Performance evaluation and yield stability test of released food barley *(Hordeum vulgare L.)* varieties in highland areas of Siltie and Gurage Zones

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ABSTRACT

Improved barley varieties under barley production were limited in study areas. Therefore, testing of food barley varieties including check over locations for their performance is of paramount important in identification of superior varieties for production. The experiments were conducted to identify high yielding and to determine the stability of the varieties, and specifically and widely adapted food barley varieties for the target areas. Combined analysis of variance showed highly significant (p<0.05) differences among the varieties in plant height, spike length and grain yield, indicating the existence of a genetic difference of barley varieties. The highest mean grain yield (3506.80 kg ha^{-1}) was obtained from variety Adosha and Robera (3279.20 kg ha^{-1}) but HB-1307 which was check variety gave the relatively lowest mean grain yield (2465 ha^{-1}). Regarding Wricke's (Wi2), cultivar superiority measure (Pi) and CVi stability parameters, varieties Adosha and Tiret with lowest value were considered to be stable, showed wider adaptation and ranked best mean grain yield and were 1st and 4th, respectively; whereas HB-1307 and EH-1493 with higher value were unstable and shows specific adaptation. A large portion of the total sum of squares taken by genotype by environment interaction (GEI) (69.91%) shown there is vulnerability of grain yield to the influence of GEI. The highest yielding genotypes Robera and Adosha were winning over the environments; the existence of different winning genotypes in different environments confirmed the presence of crossover type of GEI. Therefore, the results suggested that the varieties Robera, Adosha and Cross-41/98 with other recommended management practices have to be promoted to the study areas and similar agro ecologies.

Keywords: Barley, Grain yield, Variety, Stability.

INTRODUCTION

Barley has been produced, since ancient times as staple food crops in the highlands of Ethiopia (MoA, 2019). It has great importance in social, food habit and malting purpose in the country. At the national level in 2015/16 cropping season, 944,401.34 ha of land is covered by food and malt barley and over 1856704.28 tons are produced. Major constraints affecting barely productivity are inadequacy of broadly adapted, high yielding, disease and insect resistant varieties; the weather conditions varying between seasons and locations; low level of crop management practices; the increasingly dwindling soil fertility situation, incidence of erratic diseases and insect pests, and escalation of climatic changes are growing concerns for barely production in Ethiopia. However, so far, studies on evaluation on food barley varieties in the study areas are limited (Hussein et al., 2000). Therefore, evaluating food barley varieties for their performance is a paramount important in identification of superior varieties for production. Hence the present study was initiated with the following objective: to identify high yielding and to determine the stability of the varieties, and identify specifically and widely adapted food barley varieties for the target areas (Eberhart and Russell, 1966).

MATERIALS AND METHODS

Description of the study area
The experiment was conducted under rain-fed conditions during the 2019 to 2020 for two years (June to December). The experimental sites are representing the major agro-ecologies of two and six-row food barley growing areas. In these areas, ensete, barley, wheat, horse beans and field peas are the main food crops, in descending order of importance. Cabbage (kale) and carrot are the major cash crops in both zones (Mamo, 2017).

Experimental materials and design
In this experiment 11 nationally released food barley varieties were used. These were Robera, Cross-41/98, Adosha, EH-1493, Abdane, Gutaa, Tiret, Biftu, HB-1965, HB-1966 and HB-1307 were selected based on year of release, performance in previous trials and the agro-ecologies for which they were released.
The experimental layout used was randomized complete block design with three replications.

Seed was hand drilled on plot consisting of six 2.5 m long rows spaced at 0.20 m apart with a plot area of 3 m^2. Spacing between blocks and plots was 1 m and 0.4 m, respectively. The middle four rows (2 m^2) were used for data collection. Seed was sown at 125 kg ha^{-1}, while fertilizers was applied uniformly at a rate of 38/19/7 kg ha^{-1} N/P2O5/S, respectively for all locations during sowing and urea was 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.

Data collection
Observations were made both on individual plants and plots in which the middle four rows were considered for plot and individual plant based data collection.

Tiller number per plant (TIPP): Was estimated from randomly taken area of 0.25 m^2 (0.5 m × 0.5 m) by counting the number of plants after emergence and number of plants bearing fertile spike at maturity and considered their difference as tiller number.

Plant height (PH) (cm): Height of five randomly taken plants from each plot was measured from the ground surface to the base of the main stem spike and the average was recorded (Mekiso and Getahun, 2016).

