

ESTIMATE OF HETEROSIS, CORRELATION AND PATH ANALYSIS FOR GRAIN YIELD PER SPIKE AND SOME AGRONOMIC TRAITS ON DURUM WHEAT (*TRITICUM DURUM* DESF)

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ABSTRACT

This study was carried out between 2005-2007 cropping season at the experimental fields of Uludağ University Faculty of Agriculture, Agricultural Application and Research Center. In this study 3 advanced breeding lines and 2 durum wheat cultivar and their F₁ crosses have been used as material. In the research, grain yield per spike and some agronomic traits on durum wheat (*Triticum durum* Desf) were researched for heterotic and heterobeltiotic effects, correlations and path analysis. It is concluded that the hybrids of 11-27 × Gediz for plant height, 12-21 × Gediz for spike length, spikelet number per spike, 9-65 × 12-21 for grain number per spike, Pınar-2001 × Gediz and 12-21 × Gediz for grain yield per spike and Pınar-2001 × 9-65 for 1000 grains weight had the highest heterosis and heterobeltiosis values. The correlations between traits revealed that important characters, influencing grain yield per spike were spike length, spikelet number per spike and grain number per spike. The results of path analysis also indicated that spike length, spikelet number/ spike and grain number per spike had the maximum direct effects on grain yield per spike.

Key words: Durum wheat, heterosis, heterobeltiosis, correlation, path analysis.

INTRODUCTION

Durum wheat or macaroni wheat is the only tetraploid species of wheat of commercial importance that is widely cultivated today and in Turkey. Durum wheat is an important crop for making pasta, bulgur, couscous and the other products. It differs from other durum wheats in that the starch swelling capacity is greater and the gluten has different characteristics which results in tough, elastic doughs. As compared to durum wheat dough it can be extruded through a small hole at lower pressure and in breads results in lower loaf volume (Arnold, 1990). Addition to this, high yield and high protein concentration with desirable milling and baking qualities have been the main criteria in wheat breeding. Among others, plant height, spike length, spikelet number/spike, number of grains/spike and thousand grains weight etc (Topal *et al.*, 2004).

A great success of developing high yielding wheat genotypes has been achieved through breeding. But before starting any breeding program it is crucial to learn information regarding the correlation of yield with other contributing parameters. Thus, some breeders have expressed about total reliance on yield component analysis. Path studies provide an opportunity to study the magnitude and direction of association of yield with its direct and indirect components and also among various components (Mahmood *et al.* 2006).

Heterosis effect has been used in breeding of open pollinated plants such as maize or rye. At present, hybrid breeding also being focused on self-pollinated

plants, including wheat (Krystkowiak *et al.* 2009). Development of hybrid durum wheat rests on the premise that there is heterosis in this crop (Elfadl *et al.* 2006).

The present study was designed to determine optimum combination of yield contributing characters and components influencing the yield substantially in genetically different genotypes and their F₁ hybrids.

MATERIALS AND METHODS

Advanced breeding lines numbered 9-65, 11-27, 12-21 and 2 durum wheat cultivar that have adapted to the region (Gediz and Pınar-2001) and their F₁ have been used as material. Seeds of parents and F₁ plants were sown in two rows with spacing 30 cm between rows and 15 cm between plants according to the randomized blocks design with 3 replications. Ten competitive plants in parents and F₁'s were sampled randomly.

The percent increase or decrease of F₁ hybrids over mid parent as well as better parent was calculated to estimate possible heterotic effects for above mentioned parameters (Fonseca & Patterson, 1968).

$$Ht (\%) = (F_1 - MP) / MP \times 100$$

$$Hbt (\%) = (F_1 - BP) / BP \times 100$$

Where

Ht = Heterosis

Hbt = Heterobeltiosis

MP = Mid Parent Value

BP = Better Parent Value

Analysis of variance correlation, direct and indirect path coefficient (Dewey and Lu, 1959) calculated

by TARPOGEN Statistical Computer Program (Özcan, 1999).

Analysis of variance revealed significant differences at 1 % probability level among genotypes for all traits studied (Table 1).

RESULTS AND DISCUSSION

Table 1. Analysis of variance for traits examined in F₁ generations.

Source of variation	DF	Plant height	Spike length	Spikelet number/spike	Grain number/spike	Grain yield/spike	1000 grains weight
Replication	2	35.174	0.572	2.067	108.441	0.075	3.200
Genotypes	14	129.93**	5.053**	13.750**	259.445**	1.144**	31.252**
Error	28	25.669	0.214	1.285	52.378	0.173	2.547

** p<0.01

Heterosis and heterobeltiosis effects: Heterotic and heterobeltiotic effects of the triats are given in the Table2.

