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Full Length Research Paper

Effect of production site, seed age and varieties on yield and yield components of malt barley

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The major constraints in fulfilling the growing demand of malt barley in Ethiopia are limited as a result of the selection of a favourable production environment and long-time seed storage for market advantages among others are few to mention. Besides, few research findings are available on evaluation of the potential differences across sites and crop management practices to meet malting and brewery industry quality standards. The present study was conducted to evaluate the effect of seed sources and seed age on yield and yield related traits of malt barley. The experiment was conducted at Bokoji sub site of Kulumsa Research using 12 treatments consisting of 3 malt barley collections obtained from Debrebrhan Agricultural Research Centre, Ethiopia Seed Enterprise and Oromia Seed Enterprise, two seed age (year 1 and year 2) and two barley varieties (Beka and Holker). Field experiment was laid out using RCBD factorial with three replications. Highly significant ($P \leq 0.01$) differences were achieved for days to physiological maturity and number of seeds per spike indicating the presence of variability among varieties due to genetic and environmental influences. Likewise, significant ($P \leq 0.05$) variation were obtained for number of seeds per spike and yield (kg/ha). The interaction effect of seed source and variety were found significant ($P \leq 0.05$) difference for days to physiological maturity. Positive and highly significant ($P \leq 0.01$) correlations were found between days to heading, day to physiological maturity and number of seeds per spike. Our study suggests that seed sources and varietals difference were salient factors in creating field performance variability among malt barley cultivars. Therefore, evaluating the effect of genotypes, environment, varieties and their interaction effect plays an immense role to improve yield and yield related traits in malt barley. Furthermore, the finding of this study shows that further studies should be conducted across sites and years to assess varieties performances which will help as cornerstone to fulfil the growing demand of quality malt barley seed and grain for processing industries.

Key words: Malt barley, seed age, seed source.

INTRODUCTION

Barley (*Hordeum vulgare* L.) has the ability to adapt and survive in a wide range of environmental conditions mainly produced in temperate areas and high altitudes of the tropics and subtropics (Birhane et al., 1996; Ullrich, 2002). In Ethiopia, barley is the fourth most abundant crop grown among major cereal crops in terms of area coverage and yield next to wheat, maize and tef (Harlan, 1969). Barley grain is used for the preparation of different

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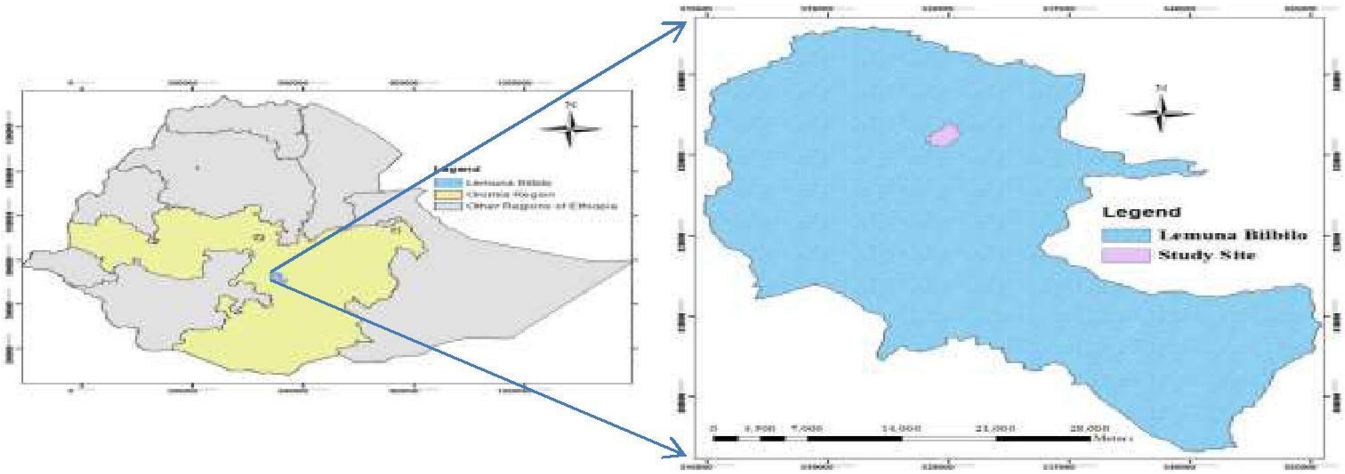

