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Genotype by environment interaction and grain yield stability of early maturing Food barley (*Hordeum vulgare* L.) genotypes in the drought prone areas of Tigray region, northern Ethiopia

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ABSTRACT

An experiment on evaluating the performance of food barley genotypes for food quality and yield related traits were carried out at Atsbi , Dugua Tembien and Gulomekeda in Tigray Region. The objectives of the study was to evaluate the yield and yield related performance of different food barley genotypes under different locations .The experiment was conducted Alpha lattice design with three replications. The trial was conducted two growing seasons (2013-2014) Performances of thirty two food barley genotypes with standard and local check (ERETH07-79, Demhay, ISEBON-60#1, ISEBON-71, ERETH07-66#1, ERETH07-69#1, ERETH07-85#1, ERETH07-65#1, ERETH07-84, Tselim Ekli#1, ISEBON-91#1, ERETH07-80#2, ERETH07-78, ERETH07-78, ERETH07-39#1, ERETH07-47#1, ERETH07-68#1, ERETH07-90, Abay#1, ERETH07-59#1, ISEBON-50#1, ERETH07-11#1, ERETH07-49#1, ERETH07-51, ERETH07-51#1, Eritrea07-78, ERETH07-80#3, ISEBON-89, Eritrea07-71, ERETH07-80, Sae'sae (local check), Fetina and Dafo(standard check)) were evaluated. The combined analysis of variance showed that there were significant variations among genotypes, environments and their interaction. Based on grain yield, ERETH07-51 (1.74 t/ha) and ERETH07-80 #3(1.72 t/ha) had scored the highest yield, while the local check yielded the least (1.43t/ha). With respect to the multivariate stability parameters, the different models identified the stability performance of the genotypes. Based on the overall rank sum of stability parameters, the lines, ERETH07-80#2, ERETH07-80#3 and ERETH07-51#1 were the most stable varieties, while ERETH07-47#1and ERETH07-65#1 the least stable once. Since the tested varieties had shown differential yield responses across the environments, it is concluded that varietal recommendation should be based not only on overall mean yield, but also on their stability performance

Key words: Stability, Grain yield, Environment, Genotypes, Tigray

INTRODUCTION

Barley (Hordeum vulgare L.) is an annual herbaceous plant with a fibrous root system. It is a member of the grass family Poaceae and descended from wild barley (Hordeum spontaneum K). Both forms are diploid with seven pairs of chromosomes (2n = 14) (Marcel et al, 2008).

Barley was grown when agriculture was first developed in Mesopotamia, essential in ancient Egypt. It is the most important bread cereal of both the Greeks and the Romans. At present, barley is the fourth most cultivated cereal in the world, after wheat, maize and rice (Marwat et al., 2012). The species is divided into three subgroups, six-row (Hordeum vulgare), two-row (Hordeum distichum) and intermediate (Hordeum irregulare), and both spring- and autumn-sown types are grown. It is the major cereal grain used for malt production for beer and whiskey, and animal feed.

Barley is the fourth most important cereals of the world after wheat, rice and maize .it is a major food source of food for large population of cool and semi-arid areas of the world, where wheat and other cereals are less adapted. According to farmers, barley is the "king of crops" and it is put for diverse uses with more than 20 types of barley dishes and beverages reportedly prepared in the study area. The products are prepared from either boiled/roasted whole grain, raw- and roasted-milled grain, or cracked grain as main, side, ceremonial, and recuperating dishes. The various barley traditional foods have perceived qualities and health benefits by the farmers (Hailemichael and Sopade, 2011).

According to Karvy (2010), barley is the fourth-largest cereal crop in the world, with a share of 7% of the global cereals production. In 2009 and 2010, world production of barley was 152 and 124 MMT, respectively (Nikkhah, 2012). According to this author, the top barley producing countries are Germany, France, Ukraine and Russia. According to FAOSTAT (2010) reports Ethiopia was 21th in the world and third in Africa next to Morocco and Algeria for barley production. In West Asia and North Africa, the major producers are Turkey, Morocco, Syria, Iran, Iraq, Algeria and Ethiopia(FAO,2003).