Spike length (SL) (cm): Length of spikes from five randomly taken plants from each plot was measured from the base to tip of the spike and the average was recorded.

Number of kernels per spike (NKS): Were recorded from randomly selected five plants in the four middle rows from each plot after threshing counted by hand and averaged.

Biomass yield (BM) (kg ha^{-1}): The total above ground biological yield (grain and straw), of the 4 middle rows was recorded for each plot after carefully sun drying the whole above ground harvested plants for three days (Francis and Kannenberg, 1978).

Thousand kernels weight (TKW) (gm): Was obtained by carefully counting 500 kernels samples from each plot and weighing on sophisticated sensitive balance after adjusted to the standard moisture content (12.50%) and then multiplying the result by two.

Grain yield (GY) (kg/ha): Was estimated by harvesting the middle four rows and adjusting the yield to standard moisture content 12.50% when the crop reached its physiological

maturity and the average value was calculated and recorded.

Adjusted grain yield (kg/plot)=

100-GMC*(Yield per plot)
  100-SMC (12.5%)

Where, GMC is moisture content of grain yield at harvest, SMC is standard moisture content.

Statistical data analysis

The data on 7 quantitative traits, including phenologic traits growth parameters plant height, spike length, tillers per plant, grain yield and yield components Number of kernels per spike, biomass yield, and thousand kernel weight were subjected to the analyses. Analysis of variance of data from combined over locations were conducted for all quantitative traits using SAS computer program using the models (Gomez and Gomez, 1984). The significance of differences among means was compared by DMRT (Duncan's multiple range tests) at a probability level of 5%. The following RCBD ANOVA statistical model was used at each environment: $Y_{ij}=\mu+G_i+B_j+e_{ij}$, Where, Y_{ij}=observed value of genotype i in block j, μ is the grand mean of the experiment, G_i=the effect of genotype i, B_j=the effect of block j, e_{ij}=error effect of genotype i in block j.

The model by Eberhart and Russell (1966), $Y_{ij}=\mu_i+\beta_iI_j+\delta_{ij}$, define stability parameters that may be used to describe the performance of a variety over a series of environments. Y_{ij} is the varieties mean of the ith variety at the jth environment, μ_i is the ith variety means over all environments, β_i is the regression coefficient that measures the response of the ith variety to varying environments, δ_{ij} is the deviation from regression of the ith variety at the jth environment, I_j is the environmental index. Shukula stability variance (σ_i^2) was computed, where varieties with minimum values are considered stable.

Stability was also measured by combining the mean yield and coefficient of variation (CV_i) by Francis and Kannenberg's, 1978. Ecovalence (W_i^2) suggested by Wricke (1962) and cultivar/environmental superiority measure (P_i) were computed to further describe stability. Statistical AMMI analysis of grain yield the AMMI model's IPCA1 and IPCA2 scores and GGE biplot for each variety were computed (Gauch and Zobel, 1997).

RESULTS AND DISCUSSION

A significant variation was found among the food barley varieties in plant height, spike length, number of kernels, thousand kernel weights and grain yield at Alicho wuriro; plant height and grain yield at Endegagn and all parameters except number of tillers per plant at Geta district (Gauch and Zobel, 1988). The highest mean grain yield of the varieties Robera, Adosha and Abdane (3772.30, 3523.90 and 3160.70 kg ha^{-1}) was obtained at Alicho wuriro district. The highest grain yield was obtained by variety Robera followed by Adosha have yield advantage of 83.17% and 71.10% over the check (HB-1307). The highest mean grain yield of the varieties HB-1966, EH-1493 and HB-1307 (3652.30, 3614.40 and 3592.00 kg ha^{-1}) was obtained at Endegagn district. The highest grain yield was obtained by variety Robera followed by Adosha have yield advantage of 1.68% and 0.62% over the check (HB-1307). The highest mean grain yield of the varieties Cross -41/98, Adosha and Gutaa (4080.10, 3701.40 and 3632.40 kg ha^{-1}) was obtained in Geta district. The highest grain yield was obtained by variety Cross-41/98 followed by Adosha have yield advantage of 134.06% and 112.30% over the check (HB-1307) (Table 1A).

Plant height of the varieties was ranged from 53.57 (HB-1307) at Alicho wuriro to 97.33 cm (Abdane) at Alicho wuriro whereas thousand seed weight also ranged from 26.52 (Adosha) at Endegagn to 56.70 gm. Generally, Endegagn had better grand mean performance in grain yield for food barley production despite the need for testing across seasons (Table 1B).

