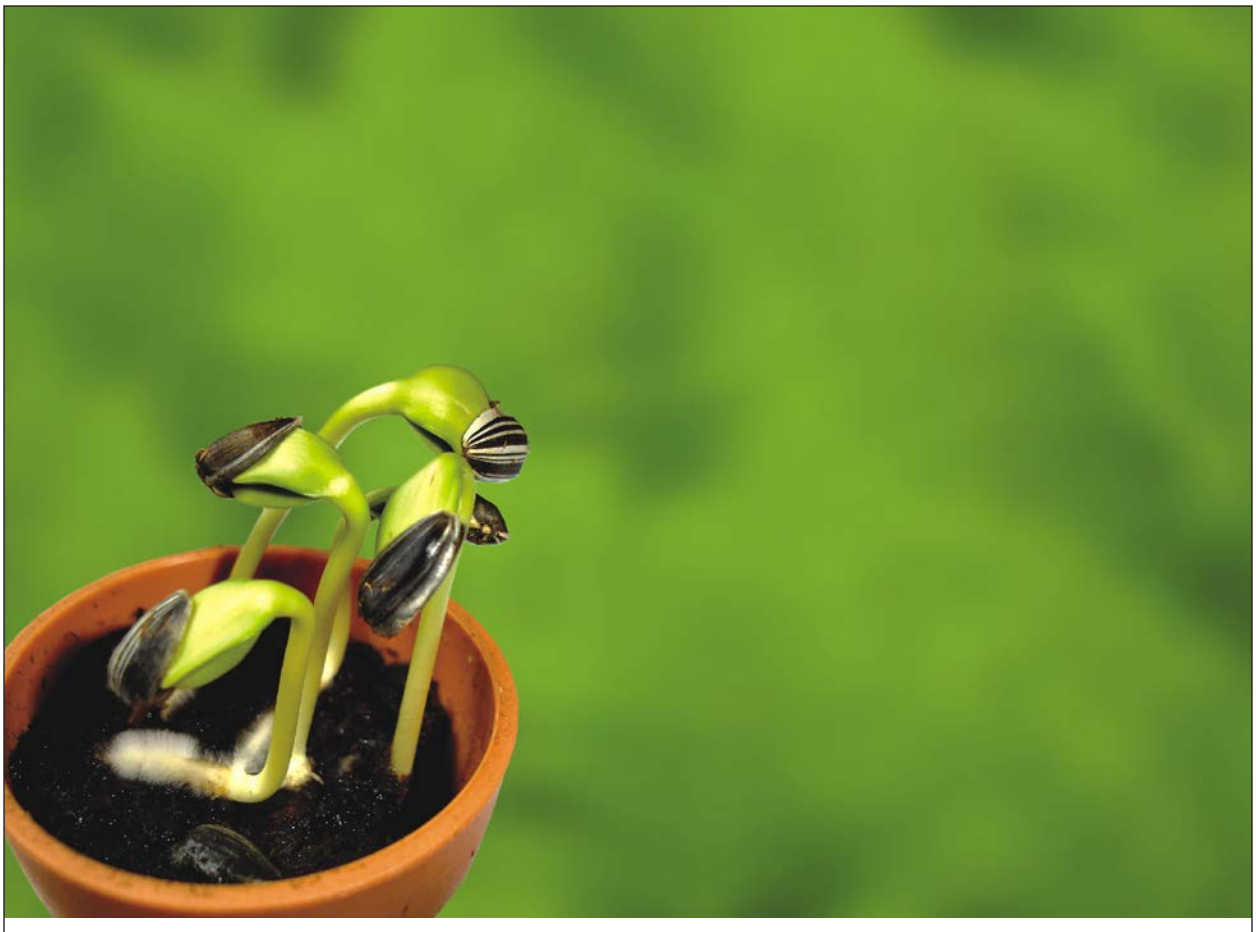

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Research Article
Evaluation of Malt Barley (*Hordeumdistichon* L.) Genotypes for Grain Yield and Malting Quality Parameters at Koga Irrigation in Western Amhara Region

Molla Mekonnen Kassie, Yihenew Awoke and Zina Demesie

Amhara Regional Agricultural Research Institute Adet Agricultural research center, P.O. Box 08, Bahir Dar, Ethiopia