Figure 1. Map of the study site.

foodstuffs (bread, porridge) and malting (beer, gruel) (Zemedie and Bothmer, 1990; Getachew et al., 2007). The malting quality of barley is one of the economically important trait which is controlled by many genes and strongly influenced by environmental factors (Fox et al., 2003). Even though there is favorable environment for malt barley production in Ethiopia, the country on an average imports about 67,453 tons annually valued at 22.7 million Birr (Mohammed and Getachew, 2003). There is heavy financial penalty to malting industry and breweries due to short supply to meet the demand. Therefore, import substitution with local malt barley production is salient for sustainable supply for processing industries which will minimize importation cost and delivery time of produce and also generate income for farmers. Accordingly, improves quality malt barley production and minimize dependence on other countries (Mohammed and Getachew, 2003). Few studies have been conducted on malt barley variety performances across locations and on seed aging. Few years back, Altenbach et al. (2003) reported the significance of variety testing across sites or years and found higher explained percentage of environmental effect on the actual performance of varieties. These studies suggested that for sustainable improvement of malt barley production and to meet brewery companies seed quality standards, evaluating varieties across sites play an immense role to systematically identify which variety win. Therefore, in view of the important investigation of the effect of production site, seed age and varieties on yield and yield components of malt barley is useful for future malt barley improvement programs.

MATERIALS AND METHODS

The field experiment was conducted at Bekoji sub site Kulumsa Agricultural Research Centre. It is located in Arsi zone of Oromia National Regional state, Ethiopia during 2011 main cropping season. The study was conducted to investigate the effect of seed sources and seed age on yield and yield related traits and seed quality of malt barley varieties. The experimental site is situated at 231 km from Addis Ababa at 07° 32' 37'' N latitude and 39° 15' 21'' E longitudes. Different varieties of malt barley seeds were obtained from Ethiopia Seed Enterprise (ESE), Oromia seed enterprise (OSE) and Debrebirhan Agricultural Research Centre (DARC). Factorial experiment was used based on randomized complete block design with three replications. The station soil type is classified as Eutric Nitosol, exhibiting a clay content of approximately 48.5% (Tanner et al., 1993) and is relatively deficient in phosphorus with pH of 5.3. The station is situated at an altitude of 2780 m.a.s.l. The site receives an annual average rainfall of 1020 mm. It has a long term mean minimum and maximum annual average temperatures of 8 and 20°C, respectively (Figure 1).

Description of experimental materials

Seed samples of two improved malt barley varieties, namely Beka and Holker, harvested in 2009 designated as year two and 2010 designated as year one and three malt barley collection sites. Representative samples were obtained from DARC, ESE, and OSE. The class of seeds employed for this experiment was certified cycle one.

Experimental design and procedure

Field experiment was laid out in Randomized Complete Block Design (RCBD) using factorial arrangement in three replications. Treatments were assigned to each plot in random manner. The plot size was 3 m2 which accommodates six rows of 2.5 m length and

1.2 m width. Spacing between rows was 0.2 m, while plots and blocks were separated by 0.5 and 1 m, respectively to prevent inter-plot interference. In both sides of the plots one row was left to control border effect while the remaining four rows were used to measure grain yield.

Field management

Land preparation was done after the onset of rains. Seeds were sown in rows by hand using recommended seeding rate of 100 kg/ha in 2011. Diammonium phosphate (DAP) fertilizer was applied at a rate of 100 kg/ha during sowing time. All the agronomic practices recommended for seed production, such as hand weeding, cultivation and rouging were undertaken from land preparation through seed processing and drying.

Agronomic parameters

Days to heading and maturity, number of fertile tillers and plant height

Days to heading and maturity, number of fertile tillers and plant height were recorded when 50 and 95% of the plants attained their respective phenological stages, respectively. Two middle rows were randomly selected from each plot at late tillering and physiological maturity stages to determine number of fertile tillers and plant height from 1 m row length.

