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Research Article

Performance variability of farmers' and improved varieties of barley for yield components and seed quality

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The objective of this study was to assess performance variability between farmers' and improved varieties of barley for yield and yield related traits and seed quality attribute. Seven Farmer's varieties (FVs') and three improved varieties were tested at three locations and three replications by RCBD design during 2010 cropping season. Seed quality test was conducted as per International Seed Testing Association standard. Data were subjected to analysis of variance using software SAS version 9. Treatment means were separated using Duncan's Multiple Range Test (DMRT). Relatively G/gurrachaa was superior in yield potential and seed quality traits. The analytical purity analysis tests were ≥ 98.17% physically pure which was greater than 85% of the national standard. Barley seed exhibited dormancy and germinated poorly. Varieties showed seed dormancy break after-ripening. The presence and type of fungi were determined according to their development on seed. Accordingly, out of sixteen different fungi genera identified, eight were known to be seed transmitted and the rest were seed deteriorating fungi. Significant different was observed among varieties for pathogen infection. The study indicated that greater yield response could be obtained through direct selection scheme in FVs'. Minimum improvement should be vital for adopting early maturing varieties in an area of short rainfall so as to attain food security. Varieties differ in dormancy duration. Hence, dormancy behavior of the genotypes needs to be studied.

Keywords: Farmers varieties, variety evaluation, seed dormancy, seed health

INTRODUCTION

Farmers' varieties are an important element of crop genetic resources and are valued by plant breeders and farmers because of diversity (a heterogeneous population), rarity (embodying unique traits) and adaptability (exhibiting wide ecological and socio-cultural adaptation) (Brush and Meng, 1998; FAO, 1998; Smale, 2006; Smale, 2006). Farmers throughout the world continue to maintain and manage farmers' varieties within their production systems (Frankel and Bennett, 1970; Hawkes, 1971; Duvick, 1984; Brush *et al*., 1995; Brush 2004; Jarvis *et al*., 2008; FAO, 2010). Yet the value they contain for the farming communities that maintain them has not been fully capitalized on.

Not all landraces and improved varieties are equally valued by farmers for yield and yield related components and seed quality attributes. Some landraces are adapted to marginal ecosystems (Vandermeer, 1995,; Barry *et al*., 2007; Rana *et al*., 2008; Bezancon *et al*., 2009). Others have cultural, religious, or nutritional value (Johns and Sthapit, 2004; Sthapit et al., 2008). Some landraces maybe highly valued but their use is constrained by poor access to quality and quantity of seeds or planting materials (Tripp, 2001; Almekinders et al., 2006; Hodgkin et al., 2007; Sperling et al., 2008). Landrace populations may, themselves, not be uniform in their adaptive or quality

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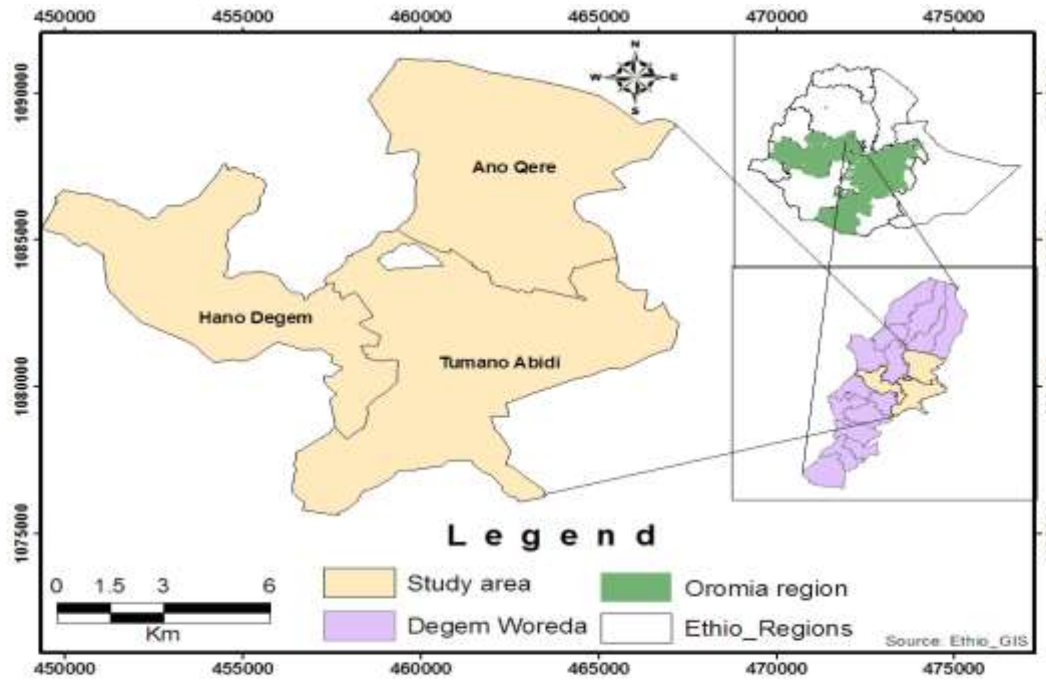


Figure 1. Map of Ethiopia, Oromiya and Degem wereda showing the study area
Source: Megersa, 2014

traits, having significant variation both within and amount populations (Harlan, 1975; Teshome et al., 2001; Mariac et al., 2006; Barry et al., 2007).

Some landraces and improved varieties are not equally affected by seed pathogen .Seed health is indirectly revealed during viability, germination or vigor tests since infected seeds are often unable to germinate or appear non-viable when examined by e.g. X-ray, TZ test or other viability test methods, or they germinate slowly and produce poor seedlings. However, in some instances a more thorough examination of the presence and type of seed-borne pests and pathogens is relevant. Especially in international transfer of seed, where there is a risk of introducing seed borne organisms together with seeds, a special health test may be required (ISTA,2009).

The recent movement in participatory and decentralized plant breeding over the last decade has shown that improving varietal performance in low input systems can help improve local livelihoods (Ceccarelli et al., 2000; Zeven, 2000; Smith et al., 2001; Dawson et al., 2008). Varieties can be improved by selection of preferred traits from the heterogeneous populations, collected locally before any crop improvement programme is initiated. However, insufficient attention has been given to the potential use of the existing landrace variability in production systems to provide direct benefits to local communities (Sthapit and Rao, 2009).

There was no study conducted on performance variety evaluation among FV's and improved varieties for yield, marginal area adaptability, seed quality and seed pathogen in the study area. Variability in adaptation and quality for socio-cultural preferences is the main concern of consumers and market entrepreneurs. This significant quality variation coupled with poor access to quality seed and inadequate policy support, including variety release policies. Quality seed production for landraces, has limited the ability of FVs' to be competitive in relation to other high quality barley varieties. Moreover, FVs' are exposed to genetic erosion.

Hence, research on crop genetic resource management is indispensable for performance variety evaluation and wise use of crop varieties by research and seed producers for further improvement and conservation in particular, research on traditional management of crop genetic resource in a marginal areas help to develop sustainable on-farm conservation strategy.

Therefore, the objectives of this study were: to assess the performance of improved and FV's for yield and yield component and seed quality attribute, to assess the potential of FV's for commercial seed production and to identify seed pathogen observed on barley seed.

MATERIALS AND METHODS

Description of the Study Sites

The experiment was conducted at Degem wereda, North Shewa Zone of Oromiya (Figure 1) selected for the following reasons: (I) barley was the dominant crop in the area, (II) Some FV's were still being grown, (III) less government attention with regard to conservation of FV's of barley, (IV) there was no known similar study of any kind that was done before in the study area that

Table 1. Descriptive of barley varieties used for the field experiment

S.No.	Name	Pedigree	Year of release	Seed color	Row type
1	*Garbuu adii*	Farmers' variety	-----	White	6R
2	HB-1307*	A cross made at Holetta from Awura gebs-1/IBON 93/91	2006	White	6R
3	*Garbuu hadhoo*	Farmers' variety	-----	Purple	Irregular
4	HB-42*	A cross made at Holetta from IAR/H/81/Comp29/Comp 14/20/Cost	1985	White	6R
5	*Damoy*	Farmers' variety	-----	White	6R
6	*Garbuu gurracha*	Farmers' variety	-----	Black	6R
7	*Shagee* (Line 3333-20)*	Landrace selection from Arsi collection	1996	White	6R
8	*Tolasee*	Farmers' variety	-----	White	6R
9	*Karfee*	Farmers' variety	-----	Black	6R
10	*Magee*	Farmers' variety	-----	Purple	6R

*Source: Fekadu, 1987 (NCIC); Crop variety registration, 2006

could be used as a baseline reference. This assumption emanates from the fact that the prevailing networks in the farmers' seed system had been highly influenced by the formal seed system.

FIELD EXPERIMENT

Experimental design and treatments

Three representative peasant associations (PAs), namely *Anno Degem, Anno Qarree* and *Tumno Abdii* were selected for the field experiment. Ten food barley varieties were included in the field experiment, of which, five FV's currently under production (*Damoy*, *G/adii*, *Tolasee*, *G/gurracha, Magee*), two replaced FV's (*Hadhoo and Karfee)* and three improved varieties (HB42, HB1307 and *Shagee)* (Table 1). Seeds were planted at a seed rate of 30 g plot^{-1} in a plot size of 3.0 m^2 (six rows of 2.5 m long spaced 0.2 m apart between rows).

Seed Quality Analysis

Barley seed obtained from experimental plots was used to make seed quality analysis. The experiment was conducted in a Complete Randomized Design (CRD) with four replications as per ISTA seed quality testing methods.