In Table 2 indicated that combined analysis of variance showed highly significant ($p<0.05$) differences among the varieties in plant height, spike length and grain yield, indicating the existence of a genetic difference of barley varieties. The tallest mean plant height was recorded by Tiret (87.70 cm), while HB-1307 was the shortest (61.31 cm) which was below the grand mean among the tested varieties. Even though analysis of variance showed no significant difference among varieties, thousand kernel weights ranged from variety HB-1307 (37.54 gram) to Cross-41/98 (49.33 gram) was obtained, respectively. The highest mean grain yield (3506.80 kg ha^{-1}) was obtained from variety Adosha followed by Robera (3279.20 kg

ha^{-1}) but HB-1307 which was check variety gave the relatively lowest mean grain yield (2465 ha^{-1}) in the two cropping years. This result is supported by the finding of the same study which reported that varieties differ in grain yield (Teshome, 2017) (Tables 1-A and 1-B).

Stability analysis

After testing the significance of GEI mean square in combined ANOVA, stability analysis was conducted for grain yield using means of genotype in each location. SAS (Hussein et al., 2000) was used to conduct stability analysis (Table 2). Regarding Wricke's (Wi2) stability parameter, varieties G7, G3 and G8 with lowest Wricke's Eco valence were considered to be stable as they contribute 74826.92, 172839.70 and 186231.10% to the interaction sum of squares, showed wider adaptation and G3 and G7 were ranked best mean grain yield and were 1st and 4th, respectively; whereas G11, G1 and G2 with higher Wricke's Eco valence value were unstable and made the highest contributions 1610214, 1153793 and 1114903% to GEI with higher average grain yield than grand mean except G11 and shows specific adaptation. However, cultivar superiority measure (Pi) depicted G3, G7 and G1 as stable, indicating wider adaptation across the environments; whereas G11, G5 and G4 were the most unstable varieties, respectively that showed limited adaptation. Parameter CVi, varieties G7, G3 and G8 were stable and had the lowest CVi, but higher grain yield than grand mean except G8, whereas G11, G2 and G4 with the highest CVi values had low yield performances, indicating unstable varieties. Accordingly varieties G3, G1, G2 and G7 the highest yielding varieties over all environments had linear regression coefficient of -0.73, -4.33, 1.45 and 0.23, respectively. Varieties with the lowest bi; G1, G5 and G3 were more adapted to marginal environments, whereas G11, G4 and G10 were input sensitive adapted to ideal environments for selecting varieties with specific adaptation (Table 3).

AMMI analysis of GEI

The proportion of sum of square of the treatment accounted for environment, genotype and GxE (Table 4). In the case of grain yield, the result showed that the variation explained by GEI was 69.91%, varieties took 25.99% and environment had shared 4.10% total sum of square. This result is in agreement with the findings of Gauch and Zobel (1997) who found significant differences among the genotypes, environment and GEI effects variation in barley grain yield. A large portion of the total sum of squares taken by GEI shown there is vulnerability of grain yield to the influence of GEI. The GEI was further partitioned by PCA. It is evident from Table 3 that using biplot in interactions was very limited where the first IPCA axes explain 71.91% of the total interaction. The partitioning of %SS indicated that the interaction effect was a predominant source of variation followed by the variety and environment effect. The variety effect was approximately six times higher than environment, which suggests the possible existence of different variety groups (Crossa et al., 1990) (Figure 1).

In the graph (Figure 2), a polygon is formed by connecting the genotypes that are on the vertex, while the other genotypes are contained in the polygon. A graph includes many rays divides the biplot into several sectors and the winning genotype for each sector is the one located on the respective vertex (Yan and Tinker, 2006). The highest yielding genotypes G2, G3, G1, G6, G9 and G7 were winning in the environment Geta, with in the vertex G2 and G1, while G10 and G4 with vertex G11 genotypes were the winning and high yielding once in environment Endegagn. The highest yielding genotypes G1, G3 and G5 were winning in the environment Alicho wuriro, with in the vertex G1. The existence of different winning genotypes in different environments confirmed the presence of crossover type of GEI.