Number of seeds per spike

Number of seeds per spike was determined from 10 randomly selected plants of each plot at maturity. Plants from the central four rows of each plot were subjected to yield evaluation and seed quality analysis.

Seed moisture content

Seed moisture content was determined using the digital moisture meter in the field so as to determine harvesting. After harvest, threshing, and drying, seeds of the same treatments from the three replications were separately weighed and bulked together whereby sampled for laboratory analysis.

Seed yield and 1000 kernel weight

Seed yield and 1000 kernel weight were determined in kg ha-1 and g, respectively at adjusted moisture content (MC%) of 12.5% using the following relationship and converted to ha-1 (Gassim, 1988). Data on days to heading and maturity were recorded on a plot basis and plant height was averaged over five plants randomly selected from each plot.

RESULTS AND DISCUSSION

Agronomic parameters, yield components and yield

Analysis of variance indicated that days to maturity and number of seeds per spike were highly ($P \leq 0.01$) affected by main effect of production site. This is in agreement with the result of Delouche (1980) who reported significant effect of environmental factors on seed quality and growth of some plants. Mati et al. (1989) also reported that the centrality of some special regions for the production of some products is a convincing reason for the effect of the environment on growth and quality of seeds. Environmental interactions during grain filling alter the time course for grain development and influence final grain weight, protein and starch contents (Altenbach et al., 2003). Meanwhile, no detectable variations were demonstrated on days to heading, productive tiller number and plant height due to main effect of seed age. Hence, the longest days to maturity was recorded in seed samples collected from ESE (143 days) followed by samples collected from DARC, while the shortest duration to maturity were recorded in samples collected from OSE (Table 1). This indicates harvesting of seeds at physiological maturity is better to have maximum dry weight, higher viability and vigor, besides higher seed yield and yield attributing parameters (Vasudevan et al., 2008). This indicates that barley varieties tend to maintain their relative days to maturity regardless of seed age, which intern indicated that environmental effect played a significant role in determining barley maturity irrespective of seed age. According to Waddington et al. (1986), modern genotypes had the highest rates of total grain sink filing period, reflecting their larger grain sink. Intact barley spikes sampled randomly from the field at different dates during the maturation period can be used for determining the number of days to maturity where it was affected by genotype. Higher numbers of seeds per spikes were recorded in Holker (112 seeds) as compared to Beka variety with (103 seeds).

Since there was no interaction effect between seed age, site and variety, it tends to maintain their relative days to maturity from year to year and from location to location as well as from variety to variety. Days to physiological maturity can change depending on weather conditions prevailing in a given year. In consistent to this result, Bayeh and Grando (2011) stated that the interaction effect of variety by seed age was not significant, indicating that malting barley can be produced without yield fluctuation risk in the study area. The main effect of variety had resulted in significant ($P \leq 0.05$), while site had posed highly significant ($P \leq 0.01$) on seeds per spike effect. Similarly, other reports have shown the variation of number of kernels per spike as a function of genotypes and environment (Martin, 1987; Schulthess, 1992; Zewdu et al., 1992; Tilahun et al., 1996).

Analysis of variance depicted that the interaction effect of site by variety significantly ($P \leq 0.05$) affected days to physiological maturity while the rest measured traits did not show any significant variation. Nevertheless, the longest duration of maturity (142 days) were recorded in seed samples collected from DARC as compared to the other seed sources (Table 2). According to Tekrony and Egli (1997) physiological maturity is a good sign of achieving maximum seed quality on the mother plant.

Table 1. Main effect of seed age, site and varieties on some agronomic traits of barley.

Treatment	Parameter					
Age	**DH**	**PTN**	**PH**	**DPM**	**SPS**	**GY**
Year 1	82.56[a]	5.01[a]	95.89[a]	141.94[a]	109.59[a]	2712.4[a]
Year 2	80.00[a]	4.90[a]	95.08[a]	142.28[a]	105.27[a]	2604.6[a]
P≤0.05	ns	ns	ns	ns	ns	ns
Site						
DARC	84.08[a]	5.03[a]	96.47[a]	142.25[ab]	116[a]	2683.50[a]
ESE	80.33[a]	4.83[a]	95.60[a]	142.50[a]	100[b]	2605.10[a]
OSE	79.42[a]	5.03[a]	94.37[a]	141.58[c]	107[ab]	2686.70[a]
P≤0.05	ns	ns	ns	0.77	10.2	ns
Variety						
Beka	80.61[a]	5.03[a]	94.62[a]	141.67[b]	103[a]	2575.1[b]
Holker	81.94[a]	4.89[a]	96.34[a]	142.56[a]	112[a]	2741.8[a]
P≤0.05	ns	ns	ns	0.63	ns	13.55

