Food Science and Quality Management
ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online)
Vol.71, 2018

Adaptability Evaluation of Early Maturing Food Barley in Highland Areas of Southern Ethiopia

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Abstract
In Ethiopia, there are several barley production constraints, among which shortage of high yielding and stable improved food barley varieties is the major one. The field experiment was conducted at Chencha district in the 2015 and 2016 cropping season using eleven improved food barley (*Hordeum vulgare* L.) varieties with one local check with the objective of evaluating the mean performance of food barley varieties for grain yield and other agronomic traits over years and across locations. The improved varieties studied include Biftu, Basso, Diribe Tila,Dafo, Misirach, Abay, Mulu, Mezezo, Setegn and Dinsho. These varieties, as experimental treatments, were arranged in a randomized complete block design with three replications. They were evaluated for days to 50% heading, days to 95% physiological maturity, plant height, spike length, tiller number and grain yield. Significant variations were recorded among the tested varieties for the measured traits over the years and across environments. The highest average grain yield (2279 kg ha-^{1}, 2186 kg ha^{-1} and 2137) were obtained from varieties Diribe, Setegn and Basso without significant differences between the three) respectively**.** Based on the results obtained under these study varieties Diribe, Seteg and Basso could be used for demonstration, popularization and pre-scaling up in Chencha and in the farming communities of similar agro-ecologies.
Keywords: food barley, varieties, grain yield

1.Introduction

Barley is thought to have originated in the Fertile Crescent area of the Near East from the wild progenitor Hordeum spontaneum. It is one of the first cereals to have been domesticated, having been cultivated for more than 10,000 years, with archaeological evidence of barley cultivation in Iran as long ago as 8,000 BC. Barley is a cool-season crop that is adapted to high altitudes. It is grown in a wide range of agro climatic regions under several production systems. At altitudes of about 3000 masl or above, it may be the only crop grown that provides food, beverages and other necessities to many millions of people. Barley grows best on well-drained soils and can tolerate higher levels of soil salinity than most other crops. Food barley is commonly cultivated in stressed areas where soil erosion, occasional drought or frost limits the ability to grow other crops (Berhanu et al., 2005).

Barley (*Hordeum vulgare* L.) is a major cereal crop in Ethiopia and accounts for 8% of the total cereal production based on a cultivation area of 1,018,753 ha in 2013 (CSA, 2013). Ethiopia is a center of barley diversity (Lakew *et al.,* 1997) with a high level of morphological variation between landraces that resulted from adaptation to diverse climatic conditions and soil types. In the present time, farmers cultivate barley in Ethiopia from 1,400 to over 4,000 meters above sea level (m.a.s.l) under highly variable climatic and edaphic conditions (Asfaw, 2000). Barley is used as food, fodder and beverage in more than 20 different ways, which reflects its cultural and nutritional importance (Shewayrga and Sopade, 2011; Abraha *et al., 2013*). Lack of improved varieties, non-adoption of improved technologies, disease and pests are some of the most serious production constraints in barley production, generally in Ethiopia and southern region in particular. Some varieties of Barley were released by the different national and regional research centers in Ethiopia; however, most of them were not evaluated around areas of southern Ethiopia of Gamogofa Zone in the case of Chencha distirct. Therefore, the objectives of this study were to evaluate and select improved barley varieties which are adaptable and high yielding in southern Ethiopia.

2. Materials and methods

The experiment was conducted at Chencha district in 2015 and 2016 cropping season using eleven improved food barley varieties *viz*, Biftu, Basso, Diribe, Tila, Dafo, Misirach, Abay, Mulu, Mezezo, Setegn Dinsho and local check were taken from national and regional Agricultural Research Center. The trial was conducted at two (2) locations of high land agro-ecologies of Gamogofa Zone, Chencha district *viz*. Gendo-gambella and Doko-tsida Kebele farmers field for two years (2015 and 2016) cropping season. RCBD experimental design with three (3) replications was used on plot size of 2mx2.5m spacing of 20cm, 1m and 1.5m between plot and block was used.

2.1. Data Collection

Five plants from the four internal rows of each plot were randomly tagged and data like plant height, spike length and tiller numbers per plant were recorded. Days to 50% heading and days to 95% physiological maturity, were recorded as whole plot base. Agronomic practices recommended for barley production were undertaken throughout the phenological stages of the crop. All plants from the four internal rows of each plot were subjected to yield

evaluation.

2.2. Data Analysis

The analysis of variance was done using statistical analysis system, Genstat Software. Mean separation was made and used with Least Significant Difference (LSD) for the comparison among the experimental varieties at 5% probability level.

