Greener Journal of Agricultural Sciences
ISSN: 2276-7770; ICV: 6.15
Vol. 7 (6), pp. 126-131, August 2017

http://gjournals.org/GJAS

Research Article (DOI: http://doi.org/10.15580/GJAS.2017.6.071617088)

# Adaptations of Exotic Barley Genotypes to Low-moisture Environments in Southern Ethiopia

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**ARTICLE INFO**

***Article No.:*** *071617088*
***DOI:*** *10.15580/GJAS.2017.6.071617088*

***Submitted:*** *16/07/2017*
***Accepted:*** *21/07/2017*
***Published:*** *22/08/2017*

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***Keywords:***
*adaptation, barley, genotypes, low-moisture, terminal drought, tolerant*

**ABSTRACT**

**Barley is commonly cultivated in marginal areas of Ethiopia where the production of other cereals is limited. The objective of this study was to evaluate introduced barley cultivars in low moisture areas at Halaba and Enseno districts of southern Ethiopia. Five introduced barley genotypes and a standard check (‘Gabula’) were tested in 2010 and 2011 main cropping seasons using RCBD with four replications. Seeds were drilled in rows at the rate of 85 kg ha $^{-1}$. Data on days to heading, maturity, disease score, lodging, plant height, spike length and spikelets spike$^{-1}$, seed spike$^{-1}$ and grain yields were taken. Significant differences among genotypes were observed for all traits except disease at Halaba and plant height at Enseno in 2010. In 2011 significant differences were observed among genotypes for all traits at both locations. The results of combined analysis over years and locations on grain yield showed a highly significant difference in year by location and treatment, and location by treatment interactions. In 2010, the yield of genotypes at Halaba ranged from 0.62 to 1.78 t ha$^{-1}$ which was low even though there were significant differences among genotypes and in 2011 ‘Aquila’ was earlier to head than the standard check ‘Gabula’. At Enseno ‘Aquila’ (4.69 t ha$^{-1}$), ‘Millennium’ (3.2 t ha$^{-1}$) and ‘Xena’ (2. 99 t ha$^{-1}$) out yielded the standard check ‘Gabula’ (2.38 t ha$^{-1}$ ). In both years the performance and yield of the genotypes were better at Enseno. Generally, the exotic varieties gave higher yield in low moisture areas of Halaba and Enseno districts.**

## 1. INTRODUCTION

Barley ( *Hordeum vulgare* L.) is one of the most important traditional Ethiopian food crops. It is commonly cultivated in marginal areas where the production of other cereals is limited (Bekele *et al*, 2005; Abay *et al*., 2009). Although barley is considered a highland crop, it is also grown in low rainfall areas of the country (Debebe & Alemu, 2011b). It occupies about 1,019,477.93 hectares of land with a total production of 1,908,262.4 tones (CSA, 2014) and a productivity of 1.87 t $ha^{-1}$. Its mediocre productivity is primarily due to the use of low yielding local cultivars in the productive system of biotic and abiotic factors and the minimal use of improved barley production technologies (Mulatu & Lakew, 2011).

On time availability and distribution of rainfall during the growing season are the major factors limiting crop yield of barley. The most important factor in barley production in low rainfall areas is early ear emergence, which is common in Ethiopian landraces. Thus, farmers in drought-prone areas grow 98.7% own landraces (CSA, 2011) that are well adapted to the local environment, but with poor yielding ability (Debebe & Alemu, 2011a). A critical shortage of improved barley varieties adapted to low-moisture conditions is a major problem and hence, farmers are forced to grow low yielding varieties.

A number of studies (Hiskias, 2011; Debebe & Alemu, 2011a; Bantayehu & Esmael, 2011; Gebre Hawaryat *et al*., 2011) were conducted and documented on barley landraces and introduced genotypes for low-moisture areas from northern and central Ethiopia however, there is no information on barley genotypes tolerant to low-moisture conditions in southern Ethiopia.

Therefore, there was a need to introduce exotic cultivars that are tolerant to low-moisture conditions. The objective of this study was to evaluate introduced barley cultivars in low moisture areas of selected districts of southern Ethiopia.

