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Full Length Research Paper

Heritability and genetic gain of some morpho-physiological variables of durum wheat (*Triticum turgidum* var. *durum*)

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The purpose of this work is to estimate genetic variability parameters and relationship among 11 agro-physiological traits studied on 18 experimental durum wheat and two checks under rainfed condition. The studied traits included the grain yield (YLD), plant height (PH), number of tiller per plant (NT), peduncle length (PL), flag length (FL), leaf dry weight (LDW), stem dry weight (STW), spike dry weight (SPW), spike height (SH), leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), leaf area ratio (LAR) and net assimilation rate (NAR). Analysis of variance showed a significantly variation among genotypes for the characters PH, NT, PL, FL, LDW, STW, SPW, SH, LAR and NAR. High correlations were found among the PL, LDW, STW, SPW, LAR and NAR. Heritability estimates were high for PH, PL, LDW, STW and NAR. High genetic gains were observed for YLD, NT, PL, LDW, STW, SPW, LAR and NAR.

Key word: Genetic parameters, genetic advance, durum wheat.

INTRODUCTION

Durum wheat (*Triticum turgidum* var. *durum*) is cultivated on 10% of the world wheat areas (Nachit et al., 1998) and is an important food crop in the world. The total area and production is about 20 million hectares and 30 million metric tons globally. Durum wheat is mainly (>90%) cultivated in the Mediterranean basin, Europe and India (Abaye et al., 1997; Nachit et al., 1998; Maniee et al., 2009; Mohammadi et al., 2009; Kahrizi and Mohammadi, 2009; Rojo et al., 1986; Saleem, 2003). The development of high yielding wheat cultivars is a major objective in breeding programs (Ehdaie and Waines, 1989). The genetic variation for the trait under selection and a higher heritability are necessary to have response to selection (Falconer and Maccay, 1996). Breeding programs depend on the knowledge of key traits, genetic systems controlling their inheritance and genetic and environmental factors that influence their expression (Kahrizi and Mohammadi, 2009; Mohammadi et al., 2010). To plan an efficient development program, it is necessary to have an understanding of the breeding systems coupled with statistical analysis of inheritance data (Yap and Harvey, 1972; Srivastava and Dhamania, 1989).

Analysis of variability among the traits and the association of a particular character in relation to other traits contributing to yield of a crop would be of great importance in planning a successful breeding programme

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Abbreviations: PH, Plant height; **NT,** number of tiller; **PL,** peduncle length; **FL,** flag leaf length; **NS,** number of spike per plant; **LDW,** leaf dry weight; **STW,** stem dry weight; **SPW,** spike dry weight; **LAI,** leaf area index; **CGR,** crop growth rate; **RGR,** relative growth rate; **LAR,** leaf area ratio; **NAR,** net assimilation rate; **LAD,** leaf area duration; **YLD,** grain yield; **h^2,** heritability; **GG,** genetic gain; **SH,** spike height.

Table 1. Mean squares for different characters in 20 durum wheat genotypes tested.

Sources	Df	Mean Square												
		LAR	NAR	RGR	CGR	SH	SPW	STW	LDW	FL	PL	NT	PH	Yield
Block	3	0.006	1470.8	0.112	0.001	1.08	4.19	4.34	0.42	12.15	15.61	4.21	52.8	0.178
Genotypes	19	0.012**	5704.1*	0.144^{ns}	0.011^{ns}	2.55**	2.80**	15.03**	0.46**	12.52*	44.69**	7.09**	469.7**	0.159^{ns}
Error	57	0.005	1077.2	0.115	0.021	0.66	0.82	1.89	0.07	2.52	7.30	1.74	59.2	0.100
CV%		19.85	13.96	24.36	25.67	10.61	29.30	27.18	27.33	10.07	28.06	25.38	9.67	13.12

*, ** Significant at 5 and 1% level of probability respectively; ^{ns} Non-significant.

(Mary and Gopalan, 2006). Development of high-yielding varieties requires a thorough knowledge of the existing genetic variation for yield and its components. The observed variability is a combined estimate of genetic and environmental causes, of which only the former is heritable. However, estimates of heritability alone do not provide an idea about the expected gain in the next generation, but have to be considered in conjunction with estimates of genetic advance and the change in mean value between generations (Shukla et al., 2006). Success in crop improvement generally depends on the magnitude of genetic variability and the extent to which the desirable characters are heritable. However, variability studies for different crops already have been done (Burton and DeVane, 1953; Johnson et al., 1955; Ehdaie and Waines, 1989; Belay et al., 1993; Moghaddam et al., 1997; Sumathi et al., 2005; Baye and Becker, 2005; Vanaja and Babu, 2006; Wani and Khan, 2006; Mary and Gopalan, 2006; Shukla et al., 2006; Kaushink et al., 2007) but very limited on durum. Knowledge of the genetic association between grain yield and its components can help breeders to improve the efficiency of selection. Therefore, it is important to study the relationships among the characters (Ehdaie and Waines, 1989). However, the objecttive of the current study is to study the variability, heritability and genetic gain of some agro-physiological traits in durum wheat under rainfed condition of Kermanshah, Iran.