3. RESULT AND DESCUSSION

For this study, combined analysis of variance was done for the locations to evaluate the varieties for the studied characters. Accordingly, combined data analysis revealed that there were – significant ($p<0.05$) difference among varieties for days to heading, days to maturity, plant height, spike length, tiller number and grain yield. These results are further supported by Teshome (2017) who reported considerable variation in the days to maturity, plant height and panicle length, days to heading and grain yield of different barley varieties when planted over years.

Table 1.Combined Anova of doko tsida for yield and agronomic of early maturing barley varieties over years

Source of variation		Traits					
	Df	DH	DM	PH	SL	TN	Y
T	11	14.317ns	49.31**	561.81**	6.164**	1.1061**	443866*
Y	1	342.347**	66.13*	10420.87***	564.704**	0.3068ns	4622320.**
T	11	37.771**	5.00ns	64.50NS	3.338ns	1.7959**	315743ns
Eror	44	7.775	10.67	59.53	1.709	0.3730	199406.
CV		3.8	3.3	8.1	13.2	20.8	23.8
LSD		4.583	5.370	12.681	2.148	1.0038	733.9

DH= days to heading, DM=Days to maturity, PH=Plant Height (cm), SL=spike length (cm), TN= Number of tillers per plant GY = grain yield (kg)/ha^{-1}

Table2. Anova of Gendo-gambella for yield and agronomic of early maturing barley varieties over years

Source of variation		Traits					
	Df	DH	DM	PH	SL	TN	Y
Trt	11	184.33**	159.92**	108.19**	7.8467**	1.4231**	638691**
Y	1	22.22ns	19.01ns	21945.12**	114.4584**	75.3378**	5644800**
T*y	11	60.19ns	1.86ns	77.06*	7.6068**	0.8533ns	12655ns
Eror	44	51.68	12.75	33.98	0.9500	0.4905	88695
CV		10.5	3.5	6.6	11.2	21.8	15.4
LSD		11.816	5.869	9.581	1.602	1.0138	489.5

DH= days to heading, DM=Days to maturity, PH=Plant Height (cm), SL=spike length (cm), TN= Number of tillers per plant GY = grain yield (kg)/ha^{-1}

3.1. Days to 50% Heading (DH)

The experimental varieties evaluated in the 2015 and 2016 main cropping season showed significant ($P < 0.05$) differences in days to 50% heading. In Dokotsida variety Mulu and Basso took the longest duration (77.67 and 74.83 days) to heading respectively without significant difference between the two, while the other tested varieties took statistically similar shortest days to heading (Table 4). At Gendo-gambella variety Dafo took shortest days to heading (55.83) similarly, Mulu and Mezezo took the longest duration (78.670 and 76.17 days) to heading without significant difference (Table 5). However, the result of the averaged data of the two years of both locations (Table 3) revealed that Mulu and Mezezo took statistically similar longest duration to heading (78.67 and75.00 days, respectively), unlike the shortest days exhibited by Dafo (63.75days). It was similarly reported that genotypes differ in days to 50% heading (Wosene *et.al.,* 2015).

Table 3. Combined Anova for yield and agronomic of early maturing barley varieties over years

Source of variation		Traits					
	Df	DH	DM	PL	SL	TN	Y
L	1	1050.84**	17.36 ns	1618.7	54.735 **	2.600ns	116679ns
Y	1	269.51**	78.03*	31305.40	593.816	33.399**	10241600**
Trt	11	137.70**	183.63**	454.82	10.372**	1.117ns	622191**
T*y	11	59.58**	3.79ns	51.30ns	8.238**	1.408ns	140285ns
T*l	11	60.95**	25.60ns	215.18	3.638**	1.432ns	460366**
L*y	1	95.06ns	7.11ns	1060.59	85.347**	43.066**	25520.ns
T*y*l	11	38.38NS	3.08	90.26ns	2.707ns	1.226ns	188113.ns
Eror	94	29.15	13.98	63.29	1.783	1.080	147208
CV		7.6	3.7	8.7	14.3	33.8	20.1
LSD		8.753	6.061	12.897	2.164	1.6846	622.0

DH= days to heading, DM=Days to maturity, PH=Plant Height (cm), SL=spike length (cm), TN= Number of tillers per plant GY = grain yield (kg)/ha^{-1}

3.2. Days to 95% Physiological Maturity (DM)

Statistically significant variation ($P < 0.05$) was observed in days to 95% physiological maturity of the tested varieties in both locations. At Dokotsida the longest duration for maturity was recorded for Mulu (108.5) whereas the other tested varieties took statically similar shortest days to heading (table 4). Similarly, in Gendo-gambella Mulu takes the longest time to mature (114.2 days) unlike, Dafo and Diribe took statistically similar shortest (94.3 and 94.8 days) to mature respectively (table5). The averaged mean value of days to 95% physiological maturity at both Dokotsida and Gendo-gambella was longest for Mulu (111.3 days) and statistically similar shortest days for Dafo and Diribe (95.8 and 97.2 days) respectively. Similar study report also revealed that varieties showed significant difference in days to maturity (Melle *et,al*.2015)

Table 4. Combined Mean grain yield and agronomic of early maturing barley varieties over years at Dokotsida.

