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On Farm Evaluation of Early Maturing Barley Varieties Suiting Double Cropping Purpose

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Abstract: **Ten barley genotypes were evaluated in randomized complete block design with three replications for their earliness in double cropping scheme under vertisol condition at three locations in Western Shoa, Central Ethiopia during 2022 and 2023 main cropping seasons. The objective of this experiment was to select early and superior barley varieties in the study area that can satisfy the double cropping practiced with residual moisture at the end of rainy season. The results of the combined analysis of variance indicated highly significant differences among genotypes for most of the traits tested at 1% and 0.1% probability level. The GXE interaction also showed highly significant differences for all characters at 1% probability except for the grain yield which was significantly different at 5% probability level. The highest mean grain yield was obtained from the genotype Gobe (2988.7Kg ha^{-1}) followed by Negelle (2922.6Kg ha-^{1}) whereas the lowest from the variety Miscal-21 (1419.4 Kg ha-^{1}).Regarding the stability, varieties 1, 9, 7, 5and 4 were seen to be stable. Therefore, the variety Gobe was chosen for its performance in the experimental field and also acceptable from farmers' preference point of view. Thus, based on the results of this study, the selected variety need to be popularized in the study areas and similar agro-ecologies**

Keywords: **Early maturity, barley genotypes, genotype by environment interaction.**

1. INTRODUCTION

Barley (*Hordeum vulgare* L.) is an annual cereal crop most widely grown over broad environmental conditions. It has persisted as a major cereal crop through many centuries and it is the world's fourth important cereal crop after wheat, rice and maize (FAO, 2022). In Ethiopia, barley ranks fifth after teff, maize, sorghum and wheat (CSA,2022) in area of production. Barley has a long history of cultivation in Ethiopia and its production is reported to have coincided with the beginning of the plow culture (Zemede, 2000). It is one of the most important crop with total area coverage of 799,127.84 hectares and total annual production of about 2.1 million tons in main season (CSA, 2022) with productivity of 2.6 tha^{-1}. Barely is the most dependable cereal and is cultivated on highly degraded 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).

Barley genotypes are different in grain yield potential as well as different yield related agronomic traits (Mariey *et al*.,2013) and (Ahmed *et al*., 2001). Genotypes also differ in their tolerance to different growing stresses and hence evaluation of genotypes at on farm levels for their performance under vertisol condition, where the double cropping scheme is practiced using chickpea and lentil as successor crops get due attention.

Evaluating early maturing genotypes is helpful for one thing to produce the crop under moisture deficiency with short rain fall or to escape terminal moisture stress and for the other to harvest the early maturing precursor crop and leave the field

for the successor crop under double cropping scheme. The successor crop could grow and perform with residual moisture after the main rainy season.

It had long been practiced that farmers dwelling in vertisol area grow early maturing barley or wheat and sometimes maize varieties harvested lately or at the end of rainy season that leave place for chickpea or lentil that could grow with residual moisture. In this cropping scheme it had been a common practice to harvest early maturing farmers' barley variety as precursor crop and growing chick pea as successor crop.

The old farmers' variety grown for many years from ancestors known as 'Semereta' is still a common variety grown in the double cropping scheme. Even though the variety has different merits it has high lodging problem which hampers the yield of the crop.

The fact that early maturing barley varieties evaluated and released for different purposes made an opportunity to evaluate and fit them into this cropping scheme.

Hence, it is found imperative to evaluate barley genotypes for their performance under vertisol for the double cropping purpose thereby enhancing barley production and productivity in the area.

Therefore, this study was conducted to evaluate and select the best performing early maturing barley genotypes and to identify variety/ies meeting the double cropping purpose and replace the old existing farmers' variety in the study area.

2. MATERIALS AND METHODS

Experimental Design and Procedures:

A total of ten barley genotypes (Negelle, Bentu, Dirribe, IBON-174/03, Miscal-21, Gobe, HB-1966, Harbu, EH-1493 and Local check) were used in the study. The experiments were laid in randomized complete block design (RCBD) with three replications. During planting, the seeds were manually drilled at a rate of 125 $kgha^{-1}$ into 2.5 meters long six rows plot spaced 0.2 m apart. NPS and UREA fertilizers were applied at the time of planting both at rate of 100$kgha^{-1}$. Hand weeding was practiced as frequently as needed.

