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Performance evaluation of food barley (*Hordeum vulgare* L.) varieties for yield and related traits in mid altitude agro ecologies in Hadiya zone, southern Ethiopia

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Abstract
Barley is one of the most cereal crops in Ethiopia for production and consumption. Using unimproved and agro ecologically non-recommendable variety was one of the problems in the study area. The experiments were conducted at Wachemo University main station and Anlemo district in 2020 main cropping season to select and recommend the best performing and high yielding varieties. Five local and five improved varieties were evaluated in randomized complete block design with three replications. The analysis of variance revealed highly significant differences in each location, across location and location treatment interaction for most of the traits. Tikurgabs (4142.90 kg/ha), Hagala (3571.40 kg/ha) and HB-1307 (3809.50 kg/ha) were showed good performance in grain yield and other important agronomic traits in both locations followed by Shage (3023.80 kg/ha); suggested for further demonstration and popularization in the study area.

Keywords: evaluation, food barley, grain yield, improved varieties, local varieties

Introduction

Barley (*Hordeum vulgare* L.) is one of the cereal crops believed to be domesticated from closest wild relatives Hordeum Spontaneous which belong to the tribe Triticeae of the family Poaceae (Harlan, 1976; Martin *et al*., 2006) [18, 21]. It is a self-fertilized crop with a diploid chromosome (2n=2x=14) plant with a large haploid genome of 5.1 Gb. Barley is widely produced in the world and ranks fourth in production area next to wheat, rice and maize (FAO, 2016) [16]. Ethiopia is considered as one of the major Vavilovian gene centres for barley crops (Lakew *et al*., 1997) [20] and cultivated in wide ranges of environments.

Barley variety has been cultivated in diverse agro-ecologies in an area on which other cereal crops are not performing well (Martin *et al.*, 2006) [21]. Predominantly cultivated in altitude ranges of 2000 to 3000 masl (MoA, 1998) [22]. Ethiopia considers having a long history for the cultivation of barley as one of the major cereal crops, it was cultivated by the ancient ages as early as 3000 before Christ (Gamst, 1969) and it is the most important crop with total area coverage of 951,993.15 ha and total annual production 2,052,996400 kg in the main season (CSA, 2018). The area coverage of barley in Hadiya zone was 7,125.53 ha and its production was 15455822 kg with average productivity of 2170 kg ha^{-1} (CSA, 2016) [9]. Barley is used to producing and provide food in a short period of time because it is an early harvested crop and is a popular hunger breaker or relief crop during seasons of food shortage in some parts of the country (Baye and Berhane, 2006) and also a principal Belg season crop second to maize in area coverage and production (Birhanu *et al*., 2005; CSA, 2008) [8].

Barley is one of the most important staple food crops in Ethiopia, mainly used for human consumption (Birhanu *et al*., 2005) and also used as homemade food, fodder and beverage. The grain is used for the preparation of different foodstuffs in the country, such as malt products, *injera, basso, porridge, qolo*; and local drinks, such as *tela, Keneto, borde*, beer and the straw is used as animal feed.

Local varieties are an important element of crop genetic resources and valued by plant breeders because of diversity (a heterogeneous population), rarity (embodying unique traits) and exhibiting wide adaptation (Brush and Meng, 1998; FAO, 1998; Smale, 2006) [6, 11, 24]. In contrast to the genetic uniformity of modern cultivars, local varieties exhibited variation for all agronomic traits. Diversity and the existence of various traits in local varieties might allow them to cope with environmental stresses, which are very important for achieving yield stability (Zhu *et a*l., 2000) [29]. Local varieties have various traits which are used to select and improve yield and quality, among the important traits that could exist are earliness, high nutritional quality, disease and pest tolerance, tolerance to drought and other forms of abiotic stress and have useful characters for low input (Yaynu, 2011) [26].

The yield reduction of food barley variety in smallholder farmers in Ethiopia has been mainly using unimproved varieties, disease, poor agronomic practices, soil acidity in some region and weak weed management (Birhanu *et al*., 2005). Similarly, in the studied area the major constraints comprise the use of unimproved varieties, water lodging, and lack of substantial information for local varieties.