MATERIALS AND METHODS

The experiment was conducted at the experimental farm of the Agricultural Faculty of Razi University, Kermanshah, Iran during the period of October 2005 to June 2006. 18 experimental durum wheat line along with a durum (Zardak) and a bread (Sardari) wheat check selected from durum wheat breeding program of Dryland Agricultural Research Institute (DARI) were used.

The experiment was laid out in randomized complete block design with four replications. Plot size was 7.0 x 1.2 m. Standard cultural practices were followed for raising the crop. The characters studied were plant height (PH), number of tiller (NT), peduncle length (PL), flag leaf length (FL), number of spike per plant (NS), leaf dry weight (LDW), stem dry weight (STW), spike dry weight (SPW), spike height (SH), leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), leaf area ratio (LAR), net assimilation rate (NAR), leaf area duration (LAD) and grain yield (YLD). Data were subjected to different analyses. The analysis of variance (ANOVA) for different characters were measured followed by Duncan's new multiple range test (DMRT) (Steel and Torrie, 1960), to test the significance difference between means. The mean squares were used to estimate genotypic and phenotypic variance according to Johnson et al. (1955). The coefficient of variation was calculated according to the formula suggested by Burton (1952). The genotypic and phenotypic coefficient of variation and heritability were calculated according to the formula used by Singh and Choudhury (1985). Genetic advance was also calculated for each studied trait (Allard, 1960).

RESULTS AND DISCUSSION

Mean square for different studied traits is presented in Table 1. Mean squares for PH, NT, PL, FL, LDW, STW, SPW, LAR and NAR were significant, indicating the presence of adequate variability among the studied genotypes in this study.

Mean performance of genotypes for each trait is given in Table 2. The progress of a breeding program is conditioned by the magnitude and the nature of the genotypic and non-genotypic variation in the various characters. Since most of the economic characters (e.g. yield) are complex in inheritance and are greatly influenced by various environmental conditions, the study of heritability and genetic advance is very useful in order to estimate the scope for improvement by selection. Heritability magnitude indicates the reliability with which the genotype will be recognized by its phenoltype expression (Chandrababu and Sharma, 1999). The estimates of variability parameters for morphological and growth characters and yield are given in Tables 3 and 4.

In the case of PH, genotypes ranged from 52.70 to 96.05 cm and the mean was 79.53 (Table 3). Average genotypic and phenotypic coefficients of variations (GCV and PCV) were observed for PH (Table 4). The PH showed a significant and posi-

Table 2. Mean performance of 20 durum wheat genotypes for different characters.