Data Collection:

Data were collected on plant and plot basis for different agronomic traits. For data collection on plant basis, five plants were randomly taken from the four middle rows of each plot excluding the two rows on both sides of each plot as borders and the mean value of those five plants was calculated and used as plot data for analysis, where for the on plot basis, the four middle rows were considered and finally harvested for the plot data. Plant height (cm), spike length (cm) and number of kernels per spike were recorded on plant basis; whereas days to 50% heading, days to physiological maturity, grain yield (kg ha^{-1}) and stand count (%) were recorded on plot basis.

Statistical Analysis:

The data were analyzed using PROC GLM in SAS software version 9.4. Mean separation was carried out using t test.

3. RESULT AND DISCUSSION

The results of the combined analysis of variance (ANOVA) showed highly significant ($P < 0.001$) and ($P < 0.01$) differences among the barley varieties for most of the characters measured (Table 1). The result indicated yield was highly significant ($P < 0.001$) except for location by genotype interaction which was significant at 5% probability level. The stand percent of the varieties also showed significant difference only at 5% probability level and this could be because of slight difference of the location effects within similar growing season, but highly significantly different for the different seasons.

The spike length of the varieties showed non-significant difference for genotype by location interaction and this could be because of the consistence of similar spike length of the varieties across locations within the same experiment season.

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Table 1: Mean squares of ANOVA for barley parameters measured in 2022 and 2023 main cropping seasons

		Mean squares					
S.V	DF	DM	PlH	SL	NKS	Stand	YLD
Loc	2	1656.8***	4261.0***	105.9*	662.8***	1757.3***	50989671.5***
Gen	9	14766.8***	20252.9***	1086.1***	5655.8***	17793.7***	35575728.6***
Yr	1	2737.8***	3181.9***	253462.6***	43334.9***	64524.8***	46105001.5***
Loc x gen	18	816.9**	2527.2**	348.5ns	1255.6**	3039.6*	12531865.5*
Yr X Gen	9	745.7***	6077.9***	634.3***	6412.3***	7673.6***	20508999.5***
Loc X Yr	2	2593.4***	9825.6***	152.1*	469.2**	2597.5***	137648412.1***
Yr X Loc X Gen	18	870.3**	3012.3***	361.8***	1002.8*	3161.1*	23461656.1***
Error		4.1	6.8	3.8	5.3	9.1	575.1
CV %		3.6	8.1	8.6	22.7	14.6	24.2

*= significantly different at 5% probability level, ** = at 1% probability level, *** = at 0.1% probability level

DM = Days to maturity, PlH = plant height, NKS = Number of kernels per spike, Stand = stand percentage at maturity, SL = spike length, YLD = grain yield

Mean values of tested genotypes for the characters studied in West Shoa in 2022 cropping season are given in Table 2

Table 2: Mean Values of Growth, Yield and yield related Parameters of Barley Varieties in Western Shoa in 2022

	DM	PlH	SL	NKS	Stand	YLD
Negelle	100.3EF	84.0D	6.3CD	44.6C	90B	6175.6A
Bentu	105D	87.6CD	6.3CD	62.6A	95A	5096.7ABC
Dirribe	110.6C	84.3D	7.3BC	63.6A	90B	5498.9AB
IBON-174/03	113.3C	75.4D	8.8A	29.3D	90B	3002.2E
Miscal-21	117.6B	97.6BC	7.6B	26.6DE	85C	2966.7E
Gobe	101.3DE	91.3CD	7.3BC	26DE	95A	5391.1AB
HB-1966	122A	108.3B	6D	52B	88.3BC	4535.6BCD
Harbu	105.3D	126.6A	7.6B	61.3A	88.3BC	4085.6CDE
EH-1493	122.3A	108.3B	6.3CD	52B	91.6AB	5182.2ABC
Local	96.3F	103.3B	9 A	22.6E	90B	3782.2DE
Mean	109.4	97.6	7.2	44.1	90.3	4571.6
LSD (0.05)	4.1	11.6	1.1	5.1	4.7	1196.5
CV	2.2	6.9	8.6	6.8	3.1	15.2

DM = Days to maturity, PlH = Plant Height, Stand = Crop Stand percentage, SL = Spike Length, NKS = Number of kernels per spike and YLD = Grain Yield in $Kgha^{-1}$

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Table 3: Mean Values of Growth, Yield and yield related Parameters of Barley Varieties in Western Shoa in 2023

