Farmers' Malt Barley Seed Sources and Seed Quality Perceptions in the Central Highlands of Ethiopia

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Abstract

Despite the release of several malt barley varieties in Ethiopia over the past four decades, most farmers have limited access to certified seeds of these improved varieties. This study investigated the malt barley seed sources and seed quality perceptions of farmers in eight major malt barley growing districts in the central highlands of Ethiopia. Data were collected using a structured questionnaire from 344 farmers, supplemented with key informant interviews and focus group discussions. Descriptive statistics were employed for data analysis. Farmer cooperatives supplied 57.3% of the total seed, considered as both certified (C-1) and recycled seed. About 31% of farmers used seeds from informal sources: own saved seed (15.4%), seeds from other farmers (8.7%), and purchased from local market (6.7%). The formal seed sector accounted for only 11.8%. Farmers selected seeds based on cleanliness, plumpness, germination potential, and being pest-free. While 59% of farmers perceived their seeds as good quality, 41% received poor-quality seeds. To improve seed availability and quality, it is recommended to strengthen farmers' cooperatives with technical training and resources, increase formal sector involvement, and implement rigorous quality control measures. These steps can ensure farmers to receive the required amount and quality malt barley seeds, enhancing crop yields and agricultural productivity.

Keywords: Malt barley; seed sources; selection; perception; central highlands of Ethiopia

Introduction

In crop production, the amount of yield obtained and quality of produces attained depends on the use of best performing improved varieties and good quality seeds. Lack of adequate number of improved varieties and quality seeds of malt barley meeting the requirements of smallholder farmers and the quality specification of agro-industries are the most important constraints hindering the expansion of malt barley production in Ethiopia (Lakew *et al.*, 2015). Farmers' access to high-quality seeds of well-adapted and farmer/consumer-preferred crop variety is central to increasing crop productivity and production, improving rural livelihoods, and ensuring food and nutritional security in rural and urban areas (Fredenburg *et al.*, 2015).

Increasing the availability, accessibility and use of quality seed of improved varieties, together with good agricultural practices such as irrigation, fertilizers, and mechanization, has the potential to significantly raise Ethiopia's annual crop production. For example, by adopting quality seeds in combination with best agronomic practices in some quarters of cropping areas, research indicated that farmers could increase maize production by over 60 percent and self-pollinated crop production (such as wheat and barley) by over 30 percent (Alemu *et al.,* 2010).

Despite the release and/or registration of several malt barley varieties during the last four decades in Ethiopia (Atilaw and Lijalem, 2013), the majority of farmers have limited access to quality seeds of these improved varieties (CSA, 2021). Lack of availability of quality seeds at the right time and place, along with low promotion, are some of the key factors accounting for the limited use of quality seeds of improved varieties. The country's formal seed system was inefficient to produce the required amount of certified seed, resulting in low availability and promotion of certified seeds (Atilaw and Lijalem, 2013). This scenario, however, is changing since more actors (both public and private) are involved in the production and distribution of certified seeds of major crops including malt barley (Asres *et al.,* 2018).

The CSA (2021) report indicated that improved seed covered only 6% of Ethiopia's barley growing areas during the main cropping season of 2020/21: the remaining (about 94%) was planted by farmers' saved seed. According to the MoA's (2021) report, 6,591 tons of certified malt barley seeds were produced, of which, 6,563 tons were distributed which potentially covered 52,504 ha (5.67% of total barley area) during the same cropping season (2020/21).

According to the information obtained from key informant interview (Ministry of Industry, 2022) 292,900 tons of malt required by breweries annually, to satisfy this ever-increasing demand and to ensure dependable and higher cash returns to the farmers, expansion of malt barley production is very important since immense potential areas are available to meet the national demand (Bizuneh and Abebe, 2019). However, as stated by Mulatu and Lakewe (2011) and Molla *et al.,* (2018), malt barley production has not expanded, and productivity at the farm level has remained low, which is due to limited access to improved malt barley varieties and associated agronomic practices, including quality seed, biotic factors (diseases, insect pests and weeds), abiotic factors (low soil fertility, low soil pH, poor soil drainage, and drought) on one hand, and the quality of the produce on the other hand. By understanding the current seed sourcing practices, the quality of seeds used, and the associated limitations, this study aims to provide actionable recommendations to enhance the efficiency of the seed system and support the expansion of malt barley production in Ethiopia.

Materials and Methods

Description of the study areas

The research was conducted in eight districts of Ethiopia's central highlands in 2021. The districts were selected purposively based on their potential for malt barley production and accessibility. The districts are located in the five zonal administrations of Amhara and Oromia Regional States. Basonaworana district is located in the North Shewa zone of Amhara region, whereas Degem is located in the North Shewa zone of Oromia regional state. Dendi and Ejere districts are in the West Shewa zone; Digulunatijo and Limunabilbilo districts are in the Arsi zone; Kofele and Shashemene are in the West Arsi zone of the Oromia Regional State. The districts are located between 7°4'51" and 9°50' N latitude and 38°10' and 39°19'60" E longitude, with an altitude range of 500 to 4,245 m.a.s.l. with mean annual rainfall and temperature ranging from 900 to 2,500 mm and 5 to 26°C, respectively (Figure 1).

