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Variability and Genetic Parameters for Related Traits to Drought Tolerance in Doubled Haploid Population of Barley (*Hordeum vulgare*)

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ABSTRACT

An experiment was conducted at two locations in Tel Hadya and Breda during year 2003 - 2004 growing season, to evaluate the yield performance and some agronomic traits of 158 barley doubled haploid for drought tolerance. An alpha- lattice with two replications design with two replications was used and 11 agronomic traits were recorded. Narrow sense heritability values were obtained ranging from 0.23 to 0.85 in Tel-Hadya and 0.16 to 0.74 in Breda. The highest heritability was obtained for 1000 kernel weight and then for days to heading in both environments, indicating that these traits are controlled by additive effects. The correlations between grain yield with peduncle length, extrude of spike, days to maturity, number of kernel per spike and 1000 kernel weight were significant in both Tel Hadya and Breda. The best DH lines when compared with the best parent showed significantly higher values for plant height, peduncle length, extrude of spike, spike length, 1000 kernel weight and grain yield in both environments. Because of low genetic gain and heritability for grain yield compared to other characters, selection based on yield components is recommended.

Key Words: Variability; Genetic parameters; Related traits; Double haploid; *Hordeum vulrare*

INTRODUCTION

Breeders instinctively look for new sources of variation when attempting to improve plants, but empirical selection in the case of drought tolerance has been difficult. The reasons are that drought tolerance is not a simple response, but is mostly conditioned by a number of components responses, which interact and may differ for different crops and in response to different types, intensity and duration of water deficit. Also, selection under controlled environments rarely correlation with performance in the field, as it is difficult to obtain consistent ranking of response to drought stress because of year-to-year variability in the environment.

Despite of these difficulties, physiologists have described a number of individual responses or traits that are claimed to be associated with or to confer drought tolerance in crop plants. Although, it may be simplistic to claim a direct relationship, there is some evidence that some of these traits may contribute to particular forms of drought tolerance (Mc William, 1989).

A practical approach to physiological breeding geared to improving drought tolerance of yield under stress is forced to start from yield and move towards underlying process. This is a consequence of the fact that at present a quantitative definition of total drought tolerance is not possible in physiological terms. Fischer (1981) named this strategy the "black box" and contrasted it to be "ideotype" strategy, which attempts to predict yield from an understanding of process. We are using a combination of the two strategies defining drought tolerance based on yield and deriving traits based on an ideotype for our environment (Richards, 1998).

Recent works on barley breeding lines in different environment showed that some traits could be recommended as important criteria for un-favorable condition. Early growth vigor (Quarrie *et al*., 1986), pubescence for stem and leaves (Richards *et al*., 1986) chlorophyll content (Havaux & Tardy, 1999; This *et al*., 2000) reported as effective traits for increasing yield production under drought stress.

Selection based on just yield cannot be effective but selection through yield and its components has more efficiency. The possibility of selecting individual genetically different from the mean of a segregating population is obviously of great interest to the plant breeder. To evaluate such a possibility, heritability is considered together with genetic advance. High heritability associated with equally high genetic advance is mainly due to the additive gene effect. But, if the heritability were due to dominance and epistasis, the genetic gain would be low.

The objective of this research was to estimate variation, stress intensity, narrow sense heritability, genetic advance and correlation of a range characters in a barley population under drought stress conditions.

MATERIALS AND METHODS

The trial consisted of 158 doubled haploid lines that were derived from a cross between varieties Wi2291 and Tadmor. Two experiments were carried out in two sites in Northern Syria using alpha- lattice with two replications in 2003 - 04. Tel Hadya (ICARDA) (36º.01` N, 36º.56`, 284 m) with a long-term average annual rainfall 350 mm and Breda (35º.56` N, 37º.10`, 354 m) with long-term annual rainfall 275 mm.

The agronomic traits evaluated based on following description. Days to heading as the number of days from emergence to appearance awns in 50% of the plants in a plot, total chlorophyll content measured in intact leaves in the field using a portable chllorophyll meter (SPAD-502, Manitola camera), plant height (cm) measured in from ground level to the base of the spike length, peduncle length (cm) from last node to the base of spikelet maturity, extrude of spike from flag leaf (cm) from base of the flag leaf to base of spike, spike length (cm) from base to tip of spike, days to maturity as the number of days from emergence to yellowish of the peduncle in 50% of the plants in a plot, grain filling period in days with distance time between days to heading to days to maturity, number of kernel per spike, 1000 kernel weight (g) and grain yield (kg ha^{-1}).

Genetic correlation between traits was calculated using Miller *et al.* (1985). Heritability and genetic gain were calculated based on Falconer and Mackay (1996) formulas. Stress intensity was estimated through Fischer and Maurer (1978) index.