## 2. MATERIALS AND METHODS

### 2.1 Description of the experimental area

The experiment was conducted at Halaba and Enseno sub centers located at the coordinates of 07$^0$ 18’ 24.42”N and 38$^0$ 06’ 29.34”E for Halaba and 08$^0$ 03’ 31.0”N latitude and 38$^0$ 30’ 33.9”E longitude for Enseno (Esayas *et al*, 2006). Halaba and Enseno sub centers are located at an elevation of 1784 and 1839 m. a.s.l respectively. The respective annual mean rainfall (2001- 2011) of the locations was 860 mm for Halaba and 590 mm for Enseno (Table 1).

**Table 1: Amount of rainfall during the growing season and long term mean rainfall at Halaba and Enseno**

| Month | Halaba | | Enseno | | Long term mean (11 years) of the growing season (2001- 2011) | |
|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2010 | 2011 | Halaba | Enseno |
| July | 140.3 | 214.5 | 84.1 | na | 114.0 | 160.7 |
| August | 99.1 | 165.1 | 131.6 | na | 120.9 | 125.6 |
| September | 130.8 | 55.4 | 70.8 | 22.1 | 113.1 | 80.0 |
| October | 32.2 | 0.6 | na | 0 | 49.3 | 28.9 |
| November | 12.8 | 84.5 | 0 | 6.4 | 34.4 | 13.9 |
| Total | 415.2 | 520.1 | | | 431.7 | 409.0 |

na- not available

*Source: raw data from Ethiopian metrological authority Hawasa branch*

### 2.2 Genotypes studied

The materials used for this study consisted of five genotypes that were introduced from the United States of America through Morrell Agro Industries PLC, Ethiopia and one standard check. The varieties were ‘Millennium’, ‘Walker’, ‘Golden-eye’, ‘Xena’ and ‘Aquila’ and the standard check ‘Gabula’. ‘ Millennium’, ‘Walker’, ‘Golden-eye’ and‘Aquila’ are six -rowed food barley (Jackson, 2011) whereas ‘Xena’ and the standard check ‘Gabula’ are two-rowed food barley genotypes. The standard check ‘Gabula’ was released for mid altitude areas ( 1800 to 2200 m. a.s.l) collected from local landraces.

### 2.3 Experimental treatments and design

Five introduced barley genotypes and the standard check (‘Gabula’) were tested during two years in 2010 and 2011 using Randomized Complete Block Design (RCBD) with four replications. Each plot was made up of six rows of 2.5 m length. The rows were 20 cm apart. The adjacent plots were separated by a blank row in both years. The trial was sown at a seed rate of 85 kg $ha^{-1}$ on 27 July 2010 and 28 July 2011 for Halaba; and 24 June 2010 and 11 July 2011 for Enseno during the main cropping season (July –November) at Halaba and Enseno sub centers. Nitrogen and phosphorous fertilizers were applied at the rate of 41 N and 46 $P_2O_5$ at planting, using urea and DAP as source of N and $P_2O_5$, respectively. Broad leaf weeds were controlled using 2; 4-D herbicide applied four weeks after planting at the rate of 1 liter per 200 liter of water $ha^{-1}$ followed by two hand weedings with an interval of 15 days after herbicide application.

### 2.4 Data collection and Data analysis

Days to heading and maturity, plant height, disease blotch (0-9 scale), lodging (0-100 %), spike length (cm), spikelets $spike^{-1}$, seeds $spike^{-1}$, and grain yield was recorded from the four central rows (harvestable rows) and the grain yield was adjusted at 12.5% moisture. Analysis of variance (ANOVA) was conducted using SAS (2002) and mean separation was done using Duncan Multiple Range Test (DMRT).

## 3. RESULTS

Analysis of variance indicated that there were highly significant differences (P<0.001) among genotypes for all traits except disease blotch at Halaba and plant height at Enseno in 2010 (Tables 2 and 3). In the first year the yield at Halaba of the genotypes were low even though there were significant differences among genotypes which varied between 0.62 ('Walker') and 1.78 t $ha^{-1}$ (the standard check 'Gabula') (Table 2).

