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The Research of the Combining Ability of Agronomic Traits of Bread Wheat in F_1 and F_2 Generations

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Abstract: This study was carried out between 2004-2007 vegetation periods at the experiment fields of Uludağ University Faculty of Agriculture, Agricultural Application and Research Center. In this study 5 advanced breeding lines and 3 bread wheat cultivars that have adapted to the region and their F_1 and F_2 crosses that have been obtained by Line x Tester crossing of these have been used as material. In the research, the plant height, spike length, number of spikelets/spike, number of grains/spike, grain weight/spike and 1000 kernel weight were researched for combining abilities. According to the traits in both F_1 and F_2 generations show that non-additive gene effects play a role on the heredity of these traits. For most of the researched traits, appropriate parents and crosses were determined for all the traits, this shows that this cross population can be used to obtain desired bread wheat for future generations.

Key Words: Bread Wheat, Line x Tester Method, Combining Ability.

Ekmeklik Buğdaylarda Agronomik Özelliklerin Kombinasyon Yeteneğinin F_1 ve F_2 Generasyonlarında Araştırılması

Özet: Bu çalışma 2004-2007 vejetasyon dönemlerinde Uludağ Üniversitesi Ziraat Fakültesi Tarımsal Uygulama ve Araştırma Çiftliğinde yürütülmüştür. Çalışmada 5 ileri ıslah hattı ve yöreye adapte olmuş 3 ekmeklik buğday çeşidi ile bunların line×tester melezlemesinden oluşan F_1 ve F_2 melez kombinasyonu materyal olarak kullanılmıştır. Araştırmada bitki boyu, başak boyu, başakçık sayısı, başakta tane sayısı, başakta tane ağırlığı ve 1000 tane ağırlığı özelliklerinin kombinasyon yeteneği araştırılmıştır. Araştırılan özelliklerde her iki generasyonda bu özelliklerin kalıtımında eklemeli olmayan gen etkilerinin rol oynadığı belirlenmiştir. Araştırılan özelliklerin tümü için uygun ebeveynlerin ve melezlerin belirlenmesi, bu melez populasyonlarının ileriki generasyonlarda istenilen özellikleri taşıyan ekmeklik buğday çeşitlerinin ıslah edilmesinde kullanılabileceğini göstermektedir.

Anahtar Kelimeler: Ekmeklik Buğday, Line x Tester Metodu, Kombinasyon Yeteneği.

Introduction

As is the case in most regions of the world, wheat is an important crop plant for nutrition of world and animal feeding in terms of both cultivation and production which is also used in industry.

The breadth of the adaptation limit of wheat, its ease of production, handling, storage and cultivation and also its ability to become bread has in many countries accelerated the variety development studies to increase its production.

Success in variety breeding studies depends on the breadth of the variation on hand and also on the ability to make the right choice out of it. If the genetic structure of the parents, the heritage of the traits to be considered are determined prior to the study, the breeding programs that are based on this information will have a high success ratio. Line x Tester method is developed to be able to use the information that will be gained by the heritage of researched traits, determination of the right parents and crosses more effectively in the breeding program (Kan and Sade, 2002).

In this study, the plant height, spike length, number of spikelets/spike, number of grains/spike, grain weight/spike and 1000 kernel weight were researched for F_1 and F_2 cross populations that were obtained by crossing 3 cultivars of bread wheat that show agriculturally and ecologically outstanding qualities and 5 advanced-generation bread wheat lines.

Material and Method

This study was conducted between 2004-2006 vegetation periods at the experiment fields of Uludağ University Faculty of Agriculture, Agricultural Application and Research Center. In this study advanced breeding lines numbered 4-9 (1),15-4 (2),15-10 (3), 17-10 (4), 18-9 (5) and 3 bread wheat cultivars that have adopted to the region (Saraybosna (6), Gönen (7), Marmara-86(8)) and their F_1 and F_2 crosses that have been obtained by Line x Tester crossing of these have been used as material.

In the first year of the research, crosses have been made between the 5 lines and 3 bread wheat cultivars. In the second year of this research, seeds of parents and F_1 plants were sown of two rows with spacing 30 cm between rows and 15 cm between plants according to the randomized blocks design with 3 replications while F_2 consisted of four rows with the spacing of 30 cm between rows. Ten competitive plants in parents and F_1's and 20 plants in F_2 progenies were sampled randomly.

