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Genotypic variation of spikes' related traits and path analysis of grain yield in durum wheat lines

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Genotypic variation of spikes' related traits was assessed using a sample of durum wheat lines. A simple lattice experiment was carried out using 58 exotic promising lines and 6 landraces of two years cropping seasons (2006/2007 and 2007/2008) at the Agriculture Research Station of Islamic Azad University, Tabriz Branch, Iran. Plant height, peduncle length, number of node per stem, number of spikes per plant, spike length, number of grain per spike, 1000 grain weight, and grain yield were measured. Combined analysis of data for two years showed that interaction of lines × year was not significant for any of the traits. This indicates that responses of traits were identical in both years. There were also significant differences for all traits among the lines, and there was genotypic variation for these traits among durum wheat lines. Mean comparisons of grain yield showed that exotic promising lines: ARAMIDES (no.33), LC/RD (no.55) and landraces lines: YAZLIG (no.62) and YAZLIG (no.64) had the highest yield than the other lines. Estimate of correlation between traits indicates that there was significant and positive correlation between grain yield and traits such as number of spikes per plant, spike length and grain per spike. Regression and path analysis showed that the traits such as number of grain per spike, spikes per plant and spike length had positive and direct effect on yield.

Key words: Combined analysis, correlation, regression, *Triticum durum*.

INTRODUCTION

Genetic diversity is a valuable tool for plant breeding and screening promising genotypes (Spagnoletti and Qualset, 1987; Souza and Sorrells, 1991; Hammer et al., 2003). Available genetic variability in landraces genotype is useful and useable for breeding purposes (Roy, 2000). Pathak and Nema (1985) in their study on some wheat landraces in India obtained genetic variations for yield, yield components and other traits such as plant height, number of spikelet per spike, fertile tiller, spike length, heading date, 1000 grain weight, grain weight per spike and grain yield per plant. Okuyama et al. (2005) reported genetic variations for spike related traits. Several researchers have also reported genetic variations for traits in studying wheat genotypes (Van Beuningen et al., 1997; Wang et al., 2002; Blake et al., 2007). The direct selection based on just yield cannot be effective, but selection via yield and its components has more efficiency. Selection of a short stem, bigger spikes per unit area and grains per spike (Hay, 1995), 1000 grain weight (Martincic et al., 1996), and higher grain weight per spike (Drezner, 1995) contributed most to a higher grain yield. Bilgin et al. (2008) reported that grain yield depended on 1000 grain weight, grain per spike and agro-ecological conditions during the growing period. Information of variability is important in enhancing the efficiency of selection.

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Table 1. Combined analysis of data for spikes' related traits in durum wheat lines based on CRBD during 2006 to 2008.

S.V.	D. F.	M.S.							
		Spikes/ plant	Nodes/ stem	Plant height	Peduncle length	Spike length	Seeds/ plant	1000 seed weight	Grain yield
Year	1	7.995**	1.96 ns	11807.5ns	2766.36ns	0.06ns	3247.575ns	8276.36**	3257.14 ns
Error1	2	4.262	1.855	10184.62	4441.98	77.29	529.471	670.43	35080.72
Line	63	1.292**	0.324**	377.44**	89**	9.67**	204.394**	72.333**	2992. 77**
Year× Line	63	0.512ns	0.07ns	23.39ns	9.88ns	0.07ns	7.734ns	9.391ns	219.67ns
Error2	126	0.731	0.118	22.52	10.57	0.84	67	14.51	885.1
CV (%)	-	23.87	10.87	7.73	12.77	13.35	24.84	15.61	29.15

*,** and ns :are significant at 5% ,1% probability levels and non significant respectively.

Table 2. Means of traits for high yielding durum wheat lines during 2006 to 2008.

Genotypes	Spikes/ plant	Nodes/ stem	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	Seeds/ spike	1000 seed weight (g)	Grain yield (g)
33	4.13	2.82	57.65	25.17	6.78	47.76	44.45	160.5
55	3.03	3.75	61.53	27.83	6.62	33.51	43.26	156.41
62	4.43	3.3	62.45	27.96	8.85	24.5	39.08	152.71
64	4.93	3.75	74.47	25.73	10.65	25.21	34.52	141.15
Total mean	3.59	3.16	61.4	25.46	6.87	32.95	42.6	92.52
LSD 5%	1.18	0.46	6.56	4.5	1.27	11.34	5.3	41.23

The objectives of this study were to evaluate the variability of spikes' related traits, grain yield and yield components of different durum wheat lines.

MATERIALS AND METHODS

This experiment was conducted for two years, during growing seasons of 2006 to 2008 in a sandy loam soil at the Agriculture Research Station of Islamic Azad University of Tabriz Branch, Iran. Research materials consisted of 64 genotypes (58 exotic advanced durum wheat lines, 6 landraces lines) and they were arranged in a lattice design (8×8) with two replications. Experimental units consisted of three rows with 20 and 5 cm between and within rows respectively. Partial block and replications were spaced 1 and 1.5 m apart, respectively. Seeds were treated with carboxin tiram fungicide prior to planting. Ammonium phosphate fertilizer was applied at the rate of 150 kg/ha before seeding on 1st of April. In this research, several traits including plant height, peduncle length, nodes per stem, spike length, spikes per plant, grain per spike, 1000 grain weight, and grain yield were evaluated. Data for each trait was obtained from single plant sampling (10% of total plants) and grain yield data were obtained from each experimental unit. Combined analysis was carried out by MSTAT-C software. LSD test was used to compare means at 5% probability level. Regression analysis and path analysis were used to identify the effective traits, direct and indirect effects of traits related to stem and spikes on grain yield, by SPSS and Pth2 software's respectively.