The existence of performance variability in local or improved varieties for important quantitative traits has a high potential for effective barley enhancement (Girma *et al*., 2014) [17]. Thus, before cultivating improved varieties to a certain area, evaluation of important yield components along the local variety is essential to select the best-fit variety. Even though, various kinds of local varieties have been cultivated and available in the study area, the efforts to assess the performance and agro-ecological suitability to the study area along improved varieties were limited. Hence, the present study was conducted to select and recommend

the best performing and high yielding varieties to the study areas.

Materials and Methods

Description of the Study Sites

The experiment was conducted during the 2020/21 main cropping season at the Wachemo University field site and Anlemo district. Wachemo University is located at Limo district, Southern Ethiopia situated at $7^0$14'to 7^0 45' N latitude and 37^0 5' to 37^0 to 50' E longitude about 232 km away south of the capital city of Addis Ababa and an altitude of 2106 masl. The mean annual rainfall is 1320 mm and the minimum and maximum annual temperatures are 12ºC, and 24ºC, respectively. Anlemo district is located at about 214 km away South of the capital city of Addis Ababa and its altitude is 2350 masl the mean annual rainfall ranges from 1001 to 1200 mm and its mean temperature is 25 ^{0}C. The main rainy season extends in both locations from June to September; whereas the maximum rainfall is received in the months of June, July and August.

Experimental Design and Treatments

The experimental materials comprise ten food barley varieties, of which, five local varieties are currently under production (Tukurgabs, Awodo, Wongara, Gichamo, Hagala) which were collected from farmers' stock and village markets. Five improved varieties (Cross-41/98, Shage, EH-1493, HB-1307 and Aridu12-60B) were collected from the Worabe Agricultural Research center. The experiments were conducted by a randomized complete block design (RCBD) with three replications. The experimental plots consisted of 6 rows of 2.5 m length and 0.2 m and 1.5 m between rows and blocks respectively. The Seed was sown at 125 kg ha^{-1}, while fertilizers were applied uniformly at a rate of 38/19/7 kg ha^{-1} N/P_2O_5/S, respectively for all locations. During sowing urea, was applied in split form half at sowing and stem elongation stages, respectively. Weed management and all other agronomic practices were carried out uniformly for all plots as required.

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

No	Varieties	Selection history	Desirable traits of the variety other than yield	Row type
1	Tikurgabs	Local variety		Two
2	Awodo	Local variety		Two
3	Wongera	Local variety		Two
4	Gichamo	Local variety		Six
5	Hagala	Local variety		Two
6	Shage	Released cultivar derived from a landrace accession # 3336 obtained from EIB through pure line selection	Good yield under low input conditions and tolerant to major leaf diseases	Six
7	HB1307	Released cultivar, a cross made at Holetta from Awura gebs-1/IBON 93/91	High yielding, lodging, leaf diseases resistant with good biomass yield and white seeded	Six
8	Aredu12-60B			Six
9	EH1493	Released cultivar, a cross made at Holetta from white sasa/ Composite 29//white sasa	High yielding, late maturing	Six
10	Cross-41/98	Released cultivar, cross made at Holetta from 50-16/3316-03// HB42/Alexis	High yielding, late maturing	Six

Source: WARC

Data collection

Days to Heading (DH): Recorded as the number of days from the emergence to the date on which 50 % of the plants in four central rows of a plot have produced their awns.

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.

Days to Maturity (DM): Recorded as the number of days from sowing to the stage when 75% of the plants in four central rows of a plot have reached maturity.

Grain Filling Period (GFP):- Number of days between days to flowering and days to physiological maturity.
Number of tillers per plant (NTPP) counting the number of tillers of ten plants in each plot and expressed its average

Spikes Length (SL): Spike length of the main tiller measured in cm from base to tip excluding the awns and expressed as an average of ten plants in a plot.

The number of seeds per plant (NSPP): Determined by counting the number of kernels produced on the main tiller of each plant and expressed as an average of ten plants in a plot.

Biomass Production Rate (BMPR): Computed by dividing the above- ground biomass yield by the number of days to physiological maturity and expressed as kg ha^{-1} day^{-1}.

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}.

Grain Yield (GY): Four central rows adjusted to 12.50 % moisture content expressed in kg ha^{-1}

Harvest Index (HI): Calculated as a ratio of the dry weight of the grain to dry weight of the total above- ground biomass yield and expressed as a percentage.