Genotypes	Characters									
	NAR	LAR	SH (cm)	SPW (g)	STW (g)	LDW (g)	FL (cm)	PL (cm)	NT	PH (cm)
D-001	14.85^{bcd}	0.0014^{b}	10.30^{a}	4.275^{ab}	9.000^{ab}	1.675^{a}	21.67^{a}	18.88^{a}	5.500^{abcdef}	95.75^{a}
D-002	21.46^{bcd}	0.0315^{b}	7.500^{bcde}	3.000^{abcd}	3.600^{fg}	1.200^{bcd}	14.80^{bc}	7.750^{bcdef}	5.050^{bcdefg}	80.25^{bcd}
D-003	24.98^{bcd}	0.0016^{b}	7.600^{bcde}	3.200^{abcd}	6.650^{cd}	1.200^{bcd}	17.38^{b}	13.57^{b}	4.000^{defg}	91.40^{ab}
D-004	24.24^{bcd}	0.0322^{b}	6.975^{de}	3.025^{abcd}	3.000^{g}	0.9500^{bcdef}	16.38^{bc}	9.950^{bcdef}	4.250^{defg}	75.63^{cd}
D-005	12.12^{bcd}	0.0159^{b}	7.350^{bcde}	2.975^{bcd}	5.075^{defg}	0.6500^{f}	16.25^{bc}	12.50^{bc}	3.000^{g}	91.30^{ab}
D-006	38.28^{bcd}	0.0009^{b}	6.875^{de}	2.350^{cde}	3.075^{g}	1.100^{bcde}	14.68^{bc}	7.900^{bcdef}	4.250^{defg}	69.18^{de}
D-007	28.63^{bcd}	0.0009^{b}	8.500^{bc}	4.500^{a}	9.475^{a}	1.175^{bcd}	16.65^{bc}	11.40^{bcde}	7.000^{ab}	79.48^{bcd}
D-008	54.28^{ab}	0.0006^{b}	7.500^{bcde}	2.500^{cde}	4.950^{defg}	0.6000^{f}	16.65^{bc}	12.13^{bcd}	6.500^{abc}	80.55^{bcd}
D-009	28.58^{bcd}	0.0013^{b}	7.000^{de}	2.300^{cde}	3.925^{fg}	0.9000^{cdef}	14.65^{bc}	9.300^{bcdef}	6.000^{abcd}	79.97^{bcd}
D-010	34.23^{bcd}	0.0008^{b}	8.250^{bcd}	1.425^{e}	4.025^{efg}	0.7000^{ef}	15.07^{bc}	7.325^{cdef}	3.500^{fg}	75.38^{cd}
D-011	97.43^{a}	0.0008^{b}	7.650^{bcde}	2.475^{cde}	3.650^{fg}	0.5750	14.90^{bc}	7.050^{cdef}	3.750^{efg}	76.72^{cd}
D-012	25.10^{bcd}	0.0012^{b}	7.525^{bcde}	1.700^{de}	3.475^{fg}	0.7750^{def}	15.07^{bc}	5.875^{ef}	4.750^{cdefg}	76.65^{cd}
D-013	34.97^{bcd}	0.0011^{b}	7.425^{bc}	3.075^{ab}	7.325^{bc}	1.375^{ab}	17.07^{bc}	11.88^{bcde}	6.000^{abcd}	96.05^{a}
D-014	51.13^{abc}	0.0012^{b}	6.675^{c}	1.875^{de}	4.250^{efg}	0.8250^{def}	13.80^{bc}	6.225^{def}	4.250^{defg}	80.32^{bcd}
D-015	26.75^{bcd}	0.0012^{b}	7.175^{bc}	3.050^{abcd}	6.525^{cd}	1.300^{abc}	15.68^{bc}	12.48^{bc}	4.750^{cdefg}	93.15^{a}
D-016	-5.02^{cd}	0.2387^{a}	7.200^{bc}	2.775^{bcde}	3.400^{fg}	0.6500^{f}	14.45^{bc}	6.450^{def}	7.500^{a}	63.13^{ef}
D-017	-2.12^{cd}	0.0024^{b}	7.775^{bc}	2.075^{de}	3.000^{g}	0.5250^{f}	15.10^{bc}	7.575^{cdef}	4.250^{defg}	52.70^{f}
D-018	-6.20^{d}	0.0019^{b}	7.675^{bc}	4.025^{ab}	4.900^{defg}	0.9750^{bcdef}	14.60^{bc}	5.250^{f}	7.000^{ab}	72.93^{cde}
Zardak	-2.27^{cd}	0.0024^{b}	8.600^{b}	2.325^{cde}	5.600^{cdef}	1.625^{a}	13.77^{c}	8.425^{bcdef}	5.750^{abcde}	84.45^{abc}
Sardari	-11.82^{d}	0.0015^{b}	7.850^{bcde}	3.800^{abc}	6.250^{cde}	0.9250^{cdef}	17.08^{bc}	10.70^{bcdef}	7.000^{ab}	75.63^{cd}

Table 3. Range, mean, standard error of mean and co-efficient of different characters of 20 durum wheat genotypes.

Characters	Coefficient of variation (%)	Standard error (±)	Mean	Range
Yield	13.12	0.04	333.33	147.37 - 330.77
PH	9.67	2.42	79.53	52.70 - 96.05
NT	25.38	0.30	5.20	3.0 - 7.5
PL	28.06	0.75	9.63	7.17 - 15.73
FL	10.07	0.40	15.79	13.77 - 21.67
LDW	27.33	0.08	0.98	0.53 - 1.68
STW	27.18	0.43	5.06	3.00 - 9.48
SPW	29.30	0.19	2.84	1.43 - 4.50
SH	10.61	0.18	7.67	6.68 - 10.30
LAR	13.96	0.012	0.0170	0.0006 - 0.2387
NAR	19.75	5.66	24.48	-11.82 - 97.43

tive correlation with PL, FL, LDW, STW, SPW and LAR (Table 5). This result indicated that plant height increase resulted in more of the above traits. NT varied from 3.0 to 7.5 with mean value 5.20 (Table 3). The heritability (h^2) and genetic gain (GG) was average for this trait, indicating that the phenotypic variations belong to genotypic variations and environmental variations in same parts (Table 4). The NT was significantly and negatively correlated with NAR and positively correlated with SPW. PL was varied from 7.17 to 15.73 with a mean value of 9.63. The values of GCV and PCV were high for PL (Tables 3 and 4). These results indicated that environment had little effect on the expression of PL. This variable was significantly and positively correlated with HP, FL, LDW, STW and SPW and negatively with NAR.