As shown in Figure 3, ranking genotypes relative to the ideal genotype is the use of GGE biplot. Genotypes found in the center of concentric circle on average environment coordinate x-axis designed to be equal to the longest vector of all genotypes and its projection on the average environment coordination y-axis was obviously zero that means it is absolutely stable (Wricke, 1962). Therefore, G3 is the ideal genotype (both stabile and high yielding) and G1, G6, G4, G7, G9 were the next ideal genotypes which were found near to Geta.

Table 1-A. Mean of different traits for 11 food barley varieties grown at three districts during 2019 to 2020.

Code of Variety	Alicho wuriro							Endegagn						
	PH	SL	NTP	BM	KNS	TKW	GY	PH	SL	NTP	BM	KNS	TKW	GY
G1	75.13abc	7.25a-d	3.33	9733.00	48cd	43.03abc	3772.3a	91.7ab	6.20	1.80	12133.0	37.44	28.58	2564.8d
G2	77.27ab	6.57cd	3.00	9733.00	51.5bcd	49.67a	2638.5abc	89.3ab	7.10	2.00	12133.0	42.44	43.70	2893.6cd
G3	75.63ab	6.4d	2.87	11067.00	50.5cd	42.67a-d	3523.9ab	70.4c	6.30	2.20	10533.0	49.89	26.52	3294.9bc
G4	69.8bcd	7.58a-d	2.53	11200.00	58.0abc	39.3bcd	2370.3bc	94.6ab	7.10	2.50	15733.0	49.22	44.08	3614.40a
G5	67.67cd	7.9ab	2.73	9067.00	46.17d	40.42bcd	3160.7abc	97.33a	6.40	2.20	10933.0	39.55	41.97	2963.8cd
G6	77.97a	6.93bcd	2.87	8533.00	52.67a-d	43.12abc	2779abc	93.5ab	6.20	1.90	10000.0	29.11	41.68	2977.3bcd
G7	76.63ab	8.21a	3.47	10267.00	48.83cd	38.82bcd	3091.9abc	96.13a	7.40	2.50	12000.0	42.11	47.42	3124.8a-d
G8	70.53a-d	8.17a	2.93	10667.00	5433a-d	37.42cd	2894.7abc	95.6ab	6.00	2.30	10133.0	38.55	28.77	3080.6a-d
G9	77.4ab	7.23a-d	4.27	11467.00	51.33a-d	45.73ab	2793.5abc	86.4b	6.70	2.00	11200.0	38.89	39.58	2838.0cd
G10	67.29d	7.77abc	3.10	9733.00	63.0a	42.25bcd	2557.3bc	90.4ab	6.30	2.60	15600.0	23.33	48.68	3652.3a
G11	53.57e	7.4a-d	2.60	6400.00	62.17ab	35.45d	2059.5c	94.5ab	6.40	3.00	15733.0	43.83	44.11	3592.0ab
Mean	71.73	7.4	3.06	9806	53.36	41.62	2876.52	90.89	6.60	2.28	12376.0	39.49	39.55	3145.2
CV%	6.23	9.68	25.6	21.47	12.31	10.33	24.46	6.02	9.54	22.97	32.31	33.15	33.02	11.59
LSD	7.61**	1.22*	1.33ns	3585.4ns	11.19*	7.32*	1198.10*	9.32**	1.07ns	0.89ns	6809ns	20.95ns	22.25ns	620.66**

NOTE: Means with similar letters are not significantly (p<0.05) different, ** highly significant at 0.01 and * significant and ns=not significant at 0.05 probability levels; PH=Plant height (cm), SL=Spike length (cm), NTP=tillers per plant, NKS=Number of kernels per spike, BM=Biomass (kg/ha), TKW=Thousand kernel weight (g/plot), GY=Grain yield (kg/ha); G1(Robera), G2(Cross-41/98), G3(Adosha), G4(EH-1493), G5(Abdane), G6(Gutaa), G7(Tiret), G8(Biftu), G9(HB-1965), G10(HB-1966) and G11(HB-1307).

Table 1-B. Mean of different traits for 11 food barley varieties grown.