Thousand Kernel Weight (TKW): Weight in a gram of random sample of thousand seeds per plot.

Data Analysis: The data were subjected to analysis of variance using SAS software 2008 version 9.2 and Treatment means were separated using Duncan's Multiple Range Test (DMRT).

Results and Discussion

The analysis of variance was carried out to determine the main effect of varieties, locations and interaction on yield and other traits. There were highly significant differences ($p<0.01$) for all traits studied on both locations and location interaction (Table 2, 3 and 6). However, non-significant differences were observed for biomass productive rate and number of tillers per plant at WCU and Anlemo district respectively. The result is inlined with the finding of (Girma *et al*., 2015 and Dereje *et al*., 2019) [16, 10] that stated analysis of variance for farmers and improved varieties were highly significant for yield and yield components.

Table 2: Significance of mean square for 12 traits of barley varieties at Wachemo University main station in 2012/13 cropping season

SV	DF	HD	MD	GF	PH	SL	NTPP	NGPP	BMPR	BMY	TGW	HI	GY
REP	2	4.63	0.70	2.03	125.70	0.04	2.43	9.74	1569.71*	16451924.6**	0.44	13.21	128574.86
Varieties	9	211.84**	395.74**	67.04**	320.31ns	2.38**	19.38**	787.67**	445.57ns	13612704.7**	182.51**	123.66**	1638778.75**
Error	18	4.45	5.40	8.99	97.94	0.39	1.90	9.73	182.14	1972426.9	1.11	14.60	523129.84
Total	29												
CV(%)		3.02	2.25	8.94	8.07	7.01	19.50	6.92	7.96	8.03	2.51	14.34	15.87

Table 3: Significance of mean square for 12 traits of barley varieties at Anlemo district in 2012/13 cropping season

SV	DF	HD	MD	GF	PH	SL	NTPP	NGPP	BMPR	BMY	TGW	HI	GY
REP	2	0.23	0.23	0.23	0.00	0.15	0.23ns	9.64	185.95	1668027.21	0.54	20.85	414802.72*
Varieties	9	253.14**	409.70**	40.13ns	0.09**	3.93**	2.78ns	612.67**	904.43**	5678306.88ns	116.15**	185.22**	1774742.25**
Error	18	2.67	3.196296	7.9	0.00	0.43	1.15	13.57	177.88	2206198	0.24	12.89	142089.2
Total	29												
CV(%)		2.33	1.69	7.86	7.02	8.22	20.38	8.53	19.63	20.99	1.06	17.88	25.73

** = significant, Ns = not significant at $p<0.01$ probability levels; SV=source of variation, DF=degree of freedom, HD=heading date, MD=maturity date, PH=plant height, SL=spike length, NTPP=number of tillers per plant, NGPP=number of grain per plant, BMPR=biomass productive rate, BMY=biomass yield, TGW=thousand grain weight, HI=harvest index, GY=grain yield

The mean performance of barley varieties for phenological traits

Heading date, maturity date and grain filling periods were exhibited highly significant variation on both locations. The days for 50% flowering were ranged from 84 to 58 days with an average mean 70.03 days at Anlemo district whereas 80 to 58 days with its mean value of 69.73 days at the main station. Local varieties revealed variable heading dates than improved varieties. Days of maturity ranges from 124 to 89 days and 124 to 87 days with the mean value 105.77 and 103.3 days at Anlemo district and Wachemo university main station, respectively. The highest and the lowest maturity dates were recorded from local varieties 'Gichamo and Wongara', respectively. The variation for both heading and maturity dates was high among the tested varieties. However, it appears more apparent in the Local varieties. The variations among improved varieties were little and all showed medium maturing date whereas most local varieties showed early flowering and maturity dates. The grain filling period ranges from 40.33 to 30.33 days at Anlemo district and 44.67 to 26.00 days at Wachemo university main station with the mean of 35.73 and 33.57 days respectively. Both Gichamo and Wongara revealed long and short- grain filling periods in both locations respectively.

However, little variation and almost relatively short grain-filling periods were recorded among improved varieties. Similarly, the finding of (Girma *et al*., 2015) [16] showed improved varieties had little variation and low grain filling periods. 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, indicating that it needs to predict moisture periods to grow barley varieties in the studied area for local' varieties.