**Table 2: Agronomic and mean grain yield (t $ha^{-1}$) of introduced barley genotypes at Halaba, 2010**

| Varieties | DM | Pht | Leafr | blotch | $Ytha^{-1}$ |
|---|---|---|---|---|---|
| 'Millennium' | 92b | 53.3b | 32.5ab | 3.8abc | 0.89bc |
| 'Walker' | 98a | 56.0b | 32.5ab | 4.5ab | 0.62d |
| 'Golden-eye' | 91c | 58.5b | 40.0a | 4.8a | 0.71cd |
| 'Xena' | 98a | 87.5a | 25.bc | 3.8abc | 0.84bc |
| 'Aquila' | 90c | 60.8a | 22.5bc | 3.8abc | 0.98b |
| 'Gabula' | 75d | 87.5a | 15.0c | 2.0c | 1.78a |
| Mean | 91 | 61.8 | 31.8 | 3.58 | 0.97 |
| CV | 1.61 | 10.49 | 19.32 | 34.68 | 13.57 |
| Sigini | *** | *** | * | ns | *** |

***= significant at p<0.001; **= significant at p<0.01;*= significant at p<0.05, **ns =** not significant; **DM**, days to maturity; **Pht**, plant height ( cm); **Leafr,** leaf rust (disease); **blotch** (disease) ;**Ytha-1**; yield tons per hectare

At Enseno the genotype 'Aquila' (4.69 t $ha^{-1}$), 'Millennium' (3.2 t $ha^{-1}$), 'Xena' (2. 99 t $ha^{-1}$) gave higher yield and out yielded the standard check 'Gabula' (2.38 t $ha^{-1}$) (Table 3). In 2011 at Halaba 'Aquila' was earlier to head than the standard check 'Gabula' which is an important character in low rainfall areas. In addition, four of the genotypes had more seeds spike $^{-1}$ while the check had the lowest seeds per spike (Table 4).

**Table 3: Agronomic and mean grain yield (t $ha^{-1}$) of introduced barley genotypes at Enseno, 2010**

| Varieties | DM | Pht | Leafr | blotch | $Ytha^{-1}$ |
|---|---|---|---|---|---|
| 'Millennium' | 93b | 80.3c | 22.5b | 5.5b | 3.20b |
| 'Walker' | 100a | 85.5abc | 15.0cd | 3.0c | 1.15d |
| 'Golden-eye' | 93b | 82.5abc | 60.0a | 8.0a | 2.07c |
| 'Xena' | 97b | 81.3bc | 12.5d | 0.0e | 2.99b |
| 'Aquila' | 93b | 88.3a | 20.0bc | 2.0d | 4.69a |
| 'Gabula' | 93b | 86.8ab | 20.0bc | 3.0c | 2.38c |
| Mean | 93.8 | 84.1 | 25.0 | 3.58 | 2.75 |
| CV | 3.07 | 4.98 | 19.32 | 17.89 | 11.98 |
| Sigini | *** | ns | *** | *** | *** |

***= significant at p<0.001; **= highly significant at p<0.01;*= significant at p<0.05, **ns =** not significant; **DH,** days to heading; **DM**, days to maturity; **Pht**, plant height (cm); **Leafr,** leaf rust (disease); **blotch** (disease) 0-9 scale; **Ytha-1**, yield tons per hectare

In the second year analysis of variance indicated that there were very highly significant differences (P<0.001) among the genotypes for all traits at Halaba and Enseno (Tables 4 and 5). In 2011 at Halaba variety 'Millennium' and 'Aquila' gave higher which is at par with yields with the standard check 'Gabula'. Four of the introduced genotypes *viz* Millennium', Walker', Aquila' and Golden-eye' had more seeds $spike^{-1}$as compared to the standard check (Table 4).