Determination of physical seed quality (Experiment-1)

Analytical Purity Test

From submitted sample of 120 g two replicates of 60 g was analyzed (ISTA, 2009). The samples were divided into three; (I) pure seed, (II) other crop seed, and (III), inert matter. The components were weighed on precision balance to the nearest two decimal places and the percentage of each component was determined (ISTA, 2009).

The percentage by weight of each component fraction was calculated by the following formula (ISTA, 2009).

$$\text{Component (\%)} = \frac{\text{Weight of each component fraction}}{\text{Total test sample weight}} \times 100$$

Thousand Kernel Weight (TKW)

Eight replicates of 100 seeds each were weighed from pure seed fraction (ISTA, 2009). The coefficient of variation was calculated to assess the acceptability of the test and the thousand kernel weight was calculated (Bishaw, 2004).

Determination of physiological seed quality (Experiment-2)

Several physiological tests such as standard germination, speed of germination, seedling shoot length, and seedling root length and seedling dry weight were measured to assess the vigour of barley seed from field experiment.

Table 2. Traits measured and derived on a plot basis for the field experiment

No.	Traits	Abbreviation	Description
1	Days to Flowering	DF	Recorded as number of days from sowing to the date on which 50% of the plants in four central rows of a plot have produced their first flower.
2	Plant Height	PH	Measured as a height in centimeter from the soil surface to the tip of the spike excluding the awns at maturity and expressed as an average of ten plants per plot.
3	Days to Maturity	DM	Recorded as number of days from sowing to the stage when 75% of the plants in four central rows of a plot have reached maturity.
4	Grain Filling Period	GFP	Number of days between days to flowering and days to physiological maturity.
5	Spikes Length	SL	Spike length of main tiller measured in cm from base to tip excluding the awns and expressed as an average of ten plants in a plot.
6	Kernel Number Per Spike	KNPS	Determined by counting the number of kernel produced on the main tiller of each plant and expressed as an average of ten plants in a plot.
7	Biomass Production Rate	BMPR	Computed by dividing the above ground biomass yield to number of days to physiological maturity and expressed as kg ha^{-1} day^{-1}.
8	Biological Yield	BY	Determined by weighing the total air dried above ground biomass harvested from the four central rows and expressed in kg ha^{-1}.
9	Grain Yield	GY	GY in kilogram of the four central rows adjusted to 12% moisture content expressed in kg ha^{-1}
10	Harvest Index	HI	Calculated as a ratio of dry weight of the grain to dry weight of the total above ground biomass yield and expressed as a percentage.
11	Thousand Kernel Weight	TKW	Weight in gram of random sample of thousand seeds per plot.

The experiment was planted on May 23 and 24 /2010. The first weeding was carried out at thirty days after crop emergence and the second weeding was performed thirty days after the first weeding. Data were collected on 11 developmental and yield related traits (Table 2).

(a) Standard Germination

(SG) test: SG test was done for all seed samples obtained from all treatments. Four hundred (400) seeds of the pure seeds component were divided into four replicates of 100 seeds each in germination box size of 18 cm, 9 cm and 13 cm (length, height and width, respectively) , which were then sown in sterilized sand media. The planted seeds were incubated at a temperature of 20^0 C for 7 days as specified by International Seed Testing Association (ISTA, 2009). At the end of the incubation period the germination boxes were removed and the seedlings were evaluated. Germinated seedlings was divided in to (I) normal seedlings, (II) abnormal seedlings, and (III) dead seeds and fresh seeds to determine the percentage of different seedlings.

$$\text{Germination (\%)} = \frac{\text{Total number of normal seedlings}}{\text{Total number of seeds kept for germination}} * 100$$

(b) Seed Vigour Test

Seed vigour is an important quality parameter which needs to be assessed to supplement germination and viability tests to gain insight into the performance of a seed lot in the field or in storage.

Seedling shoots and root length

The seedling shoot length and seedling root length were assessed after the final count in the standard germination test. Ten normal seedlings were randomly selected from each replicate after 7 days of seed sowing. The shoot length was measured from the point of attachment to the cotyledon to the tip of the seedling. Similarly, the root length was measured from the point of attachment to the cotyledon to the tip of the root. The averages shoot and root lengths were computed by dividing the total shoot or root lengths by the total number of normal seedlings measure (ISTA, 2009). Varieties producing the taller seedlings were considered more vigorous than the varieties producing shorter seedlings.

Seedling dry weight

Ten randomly selected seedlings from each replicate were cut from the cotyledons and placed in envelops to be dried in an oven at 80ºC for 24 hrs. The dried seedlings were weighed to the nearest milligram using sensitive balance and the average seedling dry weight was calculated. The seedling dry weight provides additional information for assessing seed vigour.

Vigour Index-I and Vigour Index-II

For each sample, two vigour indexes were calculated to test seed quality of FV's and improved varieties. Seedling vigour index-I was calculated by multiplying the normal germination percentage with the average sum of shoot and root length after seven days of germination and vigour index-II were calculated by multiplying the standard germination with mean seedling dry weight.

Vigor Index I=	Standard germination (%) x Seedling length (cm)
Vigor Index II=	Standard germination (%) x Seedling dry weight (mg)

Speed of germination

100 seeds were replicated into four from each sample and kept at 20ºC for maximum of 7 days in an incubator. Each day, normal seedlings were removed. Then speed of germination (GS) was then calculated (Maguire, 1962) as follows:

$$\text{GS} = \frac{\text{Number of normal seedlings}}{\text{Number of days to first count}} + \dots + \frac{\text{Number of normal seedlings}}{\text{Number of days to final count}}$$

The varieties having greater germination index were considered more vigorous.

SEED HEALTH TESTING (EXPERIMENT-3)

The agar plate method

About 15 ml of sterilized medium was poured in each Petri dish (9 cm, Pyrex, USA) under aseptic conditions under micro flow. Four hundred seeds from each sample were surface sterilized in 1% NaOCl for ten minutes and then rinsed with sterilized water, and then 20 seeds were plated in each Petri dish. The set was incubated at 22 ± 2ºC for 12 hour of alternating cycles of day and night under fluorescent light (Anon, 1996). Colonies and fruiting bodies of the fungi were identified using stereo and compound microscopes with aids of appropriate reference materials.

Mycological evaluation

Mycoflora associated with barley seed were detected by standard methods (Anonymous, 1996). The presence and type of fungi were determined according to their development on the seed, which were incubated on Potato Dextrose Agar (PDA) medium. Seeds were examined Bi-nocular microscope, Compound microscope and Centro Internacional de Mejoramiento de Maíz y Trigo **(**CIMMYT**)** manual for detection of seed-borne microorganisms and descriptions (1998). Fungi appearing on Petri plates were directly identified up to the species level with the

Table 3. Mean values of yield components of phenological traits of food barley varieties for all locations combined at Degem wereda 2010

Varieties	DF	DM	GFP	BMPR	PH
Garbuu adii	107.4^{ab}	135.6^{ab}	28.1^{d}	57.7^{bcd}	105.8^{abcd}
HB 1307	101.2^{c}	135.4^{b}	34.2^{a}	79.6^{a}	99.2^{def}
Hadhoo	100.9^{c}	132.7^{c}	31.8^{ab}	50.3^{d}	97.3^{ef}
HB42	105.3^{b}	136.0^{ab}	30.7^{bcd}	50.5^{d}	108.4^{abc}
Damoy	91.1^{e}	115.0^{f}	23.9^{e}	49.5^{d}	103.6^{bcde}
G/gurracha	96.9^{d}	128.4^{e}	28.1^{d}	78.5^{a}	111.9^{a}
Shagee	101.2^{c}	135.0^{b}	33.8^{a}	51.1^{cd}	103.3^{cde}
Tolasee	108.1^{a}	136.0^{ab}	27.9^{d}	62.8^{b}	111.6^{a}
Karfee	99.7^{c}	130.3^{d}	30.7^{bcd}	37.3^{e}	94.9^{f}
Magee	108.6^{a}	137.1^{a}	28.6^{cd}	59.4^{bc}	111.4^{ab}
Mean	102.0	132.2	30.1	57.7	104.8
CV(%)	2.3	1.3	10.7	15.8	15.9

Means followed by a common letters with in a column are not significantly different from each other at P ≤ 0.05 according to Duncan Multiple range test ,DF=Days to flowering DM= Days to maturity GFP= Grain filling period BMPR= Biomass production rate, PH= Plant height

help of a compound microscope and relevant literature (Booth, 1971; Ellis, 1976; Sutton, 1980; Nelson *et al*., 1983; CIMMYT, 1998). Data collected on incidence of fungi were analyzed statistically. Percent incidence of fungi was recorded.

$$\text{Percent incidence} = \frac{\text{No. of infected seeds}}{\text{Total number of seeds examination}} \times 100$$

Data Coding and Entry

Both close ended and open-ended questions were properly coded and entered into the computer using Microsoft Excel Application Program. Quantitative data were organized to suit the different statistical packages used in the analysis. For better interpretation of results, some of the data sets were transformed into standard units. Qualitative data were organized in such a way that cumulative of the respondent's information was presented.