Table 4: Mean of farmers' and improved food barley varieties grown at Anlemo district for 2020 cropping season

Varieties	HD	MD	GF	PH	SL	NTPP	NGPP	BMPR	BMY	TGW	HI	GY
Tikurgabs	58.00f	96.00e	38.00	115.00a	7.88b	4.86	25.20d	103.33a	9905	52.50a	30.99a	3047.6a
Awodo	66.00e	97.33e	31.33	116.00a	10.00a	6.46	26.86d	64.67c	6286	52.38a	18.07cd	1142.9cd
Wongera	59.33e	89.67f	30.33	94.66bc	7.48b	5.53	28.46d	56.29c	5048	52.44a	24.63ab	1238.1cd
Gichamo	84.00a	124.33a	40.33	64.33d	6.24c	3.06	40.13c	51.26c	6381	49.36b	5.78e	361.9e
Hagala	59.33f	91.00f	31.66	124.00a	9.62a	5.86	30.73d	94.25ab	8571	49.30b	27.65a	2381.0b
Shage	78.00b	117.33b	39.33	92.73bc	8.18b	5.00	60.93a	55.23c	6476	45.64c	16.28cd	1047.6d
HB1307	69.00d	108.67d	39.66	92.66bc	7.04bc	4.60	52.80b	57.92c	6286	46.00c	28.24a	1809.5bc
Aredu12-60B	79.00b	114.00c	35.00	83.00c	8.17b	5.26	57.86ab	60.17c	6857	36.07f	12.92d	952.4de
EH1493	73.33c	109.33d	36.00	100.00b	7.15bc	5.93	54.53ab	71.44bc	7810	39.56d	15.83cd	1238.1cd
Cross41/98	74.33c	110.00d	35.66	88.66bc	8.30b	6.00	53.93b	64.84c	7143	38.13a	20.32bc	1428.6cd
Mean	70.03	105.767	35.73	97.10	8.01	5.26	43.14	67.93	7076.19	46.14	20.07	1464.76
CV%	2.33	1.69	7.86	7.09	8.22	20.38	8.53	19.63	20.99	1.06	17.88	25.73
LSD(0.05)	2.80	3.06	Ns	11.81	1.13	Ns	6.32	22.87	Ns	0.84	6.15	646.62

Means with similar letters in the same columns are not significantly different; Where, HD=heading date, MD=maturity date, PH=plant height, SL=spike length, NTPP=number of tillers per plant, NGPP=number of grain per plant, BMPR=biomass productive rate, BMY=biomass yield, TGW=thousand grain weight, HI=harvest index, GY=grain yield CV=coefficient of variation, LSD=least significant differenc

The mean performance of spike length, plant height and number of tillers

The mean for spike length ranged from 10.00 to 6.24 cm and 10.25 to 7.62 cm at Anlemo and WCU, respectively. The highest spike length and the lowest spike length were recorded from variety Awodo and Gichamo with the pool mean of 8.01cm at Anlemo whereas, at WCU, the highest spike length and the lowest spike length were recorded from Awodo and Wongara with an average mean of 8.96cm, respectively. Most local varieties revealed the longest spike length with few numbers of spikelets rather than improved varieties. The spike length among improved varieties ranged from 9.73 to 8.27 cm which showed little variation. The tallest plant length was obtained in Tikurgabs (137.53cm) followed by Shage (134.73 cm) and comparatively the smallest was recorded by Gichamo (104.133 cm), with the mean of (122.63 cm) at WCU. On the other hand, the tallest plant length was recorded with Hagala (124 cm) followed by Awodo (116 cm) and the shortest plant length was recorded on variety Gichamo (64.33 cm) at Anlemo district. The variation among varieties in each location was due to environmental variations. Most local varieties were thin and tallest length than improved varieties so that relatively susceptible for lodging. The improved varieties had relatively short with a strong stems. The result is in agreement with Fekadu (2010) who pointed out modern varieties showed a declining trend in plant height as compared to the local varieties.

Tiller numbers ranged from 10.06 to 4.06 and 6.47 to 3.06 with the pool mean of 7.06 and 5.26 at WCU and Anlemo district, respectively. The Variety Shage had greater tillers (10.06) followed by Cross 41/98 and EH1493 with their tiller numbers (9.87) at WCU whereas at Anlemo, Awodo had (6.47) followed by Cross41/98 (6) and least tillers were recorded by Gichamo (3.07). The highest tiller number among tested variety recorded at WCU location than Anlemo district. Generally, the highest tiller numbers were obtained among improved varieties.