The crop is mainly produced in unfavorable climate and soil conditions of the world. Its wide adaptation versatile utility mainly for animal feed and food and superiority for malt and beer industry as a raw material are the main reasons that enable barley to be commonly cultivated crop plant over centuries. It is cultivated in highly diverse regions of the world from 330 m below sea level near the Dead Sea in the Middle East up to 4200 m on the Altiplano and the Andes in Bolivia (Akar et al., 2004).

It is a short-season, early maturing crop with high yield potential and a wide range of adaptation, worldwide, it can be grown successfully where other grain crops are poorly adapted, including high latitude and high elevation regions and even bordering desert. However, barley likes to grow under cool conditions but it is not particularly winter hardy. Cultivated barley can be distinguished in to two types: two-row and six-row barley which may either be hulled or hulles.

Barley is believed to have been cultivated in Ethiopia as early as 3000 BC (CSA, 2003). It is grown in a wide range of environments, from high altitude areas (>3000 m.a.s.l) to low-rainfall environments, including the Rift Valley. A long history of cultivation, together with wide agro-ecological and cultural diversity in the country, has resulted in a large number of landraces of the crop, which can adapt to different environmental conditions. Among the important traits that could exist in the landraces are earliness, high nutritional quality, disease and pest tolerance, tolerance to drought and other forms of abiotic stress, and characters useful for low input agriculture (Yaynu, 2011). It 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 (Bayeh and Berhane, 2011). Malting barley, however, requires a favorable environment to produce a plump and mealy grain. Ethiopia is a country renowned for the diversity of its native barley types and is recognized internationally to harbor valuable barley genetic resources (Fetien et al., 2008). The crop is the fifth most important crop in Ethiopia after teff, maize, wheat and sorghum. It is also the fourth most essential crop in Tigray next to sorghum, teff and wheat (CSA, 2012).

The barley contains substantially higher amounts of functional ingredient β-glucan. The use of β-glucan extracted from barley as human food due to its, positive role in human health has received a growing attention (Din eta l., 2009). Therefore, food barley varieties of early set and high yielding which were released nationally could answer the problem of low yielding barley landraces that worsen food insecurity besides low rainfall.

The Objectives of evaluate the yield and yield related performance of different food barley genotypes under different locations grown across different sites in Tigray and obtained high yielder and resistance biotic and abiotic stresses.

MATERIALS AND METHODS

3.1 Description of the experimental sites

The experiment was carried out during the main rainy season in 2014 and 2015 in two zones of the highlands of Tigray Region: in south eastern zone (DuguaTembien), and Eastern zone (Atsbi and Gulomekeda). The design of trials was implemented Alpha lattice with three replication,

Distribution of rainfall was not uniform throughout the growing period .the rainfall was very erratic particularly during early growing season and at reproductive stages.

Table1: Description of the 3 locations used for evaluation of 32 food barley genotype included standard and local landrace

Testing location	AEZ	Geographical position		Altitude (m.a.s.l)	Annual Rainfall (mm)	Annual Temperature(°c)	
		latitude	longitude			Mini.	Max.
Atsbi-wemberta	SM2	14°13''02.51'N	39°20''45.37E	2848	550	10°C	24°C
Gulo-mekeda	SM2-S	14°23''28.76N	39°23''59.97E	2528	552	7.72°C	24.14°C
Dugua Tembien		13 061'N	39°14''21.92'E	2412	884.6	14.8°c	25.1°c

Source: Abbadi (2008a.b) and New Loclim soil water (version)

Plant materials

The experimental material comprised of thirty two barley (Hordeum vulgare), genotypes with standard and local check namely ERETH07-79, Demhay, ISEBON-60#1, ISEBON-71, ERETH07-66#1, ERETH07-69#1, ERETH07-85#1, ERETH07-65#1, ERETH07-84, Tselim Ekli#1, ISEBON-91#1, ERETH07-80#2, ERETH07-78, ERETH07-78, ERETH07-39#1, ERETH07-47#1, ERETH07-68#1, ERETH07-90, Abay#1, ERETH07-59#1, ISEBON-50#1, ERETH07-11#1, ERETH07-49#1, ERETH07-51, ERETH07-51#1, Eritrea07-78, ERETH07-80#3, ISEBON-89, Eritrea07-71, ERETH07-80, Sae'sae (local check), Fetina and Dafo(standard check). These genotypes were used as treatments and evaluated in the study.

