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Heterosis and Combining Ability in a 8 X 8 Diallel Durum Wheat Population

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Özet

8 x 8 Diallel Melez Makarnalık Buğday Populasyonunda Heterosis ve Kombinasyon Yeteneği

Üçü tescilli (Edirne-1, Kunduru ve Rodur), ikisi ıslah hattı (97mbvd-11 ve 97mbvd-5) ve üçü de yerel (Akbaş, Sorgül ve Karakılçık) olan makarnalık buğday genotipleri 1997-98 yetiştirme sezonunda, resiproksuz olarak 8x8 diallel melez programına göre melezlenmişlerdir. Sekiz ebeveyn ile 28 F_1 dölü 1998-99 yetiştirme sezonunda yetiştirilmiştir.1999-2000 yetiştirme sezonuna ait F_2 verileri Griffing yöntemi ile analiz edilmiş ve heterosis de hesaplanmıştır. Yüksek özel kombinasyon yeteneğine sahip olan Akbaş x Kunduru, Karakılçık x 97mbvd-11, Karakılçık x Kunduru, Karakılçık x Edirne-1, Sorgül x Rodur melez kombinasyonları protein içeriği ve Karakılçık x Edirne-1, Akbaş x 97mbvd-5, Sorgül x Rodur, Edirne-1 x 97mbvd-5 ve Kunduru x 97mbvd-11 melez kombinasyonları ise verim bakımından yüksek özel kombinasyon yeteneğine sahip olduklarından ümitvar bulunmuşlardır.

Anahtar sözcükler: F_2 Makarnalık buğday melezleri, heterosis ve kombinasyon yeteneği.

Introduction

Durum wheat breeder's purpose is to develop genotypes with higher yield and better quality which are mostly negatively associated. To achieve this goal, diallel crossing programs were applied (1, 4, 11). However, breeder faces with the problems such as identifying, selecting parents and applying selection for the promising segregation progenies at early generations. The main reason for these difficulties is that the traits considered are under polygenic control with continuous variations. Hence, the breeder makes the preliminary observations on possible parents to choose the appropriate ones and to cross them.

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Heterosis defined as the percentage of F_1 over parental mean and known as hybrid vigor is desirable but much lower for grain yield in wheat than the other field crops such as corn (8). Breeder uses the combining ability concept to initially classifying lines relative to their cross performance. Sprague and Tatum (9) refined this concept as general (GCA) and specific combining ability (SCA), which have had a continuing impact on line development and population improvement in plant breeding. They partitioned the general and specific combining ability in a diallel analysis. GCA was defined as the average performance of a parent in hybrid combination with other parents, and was attributed to genes having largely additive effect (9). SCA was defined as instances in which a particular hybrid combination performs better or worse than the expected based upon the average of its inbred parents in crosses. Specific combining ability is considered as an indication of loci with epistatic or dominance effects.

Hence, the objective of this study was to estimate the heterosis, GCA and SCA for certain quantitative traits in a 8x8 diallel cross population derived from durum wheat x landrace genotypes.

Materials and Methods

Eight parents including three commercial durum wheat cultivars (Edirne-1, Kunduru and Rodur), two breeding lines (97mbvd-11 and 97mbvd-5) and three landraces (Akbaş, Sorgül and Karakılçık) originated from Gürünlü, Süleymana and Lice villages in the south eastern part of Turkey were crossed by hand to have an 8x8 diallel crossing program without reciprocals in the 1997-98 growing season. The eight parents and the 28 F_1 progenies were grown at Bornova in the 1998-99 growing season. The seed of each entry was sown in single meter rows spaced 30 cm apart with each other in order to have higher amount of F_2 seed. In the 1999-2000 growing season, the F_2 seed obtained were sown in a plot that consisted of two single one meter rows with one meter length row spaced 30 cm apart. Seed of 20 g was sown in each row. Days to heading (days), plant height (cm), grain yield (g/plot) and thousand kernel weight (g) were measured and protein contents were determined by using the "Near Infrared Reflectance Spectroscopy (NIR-S)" technique (10).

Data obtained from the 28 F_1 progenies and eight parents were analysed by applying Griffing's (6) procedure (Method 2, Model 1). Griffing analysis was performed by using the TarPopGen program developed by Özcan and Açıkgöz (7). Heterosis (H) values were

calculated with the following formula: H = ((F_2-mean of parents) / (mean of parents)) x 100.