The numbers of seeds per plant were ranged from 64 to 24 and 60.93 to 25.2 with the pool mean of 45.07 and 43.15 at WCU and Anlemo, respectively. The numbers of seeds per plants were high in both locations among improved varieties. The highest numbers of seed were recorded by Shage (64) followed by EH1493 (58.13) and the lowest numbers were recorded in a variety Tikurgabs (24) at the WCU location. Similarly Shage had a greater seed number per plant (60.93) at Anlemo district followed by Aredu12-60B (57.87). The result is inlined with Zeleke *et al.,* (2018) [28] who reported the highest seed numbers per plant were relatively high in improved varieties.

Table 5: Mean of farmers' and improved food barley varieties at WCU in 2012/13 cropping season

Varieties	HD	MD	GF	PH	SL	NTPP	NGPP	BMPR	BMY	TGW	HI	GY
Tikurgabs	58.67f	93.00de	34.33b	137.53	8.13cd	5.00cd	24.00c	182.56	16952bcd	51.61a	30.90b	5238.1ab
Awodo	64.00e	96.00d	32.00b	126.9	10.25a	8.13ab	26.13c	170.62	16381cde	51.27ab	24.99bcd	4095.2bc
Wongera	61.00ef	87.00f	26.00c	114.32	7.62d	4.06d	28.66c	162.14	14095e	49.76b	30.00b	4285.7bc
Gichamo	80.00a	124.67a	44.66a	104.13	9.07abc	4.06d	54.80b	162.96	20286a	46.43c	15.21e	3047.6c
Hagala	59.667f	91.00e	31.33b	116.20	10.13a	4.13d	27.33c	178.93	16286cde	44.71c	29.18bc	4761.9ab
Shage	78.00ab	111.33b	33.33b	134.73	9.73ab	10.06a	64.00a	171.02	19048ab	39.64d	26.44bcd	5000.0ab
HB1307	68.00d	104.00c	36.00b	128.53	8.26cd	7.13bc	54.80b	142.10	14762de	35.03e	39.54a	5809.5a
Aredu12-60B	78.00ab	110.00b	32.00b	117.40	8.26cd	8.26ab	55.46b	171.40	18857abc	31.97f	22.69cd	4285.7bc
Eh1493	74.00c	108.33b	34.33b	118.0	8.93bc	9.86a	58.13b	184.41	19971a	34.56e	22.48d	4476.2b
Cross41/98	76.00bc	107.67bc	31.66b	128.6	9.20abc	9.86a	57.33b	169.75	18286abc	33.50def	25.03bcd	4571.4ab
Mean	69.73	103.30	33.56	122.62	8.95	7.06	45.07	169.59	17492.4	41.85	26.64	4557.14
CV%	3.02	2.25	8.93	20.19	7.00	19.49	6.92	7.95	8.03	2.51	14.34	15.87
LSD(0.05)	3.61	3.98	5.14	Ns	1.07	2.36	5.35	Ns	2409.2	1.80	6.55	1240.7

Means with similar letters in the same columns are not significantly different; Where, HD=heading date, MD=maturity date, PH=plant height, SL=spike length, NTPP=number of tillers per plant, NGPP=number of grain per plant, BMPR=biomass productive rate, BMY=biomass yield, TGW=thousand grain weight, HI=harvest index, GY=grain yield CV=coefficient of variation, LSD=least significant differences

The mean of Biomass productive rate (BMPR) ranges from 103.33 kg/ha/day to 51.26 kg/ha/day with an average mean of 67.94 kg/ha/day at Anlemo. The greater BMPR was obtained from Tikur gabs (103.33kg/ha/day) followed by Hagala (94.25kg/ha/day) and the least was obtained from Gichamo (51.26 kg/ha/day). The mean of biomass ranged from 20286 kg/ha to 14095 kg/ha with a pool mean of 17492.4 kg/ha and 9905 kg/ha to 5048 kg/ha with the pool mean of 7076.19 kg/ha at WCU and Anlemo district, respectively. The highest biomass yield was obtained by Gichamo (20286 kg/ha) followed by Shage (19971 kg/ha) and the lowest BMY also recorded by Wongara (14095 kg/ha) at WCU, on the other hand at Anlemo, Tikurgabs showed the highest biomass yield (9905 kg/ha) followed by Hagala (8571 kg/ha) and the least was recorded from Wongara (5048kg/ha). The results of biomass yield revealed variable performances were recorded among the local varieties. In general, the highest biomass and grain yield performance was recorded among improved varieties. Similarly, Sinebo (2002) [23] reported that high biomass yield is essential to high grain yield production.