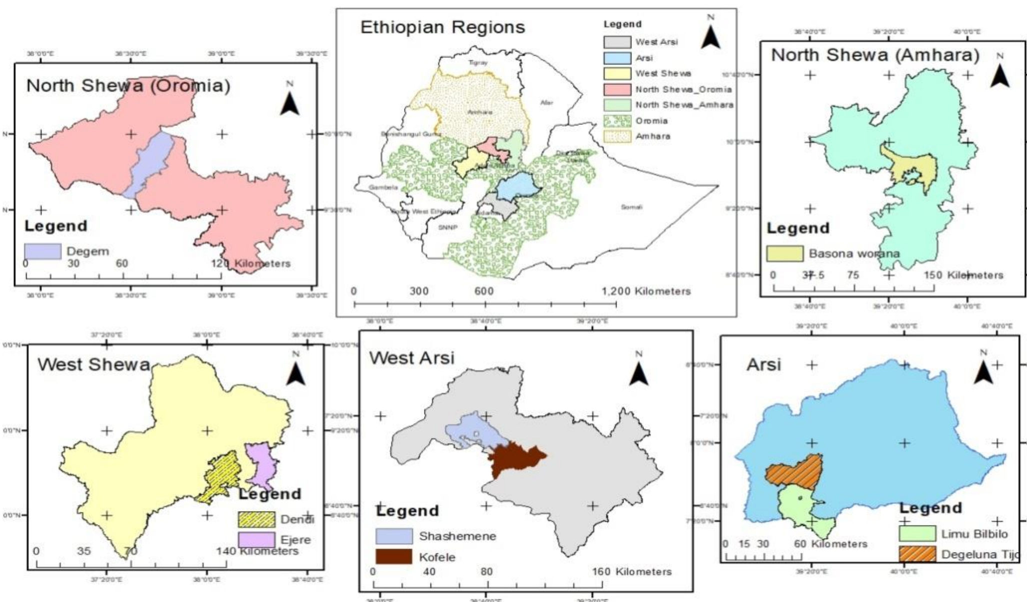

Figure 1. Map of the study areas

Sampling techniques and sample size

A multistage sampling technique was employed to select a representative sample of farm households from eight districts. First, from the Oromia and Amhara regional states in central Ethiopia, five zones with the highest barley cultivation were chosen purposively. According to the CSA (2021) report, these zonal administrations contributed 35.6% and 40.6% of the nation's total barley area coverage and production in the main cropping season of 2020/21, respectively. Second, two districts (*woredas*) were selected from each of the five zonal administrations. Third, two *kebeles*[1] from each district were chosen based on their accessibility. From the total households in the selected districts and *kebeles*, 344 malt barley-growing farm household heads were selected, referring to the farmers' list in the *kebele* files (Table 1). The total sample size was calculated using Yamane's (1967) formula.

$$n = \frac{N}{[1+N(e^2)]} \qquad (1)$$

where N is the population size, n is the sample size, and e is the level of precision (5% in this study). The overall sample size (400) was determined using the above formula from the total number of barley-growing farmer household heads in the study areas. Of the total 400 participants, 344 farmers were found growing malt barley (adopted malt barley variety) in the study year.

Table 1. Sample size and distribution by districts

Districts	Number of farmer household heads				
	Male	Female	Total	Sample size	MB growers
Degem (NS-O)	21,249 (88.8%)	2,680 (11.2%)	23,929	53	32
Ejere (WS)	12,689 (87%)	1,891 (13%)	14,580	33	28
Dendi (WS)	16,261 (84.5%)	2,972 (15.5%)	19,233	43	39
Basoworana(NS-A)	20,168 (71.3%)	8,133 (28.7%)	28,301	63	62
Digelunatijo (A)	15,320 (84%)	2,911 (16%)	18,231	41	33
Limunabilbilo (A)	19,154 (85.3%)	3,290 (14.7%)	22,444	50	42
Kofele (WA)	17,015 (80%)	4,248 (20%)	21,263	48	42
Shashemene (WA)	21,600 (70%)	9,200 (30%)	30,800	69	66
Total			**178,781**	**400**	**344**

Source: Agricultural office of each district (2021) and own survey data (2021); numbers in parentheses indicate percentage share of gender; MB=malt barley; NS-O=North Shewa-Oromia; NS-A=North Shewa-Amhara; WS=West Shewa; A=Arsi; WS=West Arsi

Method of data collection

This study was conducted using a cross-sectional research design. Primary data on farmers' malt barley seed sources and seed quality perception at the household level were collected using a pre-tested and structured questionnaire. The tablet-based technology called CAPI[2] equipped with CSPro[3] software was used for data collection. The data were verified through key informant interviews (KII) and focus group discussions (FGD) with agricultural experts, cooperative representatives, and development agents at the *kebele* level. Secondary data were also collected from many sources, including the internet, publications, reports from district and zonal agricultural offices, the Ministry of Agriculture, agricultural research centers, and seed enterprises. Experienced enumerators, familiar with the culture of the society and the CAPI technique, collected the data from individual interviewees.

[1]Kebele = Ethiopia's lowest administrative level
[2] CAPI = Computer-Assisted Personal Interview device
[3] CSPro = Census and Survey Processing System

Data analysis

The quantitative data collected through the questionnaires was analyzed using SPSS version 22 software. Descriptive statistics (frequency, percentage, mean, and standard deviation) were employed to summarize the data. Additionally, a chi-square test was used to assess the relationships between categorical variables in the quantitative data. This test helped to determine if there's a statistically significant association between two or more categories. Qualitative data were also gathered through key informant interviews (KIIs) with development agents, farmers' cooperative representatives and district's agricultural experts, and focus group discussions (FGDs) with farmers. These data were cleaned, coded, and analyzed to provide a deeper understanding of farmers' perceptions and experiences regarding malt barley seed quality and sources, complementing the quantitative findings.

Results and Discussion

Demographic characteristics of sample farmers

Table 2 shows the household head's gender, educational level, age, and the family size of the household. Of the 344 sampled households, about 84% were headed by men, while the remaining 16% were headed by women. Similarly, Tigabie *et al.*, (2013) found that the male-to-female ratio among malt barley-producing household heads in their study areas was 79% male and 21% female (n=179). This comparison indicates a predominantly male-headed household structure in both studies, suggesting a common trend in the gender dynamics of household heads involved in malt barley production in Ethiopia.

Education is critical for the farming community to use agricultural technologies and improved farming practices properly. Farmers with better education are more likely to use agricultural inputs such as certified seed of malt barley and adopt improved farm management practices, as advised by agricultural experts, than illiterate or less educated ones. According to Bekele and Regasa (2019), education improves farmers' ability to acquire and apply information on improved technology, as well as their innovativeness, also when combined with increased experience, could help farmers improve their management skills. About 76% of respondents obtained formal education (elementary and above), while 18.3% of their counterparts were illiterate (not able to read and write), and the remaining 5.8% of household heads attended informal education (read and write) as shown in Table 2. The increase in literacy level could be attributed to better access to formal education across malt barley growing areas because of the establishment of schools and farmer training centers (FTCs) in the villages or nearby villages of the farming community. This result is consistent with the findings of Kebede and Tadess (2015) who found 82% of malt barley technology adopters and 43.2% non-adopters were literate (n=120).

Tigabie *et al.,* (2013) also found that in their study on malt barley technology adoption, over 80% of the households had access to formal education.

The sample farmers' average age was 40.5 years, ranging from 37.1 years in the Basonaworana district to 44.6 years in the Degem district. Begna *et al.,* (2014) and Ganewo *et al.,* (2022) also found similar mean age of barley farmers (41.87 and 40.12 years, respectively) in Honkolowabe and Chole districts (Arsi zone, Oromia region) and Melga district (Sidama region), respectively. Of the total respondents, 94.2% were between the ages of 19 and 60 (considered the active age for agricultural activities in Ethiopia), with an additional 5.8% over the age of 60. Most farmers over the age of 60 did not fully engage in agricultural activities but instead supported by family members and hired assistance. Household size has a vital role when defining farm households. Crop production requires the engagement of a larger number of farmers who produce the highest quality grain and seed that meets quality specifications and market demand. As a result, households with large family size can perform malt barley production tasks on their own rather than hiring from outside. The average household size was 6.4, ranging from 5.5 in the Basonaworana district to 7.5 in the Limunabilbilo and Kofele districts (Table 2). Similarly, Kebede and Tadesse (2015) found a mean household size of 6.2 in their malt barley technology adoption study.