Code of Variety	Geta						
	PH	SL	NTP	BM	KNS	TKW	GY
G1	90.22a	7.0a	2.11	10133.0a	50.17b	54.3a	3500.4abc
G2	88.44a	7.0a	2.11	11333.0a	49.0bc	54.63a	4080.10a
G3	90.56a	6.89a	1.89	11067.0a	55.67ab	51.47a	3701.4ab
G4	90.0a	8.33a	1.89	8533.0a	61.17ab	53.37a	2610.8bcd
G5	86.33a	7.67a	2.22	8667.0a	48.5bc	47.73a	2054.0d
G6	88.55a	6.89a	2.45	11467.0a	67.67a	56.3a	3632.4abc
G7	90.33a	8.0a	2.45	11200.0a	56.0ab	53.17a	3394.9abc
G8	90.89a	8.0a	2.22	10933.0a	54.17ab	55.27a	2484.9cd
G9	84.11a	6.78a	2.33	10267.0a	49.33bc	56.7a	3454.9abc
G10	92.78a	8.22a	2.33	10933.0a	59.50ab	53.77a	2692.3bcd
G11	75.35b	4.0b	0.78	4133.0b	35.5c	33.10b	1743.4d
Mean	84.40	7.16	2.07	9878.80	53.33	51.80	3031.73
CV%	12.1	16.58	25.91	17.95	15.92	10.22	23.05
LSD	17.39*	2.02**	0.91ns	3020.6**	14.46*	9.02**	1190.3**

NOTE: Means with similar letters are not significantly ($p < 0.05$) different, ** highly significant at 0.01 and * significant and ns=not significant at 0.05 probability levels; PH=Plant height (cm), SL=Spike length (cm), NTP=tillers per plant, NKS=Number of kernels per spike, BM=Biomass (kg/ha), TKW=Thousand kernel weight (g/plot), GY=Grain yield (kg/ha); G1(Robera), G2(Cross-41/98), G3(Adosha), G4(EH-1493), G5(Abdane), G6(Gutaa), G7(Tiret), G8(Biftu), G9(HB-1965), G10(HB-1966) and G11(HB-1307).

Table 2. Combined mean of different traits of 11 food barley varieties grown at three districts during 2019 to 2020.

Code of variety	PH (cm)	SL (cm)	NTP	BM (kg)	KNS	TKW (g)	GY (kg)
G1	85.70ab	6.82bcd	2.43	10667.00	45.20	41.97	3279.20ab
G2	84.99ab	6.90bc	2.37	11067.00	47.65	49.33	3204.10ab
G3	78.86b	6.64cd	2.32	10889.00	52.02	40.22	3506.80a
G4	84.80ab	7.68ab	2.32	11822.00	56.13	45.58	2865.20bc
G5	83.78ab	7.31abc	2.38	9556.00	44.74	43.37	2726.20bc
G6	86.66a	6.69cd	2.42	10000.00	49.81	47.03	3129.60ab
G7	87.70a	7.88a	2.81	11156.00	48.98	46.47	3203.90ab
G8	85.67ab	7.39abc	2.47	10578.00	49.02	40.48	2820.10bc
G9	82.64ab	6.90bc	2.87	10978.00	46.68	47.34	3028.60abc
G10	83.49ab	7.44abc	2.67	12089.00	48.61	48.23	2967.30abc
G11	61.31c	5.93d	2.13	8756.00	47.16	37.54	2465.00c
Mean	82.33	7.05	2.47	10686.87	48.73	44.33	3017.80
CV%	8.71	12.47	25.34	26.22	19.35	19.19	20.21
LSD	6.76**	0.83**	0.59ns	2642.60ns	8.89ns	8.02ns	575.14**

Table 3. The AMMI analysis of variances for grain yield of 11 food barley varieties across environments in 2019 to 2020 cropping season.

Source	DF	SS	MS	Fpr	% SS (Var+Env+Var × EN V)
Total	98	66461452	678178		
Treatment	32	39815037	1244220	3.34	
Variety	10	11830720	1183072	3.18	25.99
Environment	2	1298550	649275	0.90	4.10
Block	6	4325370	720895	1.94	
Interactions	20	26685768	1334288	3.59	69.91
IPCA1	11	21163025	1923911	5.17	71.91
IPCA2	9	5522743	613638	1.65	28.09
Residuals	0	0			
Error	60	22321045	372017		

Table 4. Mean grain yield and stability parameters for 11 food barley varieties.