Thousand- grain weights ranged from 51.28 gram to 31.97 gram at WCU and 52.5 gram to 36.08 gram at Anlemo district with the grand mean of 41.81 gram and 46.14 gram, respectively. At both locations, Tikurgabs (51.28, 52.5gram) had greater thousand- grain weights whereas the least were recorded from Aredu12-60B (31.97, 36.06 grams). The highest mean for thousand- grain weights were obtained relatively among local varieties than improved varieties the reason might be local varieties of the studied were two-rowed which provides an opportunity for uniform seed setting. This is in line with Assaye *et al., (*2020)

The mean harvest index ranged from 39.54 to 15.22 with an average mean of 26.65 at WCU and 30.99 to 5.78 with the pool mean of 20.07 at Anlemo district. The highest men for harvest index was obtained from HB1307 (39.540) followed by Tikurgabs (30.90) and the smallest harvest index recorded from Gichamo (15.22) at WCU whereas at Anlemo

district the highest values were recorded from Tikur gabs (30.99) followed by HB1307 (28.24) but, the smallest value was recorded by Gichamo (5.78).

Grain yield revealed highly significant differences in both locations ($p<0.01$). The mean of grain yield ranged from 5809.5 kg/h to 3047.6 kg/ha with an average mean of 4557.142 kg/ha at WCU and at Anlemo district. On the other hand at WCU the mean ranged from 3047.6 kg/h to 361.9 kg/h with its average mean value of 1464.762 kg/h. At WCU the highest mean were recorded from HB1307 (5809.5 kg/h) followed by Tikurgabs (5238.1 kg/ha) but, the lowest grain yield was recorded in Gichamo (3047.6kg/ha) while at Anlemo district the highest mean was recorded by Tikur gabs (3047.6 kg/ha) followed by Hagala (2381.00 kg/ha) however, the lowest grain yield was recorded from Gichamo (361.90 kg/h). In general among the tested varieties relatively the highest grain yields were recorded among local varieties at Anlemo district whereas at WCU the highest grain yield was recorded from most of the improved varieties. This indicated that the tested varieties have different yield potentials in the different environments. The result is in agreement with (Girma *et al*., 2014) [17] who stated that farmers' varieties of food barley had good yield performance than improved varieties on low input farmer's conditions. Similarly, Jalata (2011) [19] reported that there was a differential yield performance among genotypes across testing environments mainly due to genotypic, genotypic, and environmental interaction.

Table 6: Significance of mean squares for 12 traits of barley varieties on both locations in 2012/13 cropping season

Source	Df	HD	MD	GF	PH	SL	NTPP	NSPP	BMPR	BMY	TGW	HI	GY
Loc	1	1.35ns	91.26**	70.42**	9809.93**	13.6**	48.6**	55.29*	154993.89**	1627455420**	275.93**	648.13**	143442180.0**
Rep	2	1.81ns	0.12ns	1.55ns	55.48ns	0.16ns	0.95ns	16.97ns	880.23*	9847857*	0.09ns	13.05ns	335366.6ns
Trt	9	460.4**	799.2**	93.53**	866.82ns	5.11ns	14.16ns	1361.1**	1072.72**	11409948**	286.27**	287.49**	2888227.1**
Trt(Rep)	18	4.26ns	3.82ns	7.79ns	58.24ns	0.41ns	1.32ns	10.14ns	231.50ns	2786951ns	0.34ns	20.98*	484870.6*
Loc*trt	9	4.61ns	6.23ns	13.64ns	384.06**	1.20*	8.01**	39.25*	277.29ns	7881056*	12.39**	21.39*	525291.4*