Results and Discussion

Preliminary analysis of variance and combining ability of variance indicated that crosses were significantly different from each other for all the traits measured in the study, which enabled the diallel analysis to be run (6) (Table 1). Both GCA and SCA effects were also significantly different among the F_2 progenies for all the traits, indicating that there was enough variation to be successful in selecting the desirable cross combinations in the study.

Table 1. Mean squares obtained from preliminary analysis of variance and combining ability of variance for the traits measured in a 8x8 diallel durum wheat crosses at F_2.

Source of variation	d.f.	Days to heading	Plant height	Grain yield	1000 Kernel W.	Protein content
Rep	1	144.6**	335.1**	2814.4	1.0	0.99*
F_2 Crosses	27	41.0**	293.0**	33970.2**	64.6**	9.03**
Error	27	3.0	5.6	2448.1	1.2	0.14
G.C.A.	7	21.3**	163.4**	21829.9**	16.2**	2.13**
S.C.A.	20	20.2**	140.6**	15289.4**	37.9**	5.35**
Error	27	1.5	2.8	1224.0	0.6	0.07

The heterosis values estimated for five traits in the commercial x landrace durum crosses were given in Table 2. Heterosis values among all the crosses for heading date varied from 4.9% to –11.8%, namely Kunduru x 97mbvd-5 cross having the highest heading date (128 days) and Sorgül x Kunduru having the lowest heading date (108 days). Edirne-1 x Kunduru had the second lowest heterosis –11.1% and days to heading (112 days). Low heterosis for days to heading is desired because the high temperatures occurred during the grain filling period from the beginning of April to the end of may in the Aegean region might negatively affect the yield (1). In addition, days to heading had no significant correlation coefficient with yield and the other traits in this study.

Heterosis values of the crosses for plant height changed from –7.9% to 44% in all crosses. Sorgül x Rodur (40 %), Kunduru x Rodur (32.69), Akbaş x Edirne-1 (31.4%) and 97mbdv-11 x Rodur (28%) having the highest heterosis values had the highest plant heights, 144 cm, 138 cm, 138 cm and 130 cm, respectively. This was an expected result because the parents Sorgül (120 cm) and Akbaş (119 cm) and

Kunduru (128 cm) were considered as taller genotypes in the population. Plant height had also no significant correlation with any other trait. Budak et al (5) also indicated that the genotypes sensitive to GA_3 and so-called tall genotypes had no significant correlation with yield in durum wheat.

Especially for grain yield, there were very high heterosis values in Akbaş x 97 mbvd-5 (87%), Sorgül x Rodur (53.8%), Akbaş x Rodur (42.7%) and 97 mbdv-5 x Rodur (20.2%) which had the highest grain yields among the crosses; 790 g/plot, 615 g/plot 560 g/plot and 565 g/plot, respectively. These heterosis values were much higher than those of bread wheat (from –0.19 to 63%) reported by Budak and Yıldırım (3). These inconsistent results might be due to different genetic material used. Grain yield had only significant correlation coefficient (r=0.54 **) with thousand kernel weight, as a yield component. Sorgül x Rodur having high heterosis for grain yield had also high value of heterosis (33%) for thousand kernel weight.

For protein content, Karakılçık x 97mbvd-11 (37.9%) Karakılçık x Kunduru (31%) and Akbaş x Kunduru (31%) had the highest and Edirne-1 x Rodur (-13.3%), Edirne-1 x Kunduru (-13.3%) and Sorgül x Edirne-1 (13.3%) had the lowest heterosis values. Protein content didn't have any significant correlation with the traits measured including grain yield. Budak (2) studying the relationships between protein percentage and grain yield did not find any significant correlation, either.

General combining abilities estimated for the parents were given in Table 3. GCA and SCA effects were significantly different among the crosses. Thus, it was worthwhile to determine GCA and SCA effects in the study (Table 1). For heading date, plant height, grain yield, thousand kernel weight and protein content, Kunduru (2.5), Sorgül (4.8), 97mbvd-5 (124), 97mbvd-5 (2.5) and Karakılçık (0.86) were the best combiners while Karakılçık (-2.9), Edirne-1 (-11.8), Karakılçık (-77.9), Kunduru (-2.09) and Edirne-1 (-0.88) were the poorest combiners, respectively (Table 3). In other words, the parents having higher GCA values contributed more to the traits considered than the others. For example, 97mbvd-5 having the highest GCA for grain yield and thousand kernel weight had more contribution to these traits than the others in crosses it involved.