The data obtained for agronomic traits were calculated by using line x tester method and the general and specific combining abilities as explained by Sing and Chaudhary (1979).

Results

The line x tester variance analysis results for traits that were analyzed in F_1 and F_2 generations are given in Table 1.

The variance for line × tester analysis for examined traits indicated that no significant differences existed between replications, testers, lines except spike length in both generations and grain weight/spike in F_1 generation and parents vs. crosses for plant height in both years, grain number/spike in F_2 and grain weight/spike in F_1 generation. The analysis for variance revealed that due to parents, crosses and line × tester interaction were significant for all traits in both years of the research (Table 1).

Table 1. Analysis of variance for line × tester for traits examined in F_1 and F_2 generations.

Source of variation	DF	Mean squares											
		Plant height		Spike length		Spikelet number/spike		Grain number/spike		Grain weight/spike		1000 kernel weight	
		F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Replication	2	0.144	31.584	0.110	0.540	0.987	0.261	21.142	9.751	0.040	0.044	1.310	2.097
Treatments	22	131.56**	154.522**	6.774**	5.779**	6.903**	11.527**	182.911**	122.974**	0.330**	1.008**	39.734**	38.921**
Parents	7	199.764**	249.077**	2.903**	1.617**	5.221**	6.823**	122.181**	126.004**	0.205*	0.332**	42.763**	80.913**
Parents vs. Crosses	1	13.619	91.581	35.873**	21.221**	18.341**	54.296**	285.236**	23.584	0.004	5.087**	156.461**	59.273**
Crosses	14	105.814**	111.740**	6.631**	6.758**	6.928**	10.824**	205.97**	128.558**	0.415**	1.054**	29.883**	16.471**
Lines	4	101.032	57.182	14.057*	5.703**	9.562	12.457	382.99	170.334	0.897*	1.090	47.446	25.989
Testers	2	113,038	90.334	5.355	18.030	13.734	16.033	224.70	98.073	0.481	1.325	45.779	31.440
Line ×Testers	8	106.399**	144.371**	3.238**	4.467**	3.908**	8.705**	112.77**	115.291**	0.157*	0.968**	17.727**	7.970*
Error	44	16.660	23.931	0.699	0.463	1.397	1.103	36.527	15.220	0.070	0.086	2.953	3.139

*:$p<0.005$,**:$p<0.001$

The variance estimates and proportional relationships for the general and special combining abilities of the traits that were analyzed in this research are given in Table 2.

The fact that according to the traits analyzed the SCA variance is positive, greater than the GCA variance and that the GCA/SCA ratio is less than 1 in both F_1 and F_2 generations shows that non-additive gene effects play a role on the heredity of these traits (Topal and Akgün, 2002, Gorjanovic and Balalic, 2004,Singh et. al., 2004, Çifci and Yağdı, 2007).

When the GCA effect values given in Table 3 are examined, it can be seen that in terms of plant height the line numbered 2 in F_1 generation has the best general combining ability. In F_2 generation no significance was determined among the lines.

When the table is examined for testers, significant GCA values can be seen for cultivars numbered 7 and 8 whereas no significant GCA value was determined in F_2 generation.

In terms of the specific combining ability for the plant height, in F_1 generation the 2×6, 5×7 crosses were found to show positive significant and the 3×8, 5×6 crosses were found to show negative significant effects. For the same feature in F_2 generation, the 1×7 cross was found positive and the 1×6, 3×7, 5×7 crosses were found negative significant SCA effect values (Table 4).

For the spike length, the line numbered 3 had the best general combining ability in both generations whereas in F_1 generation the line numbered 4 and in F_2 generation the line numbered 1 showed statistically negative significance general combining ability effects.

Table 2. The variance estimations and proportional relationships for the general and special combining abilities in F_1 and F_2 generations.