Where** = significant, Ns = not significant at $p<0.01$ probability levels; Df=degree of freedom, HD=heading date, MD=maturity day, GF= grain filing periods, PH=plant height, SL=spike length, NTPP= number of tillers per plant, NSPP=number of seeds per plant, BMPR=biomass productive rate, BMy=biomass yield, TGW=thousand grain weight, HI=harvest index, GY= grain yield. Loc=location, Rep=replication, Trt=treatment

The mean squares of the variances for combining locations and treatments were highly significant ($p<0.01$) for most of the traits study. On the other hand, the variances of Loc*Trt interactions showed high significance ($p<0.01$) for the number of tillers, thousand- grain weight, and significance (<0.05) for the numbers of seeds per plant, biomass yield, harvest index, and grain yield. However, non-significance differences for the rest treatments.

Combined mean performances of barley varieties for phonological traits across locations

Days to heading and maturity revealed significant variations among varieties and ranges from 82 to 58.33 days and 124.5 to 88.33 days with a grand mean of 69.88 and 104.53 days, respectively. Tikurgabs was the earliest to heading (58.33 days) followed by Wongara (60.17 days), similarly, the earliest for maturity was recorded from variety Wongara (88.33 days) followed by Tikurgabs (94.5 days) while Gichamo took the longest day for heading and maturity (82.00 days) and (124.5 days), respectively. All the local varieties of studied showed earliest for heading and maturity days except Gichamo while improved varieties showed medium days for both heading and maturity to this regard all improved varieties need early sowing than local varieties in the study area.

The Grain filling period ranged from 42.5 to 28.16 days with an average mean of 34.65 days. Gichamo took the longest (42.5days) while Wongara had short days to grain filling (28.16 days). Varieties with the shortest grain filling periods had the advantage to escape terminal moisture stress and good character to cope up with the rainfall variability in the study area.

The performance of yield related components across locations

Plant height ranges from 126.27 to 84.33 cm with an average mean of 109.84cm. Among the tested local varieties, Tikurgabs had the tallest plant length (126.27cm), while Gichamo revealed the smallest plant length (84.33 cm). On the other hand, among the improved varieties, Aredu12-60B showed the smallest plant length (100 cm) while Shage revealed the tallest plant length (113.67 cm).

Spike length revealed highly significant differences across locations the mean ranges from 10.12 to 7.55 cm with an average mean of 8.48 cm. Awodo had a large spike length (10.12cm) followed by Hagala (9.88 cm) while the smallest spike length was obtained from variety Wongara (7.55 cm). The result is in agree with (Azeb *et al.*, 2015) [2] who pointed out two- row varieties have a large spike length than six rows. Number of tillers per plant ranges from 7.93 to 3.57 with an average mean of 6.16. Cross41/98 revealed more tillers (7.93) followed by EH1493 (7.9), while the least tiller number was recorded by Gichamo (3.57). Among local varieties, Awodo had more tiller numbers than the rest, however; all improved varieties had more tiller numbers with related performance.

Table 7: Combined mean of 12traitsfor barley varieties at both locations in2012/13 cropping season

Trt	HD	MD	GF	PH	SL	NTPP	NGPP	BMPR	BMY	TGW	HI	GY
Tikurgabs	58.33f	94.50d	36.17bc	126.27	8.00	4.93	24.60e	142.94a	13428.6a	52.05a	30.95ab	4142.9a
Awodo	65.00e	96.67d	31.67d	121.43	10.12a	7.30	26.50de	117.64bc	11333.3bc	51.83a	21.53de	2619.0c
Wongera	60.17f	88.33f	28.167e	104.40	7.55d	4.80	28.57de	109.21cd	9571.4d	51.10a	27.31c	2761.9c
Gichamo	82.00a	124.50a	42.50a	84.33	7.65d	3.57	47.47c	107.10cd	13333.3a	47.89b	10.50g	1704.8d
Hagala	59.50f	91.00e	31.50de	120.10	9.88a	5.00	29.03d	136.59a	12428.6ab	47.00b	28.41bc	3571.4b
Shage	78.00b	114.33b	36.33bc	113.67	8.96b	7.53	62.47a	113.12bc	12761.9ab	42.64c	21.36de	3023.8c