Data Analysis

Data collected from the field and laboratory experiments were subjected to analysis of variance using software SAS 2004 version 9 and GenStat Discovery Edition 3 developed by VSN International. Treatment means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Performance of Improved and Farmers' Varieties for Yield and Yield Components

Days to heading and maturity

Both days to heading and days to maturity differed significantly at $p < 0.05$ among varieties. Days to flowering ranged from 91 to 109 days with a mean value of 102 days. Days to maturity ranged from 115 to 137 days with a mean value of 132.15 days. *Damoy* was the earliest variety to heading (91) and maturity while *Mag*ee took long days (109) to heading and maturity. *Hadhoo*, *G/gurracha* and *Karfee* were medium maturing varieties. Variety *Damoy* was the dominant variety grown during the *belg* season where rainfall variability was high. The amounts of variation for the two major phenological traits were high among the test varieties and this was more apparent on the FV's. There were little variation among the improved varieties and all were late maturing (Table 3).

Grain filling period and plant height

Grain filling period ranged from 23.88 to 34.22 days with mean value of 30.11. The shortest grain filling period was observed on variety *Damoy* and the longest on *G/adii* (Table 3).Varieties with the shortest grain-filling period had the advantage to escape terminal moisture stress and good character to cope up with the rainfall variability in the highlands of Degem. Variation for plant height among the varieties ranged from 94.9 to 111.1cm with mean site value of 104.75. *Karfee* was the shortest variety (94.9 cm) whereas *G/gurracha and Magee (*111.5 cm) were the tallest varieties. Most of the FV's were tall with weak stem, which was the common character of the local FV's. The improved varieties were relatively short with strong stem. This finding is in agreement with Fekadu (2010 unpublished) that modern varieties showed declining trend in plant height as compared to the FV's.

In contrast, Martiniello *et al.* (1987) reported that the modern genotypes showed trends towards earliness in both six and two row barley genotypes compared to the oldest ones. Most of the modern barley varieties were relatively earlier than the older varieties whereas

Table 4. Yield and yield related components over all locations

Varieties	SL	NSPS	BY	GY	HI	TKW
G/ adii	6.7[a]	47.9[ab]	6190.6[c]	2672.1[cd]	0.44[a]	44.5[a]
HB-1307	6.1[a]	40.8[b]	8058.6[a]	3446.5[ab]	0.42[a]	44.2[a]
Hadhoo	6.6[a]	42.9[ab]	5068.8[d]	2354.9[cd]	0.44[a]	42.7[a]
HB-42	6.2[a]	47.4[ab]	5288.6[d]	2187.5[d]	0.40[a]	45.0[a]
Damoy	6.4[a]	51.1[a]	4504.6[de]	2178.5[d]	0.48[a]	43.6[a]
G/gurracha	6.3[a]	50.1[a]	7625.0[ab]	3573.6[a]	0.46[a]	44.1[a]
Shagee	6.4[a]	45.1[ab]	5155.9[d]	2306.9[cd]	0.44[a]	42.4[a]
Tolasee	6.7[a]	51.3[a]	6787.0b[c]	2933.8b[c]	0.43[a]	44.9[a]
Karfee	4.6[b]	42.2[ab]	3711.4[e]	1489.2[e]	0.39[a]	44.4[a]
Magee	5.8[a]	51.1[a]	6442.9[c]	2892.7[bc]	0.45[a]	45.5[a]
Mean	6.2	47.0	5883.3	2603.6	0.44	44.1
CV (%)	7.9	21.4	16.1	26.0	21.26	12.1
R^2	0.72	0.33	0.87	0.74	0.27	0.35

Means followed by a common letters with in a column are not significantly different from each other at P < 0.05 according to Duncan Multiple Range Test, SL= Spike length, NSPS= Number of spike per spikelet, GY- Grain yield (kg ha-1), BY- Biomass yield (kg ha-1), HI- Harvest index (%) and TKW=thousand kernel weight

No significant variation was observed among varieties for spike length, harvest index and thousand kernel weights. Number of spikelet per spike ranged from 42.2 to 51.1 with site mean value of 47.0 (Table 4).

maturity time was similar for all the varieties studied (Wych and Rasmusson, 1983). Furthermore, Cox *et al*. (1988) in hard red winter wheat in USA, Perry and D'Antuono (1989) in spring wheat in Australia, Austin (1999) in wheat in UK and Donmez *et al.* (2001) in winter wheat genotypes in Great Plains reported that modern varieties reached flowering and maturity earlier than the older ones. Metzger *et al*. (1984) indicated that selection for grain filling duration was not promising to improve yield of barley in Minnesota, suggesting that grain-filling duration is not yield limiting factor in barley.

Spike length and number of spikletes per spike

The spike length ranged from 4.6 to 6.7 cm with mean value of 6.2 cm (Table 4). The total variation among the varieties were small and almost most of the varieties had spike length of 6.1 to 6.7 cm. Among the varieties, tested *Karfee* had the shortest in spike length (4.6 cm) while *G/adii* and *Tolasee* were the longest (6.67 cm). The mean difference between the numbers spikletes per spike varied from 40.8 for HB-1307 to 51.3 for *Tolasee* with the mean value of 47. The number of spiklets per spike for most of the varieties was in the range of 45-51 cm. No significant different was observed among varieties on number of spikelets per spike. Similarly, Bensemane *et al*. (2011) reported that seed per spike showed no significant relationship with grain yield. In the yield components, spikes per square meter followed by kernels per spike exerted the greatest effect on grain yield. Similarly, Sinebo (2002) reported that barley spike is a source and sink of assimilates that ultimately determines grain yield. Therefore, the morphology of the spike is a major concern in crop improvement. As observed in the present study, barley kernel weight, spikelets per spike and spike length are the main components of yield (Table 4).

Biomass yield, grain yield, thousand kernel weight and harvest index

Mean differences were observed among the barley varieties for biomass and grain yield. However, mean differences were not observed among them for thousand kernel weight and harvest index (Table 4). Biomass yield ranged from 3711.4 for *Karfee* to 8058.6 kg ha^{-1} for HB-1307 with mean value of 5883.3 kg ha^{-1} (Table 4).Varieties such as *Magee*, *Tolasee* and *G/adii* was on par in biomass yield. The variation for grain yield per hectare ranged from 1489.2 for *Karfee* to 3573.6 kg ha^{-1} for *G/gurracha* 2603.6 kg ha^{-1} (Table 4). The site mean value of grain yield was 2554.6 kg ha^{-1} at *Anno Degem*, 2282.4 kg ha^{-1} at *Anno Qarree* and 2973.8 kg ha $^{-1}$ at *Tummano Abdii*. Grain yield potential of *Anno Degem* was intermediate while that of *Tummano Abdii* was relatively higher than both locations. The low yield obtained at *Anno qarree* and high yield at *Tummano Abdi* could be attributed to low and high soil fertility respectively (Table 5).

Garbuu gurracha gave the highest grain yield followed by the recently released stiff straw variety HB-1307. Grain yield performance of HB-42 and *Shagee* varieties was lower compared to other varieties except *Damoy*, which was the least in grain yield (Table 4). Harvest index ranged from 39 to 48% ha^{-1} with mean value of

Table 5. Phenological/developmental traits of ten-food barley varieties at Degem wereda 2010 by specific locations

	Locations											
	Anno Degem				***Anno qarree***				***Tumano***			
Variety	**DF**	**PH**	**DM**	**GFP**	**DF**	**PH**	**DM**	**GFP**	**DF**	**PH**	**DM**	**GFP**
G/adii	106.3^{a}	98.7^{abc}	135.3^{a}	29.0^{cd}	108.0^{a}	103.3^{abcd}	135.7^{a}	27.7^{cd}	108.0^{a}	115.3^{ab}	135.7^{a}	27.7^{cde}
HB-1307	100.0^{bc}	101.3^{abc}	135.7^{a}	35.7^{ab}	101.0^{b}	93.0^{cd}	135.3^{a}	34.3^{ab}	102.7^{b}	103.3^{bc}	135.3^{a}	32.7^{ab}
Hadhoo	101.0^{b}	101.7^{ab}	133.0^{ab}	32.0^{abc}	101.0^{b}	87.0^{d}	132.7^{b}	31.7^{abc}	100.7^{bc}	103.3^{bc}	132.3^{b}	31.7^{abc}
HB-42	100.0bc	108.7^{a}	136.7^{a}	36.7^{a}	108.0^{a}	95.7^{abcd}	135.7^{a}	27.7^{cd}	108.0^{a}	121.0^{a}	135.7^{a}	27.7^{cde}
Damoy	87.0^{e}	96.0^{bc}	112.7^{d}	25.7^{d}	95.7^{b}	100.0^{abcd}	117.0^{d}	21.3^{d}	90.7^{d}	115.0^{ab}	115.3^{d}	24.7^{e}
G/gurracha	95.0^{d}	106.0^{ab}	128.3^{c}	33.3^{abc}	97.0^{b}	112.0^{a}	128.0^{c}	31.0^{abc}	98.7^{c}	117.7^{a}	129.0^{c}	30.3^{bcd}
Shagee	104.3^{a}	97.7^{bc}	133.7^{ab}	29.3^{cd}	99.7^{b}	103.7^{abcd}	136.3^{a}	36.7^{a}	99.7^{bc}	108.7^{abc}	135.0^{a}	35.3^{a}
Tolasee	105.0^{a}	106.7^{ab}	135.3^{a}	30.3^{bcd}	110.0^{a}	111.0^{ab}	136.7^{a}	26.3^{cd}	109.3^{a}	117.0^{a}	136.3^{a}	27.0^{de}
Karfee	98.0^{c}	90.7^{c}	130.7^{bc}	32.7^{abc}	100.0^{b}	93.3^{bcd}	130.0^{c}	30.0^{bc}	101.0^{bc}	100.7^{c}	130.3^{bc}	29.3^{bcd}
Magee	105.7^{a}	106.3^{ab}	137.3^{a}	31.7^{abc}	110.0^{a}	110.3^{abc}	137.0^{a}	27.0^{cd}	111.0^{a}	117.7^{a}	137.0^{a}	27.0^{de}
Mean	100.23	101.37	131.87	31.63	103.00	100.92	132.40	29.37	102.87	112.00	132.20	29.33
CV (%)	1.26	6.16	1.92	10.07	3.32	10.29	0.88	12.89	1.74	6.90	0.93	8.89
S.E	1.03	5.10	2.07	2.60	2.79	8.48	0.96	3.09	1.46	6.34	1.00	2.13

Means followed by a common letters with in a column are not significantly different from each other at P < 0.05 according to Duncan's Multiple Range Test
DF= Days to flowering, DM= Days to maturity, GFP= Grain filling period, PH= Plant height

44%. Table 4 indicates that majority of the varieties had harvest index, between 40 and 48%.