Traits	υ^2 GCA		υ^2 SCA		υ^2 GCA/ υ^2 SCA	
	F_1	F_2	F_1	F_2	F_1	F_2
Plant height	-0.021	-1.154	29.913	40.146	-0.0007	0.028
Spike length	0.120	0.081	0.846	1.335	0.141	0.060
Spikelet number/spike	0.107	0.075	0.837	2.534	0.127	0.029
Grain number/spike	3.295	0.469	25.414	33.357	0.129	0.014
Grain weight/spike	0.009	0.003	0.029	0.294	0.310	0.010
1000 kernel weight	0.451	0.301	4.725	1.610	0.095	0.186

For testers, significant GCA abilities were determined in both generations for the cultivar numbered 6 and significance was determined for cultivar number 7 in F_1 and number 8 in F_2 generations (Table 3).

When the specific combining ability for the spike length in crosses is analyzed, the 5x6 cross in F_1 generation and 1×7, 2×8, 3×6, 3×7 and 5×7 crosses in F_2 generation were determined to be significant. For the same feature significant SCA effect values have been determined for 1×6 and 5×8 crosses in both generations (Table 4).

The line the parent number 1 and for testers the cultivar number 6 have significant general combining abilities in both generations for the spikelets number /spike (Table 3).

When the crosses are analyzed for the number of spikelets per spike, it is determined that in both generations the 5×8 cross has significant specific combining ability (Table 4).

In this research, the highest general combining ability values have been obtained from line number 1 in F_1 generation and line number 3 in F_2 generation for the grain number/spike. In both generations significant GCA values were obtained for line number 3.

Table 3. General combining ability for the traits examined in bread wheat in F_1 and F_2 generations.

Lines	Plant height		Spike length		Spikelet number/spike		Grain number/Spike		Grain weight/spike		1000 kernel weight	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
(1) 4-9	-2.347	-2.798	0.400	-1.115**	1.736**	-1.033**	10.142**	-0.796	0.463**	-0.155	0.231	0.940
(2) 15-4	5.809**	2.791	0.356	0.384	-0.731	1.133**	-2.380	-6.862**	0.059	0.223*	2.564**	-0.328
(3) 15-10	-2.113	-2.376	1.256**	1.029**	-0.309	1.222**	-6.658**	3.938**	-0.414**	0.448**	-2.458**	2.285**
(4) 17-10	-1.407	2.002	-2.100**	-0.294	-0.776	-1.300**	-3.447	3.527**	-0.010	-0.455**	1.876**	-2.204**
(5) 18-9	-0.302	0.380	0.189	-0.005	0.080	-0.022	2.342	0.193	-0.098	-0.061	-2.213**	-0.693
Tester												
(6)Saraybosna	0.669	-2.531	-0.536*	-1.160**	4.384**	-2.580*	4.384**	-2.580*	0.207*	-0.278**	1.573**	-1.139*
(7) Gönen	-3.018**	0.162	0.644**	0.140	-1.442	0.047	1.442	0.047	-0.107	0.313**	-1.880	-0.491
(8) M-86	2.349*	2.369	-0.109	1.020**	-2.942	2.533*	-2.942	2.533*	-0.099	-0.035	0.307	1.629**

Table 4. Specific combining ability for the traits examined in bread wheat in F_1 and F_2 generations.

Crosses	Plant height		Spike length		Spikelet number/spike		Grain number/Spike		Grain weight/spike		1000 kernel weight	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
1×6	-1.847	-8.469**	1.213**	-1.749**	0.184	-2.287**	3.404	-6.531**	0.053	-0.542**	-2.084*	-2.639*
1×7	-2.293	8.671**	-0.267	1.615**	0.678	2.533**	1.031	4.476	-0.056	0.777**	-0.264	0.280
1×8	4.140	-0.202	-0.947	0.135	-0.862	-0.247	-4.436	2.056	0.003	-0.235	2.349*	2.360*
2×6	7.431**	-2.491	-.0109	0.782	-0.582	1.180	3.527	-2.964	0.280	0.057	2.349*	1.090
2×7	-6.949	3.816	0.578	0.149	-0.289	-1.400*	-8.407*	-2.258	-0.409*	-0.051	-0.931	-0.818
2×8	-0.482	-1.324	-0.469	-0.931*	0.871	0.220	4.520	5.222*	0.129	-0.006	-1.418	-0.272
3×6	1.387	4.309	-0.442	0.837*	-0.704	0.524	2.671	10.869**	-0.150	0.719**	-1.362	1.616
3×7	3.773	-8.318**	0.511	-0.829*	1.122	-0.756	3.798	-2.591	0.274	-0.166	1.758	-1.032
3×8	-5.160*	4.009	-0.069	-0.009	-0.418	0.231	-6.469	-8.278**	-0.124	-0.554**	-0.396	-0.585
4×6	-0.880	1.864	0.647	0.460	1.162	1.580*	-1.540	0.447	-0.094	0.165	-1.496	0.272
4×7	-2.127	2.871	-0.500	0.060	-0.178	-0.133	0.953	-0.780	0.123	-0.327	2.224*	0.524
4×8	3.007	-4.736	-0.147	-0.520	-0.984	-1.447*	0.587	0.333	-0.028	0.162	-0.729	-0.796
5×6	-6.091*	4.787	-1.309**	-0.329	-0.060	-0.998	-8.062*	-1.820	-0.089	-0.399*	2.593*	-0.339
5×7	7.596**	-7.040*	-0.322	-0.995*	-1.333	-0.244	2.264	1.153	0.068	-0.233	-2.787**	1.046
5×8	-1.504	2.253	1.631**	1.325**	1.393*	1.242*	5.798	0.667	0.020	0.632**	0.193	-0.707