Table 2. Households' demographic characteristics

		HHH Sex (%)		HHH Educational level (%)			HHH	Average
District	N	M	F	Illiterate	Informal	Formal	Age	HH Size
Degem	32	78.1	21.9	50.0	15.6	34.4	44.6±2.1	6.0±0.4
Ejere	28	64.3	35.7	21.4	17.9	60.7	41.9±2.4	6.7±0.6
Dendi	39	79.5	20.5	23.1	5.1	71.8	42.6±1.7	6.4±0.4
B/worana	62	87.1	12.9	9.7	8.1	82.3	37.1±1.2	5.5±0.3
Digulu	33	87.9	12.1	21.2	0.0	78.8	43.2±2.4	6.4±0.5
Limu	42	83.3	16.7	19.0	0.0	81.0	38.0±2.0	7.5±0.6
Kofele	42	95.2	4.8	9.5	4.8	85.7	44.2±1.8	7.5±0.7
Shashe	66	87.9	12.1	10.6	1.5	87.9	37.6±1.3	6.1±0.5
Total	344	84.3	15.7	18.3	5.8	75.9	40.5±0.6	6.4±0.2
χ^2/F value		[a]15.2*(7)			[a]54.7**(14)		[b]3.4**(343)	[b]2.2*(343)

Source: Own survey data (2021), HHH=household head, **=significant at 1% level, *=significant at 5% level, a=chi-square value (numbers in bracket are degrees of freedom), b=f-value (numbers in bracket are error degrees of freedom), B/worana=Basonaworana, Digulu=Digulunatijo, Limu=Limunabilbilo, Shashe=Shashemene.

Livestock ownership, annual income, average farm size, and area allocated for annual crop production by the households in the study areas are indicated in Table 3. The number of farm animals owned by household heads was estimated using a tropical livestock unit (TLU) (Rothman-Ostrow *et al*., 2020). The average number of farm animals held by sample household was 7.3 TLU, with a minimum of 6.3 in the Limunabilibilo district and a maximum of 8.8 in the Degem district. Like other regions of the country, in the study areas farm animals contribute money, food, draught power, farmyard manure, and transportation for the households.

Table 3.Livestock ownership, income, and cultivated area of the households

District	N	Livestock (TLU)	Farm income (ETB)	Off-farm income (ETB)	Farm size (ha)	Annual crop area (ha)
Degem	32	8.8 ± 0.5	32,560.9 ± 3,088.9	8,281.8 ± 2,177.4	2.5 ± 0.38	2.2 ± 0.32
Ejere	28	7.0 ± 0.9	49,525.4 ± 12,775.8	28,818.8 ± 7,304.6	2.7 ± 0.34	2.3 ± 0.29
Dendi	39	6.9 ± 0.6	31,472.3 ± 4,840.2	20,706.9 ± 6,003.1	1.9 ± 0.19	1.8 ± 0.19
B/worana	62	7.5 ± 0.4	25,148.5 ± 4,259.6	21,706.2 ± 4,396.1	1.9 ± 0.15	1.6 ± 0.13
Digulunatijo	33	7.9 ± 0.6	40,089.5 ± 5,404.5	35,320.0 ± 19,290.3	1.7 ± 0.13	1.6 ± 0.10
Limunabilbilo	42	6.3 ± 0.5	23,775.8 ± 3,838.9	82,968.8 ± 19,238.7	1.9 ± 0.15	1.6 ± 0.11
Kofele	42	7.5 ± 0.6	83,833.1 ± 13,752.1	54,058.3 ± 10,265.9	1.7 ± 0.16	1.6 ± 0.15
Shashemene	66	6.8 ± 0.5	57,690.9 ± 7,136.7	37,376.7 ± 10,502.9	1.2 ± 0.12	0.9 ± 0.08
Total/Mean	**344**	**7.3 ± 0.2**	**43,213.4 ± 2,861.7**	**35,707.0 ± 3865.5**	**1.8 ± 0.07**	**1.6 ± 0.06**
F-values		**1.74^{ns}**	**7.44****	**4.96****	**5.80****	**7.27****

**=significant at 1% level, ns=not significant, TLU=total livestock unit, ETB=Ethiopian Birr

As indicated in Table 3, the average annual income of the sample households from the sale of crop and livestock products was 43,213.4 ETB[4], with a minimum of 23,775.8 ETB in Limunabilbilo district and a maximum of 83,833.1 ETB in Kofele. The survey result indicated that the average landholding per barley farmer was 1.8 hectares, ranging from 1.2 hectares in Shashemene to 2.7 hectares in Ejere. The mean annual crop coverage of the study areas was 1.6 hectares; of which 16.1% and 18.4% were allocated for food and malt barley production in the 2020/2021 main cropping season, respectively.

Annual crops grown and malt barley varieties used by sample farmers

In addition to malt barley, interviewed households produced at least one other crop (with the highest of nine crops) on their farm during the survey year. The majority of the crops were cereals. Next to malt barley (grown by all farmers who adopted the technology on a mean farm size of 0.64 hectares), 47.7%, 39%, 29.9%, 26.5%, 23.3%, 11.9%, 11.1%, and 1.7% of participants cultivated food barley, faba bean, wheat, field pea, potatoes, maize, tef, and linseed, respectively (Table 4). According to participants of the FGD, these crops provide the needs for households as sources of food, cash, and animal feed. Moreover, the crops are useful for rotation purpose. In the study areas, faba bean, field pea, linseed and potatoes use as rotational crops for barley.

[4]1ETB (Ethiopian Birr) = 0.0239 USD in April, 2021

Table 4. Major annual crops grown by malt barley technology adopter households in the central highlands of Ethiopia (n=344)

	Number of growers										Land allocation	
Crops	Degem	Ejere	Dendi	B/worana	Digulu	Limu	Kofele	Shashe	Total	%	Area (ha)	SD
F.barley	25	20	33	45	18	12	8	3	164	47.7	0.63±0.03	0.43
M.barley	32	28	39	62	33	42	42	66	344	100	0.64±0.03	0.56
Tef	0	17	8	13	0	0	0	0	38	11.1	0.68±0.10	0.59
Wheat	7	26	14	25	8	11	5	7	103	29.9	0.59±0.05	0.50
Maize	0	0	0	2	0	0	13	26	41	11.9	0.34±0.03	0.18
F.bean	18	14	17	42	16	17	9	1	134	39.0	0.37±0.03	0.28
F.pea	12	0	19	22	10	14	14	0	91	26.5	0.46±0.04	0.37
Linseed	0	0	3	0	0	3	0	0	6	1.7	0.29±0.04	0.10
Potatoes	6	2	15	15	2	1	8	31	80	23.3	0.41±0.03	0.27
Total	**32**	**28**	**39**	**62**	**33**	**42**	**42**	**66**	**344**	**100**	**[a]1.60±0.06**	**1.12**

F. barley=food barley, M. barley=malt barley, F. bean=faba bean, F. pea=field pea, SD=standard deviation, a=mean area coverage.