Performance of improved and farmers' varieties of barley for yield and yield components at each location

Analysis of variance for days to heading, days to maturity, grain filling period, biomass production rate, thousand kernel weight, plant height, number of spikelet spike^{-1}, grain yield, biomass yield and harvest index for three sites are presented.

At *Anno Degem*, the analysis of variance revealed very highly significant differences (P<0.001 or P<0.01 or P<0.05) among the varieties for all the traits measured, except for TKW. Plant height was significantly different at P<0.05, while grain filling period was significantly different at P<0.05. Moreover, most yield and yield related traits showed highly significant at P<0.05. However, number of spikelt per spike and thousand kernel weights were not significant.

The analysis of variance carried out at *Anno qarree* on the eleven quantitative traits revealed highly significant differences among the varieties for most of the traits measured. Days to heading, grain filling period, biomass production rate, and biomass yield were significantly different at p<0.05. Days to maturity and grain yield were highly significant different at p<0.05. However, spike length, plant height number of spikelt per spike, harvest index and thousand kernel weights did not show any significant differences among the varieties.

Table 6. Mean values for biomass production rate, spike length, plant height and number of spikelet per spike at the three sites

	Anno Degem			***Anno qarree***			***Tumano***		
Varieties	**BMPR**	**SL**	**NSPS**	**BMPR**	**SL**	**NSPS**	**BMPR**	**SL**	**NSPS**
G/adii	74.8^{a}	7.3^{ab}	49.3^{a}	24.0^{d}	5^{a}	44.0^{a}	74.3^{bc}	7.7^{a}	50.3^{a}
HB-1307	79.6^{a}	5.7^{cd}	42.7^{a}	76.8^{a}	5.7^{a}	38.0^{a}	82.5^{ab}	6.7^{ab}	41.7^{a}
Hadhoo	78.9^{a}	6.7^{bc}	46.3^{a}	28.4^{d}	6.0^{a}	38.3^{a}	43.4^{ef}	7.0^{a}	44.0^{a}
HB-42	62.4^{b}	5.3^{d}	54.0^{a}	32.1^{bcd}	6.7^{a}	45.7^{a}	57.1^{de}	7.0^{a}	43.3^{a}
Damoy	45.5^{c}	6.7^{bc}	53.3^{a}	54.0^{b}	6.0^{a}	48.0^{a}	49.0^{def}	6.7^{ab}	52.0^{a}
G/gurracha	64.7^{b}	6.3^{bcd}	53.7^{a}	80.2^{a}	5.7^{a}	47.7^{a}	90.8^{a}	7.0^{a}	49.0^{a}
Shagee	38.7^{d}	7.0^{ab}	54.0^{a}	51.7^{b}	6.0^{a}	45.7^{a}	62.9^{cd}	6.3^{ab}	35.3^{a}
Tolasee	61.5^{b}	8.0^{a}	54.7^{a}	50.5^{bc}	5.0^{a}	49.3^{a}	76.4^{abc}	7.0^{a}	50.0^{a}
Karfee	43.9^{cd}	2.7^{e}	45.7^{a}	28.7^{cd}	5.0^{a}	46.0^{a}	39.2^{f}	5.0^{b}	43.3^{a}
Magee	61.8^{b}	7.3^{ab}	55.0^{a}	38.7^{bcd}	5.0^{a}	38.0^{a}	77.7^{ab}	6.0^{ab}	52.3^{a}
Mean	61.19	6.3	50.9	61.19	5.6	44	65.31	6.63	46.1
CV (%)	6.27	11.3	17.47	6.2	21	17.1	12.89	15.2	27.6
S.E	3.14	0.4	7.26	10.42	1	6.43	6.89	0.82	10.4

Means followed by a common letters with in a column are not significantly different from each other at P < 0.05 according to Duncan's Multiple Range Test, BMPR= Biomass production rate, SL= Spike length, NSPS= Number of spikelet per spike

At *Tumano,* the analysis of variance revealed significant differences among the varieties for most of the traits, except for spike length, number of spikelts per spike and thousand kernel weights. Plant height was significantly different at $p<0.05$. The other morphological and yield and yield related components showed highly significant differences at $p<0.05$.

Genotypic performance for phenological traits at each site

Mean phenotypic variation for phenological/developmental/, of the 10 food barley varieties are shown in (Table 5). The amount of variation among the varieties for most of phenological traits was relatively high between the testing sites. At *Anno degem,* days to heading ranged from 87 to 106 days while at *Anno qarree* from 96 to 110 days and at *Tumano* it ranged from 91 to 111 days. The overall mean difference in DF among varieties were small (100, 103 and 103 days for *Anno degem, Anno qarree* and *Tumano*, respectively).

At *Anno degem,* plant height ranged from 90.7 to 108.7 cm with site mean of 101.4 cm while at, *Anno qarree* from 87 to 111 cm with site mean of 100.9 cm, and at *Tumano* from 100.7 to 121 cm with site mean value of 112 cm (Table 5). The variation in plant height across the three sites ranged from 100.9 to 112 cm, at *Anno qarree* and *Tumano*.

Mean days to grain filling period across the sites was 31.6 days at *Anno degem,* 29.4 days at *Anno qarree* and *Tumano*. The highest grain-filling period was observed by variety HB 42 (37 days) at *Anno degem* followed by variety *Shagee* (37 and 35 days) at *Anno qarree* and *Tumano,* respectively. Generally, FV's showed relatively short days to flowering and days to grain filling than the improved varieties (Table 5).

Agronomic /Yield component traits/ of food barley

Mean performance for agronomic/ yield component trait/ of 10 food barley varieties are shown in Table (6). The amount of variation among the varieties for most traits was relatively high among the testing sites. At Anno *Degem* biomass production rate (BMPR) ranged from 38.7 to 79.6 days while at, *Anno qarree* from 24.0 to 80.2 days and at *Tumano* from 39.2 to 90.8 days. There were no significant difference in overall mean among varieties in BMPR at *Anno degem* and *Anno qarree,* however, significant different was observed at *Tumano* site which was 65.3.

At *Anno degem,* spike length ranged from 2.7 to 8 cm with mean of 6.3 cm at *Anno qarree* from 5 to 6.7 cm with mean of 5.6 cm, at *Tumano* from 5 to 7.7 cm with site mean value of 6.6 cm (Table 6).

At *Anno degem,* number of spikelet per spike ranged from 42.7 to 55 with mean of 50.9 while at *Anno qarree* from 38 to 49 with mean of 44 and at *Tumano* from 35.3 to 52.3 with site mean of 46.1 (Table 6). The variation in number of spike per spikelet was relatively high across the three sites, it ranged from 44 to 50.9 at *Anno qarree*, and *Anno degem*.

Grain yield, biomass yield, thousand kernel weight and harvest index at each location

Mean values for grain yield, biomass yield, thousand kernel weigh and harvest index of each genotype and testing sites are shown in (Table 7). At *Anno degem*, the grain yield ranged from 1722.2 kg ha^{-1} for variety

Table 7. Mean grain yield, biomass yield, harvest index and thousand kernel weight of food barley at each location

	Anno degem				***Anno qarree***				***Tumano***			
Varieties	**BY**	**GY**	**HI**	**TKW**	**BY**	**GY**	**HI**	**TKW**	**BY**	**GY**	**HI**	**TKW**
G/adii	7958.3[a]	3437.5[a]	0.43[ab]	42.4[a]	2592.6[d]	1203.7[c]	0.46[a]	42.9[ab]	8020.8[a]	3375.0[c]	0.42[d]	48.1[a]
HB 1307	7958.3[a]	2847.2[a]	0.36[c]	47.0[a]	7759.3[a]	3596.3[ab]	0.46[a]	44.7[ab]	8458.3[a]	3895.8[abc]	0.46[bc]	41.5[ab]
Hadhoo	7968.1[a]	3395.8[a]	0.43[ab]	43.0[a]	2870.4[cd]	2037.0[abc]	0.54[a]	47.5[a]	4368.1[c]	1631.9[f]	0.37[e]	37.5[b]
HB42	6236.1[b]	2291.7[c]	0.36[c]	44.1[a]	3463.0[bcd]	2000.0[abc]	0.48[a]	45.2[ab]	6166.7[b]	2270.8[de]	0.37[e]	45.7[ab]
Damoy	3958.3[c]	1840.3[d]	0.46[a]	45.0[a]	5111.1[bc]	2514.8[abc]	0.49[a]	39.3[b]	4444.4[c]	2180.6[ef]	0.49[a]	46.7[a]
G/gurracha	6145.8[b]	2698.6[b]	0.44[ab]	45.6[a]	7777.8[a]	3777.8[a]	0.54[a]	44.4[ab]	8951.4[a]	4244.4[a]	0.47[b]	42.4[ab]
Shagee	4041.7[c]	1722.2[d]	0.42[b]	42.4[a]	5176.9[b]	2400.0[abc]	0.46[a]	39.0[b]	6250.0[b]	2798.6[d]	0.45[c]	45.8[a]
Tolasee	6458.3[b]	3763.9[b]	0.43[ab]	46.8[a]	5555.6[ab]	2405.6[abc]	0.43[a]	44.6[ab]	8347.0[a]	3631.9[bc]	0.44[cd]	43.2[ab]
Karfee	4305.6[c]	1763.9[d]	0.41[b]	40.3[a]	2870.4[cd]	1037.0[c]	0.35[a]	47.9[a]	3958.3[c]	1666.7[f]	0.42[d]	43.2[ab]
Magee	6527.8[b]	2784.7[b]	0.42[b]	41.8[a]	4259.3[bcd]	1851.9[bc]	0.45[a]	48.2[a]	8541.7[a]	4041.7[ab]	0.47[ab]	48.4[a]
Mean	6155.83	2554.58	0.41	43.85	4743.5	2282.41	0.47	44.3	6750.67	2973.74	0.44	44.24
CV (%)	6.193	6.822	4.658	14.99	28.22	48.66	34.5	10.06	13	11	3.3	10.9
S.E	311.269	142.292	0.016	5.37	1093.24	906.969	0.131	3.641	715.65	266.3	0.002	3.92