Abstract

Background and Objective: Malt barley production demand increased due to the establishment and production capacity increment of malt and beer factories in Amhara Region. It is difficult to fortify the demand of malt and beer factories in the region only under rain fed production. Therefore, to evaluate and recommend malt barley varieties, the study was conducted at Koga irrigation experimental site of Adet Agricultural Research Center with the objective of selecting high grain yielding malt barley varieties with acceptable malt qualities to boost malt barley production the irrigation areas. **Material and Method:** Twelve released malt barley varieties were tested in 2013 and 2014 irrigation session in randomized complete block design with three replications. Data of Plant height, days to heading, days to maturity, spike length, number of seeds per spike and grain yield data were collected and malt quality data grain protein and starch content of the varieties were analyzed using NIRS in Amhara agricultural research institute grain quality laboratory. **Result:** In the combined analysis Variety EH 1847 showed the highest grain yield (5.73 t ha^{-1}) while Holker had showed the lowest grain yield 3.2 t ha^{-1}. IBON 174/03 was the early to head (61.67) and Sabini was early to mature 102.8 days respectively. **Conclusion:** Variety Sabini which showed higher grain yield and acceptable protein content 5.1 t ha^{-1} and 11.07% respectively recommended for malt barley production. However, the activity should be repeated both over years and across locations to explore seasonal variation and environmental factors on malt barley genotypes grain yield and quality.

Key words: Malt barley, grain protein, malt and beer factories, grain yield, Koga

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Corresponding Author: Molla Mekonnen, Amhara Regional Agricultural Research, Institute Adet Agricultural Research Center, P.O. Box 08, Bahir Dar, Ethiopia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Barley is the primary cereal used in the production of malt in the world[1]. Malt barley has versatile uses in Ethiopia, it is used for food like bread, other traditional dishes and for malting[2]. Barley can grow in wide range of agro ecology with an altitude range of 1800-3400 m above sea level (m.a.s.l) but it grows best at altitudes ranging from 2300-3000 m.a.s.l. In 2016/17 cropping session about 323,600 ha of land was covered by barley in Amhara region[3]. The information about Malt barley and food barley production is merged in the report of Ethiopia Statistics Agency, whereas the area coverage of malt barley lower than the food barley[4].

Malt barley is one of the principal ingredients in the manufacture of beer[5]. Currently malt and beer industry in Ethiopia have been growing with increasing in beer demand associated with the rise of urbanization, population growth and the growing of incomes[6]. Ethiopian breweries annual beer production was one million hectolitres in 2003/04 but in 2017 it boosts, the total annual production capacity of the breweries was raised around 12 million hectolitres[6,7]. The growth in beer demand lead to corresponding demand growth for malt barley, the key input for beer production. In 2012/13 the total estimated demand for malt barley was around 72,000 tons of which only 35% was supplied locally. The remaining 65% of malt barley was imported from abroad[8,9]. According to Elleni[8] Gondar malt factory requires 21,000 ton malt barley/year. Hence the region plans to supply malt barley production for the malt factory from Gondar, Gojjam and North Shewa malt barley potential areas. Currently the malt demand of the country is increasing year after year. Therefore, to fulfil the malt barley demand to the factory and to cut down the import of malt barley production evaluation of improved malt barley varieties under irrigation system is the pertinent option in the region.

Koga Irrigation scheme has the potential to irrigate 7,000 hectares of land[10]. It is established through financial support of African Development Bank (ADB) and the Ethiopian government. It is planned for the cultivation of economically profitable and environmentally friendly crops to improve food security[11,12]. According to ADF[11] Barley is one of the cereal crop which is cultivated in the command area.

Selection of improved malt barley varieties in different locations under irrigation condition is important to boost the grain yield and quality of malt barley[13]. Therefore, introducing malt barley varieties in this irrigation site is essential to boost malt barley production and to improve the livelihood of the farmer. It also helps as the potential seed source for the main cropping season for malt barley producing areas of the country. The trial was conducted at Koga irrigation site with the objective of selecting best performing malt barley varieties with acceptable malting qualities for supplementary production in the irrigation command area.

MATERIAL AND METHODS

Description of the study area: Koga irrigation site is found in the North West part of Ethiopia Amhara Regional State, West Gojjam Zone in Mecha District. It is located in Blue Nile basin between 11° 10′ and 11°25′ North latitude and 37° 2′ and 37° 17′ East longitude, which is about 540 km North of the capital city, Addis Ababa along the main road from Addis Ababa to Bahir Dar. The mean annual rainfall of Merawi station is 1480 mm, of which 90% falls in the months May to October. The monthly mean temperature is 25.8°C. The elevation is 1960 meter above sea level and the slope ranges from nearly flat to 5%.