Table 5 reveals significant differences (χ^2=290.5 and df=35) in malt barley variety utilization among participating farmers. The highest proportion of participants stated growing Traveler (57.3%, n=344), followed by IBON-174/03 (24.1%) and Holker (12.2%). Only 1.7% of the participating farmers have used Fatima. Farmers selected malt barley varieties based on several criteria, including grain yield, biomass yield, and market demand, adaptability, and disease resistance. According to Begna *et al.*, (2014), the yield potential and market value were the major reasons for farmers to prefer growing malt barley varieties in their study areas. Aynewa *et al.*, (2013) also indicated that farmers have used disease resistance, crop stand, yield components such as spike length, kernel number per spike, and number of tillers per plant, as selection parameters for malt barley variety choice. Most respondents chose malt barley varieties based on grain yield (71.2%) followed with market demand (19.5%).

Table 5. Malt barley variety use and selection criteria of respondents (n=344)

Variety name	Frequency	Percent	Selection criteria	Frequency	Percent
Fatima	6	1.7	Grain yield	245	71.2
HB-1963	9	2.6	Biomass yield	7	2.0
Holker	42	12.2	Market demand	67	19.5
IBON-174/03	83	24.1	Adaptation	13	3.8
Traveler	197	57.3	Disease resistance	12	3.5
Others	7	2.0			
Total	**344**	**100**		**344**	**100**
χ^2-value	**290.5****			**58.3****	
Df	**35**			**28**	

**=significant at 1% level, χ^2=chi-square value, df= degrees of freedom

Farmers' malt barley seed sources and acquisition methods

Malt barley farmers in the study areas use a variety of seed sources to grow both seed and grain. In addition to the survey results, reports of each district, discussions with focus groups, and key informant interview responses indicated that participants access malt barley seed from both formal and informal seed sources.

The main sources of malt barley seed included seed enterprises, agricultural research centers, malt factories, farmers' cooperatives, other farmers, the local market, and own-saved seed. Based on the survey result, about 11.8% respondents obtained their malt barley seeds from public seed enterprises (The Ethiopian Seed Enterprise and Oromia Seed Enterprise), agricultural research centers (Holeta and Kulumsa), or malt factories/breweries (Assela, Soufflet, Boort malt, and Heineken) in 2020/2021 main cropping season. However, 15.4% of farmers used their own saved seed, 8.7% received it from another farmer, and 6.7% bought it from the local market (Figure 2). Respondents identified farmers' cooperatives as a key source of malt barley seed as represented by 57.3% of the respondents. Farmers' cooperatives could be sources of formal and informal seed as the cooperatives operate both as seed producers, as seed distributors and as aggregators of grain of malt barley to supply malt factories. According to the authors' observations during this study, and supported by Sisay *et al.*, (2017), farmers' cooperatives serve multiple purposes and engage in a variety of activities beyond being major malt barley seed sources. These activities include: distribution of agricultural inputs, supplying commodities for consumption, collection of agricultural products (such as certified seed, recycled seed, or malt barley grain) from members and supplying them to cooperative unions, direct selling to factories, and reselling to farmers. Some other cooperatives focus on a single activity, such as certified seed production.

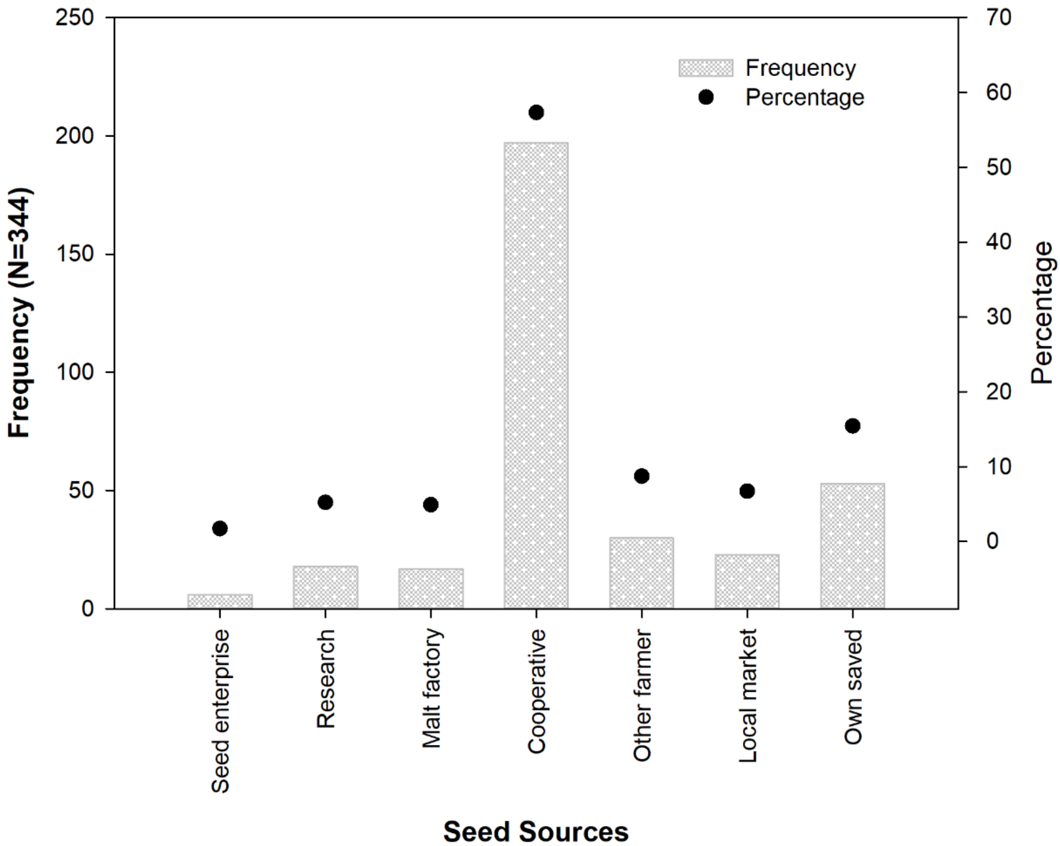

Figure 2. Farmers' malt barley seed sources

Regarding the malt barley seed acquisition methods, 66% of the respondents were accessed by paying cash, 18% by credit, 13.7% for free, and only 2.3% received by exchanges (Figure 3). Kalsa (2019) also stated that 80.6% (n=371) of wheat producers acquired certified wheat seed through cash.