Means followed by a common letters with in a column are not significantly different from each other at $P \leq 0.05$ according to Duncan Multiple Range Test, GY- Grain yield (kg ha^{-1}), BY- Biomass yield (kg ha^{-1}), HI- Harvest index (%) , and TKW=Thousand kernel weight

Shagee to 3437.5 kg ha^{-1} for variety *G/adii* followed by 3395.8 kg ha^{-1} for variety *Hadhoo* while at, *Anno qarree* it ranged from 1037 kg ha^{-1} for *Karfee* to 3777.8 kg ha^{-1} for *G/gurracha* followed by 3596.3 kg ha^{-1} for HB1307. At *Tumano* grain yield varied from 1666.7 kg ha^{-1} for variety *Karfee* to 4244.4 kg ha^{-1} for variety *G/gurracha* followed by 3895.8 kg ha^{-1} for variety HB1307. Location mean grain yield ranged from 2282.4 kg ha^{-1} at *Anno qarree* to 2554.6 kg ha^{-1} for *Anno degem* (Table 7). Variation for grain yield across the three sites was relatively high and ranged from 1037 kg ha^{-1} produced by *Karfee* at *Anno qarree* to 4244.4 kg ha^{-1} produced by *G/gurracha* at *Tumano.* Except HB 42, *Damoy* and *Karfee*, all varieties showed similar yield performance with HB-1307 (Table 7).

At *Anno qarree* mean grain yield ranged from 1037 kg ha^{-1} for variety *Karfee* to 3777.8 kg ha^{-1} for variety *G/gurracha*. Varieties *Hadhoo*, HB42, *Damoy*, *Shage* and *Tolasee* showed similar performance with an improved variety HB1307 and significantly higher than varieties *G/adii* and *Karfee* (Table 7). Moreover, the lowest and highest grain yield at Anno qarree was 1037 kg ha^{-1} and 3777.8 kg ha^{-1} for varieties *Karfee* and *G/gurracha*, respectively. *G/gurracha* variety had significantly higher grain yield than the other varieties except at *Anno degem, G/adii* had significantly higher grain yield than the other local and improved varieties. This study showed that FV's of food barley had good yield performance than improved varieties on low input farmer's condition (Table 7). Similarly, Jalata (2011) reported that there was a differential yield performance among genotypes across testing environment mainly due to genotypic, genotypic and environmental interaction. In this study, it appeared that high biomass yield is essential to high grain yield production. Similarly, Sinebo (2002) reported that high straw yield was essential to high grain yield production.

Table 8. Yield and yield related traits among local and improved varieties of barley in kg ha^{-1}at Degem in 2010

Farmer varieties	BY	GY	HI	TKW
G/adii	6190.6	2672.1	0.44	45.5
Hadhoo	5068.8	2354.9	0.44	42.1
Damoy	4504.6	2178.5	0.48	30.7
G/gurracha	7625.0	3573.6	0.46	40.2
Tolasee	6787.0	2933.8	0.43	41.3
Karfee	3711.4	1489.2	0.39	34.8
Magee	6442.9	2892.7	0.45	46.8
Mean	5761.47	2584.97	0.44	40.20
Improved varieties.				
HB-1307	8058.6	3446.5	0.42	46.2
HB-42	5288.6	2187.5	0.4	38.1
Shagee	5155.9	2306.9	0.44	39.5
Mean	6167.70	2646.97	0.42	41.27

Significant mean biomass yield differences among the varieties were observed at each site (Table 7). At *Anno degem*, mean biomass yield ranged from 3958 kg ha^{-1} for variety *Damoy* to 7968.1 kg ha^{-1} for variety *Hadhoo* followed by varieties *G/adii* and HB1307 (7958 kg ha^{-1}). Likewise, at *Anno qarree* mean biomass yield ranged from 2870 kg ha^{-1} for *Hadhoo* and *karfee* to 7777.8 kg ha^{-1} for *G/gurracha* followed by HB1307 (7759 kg ha^{-1}). At *Tumano*, mean biomass yield ranged from 3958.3 kg ha^{-1} for *Karfee* to 8951.4 kg ha^{-1} for *G/gurracha* followed by variety HB1307 (8458 kg ha^{-1}). Location mean biomass yield for *Anno degem Anno, qarree* and *Tumano* were 6155.8 kg ha^{-1}, 4743.5 kg ha^{-1} and 6750.7 kg ha^{-1}, respectively. Varietal difference for biomass yield was less marked at *Anno qarree* than the two sites, which might be due to better adaptation of all varieties to the growing conditions at *Tumano*, and *Anno degem*. Variety *G/gurracha* which gave the highest mean grain yield at *Anno qarree* and *Tumano* was also characterized by high biomass yield, 7777.8 and 8951 kg ha^{-1} at the two sites respectively. Moreover, the lowest mean biomass yield was obtained by varieties *Hadhoo* and *Karfee* (2870 kg ha^{-1}) at *Anno qarree* and the highest biomass yield was obtained by variety *G/gurracha* (8951.4 kg ha^{-1}) at *Tumano.* This result revealed that biomass yield was relatively related to grain yield for FV's except for HB-1307.

Similarly Ortiz *et al*., (2002) reported that there was significant trend in increasing straw yield in Nordic spring barley germplasm and biological yield of recent varieties and old varieties was almost the same. Fekadu (2010) also reported that the recent varieties (Dimtu and HB-1307) which gave high grain yield were also characterized by high biomass yield at all locations except HB-1307 at Holetta. Similarly, Sinebo (2002) reported that high biomass yield is essential to high grain yield production.

At *Anno degem*, the mean harvest index ranged from 0.36 for HB-42 and HB-1307 to 0.46 for *Damoy* while at *Anno qarree,* it was 0.35 for *Karfee* to 0.54 for *Hadhoo* and *G/gurracha* and that of *Tumano* was 0.37 for *Hadhoo* and HB-42 to 0.49 for *Damoy*. The highest and lowest varietal difference for harvest index was observed at *Anno qarree* than *Anno degem* and *Tumano*. The overall mean harvest index in this study varied from 0.35 for *karee* to 0.54 for *Shagee* and *G/gurracha* indicating FV's had shown significant variation for harvest index (Table 7).

There was no significant variation in thousand-kernel weight at *Anno degem*, however, at *Anno qarree* ranged from 39 to 48.2 gm with mean of 44.3 gm and at *Tumanno* ranged from 37.5 to 48.4 gm with mean of 44.24 gm. In this study, the effect of thousand-kernel weight is small for performance evaluation among the varieties tested. Similarly, Sinebo (2002) reported that the effect of kernel weight on grain yield was small.

Similarly, Kulp and Joseph (2000) reported that mean values of the varieties were recorded within the range of barley yield potential performance study as described for yield potential of barley varies from state to state in America ranged from 1451.0 to 5499.0 kg ha^{-1} and barley yield of ten top leading producing countries was within the range of 1730.0 to 5470.0 kg ha^{-1}

Comparative yield potential of farmers' varieties and improved varieties over three sites

There were significant difference in performance of local against improved varieties in yield and yield related traits on low input and marginal environment. Accordingly, *G/gurracha* was the highest in grain yield followed by *Tolasee* and *Magee* among the FV's. Ceccarelli and Grando, 2001 cited in Brush (2000) reported that black-seeded FVs' was better adapted to dry areas and less vigorous in early growth, more cold

Table 9. Estimates of Pearson correlation coefficient of combined location mean among the 10 traits

	DF	DM	GFP	BMPR	PH	SL	NSPS	TKW	BY	GY	HI
DF	1	0.88**	0.23	0.06	0.37	0.08	-0.29	0.32	0.28	0.16	-0.4
DM		1	0.63*	0.19	0.16	0.01	-0.49	0.15	0.37	0.23	-0.54
GFP			1	0.09	-0.5	-0.2	-0.64*	-0.25	0.12	0.02	-0.57
BMPR				1	0.43	0.39	-0.28	-0.02	0.97***	0.98***	0.28
PH					1	0.36	0.2	0.18	0.5	0.53	0.37
SL						1	-0.09	-0.52	0.32	0.46	0.56
NSPS							1	0.42	-0.3	-0.3	0.03
TKW								1	0.05	-0.07	-0.54
BY									1	0.97***	0.19
GY										1	0.37
HI											1

*, **, *** r-values were significant at probability level of 0.05, 0.01 and 0.001 respectively, DF= Days to flowering, DM= Days to maturity, GFP= Grain filling period, BMPR= Biomass production rate, PH= Plant height, SL= Spick length, NSPS= Number of spikelet per spike, TKW= Thousand kernel weight, BY= Biomass yield. GY=Grain yield, HI= Harvest Index.