Experimental materials and procedures: The field experiment was conducted under irrigation in Koga irrigation scheme using 12 malt barley varieties released by regional and national research centres (Table 1).

The seeds of each variety were obtained from the releasing research centres. The experiment was conducted in randomized complete block design in three replications. To maintain uniformity of experimental application during the 2 years each variety were planted at the seed rate of 85 kg ha^{-1} by hand drilling. The plot size was 5 m^2 of 10 rows. Length of each row was 2.5 m with the spacing of 0.2 m between rows. Eight middle rows were harvested. DAP and Urea fertilizers were applied in the rates of 69 kg N ha^{-1} and 46 kg P_2O_5 ha^{-1}. The whole rate of P_2O_5 was applied once during planting time whereas, N was applied two times at planting and at early tillering in equal split. The experimental plots were, ploughed three times, levelled and irrigated before sowing. The Irrigation was applied every seven days with furrows.

Data collection and analysis: The varieties were evaluated for the following phonological agronomic traits: days to 50% heading, days to maturity, plant height, spike length, number of seeds per spike and grain yield from eight central rows. Plot yields were adjusted to 12.5% moisture content and converted to ton per hectare. For malt quality data grain protein and starch content of the varieties were analysed using Near-Infrared Reflectance Spectroscopy (NIRS) in Amhara agricultural research institute grain quality laboratory.

Table 1: Description of malt barley varieties evaluated at koga during 2013 and 2014 irrigation seasons in North Western Ethiopia

Variety	Year of release	Released center	Grain yield (t ha^{-1}) at time of release	Recommended agro-ecology zone	
				Altitude (masl)	Rain fall (mm)
EH 1847	2011	HARC	3.5-4.0	2300-2800	500-800
Miscal 21	2006	HARC	2.5-4.6	1550-2850	500-800
Sabini	2011	KARC/HARC	2.5-3.0	2300-2800	500-800
IBON 174/03	2012	HARC	3.0-5.7	2300-2800	500-800
FrieGebs	2010	AARC	4.0-0.0	2300-3000	500-800
HB 120	1994	HARC	2.4-3.5	2300-3000	500-800
HB 52	2001	HARC	2.4-4.7	2300-3000	500-800
HB 1533	2003	HARC	2.6-3.0	2300-3000	500-800
Bahati	2011	KARC/HARC	2.5-3.0	2300-2800	500-800
Beka	1973	HARC	2.5-3.8	2300-2800	500-800
Bekoje	2010	KARC	3.5-4.0	2300-2800	500-800
Holker	1979	HARC	2.4-3.1	2300-3000	500-800

AARC: Adet agricultural research center, Agricultural Research Center, KARC: Kulumsa agricultural, HARC: Holeta agricultural research center Research Center, Source: MoA, Crop Variety Register (1995-2012)

Table 2: Analysis of variance of traits measured in Malt barley genotypes at Koga irrigation Western Amhara Region in 2013 and 2014 irrigation seasons

Traits	Msr	Msg	Mse	Cv	F pr
Grain yield t/ha	1.2058	3.0594	0.3006	12.2	0.001
Days to heading	10.0140	267.4040	2.8400	2.4	0.001
Days to maturity	3.1810	89.4380	2.0070	1.6	0.001
Spike length	1.9489	11.9677	0.1808	5.1	0.001
No of seeds per spike	5.3960	27.2770	3.8740	7.3	0.001
Plant height	30.2800	1063.2900	27.5000	5.0	0.001

Msr: Mean square of replication, MSg: Mean square of genotypes

Statistical analysis: Grain yield and yield related traits were analysed using the statistical software (Genstat 15th edition) to compute the analysis of variance of genotypes. Fishers least significant difference (LSD) test ($\alpha = 0.05$) was used to separate means between genotypes whether there have significant differences or not.

RESULT AND DISCUSSION

Analysis of variance of malt barley grain yield and yield related traits: Genotypes showed very highly significant difference ($p<0.001$) for the traits of grain yield ton ha^{-1}. days to heading, days to maturity, hectolitre weight, spike length, number of seeds per spick and plant height between genotypes (Table 2).

Malt barley genotypes performance for Grain yield and yield related traits: There was no significant crossover interaction observed over the 2 years. In the combined analysis Variety EH 1847 showed the highest grain yield (5.73 t ha^{-1}) but hadn't significant difference from genotypes Miscal 21 (5.21 t ha^{-1}). Genotype Bekoje depicted the lowest grain yield but hadn't significant difference from genotypes, Holker and Bahati (Table 3).