Low h^2 and GG were observed for FL (Table 4), indicating that selection for this character would not be effective due to predominant effects of non additive gene in this population. Then this is not a suitable variable or selection. This result is in agreement with those found by other report (Maniee et al., 2009).

The range of variation for LDW was 0.53 to 1.68 with mean value of 0.98. GCV and PCV values for this trait were 22.24 and 33.73, respectively (Table 4). Similar

Table 4. Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance in percentage of mean for different characters of 20 durum wheat genotypes.

Characters	Genetic gain (%)	Genetic advance (%)	Heritability (%)	PCV (%)	GCV (%)
Yield	0.03	0.09	12.85	0.102	0.036
HP	20.89	16.61	63.41	16	12.74
NT	30.12	1.57	43.45	33.73	22.24
LP	48.90	4.71	56.16	42.37	31.75
HFL	14.55	2.30	49.80	14.19	10.01
LDW	49.88	48.89	58.08	41.70	31.86
STW	69.67	3.52	69.00	48.93	40.65
SPW	31.16	0.88	37.69	40.30	24.77
SH	13.52	1.03	44.57	13.87	8.96
LAR	257.92	0.04	25.92	483.28	247.05
NAR	205.92	50.41	51.78	193.07	139.93

Table 5. Correlation coefficient among different morpho-physiological characters in durum wheat genotypes.

Characters	LAR	HE	SPW	STW	LDW	HFL	LP	NT	HP	yield
HP										0.08
NT									-0.11	0.31
LP								0.01	0.70**	-0.18
HFL							0.90**	0.08	0.51*	-0.19
LDW						0.41*	0.51*	0.20	0.62**	-0.09
STW					0.64**	0.69**	0.74**	0.34	0.65**	0.10
SPW				0.72**	0.48*	0.61**	0.55*	0.51**	0.33*	0.14
SH			-0.44**	0.63**	0.50*	0.65**	-0.53*	0.17	0.26	-0.06
LAR		-0.18	-0.00	-0.25	-0.23	-0.18	-0.23	0.36	0.35*	-0.03
NAR	-0.30	-0.21	-0.32	-0.11	-0.23	-0.07	-0.04	-0.40*	0.19	0.16

*, ** Significant at 5 and 1% level of probability, respectively.

result was observed by Pathak and Nema (1985). The STW varied from 3.00 to 9.48 with mean value of 5.06 (Table 3). GCV and PCV and h^2 were relatively high (Tables 3 and 4). These results indicated that environment had little effect on the expression of STW. It further shows that the genotypes of durum wheat were governed by additive genes. Similar result was observed by Ehdaie and Waines (1989). The STW was also significantly and positively correlated with PH, PL, FL, LDW and SPW.

The range of SPW varied from 1.43 to 4.50 g and high values of GCV and PCV (24.77 - 40.30) were observed for this trait. The average values of GCV and PCV have been reported in wheat (Das and Rahman, 1984). The SH ranged from 6.68 to 10.30 cm. The difference between GCV and PCV for spike length was little, indicating the minimum influence of the environment for its expression. The heritability estimates were high (>60%) for characters PH and STW. Earlier, a high heritability value for PH was found in durum wheat (Paul et al., 2006; Maniee et al., 2009). Characters like NT, PL, HFL, SH, SPW, NAR and LDW showed heritability values that ranges between 40 and 60%. A comparatively low value of heritability was observed for the character yield, LAR and SPW (<40%) (Table 4). The heritability estimates for different characters depend upon the genetic makeup of the breeding materials studied. Therefore, knowledge about these values in the materials in which breeders are interested is of great significance. High heritability estimates indicate that the selection for these characters will be effective, being less influenced by environmental effects (Maniee et al., 2009).

Heritability estimates have been found to be useful in indicating the relative value of selection based on phenoltypic expression of different characters. Johnson et al. (1955) reported that heritability values along with estimates of GG were more useful than heritability alone in predicting the effect of selection. High heritability estimates associated with high genetic advance as per-cent mean (GG) were obtained in the characters viz., STW, which indicated that selection for these characters would be more effective because these characters have high heritability and genetic advance (as percent of mean). High heritability values followed by high genetic advance indicated the presence of additive gene action (Johnson et al., 1955; Kashif et al., 2003).

It can be concluded on the basis of the results obtained in the present investigation that the range of variability was quite appreciable for almost all the characters studied among different genotypes.

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