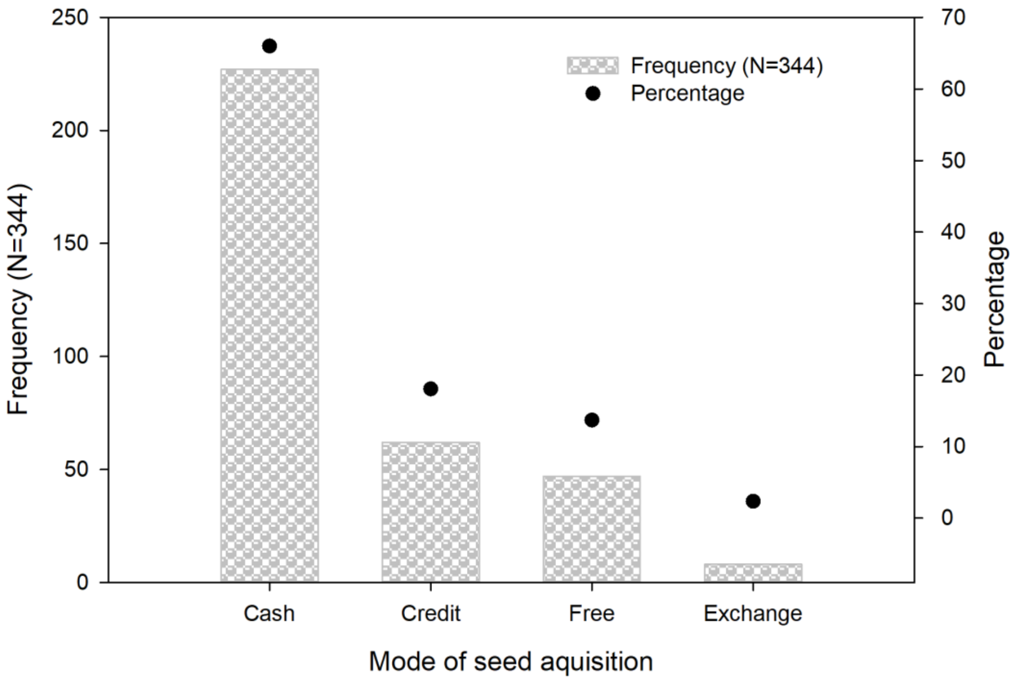

Figure 3.Farmers' mode of malt barley seed acquisition

Seed used by respondents

Farmers in the study areas covered an average of 0.54 hectares of their malt barley field with certified seed, varying significantly by district. The largest was in Degem with a mean value of 0.76 hectares, and the lowest was in Dendi with 0.26 hectares. Likewise, certified seed use differed significantly among malt barley growers in the research areas. Farmers utilized an average of 88.0 kilograms of certified seed, with Dendi having the lowest average (36.6 kilograms) and Limunabilbilo having the highest (126.4 kilograms). In general, farmers in the study areas allotted lower areas and utilized less amount of their own saved seed (0.39 hectare and 64.7 kilograms) compared to certified seed use (0.54 hectares and 88 kilograms). Similarly, Kalsa *et al.*, (2015) stated that most farmers (87.6%, n=112) covered their malt barley areas with certified seed. However, in Kofele district, on average the largest area (1.10 hectares) was allocated and the highest amount of seed utilized (110.0 kilograms) was recorded for own saved seed (Table 6).

Table 6.State of malt barley seed use of respondent farmers in 2020

District	Certified seed used			Own saved seed used		
	N	Area (ha)	Seed (kg)	N	Area (ha)	Seed (kg)
Degem	27	0.76±0.12	120.1±20.7	6	0.29±0.04	48.3±4.2
Ejere	19	0.29±0.03	43.5±3.2	11	0.50±0.12	77.6±15.7
Dendi	24	0.26±0.04	36.6±7.1	31	0.29±0.04	54.8±9.8
B/worana	49	0.36±0.03	66.9±6.6	22	0.30±0.05	50.2±8.0
Digulunatijo	33	0.72±0.10	123.6±14.4	4	0.44±0.06	77.5±19.3
Limunabilbilo	42	0.67±0.07	126.4±10.4	9	0.50±0.10	83.6±9.6
Kofele	42	0.74±0.13	97.7±9.3	5	1.10±0.49	110.0±18.7
Shashemene	66	0.45±0.04	73.7±4.6	9	0.40±0.06	78.9±13.6
Mean	**302**	**0.54±0.03**	**88.0±3.9**	**97**	**0.39±0.04**	**64.7±4.7**
F-value		**6.63****	**10.6****		**4.37****	**1.94**
Df		**7**			**7**	

**=significant at 1% level, df= degrees of freedom. B/worana=Basonaworana.

Pesticides used by respondents

Pesticide used for malt barley production was differed among districts. An average of 0.63 hectares of land was covered with 0.76 liter (n=344) of herbicide to manage weeds (Table 7). Farmers in the Limunabilbilo district had the highest herbicide coverage (0.97 hectare) with the amount used of 1.17 liter, while farmers from the Dendi districts had the lowest area coverage (0.34 hectare). The lowest amount of herbicide used per individual farmers was recorded from Ejere district (0.36 liter). The average fungicide coverage on malt barley fields in the study areas was 0.80 hectare (n=176), with a mean application rate of 0.80 liter. There were significant differences across districts in terms of fungicide coverage and application volume. The highest was in Digulunatijo district (1.16 hectares and 1.00 liter), and the lowest was in Basonaworana district (0.38 hectare and 0.29 liter). Only 85 farmers sprayed insecticides on their malt barley fields during the survey year, accounting for one-quarter of the total participants (n=344). For example, no respondents reported concerning insecticide use in Ejere, Dendi, or Basonaworana district, which could be attributed to lower insect pest risks for malt barley production in the areas.

Table 7. Pesticides used by respondent farmers for malt barley production

District	Herbicide used			Fungicide used			Insecticide used		
	N	Area (ha)	Amount (liter)	N	Area (ha)	Amount (liter)	N	Area (ha)	Amount (liter)
Degem	31	0.84±0.14	1.07±0.17	3	0.42±0.08	0.50±0.25	2	0.50±0.00	0.25±0.00
Ejere	28	0.36±0.05	0.36±0.07	4	0.44±0.06	0.42±0.20	-	-	-
Dendi	38	0.34±0.04	0.52±0.14	1	0.53±0.00	0.30±0.00	-	-	-
B/worana	59	0.37±0.03	0.44±0.07	10	0.38±0.08	0.29±0.08	-	-	-
Digulu	33	0.87±0.12	0.84±0.12	22	1.16±0.15	1.00±0.15	10	0.95±0.17	0.65±0.18
Limu	41	0.97±0.10	1.17±0.12	39	1.00±0.10	0.94±0.09	22	1.08±0.15	0.63±0.11
Kofele	39	0.96±0.11	1.10±0.12	33	1.14±0.13	0.94±0.10	18	1.18±0.19	0.78±0.11
Shashe	65	0.51±0.04	0.69±0.05	64	0.52±0.05	0.70±0.06	33	0.61±0.08	0.23±0.04
Mean	**334**	**0.63±0.03**	**0.76±0.04**	**176**	**0.80±0.05**	**0.80±0.04**	**85**	**0.89±0.07**	**0.50±0.05**
F-value		**12.65****	**9.04****		**7.03****	**3.17****		**3.46***	**6.38****
Df			**7**			**7**			**4**

**=significant at 1% level, *=significant at 5% level, df= degrees of freedom, B/worana=Basonaworana, Digulu=Digulunatijo, Limu=Limunabilbilo, Shashe=Shashemene.