Variety IBON 174/03 was the early to head (61.67) and variety Sabini was early to mature 102.8 days, respectively (Table 3). This result is in agreement with the result of Aynewa *et al.*[14] tested in the main session which was conducted at Gusha Shinkureta, Awi zone Ethiopia. Variety HB 120 and HB 52 had the longest spike the highest number of seeds per spike. The smallest spike length and the lowest number of seeds per spike were observed in the variety Holker and IBON 174/03.

Malt barley genotypes performance for protein and starch content: According to Punda[5] accepted malting barley varieties must allow malt production within the parameters to fulfil brewers' quality specification. Proteins are one of the barley grain components which are essential for the quality of malt and beer[1]. High-protein contents decrease available carbohydrates[15], with a negative influence on the brewing process. Whereas, during malting and mashing proteolysis (protease hydrolysis producing amino acids and peptides from hordeins) is necessary for yeast metabolism[16]. Therefore, soluble proteins are important in beer head retention and stability[1]. 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 like high germination capacity, purity graded grain[5].

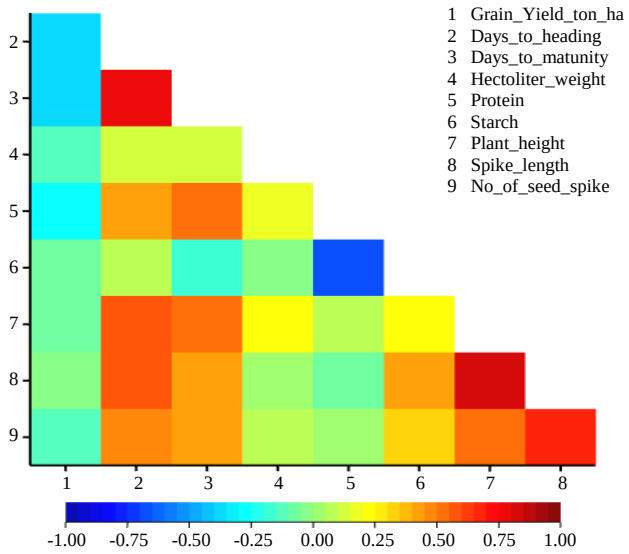

Fig. 1: Correlation matrix between pairs of traits, according to the color scale below (blue to red, increasing correlation -1 to 1)

Table 3: Mean comparison of grain yield and yield related traits of malt barley varieties tested under irrigation in 2013 and 2014 (combined) growing period Koga irrigation scheme west Gojjam

Variety	Yield (t ha^{-1})	DH	DM	NSPS	SL	PH
EH1847	5.73^{a}	69.50^{c}	109.8^{cd}	27.20^{bc}	8.067^{c}	95.8^{cd}
Miscale 21	5.21^{ab}	69.33^{c}	111.7^{bc}	26.00^{cde}	8.067^{c}	103.4^{b}
Sabini	5.07^{b}	64.00^{d}	102.8^{e}	27.2^{bc}	8.067^{c}	88.9^{e}
IBON 174/03	5.05^{b}	61.67^{e}	104.5^{e}	24.80^{de}	7.133^{ef}	91.0^{de}
FrieGebs	4.94^{bc}	63.83^{d}	108.2^{d}	27.67^{e}	7.467^{de}	106.1^{b}
HB-120	4.37^{cd}	79.17^{a}	116.0^{a}	30.40^{a}	11.067^{a}	126.4^{a}
HB-1533	4.31^{cde}	64.00^{d}	107.8^{d}	25.87^{cde}	7.933^{cd}	105.9^{b}
HB-52	4.19^{de}	79.50^{a}	113.0^{b}	30.53^{a}	10.667^{a}	122.1^{a}
Beka	4.11^{de}	78.83^{a}	112.7^{b}	29.20^{ab}	10.000^{b}	124.2^{a}
Bahati	3.87^{def}	73.00^{b}	112.8^{b}	28.40^{ab}	7.600^{cde}	93.0^{de}
Holker	3.70^{ef}	77.67^{a}	113.2^{b}	24.40^{e}	6.867^{f}	93.7^{de}
Bekoje	3.31^{f}	70.83^{c}	111.7^{bc}	27.07^{bcd}	7.333^{ef}	100.3^{bc}
CV	12.2	2.40	1.6	7.30	5.100	5.0
LSD	0.6372	1.958	2.015	2.288	0.4941	6.094