RESULTS AND DISCUSSION

Combined analysis of data revealed that genotype × year interaction was not significant at 5% probability level, indicating that lines responded similarly to weather condition in both years (Table 1). Combined analysis also showed that they were significant for all the traits at 1% probability level. This indicates that there is genetic diversity among durum wheat lines for these traits. Several researchers (Jedynski, 2001; Garcia Del Moral et al., 2003 and Kashif and Khliq, 2004) have also found similar results in studying wheat genotypes.

Comparison of means indicated that two exotic promising lines: 33 (ARAMIDES), 55 (PLC/RD) and two landraces: 62 (YAZLIG) and 64 (YAZLIG), produced higher seed yield than the other lines (Table 2). Genotypes 33 and 55 had higher grain number per spike and 1000 grain weight than the others. Higher values for grain number per spike and 1000 grain weight would result in higher yields. Genotypes 62 and 64 had higher spike lengths and number of spike per plant as compared with those of others. Thus, in promising lines of durum wheat, grain number per spike and 1000 grain weight can be considered to be important for higher yield. However, spikes per plant and spike length in landraces lines such as 62 and 64 were promising to produce higher yields. This trait is one of the most important yield components in landraces genotypes that have a positive effect on grain yield.

Simple correlation of grain yield with number of spikes per plant, spike length, and number of grain per spike was positive and significant (Table 3). Thus, selection

Table 3. Simple correlation between traits in durum wheat lines during 2006 to 2008.

Variable	Spikes/ plant	Nodes/ spike	Plant height	Peduncle length	Spike length	Grain/ spike	1000 grain weight	Grain yield
Spikes/ plant	1	0.153	0.243	0.122	0.489**	-0.225	-0.106	0.364**
Nodes/ spike		1	0.522**	0.252	0.324**	-0.189	-0.324**	0.105
Plant height			1	0.741**	0.509**	-0.174	-0.394**	0.094
Peduncle length				1	0.061	-0.112	-0.077	0.053
Spike length					1	-0.115	-0.606**	0.361**
Grain/ spike						1	0.019	0.322**
1000 grain weight							1	-0.099
Grain yield								1

*,** are significant at 5 and 1% probability levels respectively.

Table 4. Path analysis of grain yield with related traits in durum wheat lines.

Traits	Direct effect	Indirect effect by			Correlation of traits with grain yield
		Spikes/ plant	Grains/ spike	Spike length	
Spikes/ plant	0.34	-	-0.097	0.118	0.364
Seeds/ spike	0.426	-0.077	-	-0.028	0.322
Spike length	0.244	-0.166	-0.05	-	0.361

Residual =0.151.

for these traits may improve grain yield. Monral et al. (1997) reported positive correlation of grain yield with 1000 grain weight. Hucl and Baker (1987) and Belay et al. (1993) also reported significant positive correlation between grain yield and number of spikes per plant. Although positive correlation of number of spikes per plant with grain yield was expected, positive correlation of this trait with spike length was unexpected. Probably, correlation between two recent traits is due to the heterogeneity of studied genotypes; this is because some of the genotypes were landraces and non improvement and others were exotic and promising lines. 1000 grain weight was negatively and significantly correlated with spike length, plant height, and node number per plant (Table 3). Grain yield have positive and highly significant correlation with plant height, spike length and number of grains per spike (Jamali and Ali, 2008). Plant height was also significantly and positively correlated with peduncle length and spike length. Okuyama et al. (2005) reported that under non-irrigated condition, plant height has a positive correlation with grain per spike and spike length. Slafer and Savin (1994) indicated that peduncle length has an effective role in drought resistance and yield increase under water deficit. When the photosynthesis activity was affected by drought stress condition, rate of grain filling depended on remobilization of assimilates from peduncle (Blacklow et al., 1984; Blum et al., 1994; Ehdaie et al., 2006). The highest value for this trait may be advantageous in increasing yield under drought stress condition (Ehdaie et al., 2006). Means for node number per stem revealed that exotic line 55 and landrace 64 had the highest value for nodes per stem than others (Table 2). For nodes per stem, stem stability play an effective role in remobilization and transport of assimilates to seed during grain filling period.

Regression analysis of grain yield as a dependent variable (Y) showed that traits like grains per spike, spikes per plant and spike length had positive relations with yield. Therefore, higher values of these traits would increase grain yield. Standard equations of regression were:

$$Y = 0.340X_1 + 0.426X_2 + 0.244X_3$$

In this equation, X_1, X_2 and X_3 are number of spikes per plant, grains per spike and spike length respectively. Path analysis of grain yield to its component traits (Table 4) indicated that highest direct effect of traits related to number of grains per spike (0.426), and afterward, by number of spike per plant (0.340). This means that number of grains per spike is effective in grain yield of genotypes studied. Therefore, direct selection for this trait could result in yield increase in durum wheat population. Okuyama et al. (2005) reported that grain per spike and spikes per plant have a positive direct effect on grain yield. Direct effect of spike number per plant on grain yield has been reported by several authors (Hulk and Baker, 1987; Belay et al., 1993; Wang et al., 2002). It has also been suggested that indirect selection for grain weight and number of grain per spike would improve grain yield (Monral et al., 1997; Wang et al., 2002).

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