Farmers' certified seed access and recycling of malt barley seed

Sample farmers in the study areas were asked if they accessed certified malt barley seeds regularly. Significant differences were observed among participating farmers throughout the survey districts; 49.1% of respondents (n=344) said no, while 50.9% of their counter-respondents answered yes. A significant difference in access to certified malt barley seeds occurred between districts. In Ejere, all participating farmers reported lacking regular access, primarily due to shortage of supply (75%). In Dendi, while the situation was better, around 95% of farmers still faced challenges because of shortage of supply (45.9%) and lack of suppliers (45.9%) as indicated in Table 8. Farmers in the Arsi zone (Digulunatijo and Limunabilbilo districts) and West Arsi zone (Kofele and Shashemene districts) had better access to malt barley seed (Table 8).

Table 8. Access to malt barley certified seed by respondent farmers

	Regular access to MB CS (%)			Reasons for poor access to MB CS regularly (%)					
District	N	No	Yes	N	SS	HP	US	LS	WC
Degem	32	65.6	34.4	21	76.2	19.0	0.0	4.8	0.0
Ejere	28	100.0	0.0	28	75.0	10.7	0.0	14.3	0.0
Dendi	39	94.9	5.1	37	45.9	5.4	0.0	45.9	2.7
B/worana	62	40.3	59.7	25	48.0	4.0	12.0	28.0	8.0
Digulu	33	39.4	60.6	14	71.4	14.3	14.3	0.0	0.0
Limu	42	23.8	76.2	10	90.0	0.0	0.0	0.0	10.0
Kofele	42	28.6	71.4	12	75.0	8.3	0.0	16.7	0.0
Shashe	66	34.8	65.2	23	30.4	4.3	0.0	65.2	0.0
Mean	**344**	**49.1**	**50.9**	**170**	**59.4**	**8.2**	**2.9**	**27.1**	**2.4**
χ^2-value			**91.6****				**70.4****		
Df			**7**				**28**		

**=significant at 1% level, χ^2-value=chi square value, df= degrees of freedom, MB=malt barley, CS=certified seed, SS=shortage of supply, HP=high price, US=untimely supply, LS=lack of supplier, WC=weak communication, B/worana=Basonaworana, Digulu=Digulunatijo, Limu=Limunabilbilo, Shashe=Shashemene.

Farmers mentioned a variety of reasons for lacking regular access to malt barley-certified seed (Table 8). Most farmers in the study areas (59.4%, n=170) indicated that shortage of supply was the most significant barrier to accessing certified malt barley seed regularly, followed by lack of supplier (27.1%), and high price of seed (8.2%). Kalsa *et al.*, (2015) also reported similar results for failure to get certified seed of requested malt barley varieties because of seed shortage (61.9%, n=113) and lack of supplier (27.4%).

The survey also investigated the practice of recycling certified malt barley seeds. Over half of the respondents (57.6%, n=344) reported recycling their seeds. The most common recycling frequency was two times (48%, n=198), followed by three times (33.8%), one time (9.1%), four times (6.1%), and more than four times (3%). Table 9 reveals a district-level variation in recycling practices. In Kofele and Shashemene, a high proportion (82%) of farmers recycled their seeds three times. Farmers in Degem district exhibited the highest overall recycling frequency compared to other surveyed areas. Further investigation is needed to understand the factors influencing this variation in seed recycling practices across districts.

Table 9.Trends and frequency of malt barley seed recycled by respondent farmers

District	MB seed recycling trend (%)			Frequency of MB seed recycling (%)					
	N	No	Yes	N	1 time	2 times	3 times	4 times	>4 times
Degem	32	21.9	78.1	25	0.0	20.0	40.0	28.0	12.0
Ejere	28	17.9	82.1	23	0.0	30.4	60.9	4.3	4.3
Dendi	39	15.4	84.6	33	6.1	33.3	54.5	3.0	3.0
B/worana	62	16.1	83.9	52	13.5	55.8	25.0	5.8	0.0
Digulu	33	39.4	60.6	20	15.0	35.0	45.0	0.0	5.0
Limu	42	71.4	28.6	12	16.7	75.0	8.3	0.0	0.0
Kofele	42	73.8	26.2	11	9.1	81.8	9.1	0.0	0.0
Shashe	66	66.7	33.3	22	13.6	81.8	4.5	0.0	0.0
Mean	**344**	**42.4**	**57.6**	**198**	**9.1**	**48.0**	**33.8**	**6.1**	**3.0**
χ^2-value		**89.07****					**81.53****		
Df		**7**					**28**		

MB=malt barley, N=total number of respondents, **=significant at 1% level, χ^2-value=chi square value, df= degrees of freedom. B/worana=Basonaworana, Digulu=Digulunatijo, Limu=Limunabilbilo, Shashe=Shashemene.

Farmers' perceptions of malt barley seed quality

Several parameters were used by surveyed farmers to assess the quality of malt barley seeds. They identified plumpness, cleanliness or lack of adulterants, germination potential, and freedom from pest damage as their primary seed quality evaluation criteria. Kalsa *et al.*, (2015) showed field emergence (58%, n=112) and freedom from admixture (56%) were mentioned by participant farmers as important quality criteria for malt barley seed. About 88% (n=344) of the respondent farmers considered plumpness and cleanness of the seed to judge the quality of malt barley seed (Figure 4).