Varieties with the same letter in the column are not significantly different ($p<0.05$), DH: Days to heading, DM: Days to maturity, NSPS: Number of seed per spike, SL: Spike length and PH: Plant height

Malt barley genotypes with high grain protein content causes in low extract for the brewers, while genotypes with low protein level, results in lack of enzymes necessary to modify the barley kernel and to break down the starch during brewing. Low protein also impairs the brewing performance due to poor yeast amino acid nutrition[17]. Generally, Malt barley protein content within the range of 9-12.5% can be used by malt factories to meet brewers need[5]. Form these experiment genotypes Sabini and HB 1533 had shown acceptable grain protein content 11.07 and 11.5%, respectively, whereas other genotypes had shown higher grain protein content above 11.5% than the acceptable range. According to Pettersson[18] stress due to high temperature during grain filling increases protein content. In this study, most of the genotypes were showed higher protein content this may be the reason the location has high temperature during the growing season. The highest starch content was observed in genotype Sabini (64.63%) followed by Beka (63.53%) and HB 52 (62.93%). In the other hand genotype Miscal 21 (60.53%) followed by Holker (60.93%) had shown the lowest grain starch content other genotypes were in between (Table 4).

Correlation matrix between pairs of traits: The grain protein content and starch content had strong negative correlation. Spike length has strong positive correlation with number of seeds per spike and plant height, days to heading and days to maturity had also strong positive correlation (Fig. 1). The gain yield had show week correlation with all the traits the

Table4: Grain protein and starch content of malt barley genotypes tested under irrigation in 2013 and 2014 growing period at Koga irrigation site in west Gojjam Zone

Variety	Grain protein (%)	Grain starch content (%)
EH 1847	12.70	61.27
Miscale 21	13.13	60.53
Sabini	11.07	64.63
IBON 174/03	13.00	61.07
FrieGebs	12.33	61.40
HB 120	12.90	62.67
HB 52	13.20	62.93
HB 1533	11.50	63.13
Bahati	13.67	61.73
Beka	12.83	63.53
Bekoji 1	14.03	61.43
Holker	13.97	60.93

magnitude of the correlation is negative. This negative correlation is reported in the previous study of Zerga *et al*.[19] and Tsegaye *et al*.[20] on bread wheat and durum wheat grain yield was negatively associated with days to heading, days to maturity. The negative correlation of grain yield with days to heading and days to maturity suggests that early heading and maturing genotypes would give high grain yield.

CONCLUSION AND RECOMMENDATION

Crops which are used for raw materials for industries quality and yield are inseparable parameters. Malt barley genotypes must be fulfilling malt quality parameters such as protein content, germination rate, to meet the brewers' specification. From this study, Among the tested genotypes only two genotypes namely Sabini and HB 1533 had the acceptable grain protein content which brewers' specification, the genotype EH 1847 showed highest grain yield (5.73 t ha^{-1}). However, it had higher protein content (12.7%) which is out of the acceptable range. Therefore, only Sabini which showed higher grain yield and acceptable protein content 5.07 t ha^{-1} and 11.07% respectively recommended for malt barley production in Koga irrigation areas. However, the activity should be repeated across locations to explore seasonal variation and environmental factors on malt barley genotypes grain yield and quality. Therefore, variety Sabini recommended for malt barley production in Koga Irrigation areas.

Currently there is shortage of seed for the improved malt barley varieties in Amhara Region. To solve this seed shortage, it is advisable to produce those high yielding improved malt barley varieties under irrigation in Koga irrigation area in large scale and take the seed to the rain fed malt barley growing area of the region. Since the malt barley varieties were released under rain fed by fulfilling the malt quality criteria.

SIGNIFICANCE OF THE STUDY

Malt Barley was produced only in the rainy season in Ethiopia especially in Amhara Region. The amount of malt barley produced in the century was not sufficient to fulfill the malt demand of the country. In addition to this shortage of improved malt barley variety seed is one of the bottlenecks of the rainy season malt barley production. Due to this the country is forced to import malt barley form abroad with hard currency. Whereas, recently there are new irrigation schemes constructed in the country particularly in the region. Koga irrigation scheme is the one, if it is possible to produce malt barley in this scheme it will have significant contribution for the supply of the malt barley grain. This will save the counties hard currency and it will facilitate the development of the country especially the region. The seed producers can also produce quality seed in the irrigation period and supply to the rainy season malt grain producers.

Due to the above-mentioned reasons the study will help to identify the best adaptive malt barley varieties so far there was no any malt barley variety recommend in the region. Researchers also use this result as a benchmark for farther studies in the area.

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