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Performance Evaluation and Stability Analysis of Malt Barley (*Hordeum distchon* L.) genotypes in West Shoa highlands, Central Ethiopia

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Abstract: *A total of ten malt barley varieties were evaluated to study their stability and yield performance, and the combined analysis showed significant differences (p<0.001). Variety HB-1963 showed promising results and preferred among the tested varieties. The combined locations' grain yield of the varieties ranged from 1824to 3303.5 Kgha-1, while the range was from 1824 to 3516.5 Kg ha-1. This shows that the effect of the environment on the yield of the varieties. The highest grain yield was recorded for EH-1847 followed by HB-1963, where the lowest yield was recorded for Bahati variety. The variety EH-1847 lacked stand uniformity and hence the variety HB-1963 is recommended for production in the study areas and areas with similar agro-ecologies. The principal component analysis of the varieties studied showed that the first two PCAs accounted for 90.47% of the total variability present within grain yield. Genotypes 4, 1, 9, and 10 are located near the origin and are likely to be stable among the varieties studied*

Keywords: *stability, malt, barley, yield, principal component analysis*

1. INTRODUCTION

Barley is a versatile crop used for different purposes and better produced on degraded soil than other cereal crops. It is grown over wide environmental conditions. Barley has been produced as a major cereal crop over a long period and it is the fourth important cereal crop of the globe after wheat, rice, and maize (FAO, 2005). It is one of the major cereal crops in Ethiopia with an area coverage of 926,106.9 hectares with a total production of 2,339,109.9 tonnes and ranks fifth in production following maize, wheat, teff, and sorghum. The productivity of barley is 2.53tha^{-1}, which has slightly increasing trend through the years (CSA, 2021).

Barley production makes Ethiopia among the top ten producers of the world. The country is one of the centers of diversity for the crop and it is estimated that there are about 16,000 barley accessions in the Ethiopian Biodiversity Institute. Ethiopian barley is given recognition for having typical botanical varieties. Besides, it has a group of interfertile lines distinguished by its spike patterns (Zemede Asfaw, 1988).

Barley is a highly resilient crop, which can be grown in various types of marginal environments, like in high altitude and latitude regions (Martin K. & Olga, 2018). The crop is the most dependable cereal and is cultivated on highly degraded soils of mountain slopes better than other cereal crops in the highlands of Ethiopia under extreme marginal conditions of drought, frost, and poor soil fertility (Ceccarelli *et al*.,1999).

The potential area for barley production, especially for malt barley maintaining an acceptable quality levels, is the altitude ranging from 2300 – 2800 masl. This altitudinal range is an ideal area for grain and other quality parameters of barley not only yield, since this area is accompanied by ample moisture with even distribution for efficient use of inputs and potential growth and productivity of the crop. The overall weather conditions determine the adaptability and yield performance of any crop. Climatic conditions represent major environmental variations like soil type, fertility, and moisture status of grain development. It is possible to evaluate comparable or nearly similar grain samples of genotypes within similar growing conditions (Začević V.*et al*.,2004).

The problem of crop breeding is the relationship between the target environment and selection, i.e whether the selection is for broad or specific adaptation (Ceccarelli, 1989). Hence, the adaptability study of barley varieties whether it is for wide or specific adaptation, was found imperative and released varieties of malt barley varieties were studied at different locations in the highlands of West Shoa with the objective of evaluating the yield performance and stability of malt barley varieties at different locations.

2. MATERIALS AND METHODS

Experimental design and materials:

A total of ten malt barley varieties (Fanaka, IBON-174/03, HB-1963, Miscal-21, Bekoji-I, Beka, Explorer, Bahati and HB-1964) were examined using RCBD in three replications at Mida-Kegn, Jibat, Cheliya and Dire-Inchini districts for their stability and yield performance. The trial was planted in six rows of 2.5m length each spaced with 0.2m inter-row spacing. The seeds were drilled at a rate of 100 $Kgha^{-1}$ and fertilizer was applied at a rate of 100 $Kgha^{-1}$ DAP and 50 $Kgha^{-1}$ UREA each. The trial was hand weeded twice for weed management and finally the four middle rows were harvested for yield data.

Data collection:

Data were collected for yield and traits contributing to yield viz. grain filling period (GFP), plant height (PlH), stand percent, spike length (SL), and grain yield (YLD) on plant and plot basis. On a plant basis, data were collected from five plants randomly selected from the four middle rows of each plot. The two side-rows were excluded as borders and the mean values of those five plants was computed and used as plot data for analysis, where the on plot basis data were collected from the four middle rows and finally harvested for the plot data. Spike length, plant height and number of kernels per spike were measured on plant basis; whereas days to 50% heading, days to physiological maturity, yield, and stand count were recorded on a plot basis.