HB1307	68.50d	106.33c	37.83b	110.50	7.65d	5.87	53.80b	100.01d	10523.8cd	40.51d	33.89a	3809.5ab
Aredu12-60B	78.50b	112.00b	33.50cd	100.20	8.22bcd	6.77	56.67b	115.79bcd	12857.1ab	34.02g	17.81f	2619.0c
Eh1493	73.67c	108.83c	35.17bc	109.03	8.04cd	7.90	56.33b	127.93ab	13890.5a	37.06e	19.16ef	2857.1c
Cross41/98	75.17c	108.83c	33.67cd	108.47	8.75bc	7.93	55.63b	117.29bc	12714.3ab	35.82f	22.68d	3000.0c
Mean	69.88	104.53	34.65	109.84	8.48	6.16	44.11	118.76	12284.29	43.99	23.36	3010.95
CV%	2.43	2.03	8.298	8.39	7.24	21.31	7.88	12.00	11.73	2.26	12.08	14.21
LSD(0.05)	2.04	2.52	3.46	Ns	0.74	Ns	4.18	17.17	1736.8	1.19	3.39	515.36

Means with similar letters in the same columns are not significantly different; Where, HD=heading date, MD=maturity date, PH=plant height, SL=spike length, NTPP=number of tillers per plant, NGPP=number of grain per plant, BMPR=biomass productive rate, BMY=biomass yield, TGW=thousand grain weight, HI=harvest index, GY=grain yield CV=coefficient of variation, LSD=least significant differences

The number of seeds per plant ranged from 62.47 to 24.6 with an average mean of 44.11. The highest seed numbers per plant were obtained in Shage (62.47) followed by Aredu12-60B (56.67) but, the least numbers resulted in Tikurgabs (24.6). In general among tested variety, all improved varieties showed high seed numbers per plant. Biomass productive rate revealed significant differences across location and treatment but, non-significance differences for location treatment interaction.

Biomass yield showed highly significant differences across location as well as location treatment interactions. The mean ranges from 13428.6 kg/ha to 9571.4 kg/ha with an average mean of 12284.29 kg/ha. The highest biomass mean was recorded by Tikurgabs (13428.6 kg/ha) followed by EH1493 (13890.50 kg/ha) while the least number was recorded in Wongara (9571.40 kg/ha). Thousand -grain yields showed highly significant differences among locations and varieties of the study. Its mean values ranged from 52.05gm to 34.02gm with an average mean of 43.99gm. The highest mean of thousand- grain weight obtained in Tikurgabs (52.05 gm) followed by Awodo (51.83 gm) while the smallest thousand- grain weight was recorded from Aredu12-60B (34.02gm). Among the tested varieties, all local varieties had the highest thousand- grain yield than improved varieties, this might be most local varieties were two-rowed and each spikelets had enough space to set seed with sufficient endosperm development whereas all improved varieties had more than two rows with a small seed.

Harvest index showed highly significant differences among location as well as treatment and interaction potential. The mean values ranged from 33.89 to 10.50 with an average mean value of 23.362. The highest mean for harvest index was obtained by HB1307 (33.89) followed by Tikurgabs (30.95), however, the lowest harvest index was recorded by Gichamo (10.50). Among the tested varieties, most local varieties had revealed the highest harvest index. Similarly, among improved varieties HB1307 showed the highest harvest index. Grain yield also revealed highly significant differences among location, treatment, and location treatment interaction. The mean value ranged from 4142.9 kg/ha to 1704.8 kg/ha with an average mean of 3010.952 kg/ha. The highest mean of grain yield was obtained in Tikurgabs (4142.9 kg/ha) followed by HB1307 (3809.50 kg/ha), while Gichamo showed the smallest grain yield (1704.80 kg/ha).

Conclusions and Recommendations

The analysis of variance for yield and other traits of studied at different locations revealed highly significant differences ($P<0.01$). Tikurgabs and Hagala had good performances in all important traits among local varieties. Similarly, among improved varieties, HB1307 and Shage had good performance for yield and yield components. The varieties Tikurgabs (4142.90 kg/ha), HB1307 (3809.50 kg/ha and Hagala (3571.40 kg/ha) had good performance in mean grain yield over both tested locations, respectively. Therefore, those varieties were recommended for wider scaling up at study areas to improve production and productivity. Attention should also be taken to conserve various kinds of local varieties with valuable genetic sources for further improvement.

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