medagai)
Longitude	12 40, 10, N	12 03, 11.3, N
Latitude	38 30, 41, E	39 02, 96, E
Altitude (m.a.s.l.)	2400	2176
Average annual rainfall (mm)	713	768.5
Average maximum temperature (C°)	23.5	24.7
Average minimum temperature (C°)	11.1	13.6

Source: Kombolcha weather substation in the years 2016 and 2017.

Table 2: Description the eight malting barley varieties used for the trial.

Variety	Altitude (m.a.s.l)	Maintainer	Year of releasing	Days to heading	Days to maturity	Yield at on station (q ha^{-1})	Protein % during releasing	Disease reaction
Traveler	2000–2600	HEINKEN/ HARC	2013	79–93	130–160	20–40	10–11.1	Resistance to net blotch
Holker	2500–3000	HARC	1979	—	—	—	—	—
IBON174/ 03	2300–2800	HARC	2012	70	120	—	10	Scald tolerant
Sabini	2300–2800	KARC	2011	46	64–83	25–40	8.5	Susceptible to scald
Fre-Gebs	2300–3000	AARC	2010	62–87	100–127	20–25	9–10.5	Moderately resistant to net blotch
EH1847	2200–2800	HARC	2011	71–90	126–161	35	10.6–11.7	—
Bahati	2300–2800	KARC	2011	72–85	126–158	25–40	8.7	Resistant to net blotch
Bekoji-1	2300–2800	KARC	2010	89–111	121–163	24–28	11.7	Resistant to net blotch and scald

m.a.s.l = meter above sea level, IBON = International Barely Observation Nursery, HARC = Holeta Agricultural Research center, AARC = Adet Agricultural Research Center, KARC = Kulimssa Agricultural Research Center. Source: Ministry of Agriculture, Animal, and Plant Health Regulatory Directorate, crop variety registers from 1979–2013, Addis Ababa, Ethiopia.

small samples of ground grain or nondestructively on whole grain laboratory.

Bartlett's test was used to assess homogeneity of error variances prior to combined analysis, and the combined analysis of variance over location and years was performed using SAS software program. Mean separation was carried out using least significant difference (LSD) at 5% level of significance.

3. Results and Discussion

3.1. Grain Yield, Quality, and Agronomic Traits. The combined analysis of variance across the four environments (two years with two locations) shows a significant difference at $p < 0.05$ for grain yield and yield-related traits. Mean grain yield of malting barley varieties ranged from 1853 kg ha^{-1} for Holker to IBON174/03, (3351 kg ha^{-1}) (Table 3). The mean grain yield over all the varieties was 2868 kg ha^{-1}. EH1847, IBON174/03, and Bahati were the first three best performing varieties with an average grain yield greater than the grand mean.

Varieties EH1847 and IBON174/03 showed that the best with a grain yield of 3340 kg ha^{-1} and 3351 kg ha^{-1} followed by Bahati 3240 kg ha^{-1}. Molla Mekonnen et al. [11], Misganaw Ferede and Zina Demsie [15], and Muez Mehari [16] also reported that EH1847 and IBON174/03 are high-yielder malt barely genotypes, and the result is in line with the abovementioned three findings, while Holker (1853 kg ha^{-1}) and sabini (2642 kg ha^{-1}) are the low-yielding variety.

The mean thousand kernel weight of varieties ranged from 38.63 g for traveler and 45 g for Fre-Gebs (Table 3). As Ryan et al. [17], Amare Assefa et al. [18] also reported the variation in kernel of the malt barely variety.

Kernel protein content of varieties was between 9.85% for Bekoji-1 and 11.11% for EH1847 (Table 3). The standards set for thousand kernel weight and kernel protein content by the National Standard Authority (NSA) ranged from 35 to 45 g and 9 and 11.5%, respectively According to Gondar malt factory quality standard low protein content (9–11.5%) is one of the quality parameter for malt barley in addition to other quality criteria such as high germination capacity, purity graded grain Punda [10].

Accordingly, the results indicated that all tested varieties are under the acceptable range of the standard set by NSA for thousand kernel weight and kernel protein content. The mean value of the kernel moisture content ranged from 9.98 to 10.03% in this study. Moisture determination in malting barley is primarily to permit other quality factors to be expressed on dry matter basis and for safe storage [19]. Molla Mekonnen et al. [11] also reported that varieties IBON174/

Table 3: Mean values of agronomic, yield, and quality traits of malting barley varieties tested at four environments (two locations in two years).