Table 10. Physical purity of barley seed obtained from field experiment at Degem wereda 2010

	Composition by weight			
Variety	**ANPU**	**OCS**	**INM**	**TKW(g)**
G/adii	99.76[a]	0.14[f]	0.00[b]	45.7[b]
HB 1307	99.69[a]	0.17[ef]	0.00[b]	46.2[ab]
Hadhoo	99.08[b]	0.53[c]	0.04[a]	42.1[c]
HB42	99.60[ab]	0.24[de]	0.00[b]	38.1[e]
Damoy	99.54[ab]	0.25[de]	0.04[a]	30.7[g]
G/gurracha	99.59[ab]	0.49[c]	0.00[b]	40.2[d]
Shagee	99.55[ab]	0.30[d]	0.00[b]	39.5[d]
Tolasee	99.06[b]	0.62[b]	0.00[b]	41.3[c]
Karfee	98.17[c]	1.12[a]	0.00[b]	34.8[f]
Magee	99.74[a]	0.27[d]	0.00[b]	46.8[a]
Mean	99.38	0.41	0.01	40.58
CV (%)	0.24	9.14	45.15	2.68
R^2	0.87	0.99	0.97	0.95
Signficance	0.0016	<.0001	<.0001	<.0001

Means followed by a common letters with in a column are not significantly different from each other at P< 0.05 according to Duncan's Multiple Range Test; ANPU= % Analytical purity, OCS= Other crop seeds, INM=Inert matter, TKW= Thousand kernel weight (g),

resistant and more productive under stress than improved cultivars. However, HB-1307 gave high yield (3446.5 kg ha^{-1}) than other improved varieties and FV's except *G/gurrach* that gave 3573.6 kg ha^{-1}. High biological yield was obtained on HB-1307 (8058.6 kg ha^{-1}) and followed by FV's *G/gurrach, Tolasee, Magee* and *G/adii*. On the contrary, high TKW was observed by variety *Magee* followed by HB-1307. *Karfee* was the lowest in harvest index and *Damoy* was the highest in harvest index. In this study, *Karfee* was the lowest performing FV's. In contrast, HB-1307 gave relatively better yield and yield related traits over the other two improved varieties and the FV's except *G/gurrach*, which was superior in some traits (Table 8).

Correlation among the quantitative traits

The correlation coefficient among the quantitative traits were computed on the mean trait values of the two sites i.e., *Anno degem* and *Tumano* (Table 9). *Anno qarree was* excluded because of high CV value (>30 %). Significant and strong positive correlation coefficients were found for DH with DM (0.88), BMPR with BY and GY (0.97 and 0.98, respectively) and BY with GY (0.97). Days to heading was positively correlated to grain filling period. On the other hand, days to grain filling period was negatively correlated to number of spikelet per spike at (r=-0.64) (Table 9). Similarly, (Ahmad, 2004; Tarekegn, 2009) reported that days to heading were positively and significantly correlated with days to maturity. Moreover, biomass yield showed significant correlation with grain yield. Sinebo (2002) reported that grain yield was correlated positively with mature heights, and grain-filling duration. On the contrary, grain yield was not correlated with kernel weight.

This finding suggests that characters showing positive correlation could effectively be utilized in enhancement of FV's. The tendency of positive correlation among developmental traits, in spite of wide range of genetic diversity in FV's could effectively be utilized to enhance barley FV's.

Seed Quality Analysis

Seed testing evaluates seed lot quality and is essential for both seed production and commercial seed transactions (AOSA, 1981). Seed testing is done to assess seed lot attributes to determine overall quality and value for seedling production and storage. Seed testing standards provide set procedures for facilities to conduct tests in a uniform manner to ensure comparable results that are within acceptable ranges (ISTA, 2009).

Analytical purity analysis

The analytical purity analysis test showed that seed samples collected from field experiment were ≥ 98.17% physically pure which was greater than 85% of the national standard for commercial seeds in Ethiopia (Casas *et al*.,1999). Physical purity in this study, however, ranged from 98.17 to 99.76% with an average of 99.38%. There was no difference in physical purity level between seed sources. However, varieties showed significant difference for other crop seed, which ranged from 0.14 for *G/adii* to 1.12% for *Karfee* with mean of 0.41%. This variety contains more other crop seed than other varieties. Thousand seed weight also showed significant difference which ranged from 30.7 to 46.25 g with mean of 40.58 g. *Damoy* was the least in thousand seed weight followed by *Karfee,* which was

Figure 2. Standard germination after one month of harvest

Accordingly, second germination testing was made after four months of harvest. During the second germination test, varieties mean differences for the trait ranged from 98.5% for *Tolese* and HB-42 to 99.75% *Shagee* (Figure 3). The result indicated that all varieties were above nationally recommended standard germination range after-dormancy break for four months and showed that dormancy was fully broken**.**

Figure 3. Seed germination four-month after-ripening

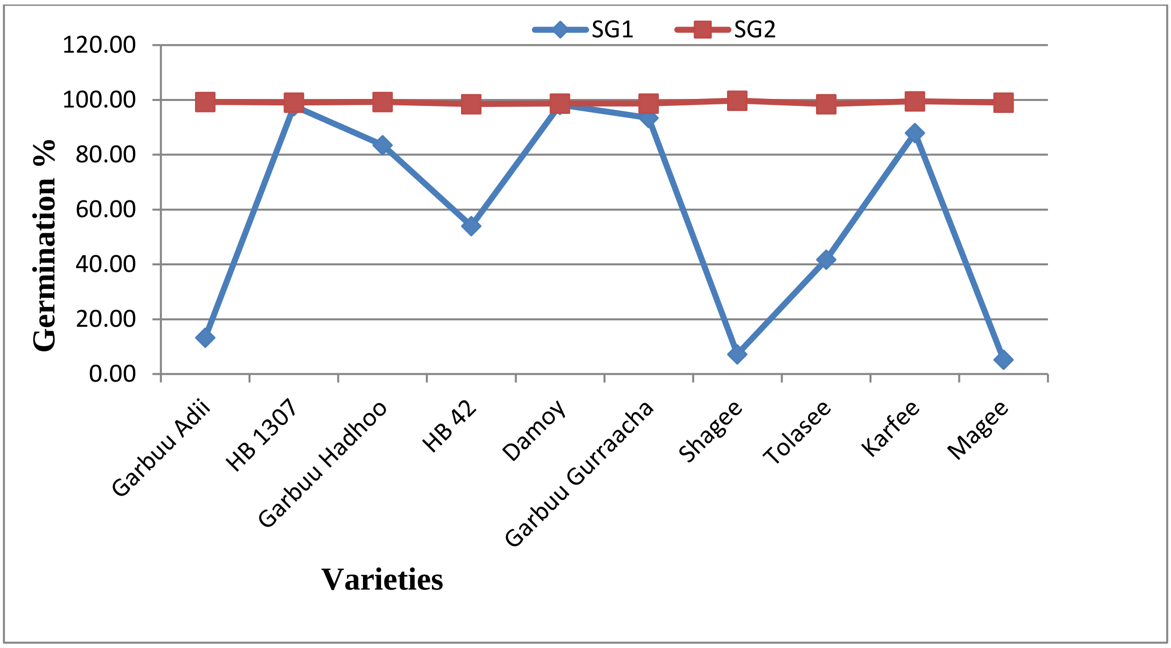
Significant in seed germination differences were observed between the first and the second time of analysis (Table 11). This study revealed that seed dormancy was broken after-ripening **(**dry storage**)** for four months although varieties had different in period of seed dormancy (Figure.4).

Accordingly, second germination testing was made after four months of harvest. During the second germination test, varieties mean differences for the trait ranged from 98.5% for *Tolese* and HB-42 to 99.75% *Shagee* (Figure 3). The result indicated that all varieties were above nationally recommended standard germination range after-dormancy break for four months and showed that dormancy was fully broken.

34.8 g. On the contrary, the highest seed weight was observed on *Magee* 46.8 gm followed by HB-1307 and *G/adii* (Table 10).

Hull thickness has an effect on barley seed germination as observed during threshing and de- hulling. Those varieties showed seed dormancy during germination test after one month of harvest owed thick hull character.

Following the various steps of seed maturation, the seed enters the situation of dormant or non-dormant status. Seeds were often dispersed from the parent plant with different levels of dormancy, linked to different conditions due to genotype effects and the environment during seed development. Frequently, this variation was also observed in seed color, seed size and coat thickness. Dormancy in many cases is observed



SG1=Standard Germination after one month of harvest SG2= Standard Germination after four month of harvest
Figure 4. Standard germination after one and four months after harvest

observed only in the intact seed, due to a coat imposed and/or embryo dormancy as (Bradrord *et al*., 2008).

