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Effect of terminal drought stress and Tolerance of some agronomic traits in advance lines of barley (Hordeum vulgar) cultivars

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ABSTRACT: In order to evaluate seven advance barley lines (Hordeum vulgar): (MB-87-10, MB-87-14, MB-87-19, MBD-87-13, MBD-87-15, MBD-87-16) and two control cultivars (Nosrat and Yosef) under drought stress and non-stress conditions, carried out two separate experiments in a randomized complete block design with three replications during 2011-2012. Some traits such as (PLH), (DH), (DM), (TKW) and (GY) were meager and evaluated. The results showed differences between barley lines for all studied traits. S1×MB-87-19 interaction effect had the highest grain yield (7.52 ton /ha^{-1}) and S2×MBD-87-15interaction effects had the lowest grain yield (3.77 ton/ha^{-1}), respectively. (Table 5).The highest plant height was related to S1×Yosef interaction effect (103.67 cm) and the lowest plant height were related to S2×MBD-87-13 interaction effects (92.00 cm). S1×MB-87-14 and S2×MBD-87-16 interaction effects had the highest and lowest amounts of Days to Heading (187.33 and 179.33 days, respectively). S1×MB-87-14 interaction effect had the highest Days to Maturity (228.67 days) and Nosrat had the lowest Days to Maturity (210 days) and S1×Nosrat interaction effect had the highest Thousand Kernel Weight (44.16 g) and S2×MB-87-14 had the lowest Thousand Kernel Weight (32.69 g)

***Keywords*:** Barely, Combined Analysis, Grain Yield, Phonological and Morphological Traits, and Terminal Drought Stress

INTRODUCTION

Barley is one of the most important cereal crop grown in many countries where it is often subject to extreme drought stress that significantly affects production (Ceccarelli et al., 2007). Such information is important for plant breeders to select traits for drought tolerance and to farmer for better crop management to avoid the occurrence of a drought period at the critical stage of development (Yazdchi, 2008). (Kilic et al., 2010) reported that due to earliness and its ability to escape terminal drought stress, barley would be a suitable crop in areas where irrigation is poorly available. The genetic structure and phenotypic expression of a quantitative trait are highly influenced by environmental factors, thus one barrier for understanding the inheritance of a quantitative trait is genotype × environment interactions (Breese, 1969). Genotype × environment reduces the rate of genetic improvement in crop plants and makes it necessary to test selections over several seasons and sites (Yau and Ortiz- Ferrara, 1994). Stress resistance of a given plant genotype cause the product of many physiological and morphological characters which effective selection criteria have not yet been developed (Fischer and Maurer, 1978). Therefore, grain yield and its components remain as the major selection criteria for improved adaptation to a stress environment in many breeding programs (Kutlu and Kinaci, 2010). (Gavuzzi et al., 1997) concluded that, when good standardization of procedures are obtained, the tests investigated can be regarded as possible tools in breeding programs for tolerance to heat and drought stress.

MATERIALS AND METHODS

This experiment was carried out in (2011) in Research Center of Agriculture and Natural Resources of Kermanshah in Iran. This filed placed in (34°/08´) latitude, and (26°/47´) longitude with 1346 m height and 538 mm. rainfall annual average. Two separate experiments carried out in a Randomized Complete Block Design(RCBD) with three replications using seven advance barley lines (Hordeum vulgar): (MB-87-10, MB-87-14, MB-87-19, MBD-87-13, MBD-87-15, MBD-87-16,), and two control (Nosrat and Yosef) in stress and non-stress conditions. Experiments carried out in the same conditions and stopped the irrigation at Early Heading stage in one of them. Seeds were planted in 3 to 5 cm deep on October 28 in 2010. Individual plot consisted of 6 rows with 240 cm long, 20 cm distances between rows and 5 cm distances between plants (400 seeds in 1 m^2). Used fertilizers include 200 kg/ ha phosphate and 150 kg/ha ammonium (the hole of phosphate and 1/3 of ammonium applied prior to planting and 2/3 of ammonium at the two stage of growth, Raw Rating and Early Heading). Weeds were weeded four times during the season. 10 plant samples were randomly chosen from middle part of each row. and were recorded days to heeding (DH), days to maturity(DM), plant height(PLH), Then, plant samples were measured for the following traits Thousand Kernel Weight(TKW) for each plot or the mean of 10 randomly selected plants in the center rows of each plot. Grain yield was measured by harvesting 1 m of the central part of each plot at physiological maturity. Reduction percentage was calculated as follows (Choukan *et al.,* 2006) Where Yp is the yield under non-stress condition and Ys the yield under stress:

$$\% \mathrm{Re}\, duction = (\frac{Y_P - Y_S}{Y_P}) \times 100$$

The data were tested for Skewness, kurtosis and homogeneity of variance for normality. Conducted combined analysis of variance based on (RCBD), compared quantitative traits means based on Duncan's new multiple range tests and performed Interaction analysis by used of SAS9.2 and SPSS20 software's.

RESULTS AND DISCUSSION

Results of variance analysis revealed that genotype effects were statistically significant at 1% and 5%level probability for all traits in non-stress and terminal drought stress conditions, indicating the existence of genetic variability for studied traits. Genotype effects were significant for all traits except (DM) and (GY) in non-stress and terminal drought stress conditions indicating the effects of terminal drought stress on these traits to decrease its variability (Table1). Results indicated that the magnitude of differences in genotypes was sufficient to select them against drought.(Kutlu and Kinaci, 2010; Noshadifard, Zare ,2012 and Niazi Fard et al., 2012) also reported similar results for plant height, and grain yield in both terminal drought stress and non-stress conditions.

Table 1. Variance Analysis for studied traits in ten barley genotypes under non-stress and stress conditions

	S.O.V	DF	Mean Square				
			PLH	DH	DM	TKW	GY
Normal Condition	BLOCK	2	0.0003ns	0.0001*	0.00002ns	0.0016ns	0.0023ns
	GENOTYPE	7	0.0009**	0.00009**	0.0002**	0.0019*	0.0067*
	ERROR	14	.0001	0.00002	.00002	0.0007	0.0024
	S.V		0.51	0.19	0.19	1.71	1.29
Terminal Drought Stress Condition	BLOCK	2	0.00054ns	0.00002ns	0.00002ns	0.0009ns	0.00009ns
	GENOTYPE	7	0.00066**	0.00012**	0.0002**	0.004**	0.017**
	ERROR	14	0.00007	0.00002	0.00004	0.0004	0.0015
	S.V		0.43	0.19	0.26	1.33	1.03

Morphological traits: Plant Height (PLH); Days to Heading (DH); Days to Maturity (DM); Thousand Kernel Weight (TKW) and Grain Yield (GY)

**significant at 1%level probability, *significant at 5%level probability, ns Non-significant

Table 2. Effect of Genotypes on studied traits in ten barley genotypes under non-stress and stress conditions

	PLH	DH	DM	TKW	GY
Normal Condition					
YOSEF	103.67 a	186.67 ab	226.33 ab	42.33 a	7.32 a
MB-87-10	95.33 bc	185.00 ab	224.00 bc	37.40 b	6.80 ab
MB-87-14	102.00 a	187.33 a	228.67 a	39.27 ab	6.40 ab
MB-87-19	92.67 c	184.33 bc	227.00 ab	41.00 ab	7.52 a
MBD-87-13	92.67 c	183.33 bc	224.67 bc	43.00 a	6.23 ab
MBD-87-15	98.67 ab	183.67 bc	221.00 cd	43.27 a	5.52 b
MBD-87-16	95.67 bc	180.33 c	218.33 d	42.87 a	6.08 ab
NOSRAT	99.67 ab	182.00 c	220.67 cd	44.16 a	7.19 a
Terminal Drought Stress Condition					
YOSEF	98.67 a	185.00 ab	218.00 ab	38.10 bc	5.78 ab
MB-87-10	93.33 cd	183.33 bc	216.67 ab	35.65 c	5.45 ab
MB-87-14	97.67 ab	187.33 a	220.67 a	32.69 d	5.40 ab
MB-87-19	90.33 e	183.00 bc	220.33 a	38.01 bc	6.20 a
MBD-87-13	92.00 de	181.00 c	220.67 a	38.64 bc	5.03 b
MBD-87-15	96.33 ab	182.67 bc	212.33 bc	41.05 ab	3.77 c
MBD-87-16	95.33 bc	179.33 c	210.33 c	39.36 abc	4.25 c
NOSRAT	97.33 ab	180.00 c	210.00 c	42.65 a	6.14 a

Morphological traits: Plant Height (PLH), Days to Heading (DH); Days to Maturity (DM); Thousand Kernel Weight (TKW) and Grain Yield (GY).