Statistical analysis

Stability analysis of variance and stability parameters like linear regression coefficient (bi) and deviation from regressions of genotypes measured over environmental index (S2di) were computed for grain yield as suggested by Eberrhart and Russell (1966) using GenStat Version 12 (Virk and Witcombe, 2008).

The analysis was conducted used SAS and Genstat software version 9 and 16 respectively.

RESULTS AND DISCUSSIONS

The analysis of variance for grain yield revealed significant differences among the genotypes while significant variations among locations for grain yield (Table 1). This indicates that the locations are different in productivity that might be attributed to variations in soil type, soil fertility, moisture availability, management and temperature. In line with the current study, a finding on GxE interaction on bread wheat lines in Southern Sudan revealed similarly significant difference in location (Mohhamed, 2009).

Table1: means Analysis of variance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	2	349770.	174885.	0.93	
Rep.*Units* stratum					
Genotype	31	16319426.	526433.	2.80	<.001
Location	2	237057746.	118528873.	629.89	<.001
Genotype.Location	62	17504038.	282323.	1.50	0.020
Residual	190	35753320.	188175.		
Total	287	306984299.			

Variate: GY_kg_ha

Genotype	Atbi(t/ha	D/T(t/ha)	Gulomekeda(t/ha)
Abay#1	0.69	1.697	2.327
Dafo	0.773	1.276	1.646
Demhay	0.872	1.352	1.587
ERETH07-11#1	0.656	1.889	1.904
ERETH07-39#1	0.649	1.43	1.93
ERETH07-47#1	0.695	1.282	1.494
ERETH07-49#1	0.603	1.676	2.08
ERETH07-51	0.524	2.105	2.578
ERETH07-51#1	0.738	1.942	2.427
ERETH07-59#1	0.57	1.794	1.903
ERETH07-65#1	0.504	1.335	1.581
ERETH07-66#1	0.809	1.477	2.362
ERETH07-68#1	0.625	1.485	1.98
ERETH07-69#1	0.608	1.195	1.982
ERETH07-78	0.585	1.529	2.004
ERETH07-79	0.588	1.724	1.924
ERETH07-80	0.6	1.864	2.548
ERETH07-80#2	0.845	1.812	2.335
ERETH07-80#3	0.876	1.765	2.512
ERETH07-84	0.657	1.735	1.818
ERETH07-85#1	1.101	1.547	2.355
ERETH07-90	0.723	1.705	1.546
Eritrea07-71	0.618	1.48	2.177
Eritrea07-78	0.779	1.326	2.127
Fetina	0.737	1.326	1.754
ISEBON-50#1	0.746	1.573	2.315
ISEBON-60#1	0.656	1.533	2.23
ISEBON-71	0.777	1.698	2.258
ISEBON-89	0.658	1.79	2.371
ISEBON-91#1	0.645	1.723	2.501
Sae sae	0.6	1.605	2.071
Tselim Ekli#1	0.668	1.376	2.129

CONCLUSION AND RECOMMENDATIONS

The trials were conducted three drought prone areas of Northern Ethiopia, Tigray Regions that are affected irregular rainfall distribution at vegetative stage had higher amount of rain fall exposed the crop for waterlogging and at the grain fulling stage moisture deficit problem influenced yields. Based those fluctuated problems Mekelle Agricultural Research center design of genotype by environment interaction and grain yield stability of early maturing food barley was conducted as the result two genotype ERETHO7-51 and ERETHO7-80 evaluated by national crop committees and released to varieties those two varieties were high yielder and suitable for drought prone areas those early maturing compared for the standard checks..

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Competing interests:

None of the authors have an association that poses any conflict of interest. The funders had no part in the decision to publish the manuscript.

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