At harvest, intact barley grains exhibited dormancy and germinate poorly. Bradrord *et al*. (2008) reported similar result that restriction to germination is attributable to the presence of the glumellae or hulls, as their removal or excision of the embryos greatly improves germination capacity. The restriction of germination by the hull has been attributed largely to its ability to reduce the availability of O_2 to the embryo (Lenoir *et al*., 1986). This was supported by using an O_2-time threshold model Bradford *et al*., (2008) quantified the base O_2 thresholds for germination of intact dormant barley seeds and excised embryos. Dormant seeds can slowly lose their dormancy by the process known as dormancy break, perhaps requiring as little time as a few weeks (e.g. barley), or as long as 60 months in the case of some weed species such as curly dock (*Rumex crispus)*. Speed of germination after dormancy break depends on the environmental conditions such as moisture, temperature and oxygen. Temperature can be used to accelerate the loss of dormancy in agriculturally important species such as barley, wheat and rice. Bradford *et al*. (2008) reported that germination rates and percentages improved following after dormancy break for both seeds and embryos .This finding was supported by five months of after dormancy break allowed almost complete germination of seeds in 21% O_2, but germination remained highly sensitive to O_2 percentage as (Bradrord *et al*., 2008).

The threshold O_2 percentage for germination of seeds decreased approximately 10-fold for every 5 months of after dormancy break. Similar changes occurred in germination of excised embryos following dormancy break. Thus, the major effect of after dormancy break in improving germination of both seeds and embryos was the reduction in the minimum O_2 threshold with less variation in thresholds among seeds also contributing to the more uniform germination following dormancy break (Bradrord *et al*., 2008).

Speed of germination

Mean difference in speed of germination ranged from 18.47 for HB-1307 and *Hadhoo* to 22.86 for *G/gurracha*. The others were in par for this trait. Least mean shoot length was observed on *Magee* while, *Hadhoo* was the highest in shoot length. Likewise, *G/gurraha* was the shortest in root length but *G/adii* was the longest (Table 11). The speed of germination measures the rate at which the seeds were germinating and those seedlings with higher index or highest germination were expected to show rapid germination and seedling emergence and to escape adverse field conditions.

Seedling shoots and roots length

Mean difference in seedling shoots length ranged from 13.15 cm for *Tolasee* and 16.69 cm for *Hadhoo* with grand mean of 15.19 cm. Moreover, *Hadhoo*, HB-1307 and *Damoy* were in par for this trait. Likewise, mean difference in root length ranged from 10.22 cm for *G/gurracha* to 13.59 cm for *G/adii* with grand mean of 12.25 cm. *Hadhoo,* HB42 *Damoy* and *Karfee* were in par for the trait considered (Table 11). HB1307, *G/gurracha, Hadhoo, Damoy* and *Karfee* showed longer in their shoot length and *G/adii, Hadhoo* and *Karfee* showed longer in their root length. Significant variations were observed among varieties for seedling shoots and root length at ($p<0.0001$). Seedlings with well-developed shoot and root systems would withstand any adverse conditions and provide better seedling emergence and seedling establishment in the field.

Table 11. Mean physiological quality (vigour) of barley seed from field experiments at Degem wereda 2010

Varieties	SG1 (%)	SG2 (%)	SPG	SL (cm)	RL(cm)	SDWT(g)	VIG1	VIG2	TKW
G/adii	13.25^{g}	99.25^{a}	19.76^{bc}	14.94^{b}	13.59^{a}	0.055^{ab}	2831.99^{bc}	5.23^{ab}	45.7^{b}
HB-1307	97.75^{ab}	99.00^{a}	18.47^{c}	16.56^{a}	11.67^{c}	0.032^{b}	2780.22^{bc}	3.23 ^{b}	46.2^{ab}
Hadhoo	83.50^{d}	99.25^{a}	18.48^{c}	16.69^{a}	13.25^{ab}	0.047^{ab}	2972.28 ^{a}	4.48^{ab}	42.1^{c}
HB-42	54.00^{e}	98.50^{a}	20.24^{b}	15.02^{b}	12.67^{b}	0.077^{a}	2729.25^{bc}	7.63 ^{a}	38.1^{e}
Damoy	98.25^{a}	98.75^{a}	22.46^{b}	16.19^{a}	12.90^{b}	0.025^{b}	2873.35^{ab}	2.47 ^{b}	30.7^{g}
G/gurrach	93.5^{b}	98.75^{a}	22.86^{a}	15.74^{ab}	10.22$_{d}$	0.055^{ab}	2564.94^{ef}	5.44^{ab}	40.2^{d}
Shagee	7.25^{h}	99.75^{a}	19.60^{bc}	14.61^{b}	11.67^{c}	0.047^{ab}	2621.91^{de}	4.74^{ab}	39.5^{d}
Tolasee	41.75^{f}	98.50^{a}	19.29^{bc}	13.15^{c}	11.84^{c}	0.075^{a}	2462.35 ^{f}	7.39 ^{a}	41.3^{c}
Karfee	88.00^{c}	99.50^{a}	20.25^{b}	15.65^{ab}	12.99^{ab}	0.032^{b}	2849.5^{abc}	7.68^{a}	34.8^{f}
Magee	5.25^{h}	99.00^{a}	20.25^{b}	13.31^{c}	11.84^{c}	0.075^{a}	2790.52^{ef}	3.23^{b}	46.8^{a}
Mean	58.25	99.02	20.16	15.19	12.25	0.052	2117	5.15	40.58
CV (%)	5.3	0.9	5.13	3.35	3.54	52.15	3.57	52.16	2.68
R^2	0.99	0.2	0.7	0.8	0.86	0.37	0.79	0.37	0.95
Significance	<0.001	0.58	<0.001	<0.001	<0.001	0.06	<0.001	0.07	0.001

Means followed by a common letters with in a column are not significantly different from each other at P <0.05 according to Duncan's Multiple Range Test, SG1=Standard germination after one moth of harvest, SG2=Standard germination after four month of harvest, SPG=Speed of germination, SL (cm) =Shoot length, RL (cm) = Root length, SDWT (gm) =Shoot dry weight, VIG I= Vigor index I, VIG II= Vigor index II, TKW= Thousand kernel weight

Seed vigour test (Viguor Index I and Viguor Index II)

Mean difference in vigour index I ranged 2462.35 for Tolasee to 2972.28 for Hadhoo with grand mean of 2117. G/adii, HB1307, HB 42 and Karfee were in par for this trait. Hadhoo, Damoy and Kerfee showed higher vigor index I while Tolasee, Magee and G/gurracha were lower in vigor index I (Table 11). Significant variations were observed among varieties for vigour index I at (p<0.05). On the other hand, no significant difference observed among varieties for vigour index II at (p<0.05).

Varieties that had higher in speed of germination were generally considered more vigorous. Moreover, vigorous varieties could be stored for longer periods without loss of germination. Vigor tests measure the potential for rapid, uniform emergence of seeds under a wide range of field conditions (Elias et al., 2011). Its results may be more closely associated with field emergence than the standard germination test (Elias et al., 2006). Therefore, if 2 varieties have equal germinations, the one with the lower vigor might be considered for first use, because the germination of this lot will likely decrease faster than a variety of higher vigor.

Mycological evaluation

The presence and type of fungi were determined according to their development on seed, which had been incubated on Potato Dextrose Agar (PDA) medium. Accordingly, sixteen different fungi genera were identified. Their importance, in relation to their occurrence were Helmithosporium sativum, Helminthosporum teres, Fusarium graminarum, Fusarium oxysporum, Fusarium avenacerum, Cladosporium spp., and Stemphylium sp.. In addition, storage fungi associated to barley seed were also Identified, which include penicillium spp., Trichoderma

Table 12. Fungi detected on Food barley seed collected from Degem wereda in 2010

Fungi	Percentage of pathogen observed on different varieties										
	G/Adii	**HB 1307**	***Hadhoo***	**HB 42**	***Damoy***	***G/gurraacha***	***Shagee***	***Tolasee***	***Karfee***	***Magee***	**Mean**
HS	0.00	2.00	0.00	1.80	1.80	2.00	0.30	0.80	0.50	0.30	0.93
HT	0.30	0.00	0.30	0.80	1.00	0.00	0.00	0.30	0.00	0.00	0.25
FG	1.00	2.30	1.80	0.30	0.50	3.30	5.30	2.00	0.00	2.50	1.88
FO	0.30	0.50	2.00	1.00	0.80	0.80	1.00	0.50	0.30	1.80	0.88
FA	0.00	0.00	9.50	1.00	28.80	2.00	0.80	8.50	0.00	7.30	5.78
Fus	6.50	8.00	6.00	0.80	0.50	4.00	3.00	4.30	1.50	5.30	3.98
CL	0.50	0.30	1.00	0.30	0.80	1.30	0.00	0.50	0.00	1.30	0.58
AL	0.00	1.80	0.00	5.80	0.80	1.00	3.30	0.00	0.00	0.00	1.25
AS	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
CH	4.50	0.30	0.00	3.30	0.30	0.00	8.50	0.00	0.80	0.00	1.75
PE	1.50	8.30	3.50	4.00	1.80	6.50	0.00	3.00	0.30	7.00	3.58
TR	0.30	0.00	1.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.15
PH	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	51.50	0.00	20.70
BO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.03
RH	0.00	0.00	0.00	1.00	0.30	0.00	0.00	2.30	0.00	1.00	0.45
ST	0.30	1.00	0.30	1.00	1.80	0.30	0.50	0.30	1.50	0.00	0.68
Mean	0.98	1.52	1.61	1.30	2.44	1.31	1.41	1.39	3.52	1.66	2.68

HS=*Helmithosporium sativum,* HT=*Helminthosporum teres*, FG=*Fusarium graminarum*, FO=*Fusarium oxysporum*, FA=*Fusarium avenacerum, CL=Cladosporium, AL=Alternaria, BO=Botryodiplodia, PH=Phoma,* ST= *Stemphyliu*m, *PE=Penicillium, TR=Trichoderma, AS=Aspergillus,* CH=*Chaetomiu*m Rh**=***Rhinchosporium scalis* and Fus= *Fusarium spp*

sp., Aspergillus spp. and Chaetomium funicola (Table 12).