Code of variety	Mean of yield kg/ha	Variation co-efficient CVi (%)	Eberhart and Russell (bi)	Shuckla's Variance δ2	Wricke's Ecovalence (Wi)	Superiority Measure (Pi)	Non parametric Nassar and Huehn	
							Si(1)	Si(2)
G1	3279.15	19.32	-4.33	667217	1153793	253104.3	5.67	26.5
G2	3204.09	24.01	1.45	643450.8	1114903	310146	3	19
G3	3506.77	5.81	-0.73	67745.6	172839.7	55,460.95	1.33	1.5
G4	2865.19	23.03	4.45	318823.3	583694	687599.7	4.67	17.5
G5	2726.19	21.66	-1.11	459864.0	814488	825503.2	2.33	13
G6	3129.59	14.27	1.02	182750.3	361029.2	273753	1.33	5.5
G7	3203.90	5.19	0.23	7848.9	74826.92	201,751.5	0.67	1
G8	2820.08	10.81	0.49	75929.25	186231.1	606918.4	1.33	4.5
G9	3028.60	12.20	0.41	132916.2	279482.5	335450.8	3	7
G10	2967.28	20.12	3.89	247297.1	466651.2	567036.4	4.67	17.5
G11	2464.95	40.11	5.25	946141.1	1610214	1399609	5.33	21.5

NOTE: Wi=Wricke's ecovalence, (Pi) Lin and Binns's cultivar performance measure, regression coefficient (bi), deviation from regression (S2d), CV=Coefficient Variability; G1(Robera), G2(Cross-41/98), G3(Adosha), G4(EH-1493), G5(Abdane), G6(Gutaa), G7(Tiret), G8(Biftu), G9(HB-1965), G10(HB-1966) and G11(HB-1307).
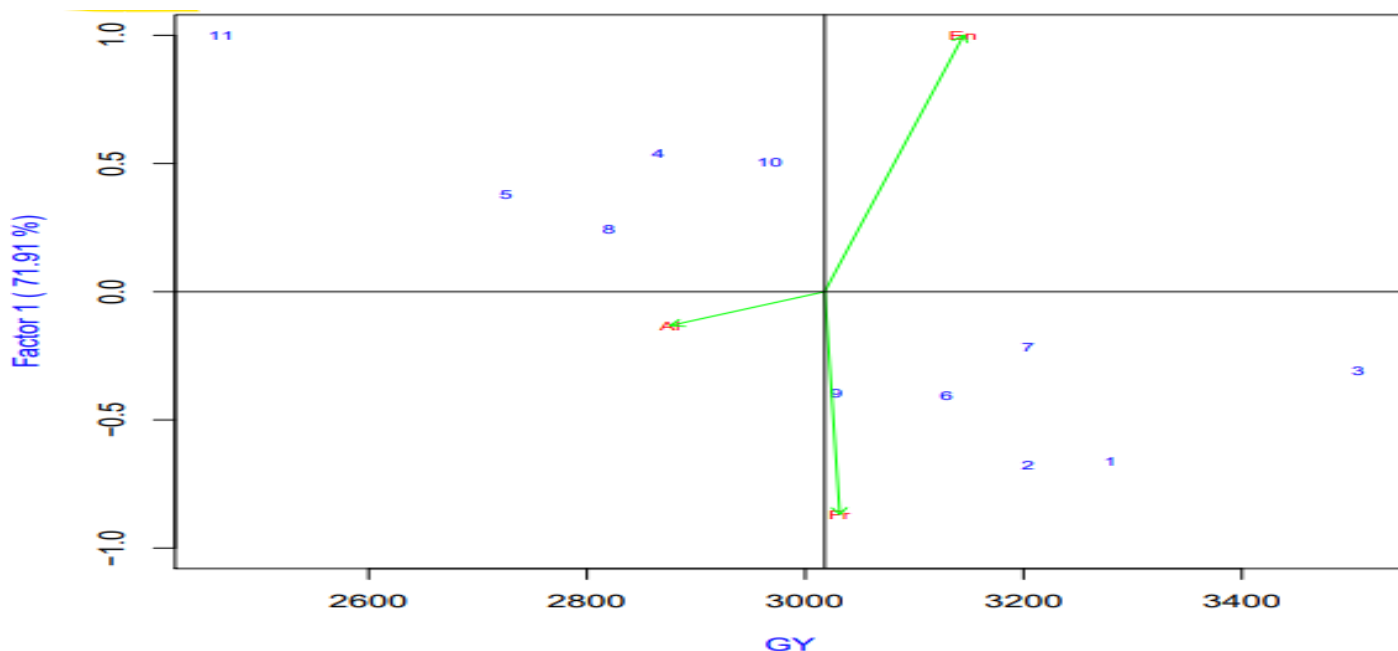
Figure 1. AMMI biplot of 11 Varieties and 3 environments for grain yield. **NOTE:** Where, Al=Alicho wuriro, En=Endegagn and Fr=Geta; G1(Robera), G2(Cross-41/98), G3(Adosha), G4(EH-1493), G5(Abdane), G6(Gutaa), G7(Tiret), G8(Biftu), G9(HB-1965), G10(HB-1966) and G11(HB-1307).