Varieties	Mean Values					
	DM	PlH	SL	NKS	Stand	YLD
Negelle	116.1D	71.3G	7.5DE	43.5C	75.4E	1760.4CD
Bentu	114.5D	72.4FG	7.2DE	57.4A	78.6DE	1891.3CD
Dirribe	122.8C	77.4EF	8.7AB	57.6A	78.2E	2265.4B
IBON-174/03	116D	74.2EFG	8.5B	30.9D	84.7ABC	2002.2BC
Miscal-21	127.8B	74.8D	8.6AB	25.3E	76.8E	1289.9F
Gobe	115.6D	78.7DE	8.2BC	32.3D	87.6AB	2784.1A
HB-1966	128.2B	85.2BC	7.2E	49.5B	82.1CD	1423.7EF
Harbu	109.3E	92.4A	7.8CD	61.5A	88.3A	1854.5CD
EH-1493	137.3A	83.6BCD	8.1C	43.2C	83.1C	1610.4DE
Local	101.8F	85.5B	9 A	27.5DE	84.5BC	1732.1CDE
Mean	118.9	80.1	8.1	42.9	81.9	1861.3
LSD (0.05)	3	5.9	0.5	5.4	3.7	316.4
CV	2.6	7.7	6	13.4	4.7	17.8

DM = Days to maturity, PlH = Plant Height, Stand = Crop Stand percentage, SL = Spike Length, NKS = Number of kernels per spike and YLD = Grain Yield in $Kgha^{-1}$

The days to maturity was an important parameter in the current study as it is measure of earliness of the varieties so as to rank them considering the yield and it ranged from 99 days for the local variety to 131 days for EH-1493. Following the farmers' local variety, varieties Harbu and Gobe matured in 106 and 107 days respectively. Gobe variety had about 511.7 $Kgha^{-1}$ and 534.7$Kgha^{-1}$ yield advantage over the local and Harbu varieties respectively even though the early variety matured about a week earlier. Studies indicated that earliness penalizes grain yield (Mekasa and Mohammed, 2021), where Gobe variety gave the highest yield with promising earliness.

Table 4: Combined Mean Values of Growth, Yield and yield related Parameters of Barley Varieties in Western Shoa in 2022 and 2023 main cropping seasons

Varieties	Mean Values					
	DM	PlH	SL	NKS	Stand	YLD
Negelle	108.8DE	77.6D	6.9EF	43.2B	79.1CD	2922.6AB
Bentu	110.8D	77.4D	6.8EF	54.1A	83.5ABC	2488.8C
Dirribe	117.5C	73.8 D	7.4CD	54.1A	76.3D	2597.7BC
IBON-174/03	117C	75.4D	8.2B	32.1C	79.8CD	1954.8E
Miscal-21	124B	74.8D	7.5 C	23.9D	64.5E	1419.4F
Gobe	107E	85.4C	7.8C	28.7CD	85.7AB	2988.7A
HB-1966	124.3B	88.1C	6.6F	46.1B	81.8BCD	2012.8DE
Harbu	106.3E	109.5A	7.7C	58.1A	88.7A	2454.8C
EH-1493	131.1A	85.8C	7.1DE	44.6B	86.2AB	2358.4CD
Local	99.3F	94.4B	9 A	25.4D	87.7A	2477C
Mean	115.1	84.2	7.5	44.2	81.3	2367.5
LSD (0.05)	2.7	4.5	0.4	4.8	5.8	380.3
CV	3.6	8.1	8.6	22.7	14.6	24.2

DM = Days to maturity, PlH = Plant Height, Stand = Crop Stand percentage, SL = Spike Length, NKS = Number of kernels per spike and YLD = Grain Yield in $Kgha^{-1}$

The grain yield as well as the overall crop performance in 2023 cropping season were minimal as there was extended rain continuously for more than half a year. This hampered the crop growth and finally the grain yield especially under vertisol condition where the water logging stress is a problem in high rainfall areas. Nevertheless, it was seen from the current study that varieties differ significantly in tolerating the problem. Fig. 1 shows the grain yield of the studied varieties in the two years and their combined mean.