DARC: Debrebrhan Agricultural Research Centre; ESE: Ethiopia Seed Enterprise; OSE: Oromia Seed Enterprise; DH: days to heading; PTN: productive tiller number; PH: plant height (cm); DPM: Days to physiological maturity; SPS: seeds per spike; GY: grain yield (kg/ha); LSD (0.05%): least significant difference at 0.05% probability level.

Table 2. Interaction effect of variety x site on days to physiological maturity.

Variety	Sites		
	DARC	**ESE**	**OSE**
Beka	142.0	141	140
Holker	142.67	142.33	142.50
P≤0.05	-	1.1	
CV (%)	-	0.66	

DARC: Debrebrhan Agricultural Research Centre; ESE: Ethiopia Seed Enterprise; OSE: Oromia Seed Enterprise; DPM: Days to Physiological maturity; LSD (0.05%): Least significant difference at 0.05% probability level, CV (%): coefficient of variation.

Likewise, Bekele (1990), Tesfahun (2000), and Hailemikaiel (2000) observed the existence of high variability in barley genotypes for agronomic traits studied such as days to physiological maturity. Similarly, it is in coherent with (Djekic et al., 2011) who reported that yield is largely dependent on the genetic potential, which could be defined as yield of variety which was grown in conditions on which it had been adapted, with adequate amount of water, nutrients and efficient control of pests, diseases, weeds and other stresses.

Knowledge on interrelationship among agronomic parameters, their relationship with grain yield and their effect on grain yield plays significant role in the effort to improve malt barley meet quality requirement for seed and processing industries. Our study result indicated that, there exists positive and highly significant (P≤0.01) association between days to heading and day to physiological maturity. Similarly, days to physiological maturity and number of seeds per spike were also depicted positive and strong association at (P≤0.01) probability level (Table 3).

Conclusion

The existence of significant variation in days to physiological maturity and number of seeds per spike due to independent effect of seed sources and varieties in malt barley implies there is high performance variability in the studied quantitative traits. Analogously, considerable variation observed in number of seeds per spike and grain yield due to main effect of variety might indicate those traits are a function of genotypes. The positive and strong association found between days to physiological maturity and number of seeds per spike with days to physiological maturity might confirm that days to maturity

Table 3. Correlation coefficient between agronomic parameters.

Parameter	DH	DPH	GY	PH	PTN
DPM	0.53**	1			
GY	-0.09^{ns}	-0.08^{ns}	1		
PH	-0.04^{ns}	-0.16^{ns}	0.0107^{ns}	1	
PTN	0.13^{ns}	0.20^{ns}	-0.14^{ns}	-0.17^{ns}	1
SPS	0.59**	0.54**	-0.11^{ns}	0.14^{ns}	0.23^{ns}

DH: Days to heading; DPM: Days to physiological maturity; GY: grain yield (kg/ha); PH: plant height (cm); PTN: productive tiller number; SPS: seeds per spike.

depend on duration of heading. The number of seeds per spike also depends on the duration of maturity. In general, the main and communal effect of varieties and seed sources as well as association of agronomic parameters are major cause of variability in malt barley yield attributes and yield. Therefore, consideration of the existing phonological variability and association is substantially useful in designing efficient selection strategies in malt barley improvement. Hence, evaluating the effect of genotypes, environment, varieties and their interaction effect plays an immense role in the effort to improve yield and yield related traits in malt barley. With this, our research result ascertain that further studies should be conducted across sites and years to assess varieties performances which helps as cornerstone to fulfill the growing demand of quality malt barley seed and grain for processing industries in Ethiopia.

Conflict of Interests

The authors have not declared any conflict of interests.

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