The GEI was further partitioned by PCA. It is evident from Table 3 that using biplot in interactions was very limited where the first IPCA axes explain 71.91 % of the total interaction.

The partitioning of %SS indicated that the interaction effect was a predominant source of variation followed by the variety and environment effect.

The variety effect was approximately six times higher than environment, which suggests the possible existence of different variety groups (Crossa et al., 1990) (Figures 1-3).

In the graph Figure 2, a polygon is formed by connecting the genotypes that are on the vertex, while the other genotypes are contained in the polygon.

A graph includes many rays divides the biplot into several sectors and the winning genotype for each sector is the one located on the respective vertex (Yan W and Tinker B, 2006).

The highest yielding genotypes G2, G3, G1, G6, G9 and G7 were winning in the environment Geta, with

in the vertex G2 and G1, while G10 and G4 with vertex G11 genotypes were the winning and high yielding once in environment Endegagn.

The highest yielding genotypes G1, G3 and G5 were winning in the environment Alicho wuriro, with in the vertex G1.

The existence of different winning genotypes in different environments confirmed the presence of crossover type of GEI. As shown in Figure 3, ranking genotypes relative to the ideal genotype is the use of GGE biplot.

Genotypes found in the center of concentric circle on average environment coordinate x-axis de-signed to be equal to the longest vector of all gen-otypes and its projection on the average environment coordination y-axis was obviously ze-ro that means it is absolutely stable (Wricke G, 1962).

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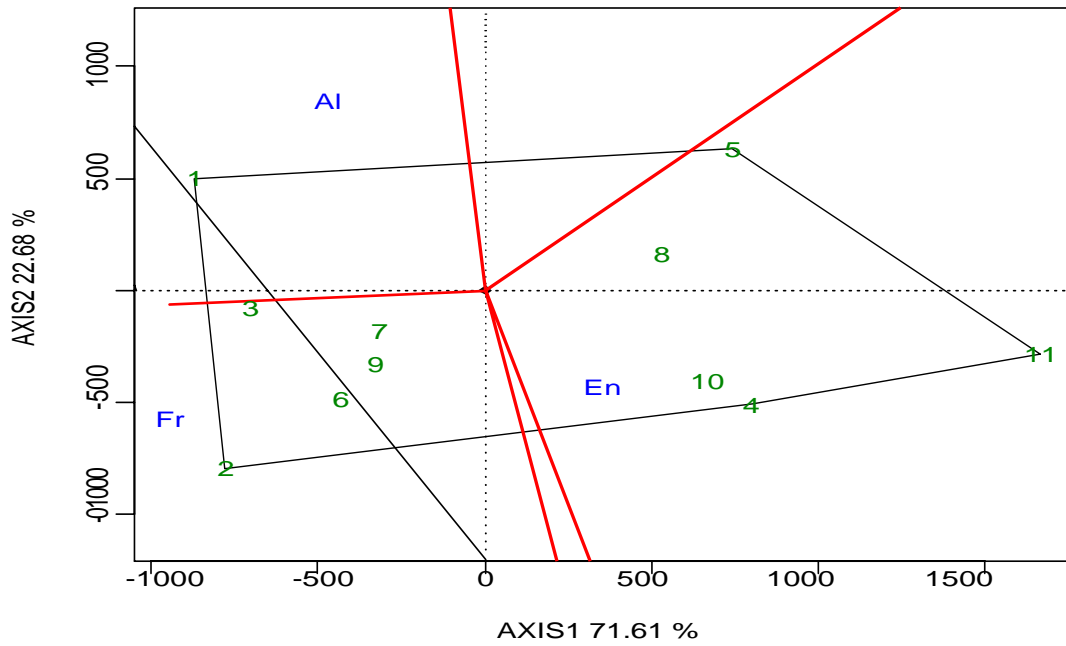
Which Won Where/What