**Table 4: Agronomic, disease and mean grain yield (t ha$^{-1}$) of introduced barley genotypes at Halaba, 2011**

| Genoypes | DH | Blotch | Pht | Lod | SPL | SPS | Seeds PS | Ytha $^{-1}$ |
|---|---|---|---|---|---|---|---|---|
| 'Millennium' | 58b | 2.0bc | 58.2b | 0.0b | 5.8c | 24b | 48ab | 1.57ab |
| 'Walker' | 54c | 1.8cd | 65.8b | 0.0b | 6.1c | 25b | 49ab | 1.38b |
| 'Golden-eye' | 58b | 2.8b | 59.5b | 0.0b | 6.4c | 23b | 54a | 0.75c |
| 'Xena' | 64a | 5.3a | 60.3b | 0.0b | 7.5b | 11c | 25c | 0.53c |
| 'Aquila' | 47e | 1.0d | 67.1b | 1.3b | 7.6b | 30a | 52ab | 1.70ab |
| 'Gabula' | 52d | 1.3cd | 92.4a | 60.0a | 9.3a | 11c | 24c | 1.99a |
| Mean | 54.4 | 2.3 | 67.2 | 10.2 | 7.1 | 20.7 | 41.9 | 1.32 |
| CV | 3.0 | 23.9 | 8.3 | 64.4 | 9.8 | 9.0 | 9.4 | 26.3 |
| Sigini | *** | *** | *** | *** | *** | *** | *** | *** |

***= significant at p<0.001; **= significant at p<0.01;*= significant at p<0.05**DH,** days to heading; ; **Blotch** (disease) 0-9 scale; **Lod**, lodging 0-100%; **Pht**, plant height (cm); **SPL**, spike length (cm); **SPS**, spikelets per spike; **Seeds PS,** Seeds per spike; **Ytha-1**; yield tons per hectare

**Table 5: Agronomic and mean grain yield (t ha$^{-1}$) of introduced barley genotypes at Enseno, 2011**

| Genoypes | DH | DM | Pht | Lod | SPL | Ytha $^{-1}$ |
|---|---|---|---|---|---|---|
| 'Millennium' | 58b | 103a | 99.8ab | 0.0b | 5.8cd | 4.38a |
| 'Walker' | 63a | 95b | 98.5ab | 0.0b | 6.5cd | 5.12a |
| 'Golden-eye' | 57bc | 93c | 90.5b | 0.0b | 6.6cd | 3.72bc |
| 'Xena' | 62a | 102.0a | 91.0b | 0.0b | 7.3c | 3.03cd |
| 'Aquila' | 62a | 94c | 98.0b | 0.0b | 8.8b | 5.78a |
| 'Gabula' | 54c | 89d | 108.3a 26.3a | | 10.1a | 2.24d |
| Mean | 59.5 | 96.0 | 97.7 | 4.4 | 7.5 | 4.13 |
| CV | 3.4 | 1.5 | 6.4 | 44.7 | 9.6 | 16.6 |
| Sigini | *** | *** | * | *** | *** | *** |

***= significant at p<0.001; **= significant at p<0.01;*= significant at p<0.05 **DH,** days to heading; **DM**, days to maturity; **Lod**, lodging 0-100% scale; **Pht**, plant height ( cm); **SPL**, spike length ( cm); **Ytha-1**; yield tons per hectare

## 4. DISCUSSION

Combined analysis on grain yield (t ha$^{-1}$) at the two locations over the two years showed a highly significant differences for location by year, location by treatment and year x treatment interactions (Table 6). In both years the performance and yield of the genotypes were better at Enseno, especially in the year 2011 the mean grain yield was higher (4.13 t/ha) than the rest environments (Table 6) because at Enseno it receives better rainfall in the growing season than the first year of the experiment.

Generally the exotic varieties gave higher yield in low rainfall areas of Halaba and Enseno in the two seasons because genotypes were tolerant to the terminal drought. In agreement to this study many other authors also reported that introduced varieties were better yielder than the local cultivars under low rainfall areas of Central high lands of Ethiopia (Hiskias, 2011; Debebe & Alemu, 2011a; Debebe & Alemu, 2011b), northwest Ethiopia (Bantayehu and Esmael 2011) and northeast Ethiopia (Gebre Hawaryat *et al*., 2011).