Table 2. Heterosis and heterobeltiosis effects (%) of the triats.

Genotypes	Plant height		Spike length		Spikelet number/spike		Grain number/spike		Grain yield/spike		1000 grains weight	
	Ht	Hbt	Ht	Hbt	Ht	Hbt	Ht	Hbt	Ht	Hbt	Ht	Hbt
P-2001×9-65	1.50	0.61	25.71**	20.37**	16.83**	9.28	31.56*	25.93	23.26	22.05	16.46**	10.83**
P-2001×11-27	11.80	1.79	15.28**	13.15**	13.18*	6.37	32.80*	29.63*	27.86	27.22	6.86*	7.23*
P-2001×12-21	8.27	2.99	16.04**	10.33*	25.51**	20.45**	21.33	6.45	52.84**	46.76**	2.72	-4.42
P-2001×Gediz	6.61	5.47	20.48**	25.85**	15.77**	15.51**	34.56*	27.97*	88.64**	73.63**	13.44**	6.86*
9-65×11-27	9.01	0.05	32.94**	29.62**	19.82**	19.22**	34.70*	32.03*	54.18**	53.43**	-0.65	-5.67*
9-65×12-21	-2.75	-8.27	21.96**	20.91**	13.62*	10.63*	78.38**	62.82**	64.43**	56.37**	-0.30	-2.65
9-65×Gediz	-0.41	-2.32	38.99**	27.87**	17.02**	9.63*	47.27**	46.25**	61.49**	48.03**	-0.95	-2.02
11-27×12-21	1.25	-1.86*	34.86**	30.38**	19.64**	17.05**	10.11	-1.30	-13.98	-15.34	-7.83**	-
11-27×Gediz	35.49**	22.18**	28.91**	21.44**	8.90	2.50	43.18**	39.42**	40.86*	29.70	-2.19	-8.08**
12-21×Gediz	-5.51	-9.20	49.39**	36.53**	34.36**	29.15**	38.72*	27.39	84.18**	76.21**	-8.71**	-9.93**
Means for Ht	6.52		28.45		18.46		37.26		48.37		1.88	
Means for Hbt	0.14		23.64		13.97		29.65		41.80		-2.23	

*:p<0.05, **p<0.01, Ht:Heterosis, Hbt:Heterobeltiosis, P-2001:Pınar-2001.

Plant height: Ranges of heterosis and heterobeltiosis for plant height were – 5.51% to 35.49 % and – 9.20% to 22.18%, respectively. Out of 10 crosses, only one cross (11-27 x Gediz) exhibited significant positive heterosis and heterobeltiosis by 35.49% and 22.18% respectively and hybrids 11-27×12-21 had significant negative heterobeltiosis in plant height. The mean heterosis and heterobeltiosis value of all combinations were 6.52 % and 0.14 %, respectively. Previously, Mahajan *et. al* (1999), Singh *et. al* (2004) and Hussain *et. al* (2007) reported positive heterosis for plant height, whereas negative heterosis has been recorded by Sadeque *et. al* (1991), Bhutta *et. al* (2005), Ilker *et. al.* (2010) and Bilgin *et. al.* (2011). Inamullah *et. al.* (2006) reported that taller plants are likely to lodge quite often. Tall plants require more energy to translocate solutes to the grain weight and Jan *et al.* (2005), also reported that negative heterosis is desirable when breeding for lodging resistance. According to this, the hybrids 9-65×12-21, 9-65×Gediz and 12-21×Gediz had the negative but non-significant heterosis and heterobeltiosis values.

Spike Length: All of the 10 crosses exhibited significant and positive heterosis and heterobeltiosis for spike length. Higher and lower heterotic and heterobeltiotic values estimated from the hybrid 12-21×Gediz (49.39 % and 36.53%, respectively) and the hybrids Pınar-2001×11-27 (15.28% and 13.15%) and Pınar-2001×12-21 (16.04% and 10.33%), respectively. These findings are supported by the results of Moiscu *et. al.* (1984), Ulukan (1997), Chowdhry *et. al.* (2005), Çifci and Yağdı (2007) and Bilgin *et. al.* (2011).

Spikelet Number / Spike: Significantly and positive heterosis values for spikelet number/spike were found eight crosses and 7 out of 10 combinations exhibited significantly positive heterobeltiosis. Higher heterosis and heterobeltiosis was estimated in the hybrid 12-21×Gediz (34.36% and 29.15%) and low effects were noted in the hybrid 11-27×Gediz (8.90% and 2.50%), respectively. Rest of the heterosis and heterobeltiosis values ranged from 13.18 to 25.51% and 6.37 % to 20.45%. These results positive significant heterosis values on spikelet number/spike are agreement with

Singh *et al.* (2004) and Ilker *et al.* (2010). Yağdı and Karan (2000) reported 2.2 % mean heterosis and -0.9 % mean heterobeltiosis for spikelet number/spike in the crosses obtained from 13 wheat lines. Their results is highly different in terms of spikelet number/ spike determined in the study.