Treatments	**Characters**											
	DH	**DM**	**PH**		**SL**		**TN**		**GY**			
Biftu	72.83 a	102.0b	95.43	bcd	9.567	b	2.467	a	1754cde			
Basso	74.83 ab	101.8b	98.13	cde	10.367	b	2.733	ab	2351a			
Local	74.33a	99.8ab	112.83	f	10.833	b	2.900	ab	1925bc			
Diribe	73.33 a	99.5 ab	82.33	a	9.393	b	2.567	ab	1871bcd			
Tila	73.50 a	99.8ab	86.87	ab	10.133	b	3.667	cd	2028abc			
Dafo	71.67 a	97.3a	93.83	bcd	10.700	b	2.900	ab	1361e			
Misirach	72.83 a	98.3ab	87.77	ab	7.133	a	2.933	ab	1795bcd			
Abay	73.17 a	98.8ab	101.07	de	10.567	b	2.333	a	1491de			
Mulu	77.67 b	108.5 c	105.40	ef	10.333	b	3.200	bcd	2005abc			
Mezezo	73.83 a	99.3ab	90.50	abc	10.033	b	2.800	ab	1870bcd			
Setegn	73.00 a	99.8ab	105.87	ef	10.700	b	3.733	d	2174ab			
Dinsho	72.17 a	99.3ab	83.20	a	9.433	b	3.017	abc	1913bc			
Grand mean	73.6	100.38	95.27		9.93		2.938		1876			
CV	3.8	3.3	8.1		13.2		20.8		23.8			
LSD	4.583	5.370	12.681		2.148		1.0038		733.9			

DH= days to heading, DM=Days to maturity, PH=Plant Height (cm), SL=spike length (cm), TN= Number of tillers per plant GY = grain yield (kg)/ha^{-1}

3.3. Plant Height (PH) and spike length

The analysis of variance showed that there was significant ($P < 0.05$) difference among the tested varieties in plant height. In Dokotsida the tallest plant height was recorded for Local, mulu and setegn varieties (112.83cm, 105.40 and 105.87) without significant differences among the three respectively, while Dinsho, Mezezo, Misirach, diribie and Tila were the shortest (83.2cm, 90.5cm, 87.7cm, 82.3cm, 86.87days) respectively (table 4). In Gendo-gambella Tila, Misirach and Dinsho showed lowest in plant height and they were statistically similar (84.21cm, 80.23cm and 82.63cm) respectively, whereas the other tested varieties took statically similar longest height (Table 5). The mean value for the averaged data (Table 6) indicated statistically similar and highest plant height for Local check, Abay, Mulu and Setegn (101.8,95.4,99.7 and 96.68 cm respectively and the shortest by Diribe,Tila,and Dinsho

(86.7,85.5 and 82.92 cm respectively). On the other hand significant difference was observed for spike length in Dokotsida, in which the shortest spike was recorded by Misirach (7.1cm) while the other tested varieties had statically similar Spike. Similarly significant difference observed at Gendo-gambella in which longest spike length was observed by Mezezo (9.98cm) where as the shortest spike length observed by Dafo (7.54cm). Tiller number was another trait for which large and significant variation was observed in which setegn (4) showed large number of tiller per plant at Dokotsida whereas at gendo-gambella Mulu (4) showed the highest tiller per plant and the local (3) showed the lowest number of tiller per plant. The average mean value for both location showed that Mulu, Mezezo and Setegn had the largest number of tiller per plant where as all the other tasted varieties showed statically similar variation.

Table 5. Combined Mean grain yield and agronomic of early maturing barley varieties over years at Gendo-gambella

Treatments	Characters					
	DH	**DM**	**PH**	**SL**	**TN**	**GY**
Biftu	67.83bc	101.8bcd	93.17a	8.283cdef	3.500abc	1680de
Basso	68.50bc	105.7b	88.07abc	9.067abcd	3.067cd	1923bcde
Local	67.67c	100.0cd	90.93ab	7.817ef	2.667d	2073bc
Diribe	65.33c	94.8ef	91.20a	9.257abc	3.067cd	2770a
Tila	66.83c	98.5de	84.21bcd	8.850bcde	2.600d	2053bc
Dafo	55.83d	94.3f	90.69ab	7.543f	3.133bcd	1587e
Misirach	68.67bc	100.7cd	80.23d	6.267g	3.200bcd	2053bc
Abay	67.33c	99.8cd	89.87ab	9.950ab	2.833cd	1773cde
Mulu	78.67a	114.2a	94.13a	7.990def	4.267a	2007bcd
Mezezo	76.17ab	103.0bc	90.13ab	9.983a	3.933ab	1680de
Setegn	67.67c	100.3cd	87.50abc	9.773ab	3.042cd	2198b
Dinsho	67.83bc	99.7cd	82.63cd	9.617ab	3.233bcd	1733cde
Grand mean	68.19	101.07	94.56	8.70	3.212	1961
CV	10.5	3.5	6.6	11.2	21.8	15.0
LSD	11.816	5.869	9.581	1.602	1.0138	482.5