The result indicated that high incidence of facultative fungal such as, Fusarium avenacerum and Phoma spp. and low incidence of field fungi like Botryodiplodia, Aspergillus, and Trichoderma. Species of Fusarium were commonly occurring as seedborne fungi and responsible for causing seed decay and seedling mortality. Likewise, some diseases were also observed in large number on different varieties. This showed that there was differential occurrence of some fungi on varieties tested. The mean difference between varieties showed that karfee (3.52%) was highly infected followed by Damoy (2.44%) while G/adii 0.98%) was the least affected (Table 12). HB-1307, HB-42, Damoy and G/gurracha were more infected by Helmithosporium sativum, while Shagee, G/gurracha

Table 13. Mean difference seed transmitted pathogen observed on seed collected from field experiment at Degem 2010

Varieties	**HS(Ω)**	**HT(Ω)**	**FG(Ω)**	**FO(Ω)**	**FA(Ω)**	**PH(Ω)**	**RH(Ω)**	**F.sp(Ω)**
G/adii	0.48^{b}	0.65^{bc}	1.00^{a}	1.0^{cdef}	0.66^{b}	1.42^{c}	0.66^{b}	0.48^{b}
HB1307	1.58^{a}	0.48^{c}	2.3^{bcd}	1.5^{abcd}	0.83^{ab}	2.68^{a}	0.48^{b}	0.48^{b}
Hadhoo	0.48^{b}	0.65^{bc}	1.8^{bcd}	1.4^{bcde}	1.56^{a}	1.99^{abc}	0.48^{b}	0.48^{b}
HB42	1.53^{a}	1.01^{ab}	0.25^{cd}	0.65^{ef}	1.13^{ab}	1.83^{bc}	0.48^{b}	0.48^{b}
Damoy	1.53^{a}	1.12^{a}	0.5^{cd}	0.83^{def}	0.95^{ab}	1.50^{c}	0.48^{b}	0.48^{b}
G/gurracha	1.62^{a}	0.48^{c}	3.25^{ab}	1.98^{ab}	0.95^{ab}	2.52^{ab}	0.48^{b}	0.48^{b}
Shagee	0.65^{b}	0.48^{c}	5.25^{a}	2.27^{a}	1.03^{ab}	0.48^{d}	0.48^{b}	0.48^{b}
Tolasee	0.95^{b}	0.65^{bc}	2.0^{bcd}	1.6^{abcd}	0.77^{b}	1.95^{abc}	0.48^{b}	0.48^{b}
Karfee	0.83^{b}	0.48^{c}	0.00^{d}	0.48^{f}	0.66^{b}	0.66^{d}	4.62^{a}	0.48^{b}
Magee	0.65^{b}	0.48^{c}	2.5^{bc}	1.76^{abc}	1.38^{ab}	2.67^{a}	0.48^{b}	0.66^{a}
Mean	1.03	0.65	1.87	1.35	0.99	1.76	0.91	0.49
CV%	33	41.7	85.86	40.59	54.56	28.64	16	22.55
Signficance	<0.0001	0.0105	0.0023	0.0007	0.3279	<0.0001	<0.0001	0.4612

(Ω)= Data was transformed by arc sine; HS=*Helmithosporium sativum,* HT=*Helminthosporum teres*, FG=*Fusarium graminarum*, FO=*Fusarium oxysporum*, FA=*Fusarium avenacerum, PH= Phoma, and F.sp= Fusarium sp*

Table 14. Mean difference seed deteriorating pathogen observed on seed collected from field experiment at Degem 2010

Varieties	CH✋	PE✋	TR✋	BO✋	RH✋	CL✋	AL✋
G/adii	0.48^{e}	0.77^{ab}	2.29^{a}	0.66^{b}	0.66^{b}	0.48^{d}	0.83^{ab}
HB1307	1.5^{bc}	0.48^{b}	0.65^{b}	0.48^{b}	0.48^{b}	0.48^{d}	0.66^{ab}
Hadhoo	0.48^{e}	0.83^{a}	0.48^{b}	1.13^{a}	0.48^{b}	2.99^{b}	1.13^{ab}
HB42	2.51^{a}	0.48^{b}	1.18^{b}	0.48^{b}	0.48^{b}	1.13^{b}	0.66^{ab}
Damoy	1.01^{d}	0.48^{b}	0.65^{b}	0.65^{b}	0.48^{b}	3.81^{a}	0.95^{ab}
G/gurracha	1.13^{cd}	0.48^{b}	0.48^{b}	0.48^{b}	0.48^{b}	1.33^{c}	1.14^{ab}
Shagee	1.92^{b}	0.48^{b}	2.87^{a}	0.48^{b}	0.48^{b}	0.95^{cd}	0.48^{b}
Tolasee	0.48^{e}	0.48^{b}	0.48^{b}	0.48^{b}	0.48^{b}	2.84^{b}	0.77^{ab}
Karfee	0.48^{e}	0.48^{b}	0.85^{b}	0.48^{b}	4.62^{a}	0.48^{d}	0.48^{b}
Magee	0.48^{e}	0.48^{b}	0.48^{b}	0.48^{b}	0.48^{b}	2.72^{b}	1.24^{a}
Mean	1.04	0.54	1.04	0.58	0.75	1.72	0.83
CV%	28.15	41.47	56	39.97	26.64	29	56.67
Signficance	<0.0001	0.2013	<0.0001	0.005	<0.0001	<0.0001	0.2539

✋= Data was transformed by arc-sine transformation, *CH= Chaetomium, PE= Penicillium, TR= Trichoderma BO= Botrytis , RH= Rinchosporium , CL=Cladosporium AL=Alternaria*

and Magee were more infected by Fusarium oxysporum. Damoy, Hadhoo, Tolasee and Magee were more infected by Fusarium avenacerum (Table 12). In general significant different was observed between varieties for different seed-borne fungi. Similarly, Grando et al., (2005) reported that most of the FV's were found susceptible to scald (Rhynchosporium secalis Oud.), net blotch (Helminthosporium teres Sacc.), spot blotch (Helminthosporium sativum Pum.), leaf rust (Puccinia hordei Otth.) and lodging. Novak et al., (2001) also reported that difference in disease incidence were due to the ability of saprophytes to colonize, rapid germination of spores, quick hyphal invasion, high competitive nature, their ability to utilize a wide variety of substrates and their nutrient composition.

Among sixteen seed fungi observed, eight of them were known to be seed transmitted (Table 13). Seed transmitted pathogens are pathogen that can affect the yield in next production season and transmit pathogen to disease free environment. Therefore, to increase the planting values of the seed, treatment should be important to handle healthy seed for the next planting season.

Significant different in seed infection was observed on varieties. High Helminthosporium sativum was observed on G/gurracha, HB-1307, HB-42, and Damoy respectively. Helminthosporium teres was more observed on Damoy followed by HB-42. More Fusarium graminarum seed infection was observed on Shagee followed by Magee and HB-1307and Fusarium oxysporum was observed on Sahgee, Magee and Tolesee. Fusarium avenacerum was more observed on Hadhoo, HB- 42 and Magee (Table 13).

On the other hand, seven of the fungi were seed deteriorating pathogen (Table 14). These seed deteriorating fungi were affecting the planting value of the seed due to their deteriorating action. Seed infection was significant at ($p<0.001$) except for Penicillium, and Alternaria. Hence, appropriate seed handling should be made during pre-harvest and post-harvest operations to ensure quality seed system.

Heleminthosporium spp, H. teres, Rhynchosporium, Ustilago nuda, U. hordi, H. graminea are common barley seedborne disease in Ethiopia. Gebere et al., (1996) reported that net blotch, scald and leaf rust are the most three important barley diseases targeted for control. Of those, net blotch was an endemic disease to the most parts of the highlands of the country where barley is important. Similarly, Hundie et al., (2001) also reported that on farm average yield loss of 28-29% was accounted for net blotch and leaf rust infection.

CONCLUSIONS AND RECOMMENDATION

The presence of significant ($p<0.01$) variation among FVs' and improved varieties for all characters considered implies that there is high performance variability among genotypes tested. This result showed that variability were existed among FVs' and improved varieties tested for important quantitative traits indicating high potential for effective barley enhancement and/or for further manipulation of the genetic resources through mass selection as FVs' are good sources of genes for many desirable traits. Damoy is the earliest in heading, maturity and grain filling period followed by G/gurracha. These traits are the advantage to escape terminal moisture stress and good character to cope up with the rainfall variability.

The maximum yield was obtained from G/Gurracha. This indicates that minimum improvement should be vital for barley yield and yield related traits improvement. Damoy has been selected as the sole variety for belg season production in the study area for its early in heading, maturity and grain-filling period and require low moisture. Improvement should be vital for adopting this variety in an area of short rainfall so as to attain food security. Varieties differ in dormancy duration. Hence, dormancy behavior of the genotypes needs to be studied. Seed treatment and quarantine measure should have to be undertaken prior to seed delivery for the end-users to improve field planting value of the seed lots. Attention should be given to exploit variability of FVs' for varietal improvement and enhancement to attain food security. In general, Ethiopian barley FVs' is contributing as major sources of variability for selection and enhancement which has many advantages than improved varieties. Therefore, the available in variability is useful to design better effective selection strategies in FVs'.

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