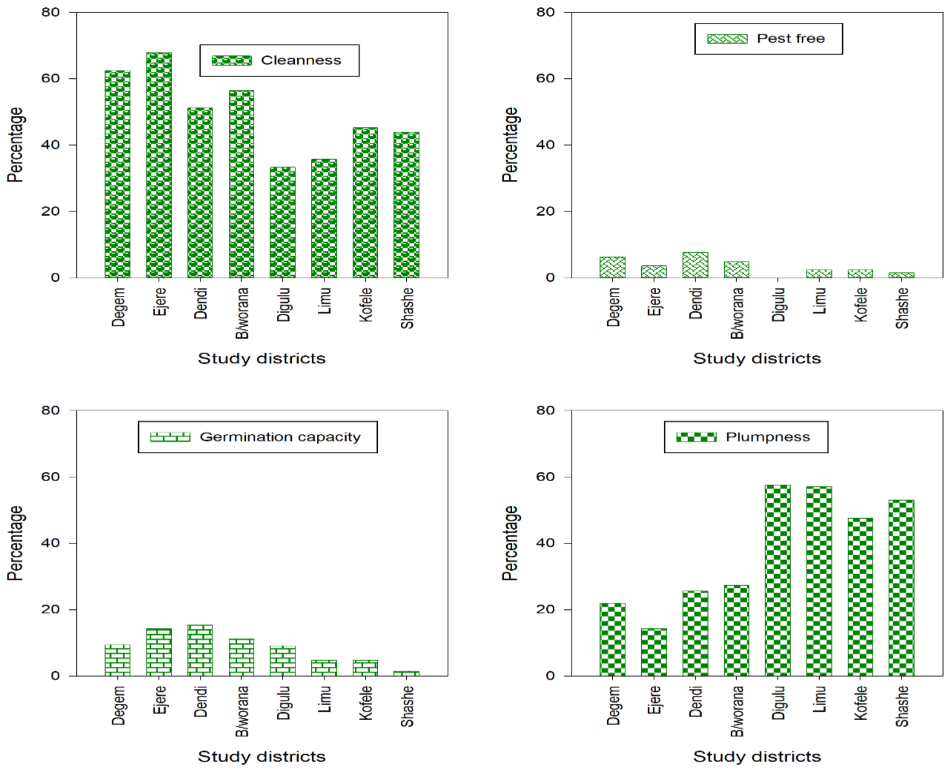

Figure 4. Farmers' criterion for evaluating malt barley seed quality

According to farmers' responses to the quality status of their malt barley seed, about 59.3% (n=344) perceived that they have received good quality seed, whereas 40.7% think they received poor quality seed. Most farmers (80%) in the Dendi district perceived they received low-quality malt barley seed, which could be attributed to a lack of access to certified seed (Table 8). In other districts, more than 60% of farmers perceived that they received good-quality seed, except in Basonaworana, where similar number of respondents was recorded for good and poor-quality seed perception (Figure 5).

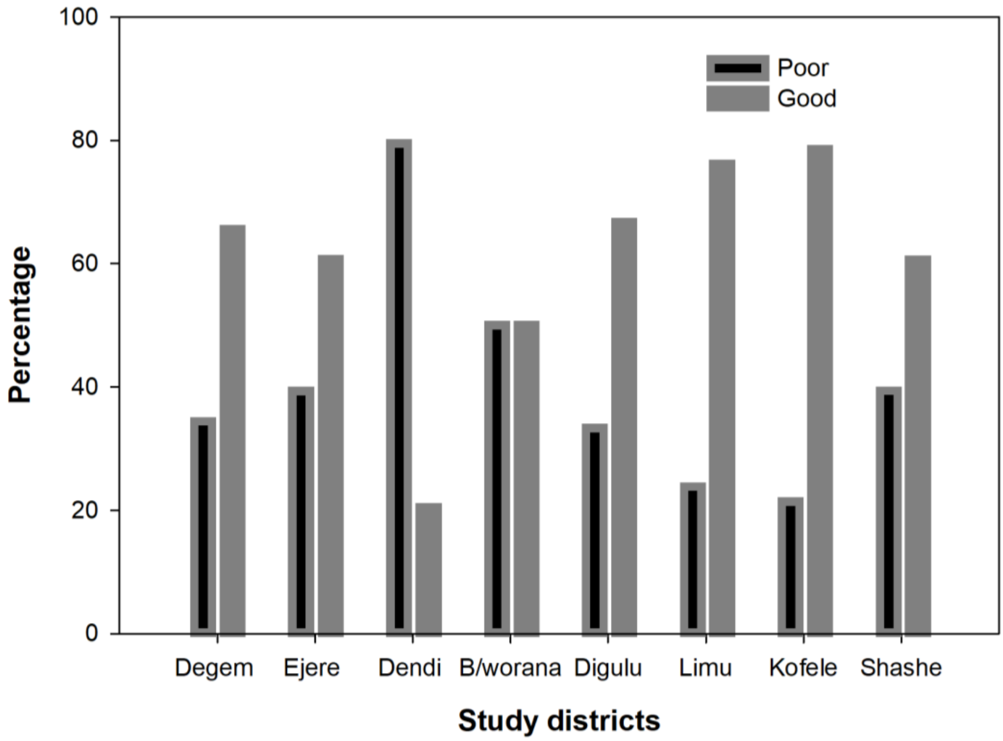

Figure 5. Malt barley seed quality perception of sample farmers

Among farmers in the study areas who perceived that they received poor quality seed (n=140) stated that malt barley seeds they got were impure (56.4%), mixed with other varieties (28.6%), poorly germinated (5%), shriveled (4.3%), mixed with other crops seed (4.3%), and diseased (1.4%). Sample farmers were also asked what they expect from using low-quality malt barley seed. Their responses included low yield (71.3%, n=344), low seed/grain price (8.4%), low grain quality (7.8%), low germination percentage (6.9%), and low demand (5.6%) (Table 10).

Table 10. Farmers' perception of malt barley seed quality

Variables		Degem	Ejere	Dendi	B/worana	Digulu	Limu	Kofele	Shashe	Mean	χ^2-value	df
		n=11	**11**	**31**	**31**	**11**	**10**	**9**	**26**	**140**		
MB seed quality problems occurred (%)	Imp	81.8	63.6	64.5	45.2	36.4	50.0	33.3	65.4	56.4	**50.0****	**35**
	Shriv	9.1	0.0	0.0	6.5	9.1	10.0	0.0	3.8	4.3		
	OV	9.1	36.4	32.3	19.4	27.3	30.0	66.7	26.9	28.6		
	OCS	0.0	0.0	3.2	16.1	0.0	0.0	0.0	0.0	4.3		
	Dis	0.0	0.0	0.0	3.2	0.0	0.0	0.0	3.8	1.4		
	PG	0.0	0.0	0.0	9.7	27.3	10.0	0.0	0.0	5.0		
		n=32	**28**	**39**	**62**	**33**	**42**	**42**	**66**	**344**		
Farmers' expectations from poor quality MB seed	LY	75.0	75.0	71.1	70.0	87.9	74.3	60.5	64.9	71.3	**63.9****	**28**
	LGQ	9.4	3.6	15.8	18.3	6.1	2.9	0.0	1.8	7.8		
	LGP	12.5	17.9	10.5	1.7	3.0	2.9	5.3	7.0	6.9		
	LD	0.0	3.6	0.0	5.0	0.0	8.6	13.2	10.5	5.6		
	LP	3.1	0.0	2.6	5.0	3.0	11.4	21.1	15.8	8.4		