RESULTS AND DISCUSSION

Minimum, maximum and coefficient of variation (CV) in Tel-Hadya and Breda for 11 characters along with stress intensity (SI) are presented in Table I. In both Tel-Hadya and Breda, high coefficients of variation were recorded for extrude of spike, 43.8 and 21.6%, respectively. For other characters, moderate to small coefficients of variation were observed. Per cent of stress intensity (SI) calculated for 11 characters showed that this component is very high for grain yield (54%), peduncle length (36.7%) and plant height (36.6%). Therefore, these characters have been affected by stress more than the others.

Narrow sense heritabilities (h^2) for 11 traits presented in Table II showed values ranging from 0.23 to 0.85 in Tel-Hadya and 0.16 to 0.74 in Breda. The highest heritability was obtained for 1000 kernel weight and then for days to heading in both environments, indicating that these traits controlled by additive effects. Genetic gains estimated were positive for all traits except extrude of spike. The highest genetic gains were obtained for peduncle length and number of kernel per spike in Tel-Hadya and Breda, respectively.

Correlation analysis revealed that there are significant relationships among majority of the characters in Tel-Hadya, and Breda (Table I). Grain yield was positively

Table I. Minimum, Maximum and Coefficient of variation (CV) in Tel-Hadya and Breda for 11 characters along with stress intensity (SI)

Character	Tel-Hadya			Breda			
	Min	Max	CV	Min	Max	CV	%SI
Days to heading	94	108	3.6	101	115	3.3	-6.9
Chlorophyll content	33.4	59	7.2	30.2	58	8.5	5.8
Plant height	48	84	6.2	31	56	7.3	36.6
Peduncle length	11.5	30	12.0	4.5	23	14.1	36.7
Extrude of spike	-13.5	7	43.8	-12	2.5	21.6	-28.2
Spike length	6.0	11	5.5	4.5	9.5	8.2	18.2
Grain filling period	30	45	4.9	22	34	5.7	29.3
Days to maturity	131	148	2.53	128	140	2.12	2.7
Number of kernel per spike	19	33	7.2	10.4	38.8	11.5	24
1000kernel weight	37	64	7.8	36.8	55.4	5.4	4.2
Grain yield	1380	5485	12.4	512	4612	6.8	54

Table II. Estimation of Narrow sense heritabilities (*h^2*) and Genetic gain in Tel-Hadya and Breda for 11 characters

Character	Tel-Hadya		Breda	
	h^2	Genetic gain	h^2	Genetic gain
Days to heading	0.70	1.6	0.68	1.5
Chlorophyll content	0.55	6.4	0.45	6.9
Plant height	0.50	5.2	0.42	5.7
Peduncle length	0.44	9.6	0.44	11.2
Extrude of spike	0.37	-35.5	0.33	-14.7
Spike length	0.23	3.2	0.36	5.8
Grain filling period	0.53	4.3	0.49	4.8
Days to maturity	0.54	1.3	0.34	0.4
Number of kernel per spike	0.56	6.5	0.53	10.0
1000 kernel weight	0.85	8.7	0.74	5.6
Grain yield	0.41	9.2	0.16	5.2

correlated with chlorophyll content (0.19), peduncle length (0.18), extrude of spike (0.29), spike length (0.28) and number of kernel per spike (0.54) and negatively correlated with plant height (-0.20), days to maturity (-0.19) and 1000 kernel weight (-0.67) in Tel-Hadya. But in Breda, correlation between grain yield and days to heading (-0.20), peduncle length (-0.34), extrude of spike (0.18), grain filling period (-0.16), days to maturity, number of kernel per spike (0.29) and 1000 kernel weight (-0.21) was statistically significant. Negative correlation between grain yield and 1000 kernel weight could be due to un-usual 20 mm rainfall in second half of grain filling period. Peduncle length and grain yield had negative correlation in Tel Hadya but positive correlation in Breda. Breeders experience suggests that peduncles are a useful trait, despite the fact that during early development the ear and the peduncle might compete for assimilates. A possible reason for the value of long peduncle of barley in Syria and other countries of the Mediterranean basin is that *Hordeum spontaneume*, the wild progenitor of cultivated barley, grows successfully as an weed in and near by fields. It hybridizes naturally with cultivated barley, the progeny inheriting the long peduncle of the *Hordeum spontaneume* parent and presumably, other genes conferring adaptation to the prevailing environment. The highest correlation was obtained between peduncle length and extrude of spike (0.93) in Tel-Hadya and the highest correlation between plant height and peduncle length (0.92) or extrude of spike (0.92) in Breda. Blum and Penuel (1990), Richards (1996) and Pillen *et al*. (2003) reported medium positive correlation (0.47) between yield and number of kernel per spike. The differential relations of yield components to grain yield may be attributed to environmental effects on plant growth (Asseng *et al*., 2002). Falconer and Mc Key (1996) believed that a character measured in two different environments should be regarded as two characters. The physiological mechanisms of these two characters are to some extent different and consequently the genes required for high performance are also different. Grain yield showed a highly significant negative correlation with days to maturity, days to heading and length of grain-filling period that is in agreement with Shakhatreh *et al*. (2001). Thus, as shown here and in other studies (Ceccarelli *et al*., 1991; Van Oosterom & Acevedo, 1991), earliness is a very important character under low- rainfall conditions. The trait having the most dominant effect on fitting a plant to its environment for maximum productivity is the appropriate phenological development (Muchow *et al*., 1994; Passioura, 1996; Richards, 1996).