Data analysis:

The analysis was done using PROC GLM in SAS software version 9.4 (Gomez and Gomez, 1984). Mean was separated using t-test.

3. RESULTS AND DISCUSSIONS

The combined ANOVA showed that the malt barley varieties showed highly significant differences statistically at ($p<0.001$) for the traits plant height and spike length and showed significance at ($p<0.01$) for the trait grain filling period. The varieties showed non-significance statistically for the traits grain yield and stand percent. The location-by variety interaction was also significantly different for the trait spike length, where it was non-significant for the other traits tested (Table 1).

Table 1: Analysis of variance (Mean squares) for malt barley characters measured in 2019 and 2020

		Mean Squares				
S.V	DF	PlH	GFP	Stand	SL	YLD
LOc	3	6976.8**	138.0*	6100.4**	1.2	3705632.0**
Gen	9	871.6**	45.1*	75.4	5.0**	49544.4
Loc X Gen	27	20.5	16.8	30.9	2.2**	44829.1
Error		16.5	7.3	140.4	0.1	18291.7
CV		4.7	4.4	14.8	4.7	24.3

The grain yield of the varieties for combined analysis over locations ranged from 1824 to 3303.5 $Kgha^{-1}$, where the highest yield was recorded for EH-1847 followed by HB-1963. Nevertheless, the range of yield of varieties for individual locations was from 1824 to 3516.5 $Kgha^{-1}$. This showed that there is an effect of environment on the yield performance of genotypes. It is important to take in to consideration the environmental conditions like edaphic factors, climate and others for the production and grain quality of barley crop (Buli &Ali, 2021).In this study, the stand percent of the varieties was

observed strongly correlating with the grain yield (Table 2). Varieties with high stand percent were also seen to be high in grain yield. This result is in agreement with a previous study of barley genotypes (Buli &Beyene, 2021).

Table 2: Malt barley parameters measured in 2019 and 2020 main growing season

Varieties	Mean Values				
	GFP	PlH	Stand	SL	YLD
Fanaka	61.3A	82.9B	81.7AB	6.9DE	499.5BCD
IBON-174/03	59.6BC	72.7C	81.4AB	6.6E	624.0A
HB-1963	61.2A	86.1B	86.9A	6.9DE	644.9A
Miscal-21	61.8A	86.3B	86.7A	7.1D	580.3ABC
Bejoji-I	59.0BC	93.0A	80.6AB	6.8DE	445.5DE
Beka	53.8E	84.8B	83.3AB	8.0B	439.8DE
Explorer	58.3CD	62.1D	78.3B	7.2CD	484.5CD
Bahati	56.8D	92.6A	87.0A	6.7E	364.8E
EH-1847	59.3BC	81.5B	82.9AB	7.6C	660.7A
HB-1964	60.3AB	83.8B	84.7AB	8.6A	593.6AB
Mean	59.2	82.6	83.4	6.4	533.8
LSD	1.6	5.6	7.5	0.4	105.6
CV	3.3	8.3	11.0	6.6	24.2

GGE biplot analysis is presented (Figures 1& 2) for grain yield using PCA1 and PCA2. The figure illustrates which genotype performs best where or which is the best in which environment.

Accordingly, genotypes 9, 2, 3, and 4 were with large positive scores, having the highest mean grain yield in the indicated order. The first two PCAs accounted for 90.47% (PCA1= 73.61% and PCA2=16.86%) of the total principal components. The first principal component on its own accounted almost 3/4th of the variability in the yield traits of the varieties studied. From the principal component analysis, it was observed that genotypes 4, 1, 9, and 10 were seen most likely to be stable. Varieties located near the origin are more stable while those located far away from it are more responsive to the environmental reaction. Varieties that are located within the same quadrant interact positively while those that are located in the opposite quadrant have a negative interaction (Laurentin &Montilla, 1999).

Genotypes have different characters in growth habit, in stress tolerance or resistance and so have different reactions to varying seasons (Mahasi et al.,2006). Even stable genotypes may react

differently to varying seasons. In the present study, variety Bahati ranked fifth among the tested ten genotypes in 2019 where it ranked last in 2020.