Grain Number/ Spike: Grains per spike directly determine the yield potential of a genotype (Ahmad *et al.*, 2006). Positive heterosis and heterobeltiosis for grain number per spike were significant in eight crosses for heterosis and six crosses for heterobeltiosis. Out of 10 crosses, only one cross showed negative non-significant heterobeltiosis. The higher heterosis and heterobeltiosis was noted in cross 9-65×12-21 (78.38 % and 62.82 %) and 9-65×Gediz (47.27 % and 46.25 %). The hybrid 11-27×12-21 had the lowest heterosis and heterobeltiosis values (10.11% and -1.30%, respectively). These results could be verified from Tiwari and Chakraborty (1992)

1000 Grains Weight: Positive heterosis values for 1000 grain weight were obtained from only 4 of the 10 cross combinations and 3 of them found to be significant. Heterobeltiosis values ranged from 16.46 % to -8.71 % and heterobeltiosis values changed from 10.83 % to -14.45 %. Higher heterosis and heterobeltiosis was noted in the hybrid Pınar-2001×9-65 (16.46%-10.83%) where as the hybrid 11-27×12-21 had the lowest heterosis and heterobeltiosis (-7.83% and -14.45%), respectively. Although the mean heterosis and heterobeltiosis over all crosses were positive for plant height (6.52% and 0.14%), spikelet length (28.45 % and 23.64%), spikelet number/ spike (18.46 % and 13.97%), grain number/spike (37.26% and 29.65%) and grain yield/spike 48.37 % and 41.80 %), the mean heterosis and heterobeltiosis over all crosses was observed to be highly low and negative for

Ahmad *et al.* (2006), Akbar *et al.* (2007) and Ilker *et al.* (2010).

Grain Yield /Spike: Seven crosses gave significant positive heterosis where as six crosses had significant positive heterobeltiosis for grain yield per spike. The higher values for heterotic and heterobeltiotic effects were estimated in the hybrid Pınar-2001×Gediz (88.64% - 73.63%) and 12-21×Gediz (84.18%- 76.21%) while the lowest values determined in the hybrid 11-27×12-21 (13.98% and -15.34%), respectively. The mean heterosis and heterobeltiosis value of all combinations were 48.37 % and 41.80 %, respectively. Similiar findings reported by Afiah *et al.* (2000), Yağdı and Karan (2000) and Çifci and Yağdı (2007), whereas Özgen (1989), Singh *et al.* (2004) and Ilker *et al.* (2010) determined negative or lack of significant positive heterosis and heterobeltiosis values.

1000 grain weight. This result indicated that in some crosses while spikelet number, kernel number and grain yield per spike increase, 1000-kernel weight may decrease significantly. These results are in agreement with the study of Ilker *et al.* (2010). Previously, Özgen (1989) reported that kernel number per spike in F1 crosses of bread wheat was negatively correlated with 1000-kernel weight ($r = -0.22$) but it positively correlated with grain weight ($r = 0.45$) as determined in the study.

Correlations: In order to identify agronomical plant traits suitable for selection for the further amelioration of grain yield per spike in durum wheat, the correlation coefficients among various agronomic traits were calculated. The results about correlation coefficients have been shown in Table3.

Table 3. Correlation coefficients among genotypes.

Traits	Plant height	Spike length	Spikelet number/spike	Grain Number/spike	Grain yield/spike
Spike length	0,049				
Spikelet number/spike	-0.009	0.845**			
Grain number/spike	0.271	0.422**	0.392**		
Grain yield/spike	0.184	0.462**	0.445**	0.706**	
1000 grains weight	0.215	-0.064	-0.047	-0.102	0.238

The results of correlation study revealed that there was positive and significant correlation between spike length and spikelet number per spike, grain number per spike and grain yield per spike. Similiar result was found by Yücel *et al.* (2009).

A positive and significant correlation was observed between spikelet number per spike and grain number per spike (0.392) and grain yield per spike. Soyulu and Akgün (2003) and Yücel *et al.* (2009) also reported positive and significant association between spikelet

number per spike and grain number per spike and grain yield per spike as the result in the study.

Association between grain number per spike and grain yield per spike was found positive and significant. Similiar result was reported by Sözen and Yağdı (2005) and Yücel *et al.* (2009).