Varieties	DH	DM	PH	SL	SS	BM	TKW	KPC	KSC	GY
Traveler	63	94	69.10	6.94	20.93	843	38.63	10.33	64	2332
Holker	62	94	78.95	6.82	21.05	874	40.67	10.30	63	1853
IBON174/03	57	90	75.38	6.67	21.93	890	41.92	10.30	64	3351
Sabini	55	88	78.42	7.58	22.42	964	40.96	10.48	65	2642
Fre-Gebs	58	88	92.47	6.86	21.20	1022	45.13	10.33	63	3045
EH1847	59	91	88.97	7.14	22.45	1052	42.83	11.11	64	3340
Bahati	59	93	83.78	7.30	23.05	1067	43.21	10.33	64	3220
Bekoji-1	62	94	98.32	7.21	22.58	1181	43.42	9.85	65	2765
Mean	59	91	83	7	22	10	42	10	64	2868
C.V (%)	4	3	11	9	9	25	6	0.5	0.76	17.0
LSD (5%)	2.12	2.85	7.69	0.52	1.64	2.02	2.04	0.04	0.39	3.41

DH = days to heading, DM = days to maturity, PH = plant height (cm), SL = spike length (cm), SS = seed per spike (No.), TKW = 1000 kernel weight (g), BM = above-ground biomass (kg/ha), KPc = kernel protein content (%), KSc = kernel starch content (%), and Gy = gain yield (kg ha^{-1}).

Table 4: Correlation of yield and other agronomic and quality traits.

	DH	DM	PH	SL	SS	BM	TKW	KPC	KSC
DH	1								
DM	0.8947	1							
PH	0.0095	−0.0797	1						
SL	−0.3225	−0.1356	0.2138	1					
SS	−0.3847	−0.0555	0.4114	0.6822	1				
BM	−0.0361	0.0159	0.9088	0.4862	0.7061	1			
TKW	−0.3163	−0.381	0.8497	0.0369	0.3951	0.7446	1		
KPC	−0.3286	−0.337	−0.1325	0.1179	0.0951	−0.1408	−0.0381	1	1
KSC	−0.2044	0	0.1044	0.7044	0.6488	0.4084	−0.1339	−0.1633	
GY	−0.5423	−0.452	0.3404	0.0682	0.5951	0.456	−0.6202	−0.3248	−0.1813

03 and EH1847 fulfill the malt quality parameters, especially protein content.

Most of the mean values of the traits show a positive correlation with grain yield and quality traits (Table 4). A negative correlation was observed between thousand kernel weight, kernel starch content, and protein percentage with grain yield. Also, Molla Mekonnen et al. [11] reported a negative correlation between malt barely quality and grain yield. Grain yield is positively correlated with all the agronomic traits except days to heading and days to maturity.

4. Conclusions and Recommendation

The malting industry in Ethiopia is often challenged by the availability of a barley variety that meets the quality and quantity requirements set by the industry. Recently, the demand for malting barley has increased significantly in Ethiopia because of the increasing number of beer industries in the country, and more attention is now being given to meeting the demand for this crop. Selection of improved malt barley varieties in different locations is important to boost the grain yield and to fill the demand of malt barley for the users.

Based on the results, three malting barley varieties, EH1847, IBON174/03, and Bahati, were found to be relatively high-yielder and best-quality malt barely varieties. Moreover, these varieties fulfilled quality parameter requirements set by the National Standard Authority for malting barley. Therefore, these varieties are recommended for production for their high yield, kernel size, and protein content. Further study is required on agronomic practices and brewing quality attributes in malt barley.

Data Availability

Data are available with the first author for a special cause.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

The authors acknowledge the Amhara Region Agricultural Research Institute (ARARI) for financial support to conduct this study. The authors also thank Mr. Daniel Tesfay for conducting grain quality parameter analysis and Aeimro Bezabih for his help in data analysis and manuscript writing.

References

[1] Food and Agricutural organizationFAO, Rome, Italy, 2008.
[2] B. Bekele, F. Alemayehu, and B. Lakew, "Food barley in Ethiopia," in *Food Barley: Importance, Use and Local Knowledge*, S. Grando and H. Gomez Macpherson, Eds., ICARDA, Aleppo, Syria, 2005.