MB=malt barley, **=significant at 1% level, χ^2-value=chi square value,df= degrees of freedom, Imp=impurity, Shriv=shriveled, OV=mixed with other variety, OCS=mixed with other crop/weed seed, Dis=Diseased, PG=poor germination, LY=low yield, LGQ=low grain quality, LGP=low germination percentage, LD=low demand, LP=low price

Farmers' malt barley seed storage

Table 11 shows 74.1% (n=344) of the respondents confirmed that they stored malt barley seed before planting, whereas the remaining didn't store. The on-farm seed storage period varied from farmer to farmer and across locations. About 12.5% (n=257) of the respondents store their malt barley seed for less than a month, 23% store one to three months, 19.1% store four to six months, 36.2% store seven to twelve months, and the remaining 9.3% store more than a year. Most respondents (n=257) stored their seeds in regular polypropylene and jute bags (85.2%); the remaining 9.7% and 5.1% used *gotera*[5] and hermetic bags, respectively. The major seed quality problems associated with seed storages were low seed germination due to insect damage (47%, n=51), impurities due to rodent and bird attacks (25.5%), low germination due to diseases (17.6%), and high moisture content (9.8%), which led to seed decay. Kalsa *et al.,* (2019) detected a significant effect of storage strategies/structures on germination percentage of their sampled wheat seed after six months of storage.

[5]*Gotera* is local seed/grain storage structure

Table 11. Malt barley seed storage

Variables		Degem	Ejere	Dendi	B/worana	Digulu	Limu	Kofele	Shashe	Mean	χ^2-value	Df
MB seed storage (%)		**n=32**	**28**	**39**	**62**	**33**	**42**	**42**	**66**	**344**		
	No	28.1	10.7	7.7	22.6	24.2	38.1	26.2	34.8	25.3		
	Yes	71.9	89.3	92.3	77.4	75.8	61.9	73.8	65.2	74.7	**16.8***	**7**
MB seed storage period in months (%)		**n=23**	**25**	**36**	**48**	**25**	**26**	**31**	**43**	**257**		
	>1	0.0	4.0	0.0	25.0	4.0	11.5	16.1	23.3	12.5		
	1-3	0.0	4.0	0.0	4.2	12.0	53.8	51.6	53.5	23.0		
	4-6	8.7	8.0	30.6	22.9	48.0	19.2	9.7	7.0	19.1	**166.8****	**28**
	7-12	78.3	52.0	63.9	45.8	24.0	11.5	12.9	9.3	36.2		
	>12	13.0	32.0	5.6	2.1	12.0	3.8	9.7	7.0	9.3		
MB seed storage structures (%)		**n=23**	**25**	**36**	**48**	**25**	**26**	**31**	**43**	**257**		
	OB	87.0	80.0	63.9	81.3	88.0	96.2	90.3	97.7	85.2		
	HB	0.0	8.0	8.3	10.4	0.0	0.0	9.7	0.0	5.1	**33.6****	**14**
	LSS	13.0	12.0	27.8	8.3	12.0	3.8	0.0	2.3	9.7		
MB seed quality problems during storage (%)		**n=23**	**25**	**36**	**48**	**25**	**26**	**31**	**43**	**257**		
	No	69.6	56.0	69.6	81.3	88.0	92.3	87.1	90.7	80.2	**20.8****	**7**
	Yes	30.4	44.0	30.4	18.8	12.0	7.7	12.9	9.3	19.8		
MB seed quality problems		**n=7**	**11**	**11**	**9**	**3**	**2**	**4**	**4**	**51**		
	LGI	71.4	54.5	36.4	22.2	33.3	0.0	75.0	75.0	47.1		
	LGD	14.3	9.1	27.3	22.2	33.3	50.0	0.0	0.0	17.6		
	Moi	0.0	0.0	27.3	11.1	0.0	50.0	0.0	0.0	9.8	**22.5**	**21**
	IRB	14.3	36.4	9.1	44.4	33.3	0.0	25.0	25.0	25.5		

MB=malt barley, **=significant at 1% level, *= significant at 5% level, χ^2-value=chi square value,df= degrees of freedom, OB=ordinary bag (polypropylene or jute bag), HB=hermetic bag, LSS=local seed/grain store (*gotera*), LGI=low germination due to insect damage, LGD=low germination due to disease, Moi=high moisture content, IRB=Impurities due to rodents and birds.

Conclusion

Malt barley is one of the primary commodities attracting the attention of farmers, malt producers, breweries, and policymakers in Ethiopia. As a cash crop, its demand has accelerated with the increased processing capacity of malt factories due to the expansion of existing breweries and the establishment of new ones. To meet this growing grain demand by agro-industries, the seed sectors must prioritize the multiplication and availability of high-quality seeds of improved malt barley varieties to farmers.

The study identified several key seed sources for malt barley, including formal sources such as seed enterprises, research centers, and malt factories/breweries, as well as informal sources like own saved seeds, seeds from other farmers, and local markets. Despite the variety of sources, farmers face significant challenges in accessing certified seeds. The primary factors contributing to the lower volume of seed availability include a shortage of supply, high prices, untimely delivery, lack of suppliers, and weak communication with suppliers.

Survey participants reported various bottlenecks in seed acquisition, notably the inconsistent availability of quality seeds. More than half of the farmers indicated that they had access to quality malt barley seed; however, a considerable number also reported issues with low-quality seeds. The main quality problems included impurities, mixtures with other varieties, poor germination, shriveled seeds, contamination with other crop seeds, and diseased seeds.

To enhance the linkage among farmers, seed producers, distributors, and maltsters while improving seed quality and availability, several measures are recommended: 1) Collaboration of the agricultural research system with other stakeholders in the development, release, and registration of improved malt barley varieties that meet market demands; and availing of quality early generation seed. 2) Formal seed producers and suppliers (public, private, and cooperatives) need to multiply and make available high-quality seeds of improved malt barley varieties including unaddressed areas. 3)Seed regulatory agencies must ensure stringent quality assurance and certification processes to verify the seed quality of improved malt barley varieties before distribution to farmers. This will help maintain consistent quality and meet the country's standards. 4) Farmers’ cooperatives, which play a major role in seed provision should be further supported and empowered to enhance their capacity in seed multiplication and distribution. Their involvement is crucial as they are currently more effective than public and private sectors in the study areas. 5) Improving communication channels between farmers, seed producers, and distributors can facilitate better coordination and timely supply of quality seeds.

While this study provides valuable insights, it was subject to certain limitations. Financial restrictions and security concerns during data collection may have limited the scope of the research. To gain a more comprehensive understanding of malt barley seed source and quality perception of farmers across the country, the authors recommend further investigations in major malt barley growing areas.

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