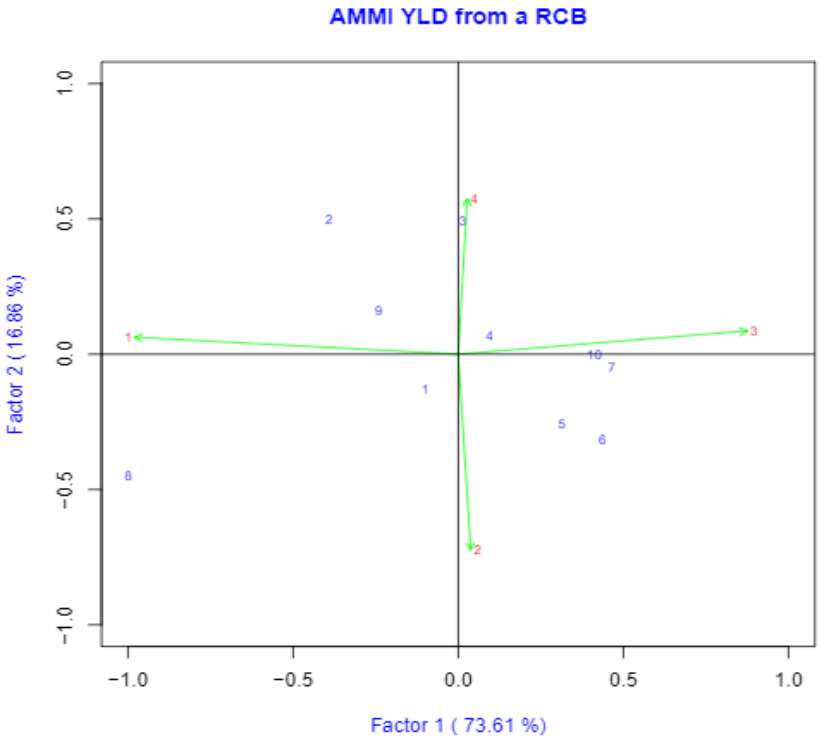

Fig. 1: First and second PCA plost for ten malt barley varieties

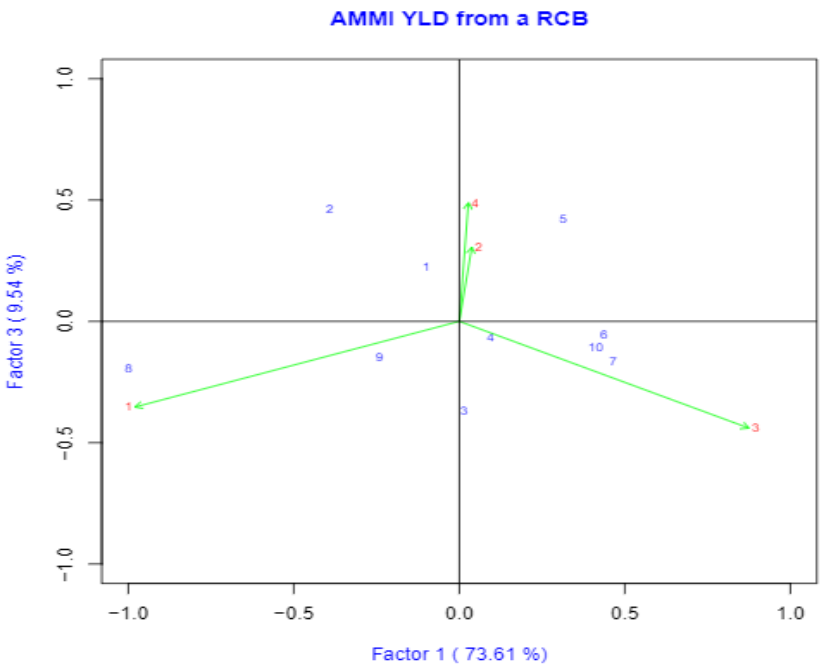

Fig. 2: First and third PCA plots for ten malt barley varieties

4. Conclusion and Recommendation

The barley varieties interacted highly with the environment and finally variety EH-1847 gave the highest yield, regardless of lacking stand uniformity, followed by Hb-1963. There was a high genotype by environment interaction. The first PCA with73.61% accounted for most of the variability

in the yield traits. The first and second PCAs added up to 90.47% of the total variability in the yield traits.

The variety EH-1847 recorded the highest yield among the varieties studied in both (2019 and 2020) years, but it lacked stand uniformity and hence the variety HB-1963 is recommended for production in the study area and areas of similar agro-ecology as it is more or less stable within the environments of test locations maintaining high yield.

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