Figure 2. The which–won–where view of the GGE biplot for grain yield food barley genotypes based on the E+G+G × E data. **NOTE:** Where, Al=Alicho Wuriro, En=Endegagn and Fr=Geta; G1(Robera), G2(Cross-41/98), G3(Adosha), G4(EH-1493), G5(Abdane), G6(Gutaa), G7(Tiret), G8(Biftu), G9(HB-1965), G10(HB-1966) and G11(HB-1307).
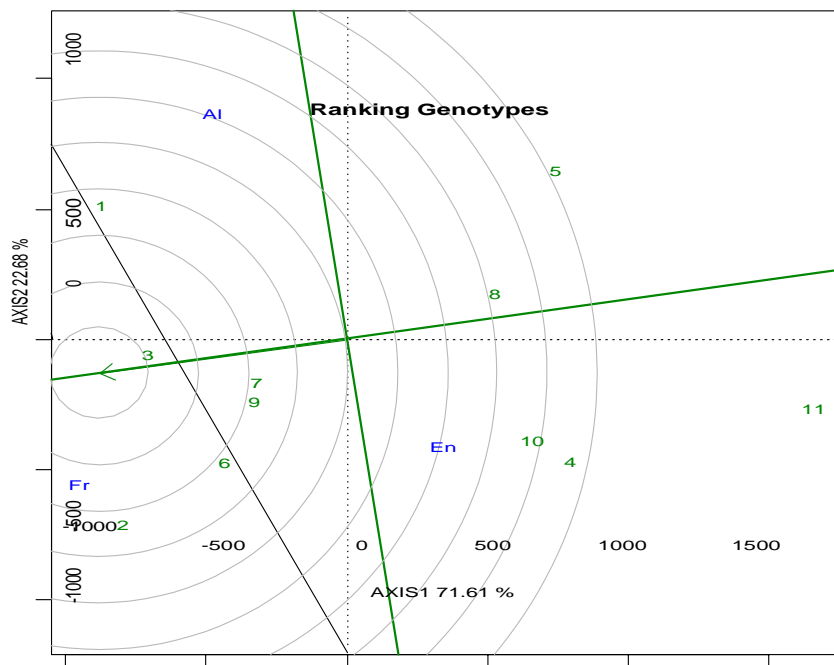

Figure 3. Ranking genotypes based on yield mean performance for barley E+G+EG. **NOTE:** Where, Al=Alicho wuriro, En=Endegagn and Fr=Fereze; G1(Robera), G2(Cross- 41/98), G3(Adosha), G4(EH-1493), G5(Abdane), G6(Gutaa), G7(Tiret), G8(Biftu), G9(HB-1965), G10(HB-1966) and G11(HB-1307).

CONCLUSION

Adaptability of 11 improved food barley varieties (Robera, Cross-41/98, Adosha, EH-1493, Abdane, Gutaa, Tiret, Biftu, HB-1965, HB-1966 and HB-1307as check) were evaluated at Alicho wuriro, Geta sub-testing site of Worabe Agricultural Research Centre and Endegagn district during 2019 and 2020 main cropping season.

Combined analysis of variance showed highly significant ($p < 0.05$) differences among the varieties in plant height, spike length and grain yield, indicating the existence of a genetic difference of barley varieties.

The highest mean grain yield (3506.80 kg ha^{-1}) was obtained from variety Adosha and Robera (3279.20 kg ha^{-1}) but HB-1307 which was check variety gave the relatively lowest mean grain yield (2465 ha^{-1}).

A large portion of the total sum of squares taken by GEI shown there is vulnerability of grain yield to the influence of GEI. The highest yielding genotypes (G2, G3, G1, G6, G9 and G7) were winning in the environment Geta, with in the vertex G2 and G1, while G10 and G4 with vertex G11 genotypes were the winning and high yielding once in environment Endegagn. The highest yielding genotypes G1, G3 and G5 were winning in the environment Alicho wuriro, with in the vertex G1.

The existence of different winning genotypes in different environments confirmed the presence of crossover type of GEI.

Therefore, based on its agronomic performances observed from this experiment variety Robera, Adosha and Cross-41/98 could be popularized and scaled up to the farming communities of the testing area and to the farmers of similar agro ecology.

Future research actions should also focus on the performance of the selected three varieties with regard to the agronomic management and their traits.

DECLARATION

CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the study design; in the collection, analysis, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

AUTHOR'S STATEMENTS

This research activity will help for food barely producer farmers and commercial producers to increase their wheat yield. The research result will also help for researcher who wants to do different research activities regarding food barely.

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