**Table 6: Combined analysis of grain yield (t/ha) of the two years and two locations**

| Genoypes | Year x treatment | | Location x treatment | |
|---|---|---|---|---|
| | 2010 | 2011 | Halaba | Enseno |
| 'Millennium' | 2.04bcd | 2.98ab | 1.23ef | 3.79 b |
| 'Walker' | 0.88e | 3.50a | 1.0ef | 3.38 b |
| 'Golden-eye' | 1.39de | 2.4bcd | 0.70f | 2.89bc |
| 'Xena' | 1.92cd | 1.78de | 0.69f | 3.01bc |
| 'Aquila' | 2.83abc | 3.73a | 1.34ef | 5.22a |
| 'Gabula' | 2.83abc | 2.11bcd | 1.88de | 2.31cd |
| Mean | 2.29 | | | |
| CV | 24.92 | | | |
| Sigini. | *** | | *** | |

| Location x Year | | |
|---|---|---|
| Location | 2010 | 2011 |
| Halaba | 0.97 | 1.32 |
| Enseno | 2.75 | 4.13 |
| Sigini | *** | |

In agreement with the finding of Hiskias (2011) that terminal drought during the growing season is the major limiting factors of yield in the low moisture areas of Halaba and Enseno. Debebe & Alemu (2011b) reported that the most important factor in barley adaptation to the low moisture areas is early ear emergence, and is common in Ethiopian landraces from low-moisture areas. Thus, farmers in drought-prone areas grow their own landraces that are well adapted to the local environment, but with poor yielding ability. The author also added that early maturity is also an important parameter when breeding for low-moisture areas, and ensures an escape mechanism from moisture shortage during the grain filling period. Even though the standard check 'Gabula' was early maturing than the introduced genotypes the yield was low in these low moisture stress areas because the exotic genotypes were better tolerant to the terminal drought. Alemu et al. (2010) confirmed that exotic genotypes from ICARDA performed better in comparison to landraces for grain yield and yield components. In this study also exotic genotypes performed better than the standard check in both seasons and locations. Saidi et al. (2005) also noted that the introduced two rowed barley from Europe gave higher yield than the predominant landraces in semi-arid agro-ecologies of Morocco. But in contrast to this result in marginal environments, local barley landraces outyield non-landrace material (Ceccarelli, 1994; Abay *et al.*, 2009). However, in high yielding environments the reverse is true.

In the second year of the experiment both sites received better rainfall during the growing season compared to the long term mean of Halaba and Enseno. Rainfall mainly relies of July and August at Halaba received 46.8% and 26.77% more rainfall respectively to the long term rainfall mean. It was seen that better growth and grain yield of barley at Enseno in 2011 showed that rainfall pattern was good relative to 2010. Terminal drought is the main problems of the area where most of the exotic genotypes performed better than the standard check both in the worst and optimum conditions.

Currently farmers in low-moisture areas forced to grow low yielding barley genotypes because they lack improved varieties adapted to low-moisture conditions. To tackle this problem it is important to introduce exotic germplasms from international sources that are high yielding and adapted to low- moisture stress areas. In short period there is a need to pre-scale up/out especially variety 'Aquila' which gave higher yield both from the exotic genotypes and the standard check. In the long run the exotic germplasms will be used as source of gene pool for genetic improvement of the local landraces through genetic recombination by hybridization of genotypes with desirable traits.

## ACKNOWLEDGEMENTS

I am grateful to Morrell Agro Industries PLC for kindly providing barely seeds. I would like to extend my thanks to Southern Agricultural Research Institute and Hawassa Agricultural Research Center, for provision of the necessary services and facilities.

## REFERENCES

Abay F., Bjørstad, A. and Smale, M. (2009). Measuring on Farm Diversity and Determinants of of Barley Diversity in Tgray, Northen Ethiopia. MEJS 1(2), 44-66

Alemu T., dos Santos, L.A and Missio, R.F. (2010). Genetic divergence among barley accessions from Ethiopia. *Crop Breeding and Applied Biotechnology* 10: 116-123. Brazilian Society of Plant Breeding.

Bantayehu, M. and Esmael, J. (2011). Achievements in food barley breeding research in the early production systems of northwest Ethiopia 83– 89, *in*: Mulatu, B. and Grando, S. (eds). *Barley Research* *and Development in Ethiopia*. Proceedings of the 2nd National Barley Research and Development ReviewWorkshop. 28-30 November 2006, HARC, Holetta, Ethiopia. ICARDA, PO Box 5466, Aleppo, Syria. pp xiv + 391.