Means in each column, followed by similar letter(s) are not significantly different at 5% probability level, using Duncan's Multiple Range Test.

Means comparison showed that Yosef control cultivar and MBD-87-13 advanced lines had the amount highest and lowest Plant Height in non-stress and Yosef control cultivar and MBD-87-19 had the amount highest and lowest Plant Height in terminal drought stress condition, respectively. MB-87-14 and MBD-87-16 advanced lines had the highest and lowest Days to Heading in non-stress and MB-87-14 and MBD-87-16 had the highest and lowest amounts of Days to Heading in terminal drought stress condition. MB-87-14 and MBD-87-16 advanced lines had the highest and lowest Days to Maturity in non-stress and MB-87-14 and MBD-87-16 had the highest and lowest amounts of Days to Maturity in terminal drought stress conditions. MBD-87-15 and MB-87-10 had the highest and lowest Thousand Kernel Weight in non-stress condition. Nosrat and MB-87-10 had the highest and lowest amounts of (TKW) in terminal drought stress condition. MB-87-19 and MBD-87-15 advance lines had the highest and lowest Grain Yield amounts in non-stress and MB-87-19 and MBD-87-15 had the highest and lowest Grain Yield amounts in terminal drought stress conditions (Table 2). Results of combined variance analysis across environments revealed that stress effects were significant for Plant Height, Days to Heading, Days to Maturity, Thousand Kernel Weight and Grain Yield that indicated these traits were influenced by drought stress conditions (Table 3). Environment effects were significant (P > 0.01) for Days to Maturity and Grain Yield and (P > 0.05) for Plant Height and Thousand Kernel Weight, indicating that all traits are influenced by drought stress conditions (Table 3). Other authors have found that drought stress effects were significant for plant height (Niazi Fard et al., 2012, Akcura et al., 2011; Naghaii and Asgharipour, 2011; Kutlu and Kinaci, 2010), biological yield (Naghaii and Asgharipour, 2011), kernel thickness (Kutlu and Kinaci, 2010), spike weight (Akcura et al., 2011; Cutlu and Kinaci, 2010), 100-grain weight (Naghaii and Asgharipour, 2011; Kutlu and Kinaci, 2010), and grain yield (Niazi Fard et al., 2012, Akcura and Ceri, 2011; Niari-Khamssi, 2011; Naghaii and Asgharipour, 2011; Yazdchi, 2008; Gavuzzi et al., 1997).

Table 3. Combined analysis of variance for studied traits in barley

		Mean Square				
S.O.V	DF	PLH	DHE	DMA	TKW	GY
Environment	1	0.0014*	0.00008ns	0.0029**	0.017*	0.13**
A Error	4	0.00017	0.00007	0.000008	0.0013	0.0011
GENOTYPE	7	0.0016**	0.0002**	0.0004**	0.005**	0.022**
GENOTYPE* Environment	7	0.0005**	0.0008**	0.0003**	0.007**	0.02**
B Error	28	0.00009	0.00002	0.00003	0.0006	0.002
S.V		0.47	0.19	0.22	1.53	1.17

Morphological traits: plant height (PLH); Days to Heading (DH); Days to Maturity (DM); thousandkernel weight (TKW) Grain Yield (GY).

**significant at 1% level probability, *significant at 5% level probability, ns Non-Significant

The decrease percent in thousand kernel weight under drought stress condition was 8.20. TKW is one of the major components of grain yield and is more important than 100-grain weight reduction in plant breeding (Ivanovska et al., 2007). Grain yield was affected under drought stress condition and it was reduced about 23.21% compared to non-stress condition (Table 4).(Niazi Fard et al., 2012) and (Naghaii and Asgharipour ,2011) and also reported similar results for biological yield, 1000-grain weight and grain yield. The results showed that the studied barley cultivars were significantly different in all traits, indicating the existence of genetic variability for them (Table 3). (Naghaii and Asgharipour ,2011) and (Niazi Fard et al., 2012) similarly revealed that genotype effects were highly significant for plant height, biological yield, 1000-grain weight and grain yield. (Niazi Fard et al., 2012) and (Kutlu and Kinaci ,2010) also reported similar results for spike length, spike weight, kernel length and grain yield.