Karakılçık x Edirne-1 (209.9), Akbaş x 97mbvd-5 (197.7), Sorgül x Rodur (192.9), Edirne-1 x 97mbvd-5 (132.4) and Kunduru x 97mbvd-11 (131.4) crosses having the highest SCA values for grain

yield had also the highest heterosis values, which suggested that the parents involved in these crosses might be used to develop a hybrid durum wheat.

Table 2. The estimated heterosis values for the traits measured in a 8x8 diallel durum wheat crosses at F_2.

Crosses	Days to heading	Plant height	Grain yield	1000 Ker. W.	Protein content
Akbaş x Sorgül	-0.42	-2.93	-7.80	0.00	-3.45
Akbaş x Karakılçık	-3.70	7.00	5.71	13.51	0.00
Akbaş x Edirne-1	-4.07	31.43	-28.71	0.00	-3.45
Akbaş x Kunduru	-6.45	17.41	8.22	1.27	31.03
Akbaş x 97mbvd-11	-5.31	7.89	-6.25	15.38	-3.45
Akbaş x 97mbvd-5	-3.36	16.07	86.98	23.26	6.67
Akbaş x Rodur	-5.65	19.60	42.68	13.25	10.34
Sorgül x Karakılçık	0.83	-2.46	6.29	0.00	-3.45
Sorgül x Edirne-1	-2.06	10.90	-32.88	-2.56	-13.30
Sorgül x Kunduru	-0.41	-1.61	-2.01	-3.90	-6.67
Sorgül x 97mbvd-11	-1.65	27.51	-26.15	15.79	-6.67
Sorgül x 97mbvd-5	-2.13	24.44	15.12	14.29	-3.23
Sorgül x Rodur	-11.84	44.00	53.75	33.33	20.00
Karakılçık x Edirne-1	-8.50	7.91	11.76	32.50	24.14
Karakılçık x Kunduru	-7.63	-7.94	6.76	6.33	31.03
Karakılçık x 97mbvd-11	-8.13	9.87	-26.80	-5.13	37.93
Karakılçık x 97mbvd-5	-4.60	23.14	-30.99	-4.65	-6.67
Karakılçık x Rodur	-9.24	27.45	-32.08	-1.20	-3.45
Edirne-1 x Kunduru	-11.11	-0.46	-30.86	-8.24	-13.30
Edirne-1 x 97mbvd-11	-8.43	15.00	-42.19	23.81	-6.67
Edirne-1 x 97mbvd-5	-0.83	10.20	19.31	-17.40	-3.23
Edirne-1 x Rodur	-8.73	20.47	-33.03	-12.40	-13.30
Kunduru x 97mbvd-11	-5.18	10.55	6.00	10.84	-13.30
Kunduru x 97mbvd-5	4.92	1.29	-18.64	-7.69	-9.68
Kunduru x Rodur	0.00	32.69	9.09	-4.55	-6.67
97mbvd-11 x 97mbvd-5	1.24	21.50	16.59	-8.89	-3.23
97mbvd-11 x Rodur	-1.99	28.04	-30.81	-14.90	20.00
97mbvd-5 x Rodur	0.00	21.08	20.21	9.47	16.13

Table 3. General combining ability effects (GCA) for the traits measured in a 8x8 diallel durum wheat crosses at F_2.

Parents	Days to heading	Plant height	Grain yield	1000 kernel W.	Protein Content
Akbaş	-0.66	4.10	24.52	0.26	-0.05
Sorgül	-0.08	4.85	-36.47	-1.32	-0.58
Karakılçık	-2.91	0.52	-77.97	-1.34	0.86
Edirne-1	-1.91	-11.81	-5.22	-0.34	-0.88
Kunduru	2.50	0.52	-40.89	-2.09	-0.24
97mbvd-11	0.41	2.85	-3.81	0.21	0.09
97mbvd-5	2.41	0.35	124.52	2.51	0.07
Rodur	0.25	-1.39	15.35	2.11	0.73
Kritik fark (% 5)	0.91	1.25	26.18	0.59	0.196

Table 4. Specific combining ability effects (SCA) for the traits measured in a 8x8 diallel durum wheat crosses at F_2.