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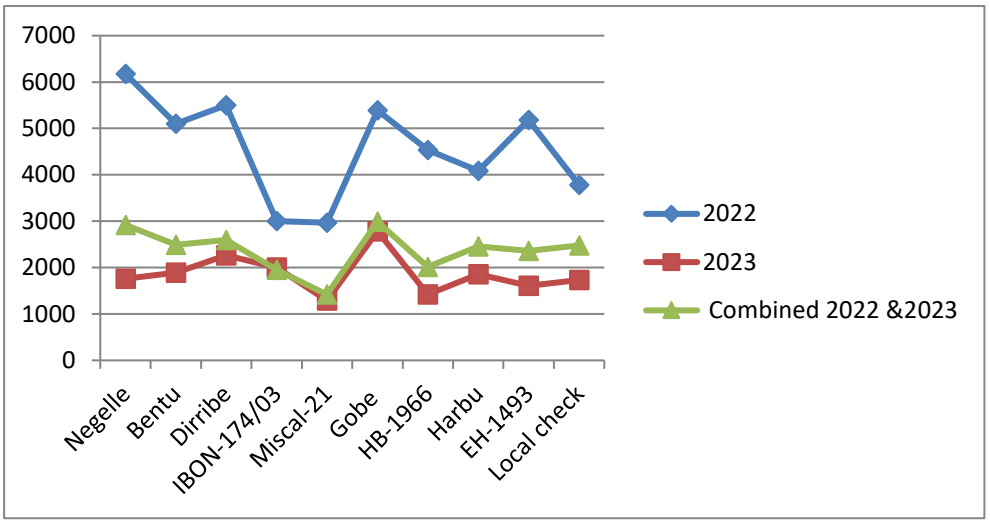
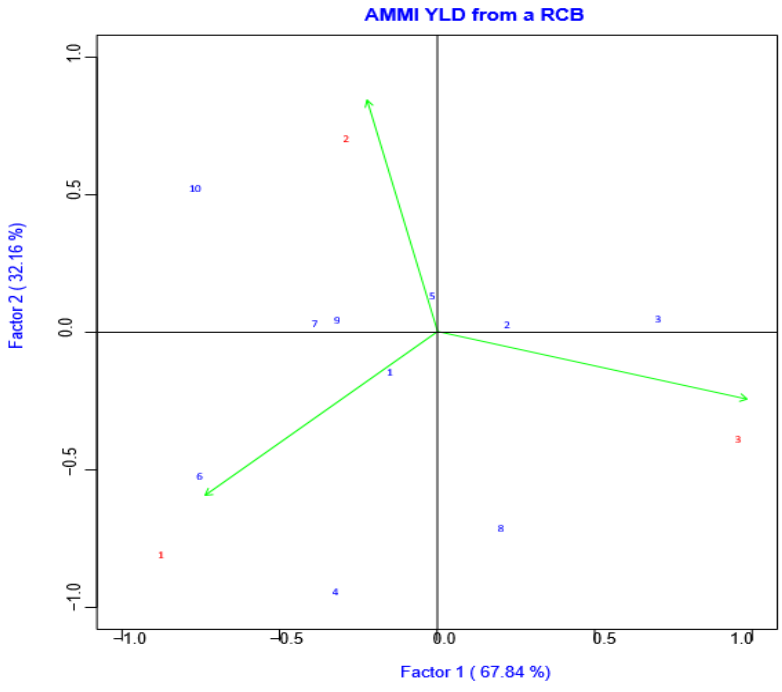


Fig. 1: Grain yield of studied varieties in 2022, 2023 and the combined mean of the two years

GGE biplot analysis is presented (Figure 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 4, 1, 6, and 10 were with large positive scores, having the highest mean grain yield in the indicated order. The first two PCAs accounted for 100% (PCA1= 67.84% and PCA2=32.16%) of the total principal components. The first principal component on its own accounted almost 2/3rd of the variability in the yield traits of the varieties studied. From the principal component analysis, it was observed that genotypes 1, 9, 7, 5and 4 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 (Gurmu *et al*. 2017; Buli, 2023). 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. This is clearly seen in the present study that variety Negelle ranked first among the tested ten genotypes in 2022 where it couldn't maintain the rank in 2023.



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4. CONCLUSION AND RECOMMENDATION

The barley varieties studied showed significant differences in earliness and grain yield attribute and also interacted highly with the environment and finally variety Gobe gave the highest yield followed by Negelle. There was a high genotype by environment interaction and the first PCA with 67.84% accounted for 2/3rd of the variability in the yield traits. The first and second PCAs added up to 100% of the total variability in the yield traits.

The variety Gobe recorded the highest yield among the varieties studied in 2022 and 2023 besides its earliness following the local check which is highly lodging variety because of weak stem resulting in poor yield. This variety got rewarding preference from the farmers of the study areas besides its yield and earliness.

Hence the variety Gobe is recommended for production areas using double cropping, producing chickpea and other pulses grown with residual moisture as this variety is more or less stable within the environments of test locations maintaining high yield.

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