Wi2291 (P1) showed significantly higher values when compared with Tadmor (P2) for traits: Chlorophyll content, number of kernel per spike, Grain filling period, days to maturity, 1000 kernel weight and grain yield in both Tel-Hadya and Breda (Table IV). The best DH when compared with the best parent showed significantly different values for plant height, peduncle length, extrude of spike, spike length, 1000 kernel weight and grain yield in both environments. Peighambari *et al*. (2005) also in comparing the best parent with best DH found significantly higher values for plant height, days to maturity, spike length and seeds per spike traits.

Genetic gains as a parameter for selection efficiency

Table III. Correlation among characters in a population of 158 DH barley and their two parents in Tel-Hadya (up) and Breda (down)

	Days to heading	Chlorophyll content	Plant height	Peduncle length	Extrude of spike	Spike length	Grain filling period	Days to maturity	Number of kernel per spike	1000 kernel weight
Chlorophyll content	-0.59**									
	-0.10									
Plant height	0.06	-0.27**								
	-0.10	-0.10								
Peduncle length	-0.22*	-0.14	0.77**							
	-0.11	-0.35**	0.92**							
Extrude of spike	-0.11	-0.35**	0.80**	0.93**						
	-0.11	-0.35**	0.92**	-0.11						
Spike length	0.01	0.51**	-0.12	-0.10	-0.32**					
	0.06	0.62**	0.24*	0.23*	-0.25**					
Grain filling period	-0.31**	0.77**	-0.21*	-0.29**	-0.54**	0.66**				
	-0.85**	0.47**	-0.29**	-0.31**	-0.39**	0.22*				
Days to maturity	0.53**	0.21*	-0.14	-0.44**	-0.57**	0.60**	0.65**			
	0.40**	0.63**	-0.24	-0.74**	-0.74**	0.49**	0.14			
Number of kernel per spike	0.08	0.18*	0.54**	0.29**	0.12	0.60**	0.12	0.18*		
	0.06	0.28**	0.30**	-0.03	-0.01	0.76**	0.11	0.30**		
1000 kernel weight	0.02	0.36**	-0.29**	-0.25**	-0.46**	0.62**	0.64**	0.58**	-0.14	
	0.16*	0.32**	-0.09	-0.17*	-0.29**	0.28**	0.14	0.53**	-0.11	
Grain yield	-0.20*	0.07	-0.01	-0.34**	0.18*	-0.08	-0.16*	-0.30**	0.29**	-0.21*
	-0.04	0.19*	-0.20*	0.18*	0.29**	0.28**	-0.10	-0.19*	0.54**	-0.67**

* and ** significant at 5 and 1 percent, respectively

Table IV. For 11 agronomic traits in a population of 158 DH barley in Tel-Hadya and Breda

	Chlorophyll content	Plant height	Peduncle length	Extrude of spike	Spike length	No. of kernel per spike	Days to heading	Grain filling period	Days to maturity	1000 kernel weight	Grain yield	SSI
Tel-Hadya												
Wi2291 (P1)	53.4	65.7	14.7	-6.1	9.3	29.5	100.5	40.2	140.9	48.1	4253	4.1
Tadmor (P2)	41.3	66.2	22.7	2.1	9.5	28.8	102.9	33.9	136.9	43.7	3403	2.6
P1-P2	11.1**	-0.5	-8.0**	8.2**	-0.2	0.7	-2.2	6.3**	4*	4.4	850**	1.5*
BDH	33.4	48	30	7	11	33	94	30	131	64	5485	1.5
BDH- BP**	-7.9*	17.7**	7.3*	4.9**	2.5*	5.5	-6.4**	-3.9*	-5.9*	15.9**	1232**	-1.1*
Breda												
Wi2291 (P1)	52.2	42.3	10.6	-8.0	7.7	22.0	107.7	27.2	134.9	45.2	2019	-
Tadmor (P2)	38.2	44.6	14.9	-4.5	7.0	17.2	109.9	23.6	133.5	42.6	2006	-
P1-P2	14**	-2.3	-4.3*	-4.0**	0.7	4.8	-2.2	3.6*	1.4	2.6	13	-
BDH	30.2	31	23	2.5	9.5	38.8	101	22	128	55.4	4612	-
BDH- BP	-8*	11.3**	8.1**	10.5**	1.8*	16.8**	-6.7**	-3.6*	-5.5*	10.2*	2593**	-

* and ** significant at 5 and 1 percent, respectively

are related to genetic variability, heritability and selection intensity. Low genetic gains and heritability obtained for grain yield compared to most of the other characters indicate that its phenotypic effect is mainly controlled by environmental variation. Therefore, for selection of the best genotype, we should concentrate mainly on yield components than grain yield.

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