[3] C. Yirga, F. Alemayehu, and W. Sinebo, "Barley livestock production system in Ethiopia: an overview," in *Barley-based Farming System in the Highlands of Ethiopia*, C. Yirga, F. Alemayehu, and W. Sinebo, Eds., Ethiopian Agriculture Research Organization, Addis Ababa, Ethiopia, 1998.

[4] Central Statistical Agency, *Report on Area and Production of Crops. Statistical Bulletin*, CSA, Addis Ababa, Ethiopia, 2017.

[5] G. Biruk and K. Demelash, "Effect of nitrogen fertilizer level on grain yield and quality of malt barley (*Hordeum vulgare* L.) varieties in Malga Woreda, Southern Ethiopia," *Food Science and Quality Management*, vol. 52, pp. 2225–2557, 2016.

[6] M. Hassena and G. Legesse, *An Overview of Malt Barley Production and Marketing in Arsi. Proceedings of the Workshop on Constraints and Prospects of Malt Barley Production, Supply and marketing*, Assela Malt Factory and Industrial Projects Service, Asela, Ethiopia, 2003.

[7] B. Lakew, H. Gebre, and F. Alemayehu, "Barley production and research in Ethiopia," in *Barley Research in Ethiopia Past Work and Future Prospect*, H. Gebre and A. G. Van lure Joop, Eds., IAR, Addis Ababa, Ethiopia, 1996.

[8] Central Statistical Agency, *Report on Area and Production of Crops. Statistical Bulletin 584, Volume I*, CSA, Addis Ababa, Ethiopia, 2020.

[9] BMBRI, *Quality Factors in Malting Barley*, https://www.Bmbri.Ca, 2005.

[10] I. Punda, *Barley Malt Beer, Agribusiness Hand Book*, FAO, Rome, Italy, 2009.

[11] K. Molla Mekonnen, Y. Awoke, and Z. Demesie, "Evaluation of malt barley (hordeumdistichon l.) Genotypes for grain yield and malting quality parameters at koga irrigation in western amhara region," *International Journal of Plant Breeding and Genetics*, vol. 12, pp. 13–18, 2018.

[12] D. Kumar, V. Kumar, R. P. S. Verma, A. S. Kharub, and I. Sharma, "Quality parameter requirement and standards for malt barley-a review," *Agricultural Reviews*, vol. 34, no. 4, pp. 313–317, 2013.

[13] H. A. Eagles, A. G. Bedgood, J. F. Panazzo, and P. J. Martin, "Cultivar and environmental effects on malting quality in barley," *Australian Journal of Agricultural Research*, vol. 46, no. 5, pp. 831–844, 1995.

[14] J.-L. Molina-cano, M. Francesch, A. M. Perez-Vendrell, T. Ramo, J. Voltas, and J. Brufau, "Genetic and environmental variation in malting and feed quality of barley," *Journal of Cereal Science*, vol. 25, no. 1, pp. 37–47, 1997.

[15] M. Ferede and Z. Demsie, "Participatory evaluation of malt barley (*Hordium disticum* L.) varieties in barley-growing highland areas of Northwestern Ethiopia," *Cogent Food and Agriculture*, vol. 6, no. 1, Article ID 1756142, 2020.

[16] M. Mehari, S. Alamerew, and B. Lakew, "Genotyep by environeme intraction an dyield stability of malt barely genotype evaluated in Tigray, Ethiopia using AMMI analysis," *Asian Jourinal of Plant Science*, vol. 13, pp. 1682–3974, 2014.

[17] J. Ryan, M. Abdel Monem, and A. Amri, "Nitrogen Fertilizer response of some barley varieties in semi-arid conditions in Morocco," *Journal of Agricultural Science and Technology*, vol. 11, pp. 227–236, 2009.

[18] B. Amare Assefa, K. Niguse, A. Wasae, and S. Habitu, "Response of malt barley (*Hordeum Distichum* L) varieties to different row spacing under contrasted environments of North gondar, Ethiopia," *International Journal of Agronomy*, vol. 2021, 2021.

[19] W. C. Burger and D. E. LaBerge, "Malting and brewing quality," in *Barley: Agronomy 26*, D. C. Rasmusson, Ed., American Society of Agronomy, Inc, Madison, WI, USA, 1985.