DH= days to heading, DM=Days to maturity, PH=Plant Height (cm), SL=spike length (cm), TN= Number of tillers per plant GY = grain yield (kg)/ha^{-1}

3.4. Grain Yield (GY)

Statistically significant ($P < 0.05$) variation was observed among the experimental varieties in grain yield in both location (Table 1 and 2). The highest grain yield were obtained from varieties *viz*. Basso (2351kg ha^{-1}), Setegn (2174kg ha-1, Tila (2028 kg ha^{-1}) and Mulu (2005kg ha^{-1}) in Dokotsida respectively without significant difference among the four (Table 4) where as varieties Abay (1491 kg ha^{-1}), Dafo (1361 kg ha^{-1}) and Biftu (1754 kg ha^{-1} gave the lowest grain yield without variation statistically respectively. In contrast, in Gendo-gambella (Table 5) Diribe was the highest yielder (2770 kg ha^{-1}), where as Dafo(1587 kg ha^{-1}), Mezezo (1680 kg ha^{-1}), Biftu(1680 kg ha^{-1}) ,Dinsho (1733 kg ha^{-1}) and Abay (1773 kg ha^{-1}) were statistically similar lowest yielders statistically similar highest mean value from the averaged grain yield (Table 6) were also obtained from Diribe (2279 kg ha^{-1}), Setegn (2186 kg ha^{-1}) and Basso (2137 kg ha^{-1}) respectively. Statistically similar and lowest average grain yield were recorded for (Abay 1632 kg ha^{-1}), Biftu (1717 kg ha^{-1}) and Mezezo (1774 kg ha^{-1}) respectively. This result is supported by the finding of the same study which reported that genotypes differ in grain yield (Teshome, 2017)

Table 6. Mean grain yield and agronomic of early maturing barley varieties over years across locations

Treatments	Characters					
	DH	**DM**	**PH**	**SL**	**TN**	**GY**
Biftu	70.33c	101.9bc	94.30bc	8.925d	2.983ab	1717def
Basso	71.67bc	103.8b	93.10cd	9.717abcd	2.917ab	2137ab
Local	71.00bc	99.9cd	101.88a	9.325abcd	2.783b	2080bc
Diribe	69.33c	97.2de	86.77def	9.325 abcd	2.817b	2279a
Tila	70.17c	99.2cd	85.54ef	9.492 abcd	3.133ab	2034bc
Dafo	63.75d	95.8e e	92.26cd	9.122cd	3.017ab	1474f
Misirach	70.75bc	99.5cd	84.00ef	6.700e	3.067ab	1924bcde
Abay	70.25c	99.3cd	95.47abc	10.258a	2.583b	1632ef
Mulu	78.17a	111.3a	99.77ab	9.162bcd	3.733a	2006bcd
Mezezo	75.00ab ab	101.2bc	90.32cde	10.008abc	3.367ab	1774cdef
Setegn	70.33c	100.1cd	96.68abc	10.237ab	3.337ab	2186ab
Dinsho	70.00c	99.5cd	82.92f	9.525abcd	3.125ab	1815cde
Grand mean	70.90	100.72	94.92	9.32	3.075	1922
CV	7.6	3.7	8.7	14.3	33.8	19.9
LSD	8.753	6.061	12.897	2.164	1.6846	618.4

DH= days to heading, DM=Days to maturity, PH=Plant Height (cm), SL=spike length (cm), TN= Number of tillers per plant GY = grain yield (kg)/ha^{-1}

4. Conclusion and Recommendations

In the current study, the tested varieties showed significant variation for days to heading, days to maturity, plant height, spike length, tiller number an grain yield. From the tested varieties the highest grain yield (2279 kg ha-^{1}, 2186 kg ha^{-1} and 2137 kg ha^{-1}) was recorded for Diribe, Setegn and Basso respectively. But, low yield was recorded (Abay 1632 kg ha^{-1}), Biftu (1717 kg ha^{-1}) and Mezezo (1774 kg ha^{-1}) respectively. Accordingly, three varieties (Diribe, Setegn and Basso) that showed better performance among the tested varieties were selected and recommended for study areas and similar agro ecologies.

ACKNOWLEDGEMENTS

The authors are grateful to Southern Agricultural Research Institute and Arbaminch Agricultural Research Center as well as cereal team members for provision of facilities, implementation of the experiment and data collection.

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