Table 4. Means value for different traits of barley under non-stress and terminal drought stress conditions

Traits	s1	s2	% decrease
Kernel YIELD	6.63	5.25	23.21
Plant Height	97.54	95.12	2.43
Days to Heading	184.08	182.71	0.75
Days to Maturity	223.83	216.13	3.45
Thousand Kernel Weight	41.66	38.27	8.20

Generally, all the studied traits except days from emergence to physiological maturity and kernel length traits were influenced by drought stress conditions (Kinaci, 2010; Akcura et al., 2011; Naghaii and Asgharipour, 2011; Akcura and Ceri, 2011; Yazdchi, 2008). Grain yield had the highest decrease percent under drought stress condition that it was probably due to reduce 100-grain weight and spike weight under drought stress. Based on the results of simple and combined analysis of variance in studied traits, MB-87-19 had the highest grain yield under drought stress and non-stress conditions, respectively and MBD-87-15 had the lowest grain yield in both stress and non-stress conditions.

Stress × genotype interaction effects were significant for Plant Height, Days to Heading, Days to Maturity, thousand kernel weight and Grain Yield. Indicating that genotypes did not respond to the environments similarly (Table 5). Other researchers have reported that genotype × stress interaction effects were significant for days from emergence to physiological maturity (Yazdchi, 2008), plant height (Akcura et al., 2011), biological yield and 1000-grain weight (Naghaii and Asgharipour, 2011), kernel length (Kutlu and Kinaci, 2010) and Plant Height and Days to Heading (Niazi Fard et al., 2012). S1×MB-87-19 interaction effect had the highest grain yield (7.52 ton /ha^{-1}) and S2×MBD-87-15interaction effects had the lowest grain yield (3.77 ton/ha^{-1}), respectively. (Table 5).The highest plant height was related to S1×Yosef interaction effect (103.67 cm) and the lowest plant height were related to S2×MBD-87-13 interaction effects (92.00 cm). S1×MB-87-14 and S2×MBD-87-16 interaction effects had the highest and lowest amounts of Days to Heading (187.33 and 179.33 days, respectively). S1×MB-87-14 interaction effect had the highest Days to Maturity (228.67 days) and Nosrat had the lowest Days to Maturity (210 days) and S1×Nosrat interaction effect had the highest Thousand Kernel Weight (44.16 g) and S2×MB-87-14 had the lowest Thousand Kernel Weight (32.69 g), (Table 5).

Table 5. Interaction effects of Stress × Genotype on studied traits in barley

Interaction	GY	PLH	DHE	DMA	TKW
S1×YOSEF	7.32	103.67	186.67	226.33	42.33
S1×MB-87-10	6.80	95.33	185.00	224.00	37.40
S1×MB-87-14	6.40	102.00	187.33	228.67	39.27
S1×MB-87-19	7.52	92.67	184.33	227.00	41.00
S1×MBD-87-13	6.23	92.67	183.33	224.67	43.00
S1×MBD-87-15	5.52	98.67	183.67	221.00	43.27
S1×MBD-87-16	6.08	95.67	180.33	218.33	42.87
S1×NOSRAT	7.19	99.67	182.00	220.67	44.16
S2×YOSEF	5.78	98.67	185.00	218.00	38.10
S2×MB-87-10	5.45	93.33	183.33	216.67	35.65
S2×MB-87-14	5.40	97.67	187.33	220.67	32.69
S2×MB-87-19	6.20	90.33	183.00	220.33	38.01
S2×MBD-87-13	5.03	92.00	181.00	220.67	38.64
S2×MBD-87-15	3.77	96.33	182.67	212.33	41.05
S2×MBD-87-16	4.25	95.33	179.33	210.33	39.36
S2×NOSRAT	6.14	97.33	180.00	210.00	42.65

S1: Non-stress condition, S2: Stress condition

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