At the study it is concluded that any significant associations were observed between plant height with the other agronomic traits. Also 1000 grain weight had non-significant correlations with all other traits. Several

researchers reported that grain yield was positively correlated with 1000 grains weight (Akram *et al.* 2008). The finding of non-significant correlation with all other traits determined in the study is contradictory to the results of this study, but it shows in agreement with other study by Anwar *et al.* (2009).

Path Analysis: It provides an effective way to find out direct and indirect sources of correlation using genotypic

correlation of different characters (Mahmood *et al.* 2006). In this study, the response variable was grain yield per spike and five predictor variables were plant height, spike length, spikelet number/spike, grain number per spike and 1000 grains weight.

Path coefficient analysis for direct and indirect effects of traits on grain yield per spike is given in Table 4.

Table 4. Path coefficient analysis for direct and indirect effects on grain yield per spike

Traits	Direct effects	Indirect effects				
		Plant height	Spike length	Spikelet number/spike	Grain Number/spike	1000 grains weight
Plant height	0.184	-	0.006	-0.001	0.160	0.042
Spike length	0.462	-0.001	-	0.092	0.250	-0.013
Spikelet number/ spike	0.445	0.0002	0.112	-	0.232	-0.009
Grain number/spike	0.706	-0.064	0.056	0.043	-	0.019
1000 grains weight	0.238	-0.005	-0.008	-0.005	0.060	-

Plant height: The direct effect of plant height on grain yield per spike was positive. The indirect effects of plant height via spike length, grain number per spike and 1000 grains weight was positive where as negative indirect effect of plant height via spikelet number per spike. Moghaddam *et al.* (1998), Khan *et al.* (1999) and Ayçiçek and Yıldırım (2006) pointed that this trait showed positive correlation with grain yield. On the other hand, some authors indicated the negative direct effect of plant height on grain yield (Subhani & Khaliq (1994), Mondal *et al.* (1997), Mohammad *et al.* (2002) and Yağdı (2009)). The research finding of positive relation between plant height and grain yield per spike indicated in our study is contradictory to the results of these studies.

Spike Length: Spike length exerted positive direct effect on grain yield per spike but its indirect effects via plant height and 1000 grains weight were negative. Positive and higher indirect effect via grain number per spike was noted (0.250). Singh *et al.* (2003) also reported positive direct effects of spike length on grain yield. However, Mahmood *et al.* (2006) reported negative direct effects of spike length on grain yield. This discrepancy in results could be due to the difference in genotypes and environment in which studies were carried out.

Spikelet Number / Spike: Examination of data for spikelet number per spike had positive direct effect on grain yield per spike while indirectly through plant height, spike length, grain number per spike. However, spikelet number per spike exerted negative indirect effect through 1000 grains weight. The highest indirect effect observed in grain number per spike. The finding of positive direct effect between spikelets number per spike

with yield determined in the study is agreement with the studies of Ugowska *et al.* (2004), Gupta *et al.* (2004) and Mahmood *et al.* (2006).

Grain Number/ Spike: Direct effect of grain number per spike on grain yield per spike was positive and high (0.706) and indirect effects via plant height was negative while via spike length, spikelet number per spike and 1000 grains weight were positive. Similar results have been reported for this trait by Pochoba and Wegrzyn (2001), Mohammad *et al.* (2002) and Ayçiçek and Yıldırım (2006). However, the direct negative effect of grain number per spike on yield had been shown by Dencic *et al.* (2000) and Yağdı (2009).

1000 Grains Weight: Positive direct effect were obtained from 1000 grains weight on grain yield per spike where as negative indirect contribution to grain yield via plant height, spike length and spikelet number per spike, but positive via grain number per spike. The findings are agreement with the studies of Mohammad *et al.* (2002), Ayçiçek and Yıldırım (2006) and Mahmood *et al.* (2006).

At the result of path analysis indicated that spike length, spikelet number/ spike and grain number per spike had the maximum direct effects on grain yield per spike (0.462, 0.445 and 0.706, respectively). Dağüstü (2008), Heidari *et al.* (2008) and Yücel *et al.* (2009) also had been reported that grain number per spike had the maximum direct effects on grain yield per spike.

Conclusion: It is concluded that the hybrids 11-27×Gediz for plant height, 12-21×Gediz for spike length, spikelet number per spike, 9-65×12-21 for grain number per spike, Pınar-2001×Gediz and 12-21×Gediz for grain yield per spike and Pınar-2001×9-65 for 1000 grains

weight were desirable hybrid combinations for further developing new durum cultivars. The correlations between traits revealed that important characters, influencing grain yield per spike are spike length, spikelet number per spike and grain number per spike. The path analysis result showed that the most importance traits on the grain yield per spike is spike length, spikelet number/spike and grain number per spike.

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