Crosses	Days to heading	Plant height	Grain yield	1000 kernel W.	Protein Content
Akbaş x Sorgül	2.0	-17.9	-106.3	-6.1	-0.4
Akbaş x Karakılçık	3.3	0.0	-19.8	-0.1	-2.3
Akbaş x Edirne-1	3.3	20.3	-102.6	-3.1	-0.5
Akbaş x Kunduru	-3.1	15.5	-31.9	-0.8	3.6
Akbaş x 97mbvd-11	-1.0	-9.4	-14.0	1.4	-1.3
Akbaş x 97mbvd-5	-4.0	0.1	197.7	7.1	0.6
Akbaş x Rodur	-0.4	-8.6	76.9	1.6	0.2
Sorgül x Karakılçık	6.2	-11.3	51.2	-4.5	-1.8
Sorgül x Edirne-1	3.7	-1.0	-57.6	-3.5	-0.3
Sorgül x Kunduru	1.8	-8.8	-0.9	-2.7	-0.4
Sorgül x 97mbvd-11	0.9	13.4	-43.0	2.3	-0.6
Sorgül x 97mbvd-5	-4.6	9.9	-36.3	3.9	0.5
Sorgül x Rodur	-10.0	15.6	192.9	10.6	2.9
Karakılçık x Edirne-1	0.0	1.9	209.9	11.8	3.0
Karakılçık x Kunduru	-2.4	-10.5	70.6	2.8	3.2
Karakılçık x 97mbvd-11	-2.3	-0.8	-6.5	-5.0	3.4
Karakılçık x 97mbvd-5	-2.8	14.7	-194.8	-2.4	-2.5
Karakılçık x Rodur	-2.1	6.0	-110.6	-2.5	-3.0
Edirne-1 x Kunduru	-6.4	-4.6	-34.6	-1.7	-0.7
Edirne-1 x 97mbvd-11	-2.3	-1.5	-64.2	9.2	-0.6
Edirne-1 x 97mbvd-5	2.2	-6.0	132.4	-6.8	1.0
Edirne-1 x Rodur	-0.6	-9.2	-83.4	-5.9	-2.1
Kunduru x 97mbvd-11	-1.7	2.2	131.4	4.7	-2.3
Kunduru x 97mbvd-5	5.3	-7.8	-166.9	-1.6	-1.2

(continued from Table 4)

Kunduru x Rodur	6.5	14.0	32.3	-0.7	-2.2
97mbvd-11 x 97mbvd-5	1.9	1.4	86.0	-4.9	-0.7
97mbvd-11 x Rodur	4.5	-5.4	-89.8	-7.7	2.0
97mbvd-5 x Rodur	2.0	-12.4	-18.1	4.7	2.2
Kritik fark (% 5)	2.03	2.78	57.95	1.31	0.43

Sonuç

Akbaş x Kunduru (3.6), Karakılçık x 97mbvd-11 (3.4), Karakılçık x Kunduru (3.2), Karakılçık x Edirne-1 (3.0) and Sorgül x Rodur (2.9) having the highest SCA values for protein content in general had also high heterosis values. These results were confirmed with those of correlation analysis run between the heterosis and SCA values for each trait, indicating that there were highly significant correlations for days to heading (r=0.55**), grain yield (r=0.60**) and protein content (r=0.97**) while there were no significant correlations for plant height (r=0.02) and thousand kernel weight (r=0.32). It means that the crosses such as Akbaş x Kunduru, Karakılçık x 97mbvd-11, Karakılçık x Kunduru, Karakılçık x Edirne-1, Sorgül x Rodur having high SCA values for protein content and the Karakılçık x Edirne-1, Akbaş x 97mbvd-5, Sorgül x Rodur, Edirne-1 x 97mbvd-5 and Kunduru x 97mbvd-11 having highest SCA values for grain yield should be evaluated and followed in next generations as promising progenies in terms of protein content and grain yield.

Summary

Eight parents including three commercial durum wheat cultivars (Edirne-1, Kunduru and Rodur), two breeding lines (97mbvd-11 and 97mbvd-5) and three landraces (Akbaş, Sorgül and Karakılçık) were crossed by hand to have a 8x8 diallel crossing program without reciprocals in the 1997-98 growing season. The eight parents and their 28 F_1 progenies were grown at Bornova in the 1998-99 growing season. In the 1999-2000 growing season, the F_2 data recorded were analyzed according to Griffing's procedure to estimate general and specific combining abilities (GCA and SCA). Heterosis values were also computed. The results indicated that the crosses such as Akbaş x Kunduru, Karakılçık x 97mbvd-11, Karakılçık x Kunduru, Karakılçık x Edirne-1, Sorgül x Rodur having high SCA values for protein content and the Karakılçık x Edirne-1, Akbaş x 97mbvd-5, Sorgül x Rodur, Edirne-1 x 97mbvd-5 and Kunduru x 97mbvd-11 having highest SCA values for grain yield were found to be promising progenies for further generations.

Key words: F_2 Durum wheat crosses, heterosis and combining ability.

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