Bekele B., Alemayehu, F. and Lakew, B. (2005). Food barley in Ethiopia.pp 53–82, *in*: S. Grando and H. Gomez Macpherson (eds.). *Food Barley: Importance, Use and Local Knowledge*. Proceedings of the International Workshop on Food Barley Improvement, 14–17 January 2002, Hammamet, Tunisia. ICARDA, Aleppo, Syria.

Ceccarelli, S.(1994). Specific adaptation and breeding for marginal conditions. *Euphytica,* 77: 205-219.

CSA [Central Statistical Agency]. (2011). Agricultural Sample Survey (Private peasant holdings, *Meher* season). Reports on Farm management practices. Statistical Bulletin. CSA, Addis Ababa, Ethiopia.

CSA [Central Statistical Agency]. (2014). Area and production of crops (Private peasant holdings, *Meher* season). Agricultural Sample Survey 2014. Statistical Bulletin. CSA, Addis Ababa, Ethiopia.

Debebe, S. and Alemu, T. (2011a). Response of exotic barley germplasm to low-moisture stressed environments pp 57 – 63, *in*: Mulatu, B. and Grando, S. (eds). *Barley Research and Development in Ethiopia*. Proceedings of the 2nd National Barley Research and Development ReviewWorkshop. 28-30 November 2006, HARC, Holetta, Ethiopia. ICARDA, PO Box 5466, Aleppo, Syria. pp xiv + 391.

Debebe, S. and Alemu, T.( 2011b). Achievements of food barley breeding research in Arsi Highlands pp 65– 72, *in*: Mulatu, B. and Grando, S. (eds).. *Barley Research and Development in Ethiopia*. Proceedings of the 2nd National Barley Research and Development ReviewWorkshop. 28-30 November 2006, HARC, Holetta, Ethiopia. ICARDA, PO Box 5466, Aleppo, Syria. pp xiv + 391.

Esayas, A., Ali A. and Tafesse D. (2006). Soils of The farm lands of Hawassa Agricultural Research Center and its testing sites.

Gebre Hawaryat, Y., Teshome, K. and Wondimu, S. (2011). Achievements of food barley breeding research for low moisture stressed environments of north east Ethiopia 91– 98, *in*: Mulatu, B. and Grando, S. (eds).. *Barley Research and Development in Ethiopia*. Proceedings of the 2nd National Barley Research and Development ReviewWorkshop. 28-30 November 2006, HARC, Holetta, Ethiopia. ICARDA, PO Box 5466, Aleppo, Syria. pp xiv + 391.

Hiskias, Y.( 2011). Response of barley landraces to low-moisture stress in a low rainfall Environment pp 47–56, *in*: Mulatu, B. and Grando, S. (eds).. *Barley Research and Development in Ethiopia*. Proceedings of the 2nd National Barley Research and Development ReviewWorkshop. 28-30 November 2006, HARC, Holetta, Ethiopia. ICARDA, PO Box 5466, Aleppo, Syria. pp xiv + 391.

Jackson, L.(2011). Barley cultivars for California. Department of plant sciences, University of California, Davis http://smallgrains.ucdavis.edu.

Mulatu, B. and Lakew, B. (2011). Barley research and development in Ethiopia – an overview pp 1–16, *in*: Mulatu, B. and Grando, S. (eds). *Barley Research and Development in Ethiopia*. Proceedings of the 2nd National Barley Research and Development Review Workshop. 28-30 November 2006, HARC, Holetta, Ethiopia. ICARDA, PO Box 5466, Aleppo, Syria. pp xiv + 391.

Saidi, S., Lemtouni, A., Amri, A. and Moudden, M.(2005). Use of Barley Grain for Food in Morocco. pp 17–21, *in*: S. Grando and H. Gomez Macpherson (eds.). *Food Barley: Importance, Use and Local Knowledge*. Proceedings of the International Workshop on Food Barley Improvement, 14–17 January 2002, Hammamet, Tunisia. ICARDA, Aleppo, Syria.

SAS Institute Inc. (2002). SAS/STAT User's Guide, Version 9, Carry,NC, USA.

**Cite this Article:** Shegaw D (2017). Adaptations of Exotic Barley Genotypes to Low-moisture Environments in Southern Ethiopia. Greener Journal of Agricultural Sciences, 7(6): 126-131, http://doi.org/10.15580/GJAS.2017.6.071617088.