*:$p<0.005$,**:$p<0.001$

For testers, significant GCA was determined for the cultivar number 6 in both generations (Table 3).

When the SCA for the grain number/spike is analyzed for crosses, significant SCA values were obtained for 2x7 and 5x6 crosses in F_1 generation and for 1×6, 2×8, 3×6 and 3×8 crosses in F_2 generation (Table 4).

The significant GCA for the grain weight in the spikes were obtained in line number 1in generation F_1 and lines number 2 and 4 in generation F_2. In both generations significant GCA values were obtained in line number 3. For testers whereas significant GCA was obtained for cultivar number 6 in both generations, significant GCA was determined in cultivar number 7 in generation F_2 (Table 3). Whereas for the grain weight in the spike the significant SCA ability was determined in only one cross (2×7) in generation F_1, in generation F_2 significant SCA effects were determined in 1×6, 1×7, 3×6, 3×8, 5×6 and 5×8 crosses (Table 4).

Significant GCA values are obtained in line 3 and 4 and for tester number 6 for 1000 kernel weight in both generations (Table 3).

When Table 4 is examined for crosses it has been determined that 1×6 and 1×8 numbered cross lines show significant SCA values in both generations.

Discussion

This study was arranged to investigate genetical structure of agronomic traits for determining the suitable parents and crosses for improving new cultivars in bread wheat. 'In a breeding program, the choice of parents is a very important task.

Combining ability studies are used by plant breeders to select parents with maximum potential of transmitting desirable genes to the progenies. In autogamous crops like wheat, where the ultimate aim is to develop pure line varieties, the estimates of general combining ability (GCA) are very useful because the variance due to general combining ability is attributable to additive gene action and A x A interaction which can be fixed in further generations, while the variance due to specific combining ability is attributable to non-additive gene action.'(Gorjanovic and Balalic,2005).Thus, the line × tester crossing scheme was used to evaluate the effects of GCA and SCA in plant material used in this study.

The analysis of variance for combining ability (GCA) were significant for spike length in both F_1 and F_2 generations and grain weight/spike in F_1 generation. The findings Singh et al.(2004) and Hasnain et al.(2006) are agreement with the present results. The findings of the study revealed that the analysis of variance showed significant SCA variances for all traits in F_1 and F_2 generations. Similar results were obtained by Joshi et.al (2004) and Housmand and Vanda (2008).Generally, SCA variances were higher than GCA and the GCA/SCA ratio is less than 1 in both generations. This result showed that non-additive gene effects were main factor affecting agronomic traits studied in the research. The present findings were supported by the results Khamandosh et al. (1991),Chowdhry et al. (1999), Akgün and Topal (2002), Aydoğan (2003), Singh et al. (2004), Gorjanovic and Balalic (2004),Gorjanovic and Balalic (2005), Çifci and Yağdı (2007).Whereas additive gene effects were reported by Li et al. (1997), Rasal et al. (1991), Menon and Sharma (1994), Javaid et al. (2001), Joshi et al. (2004) and Wagoire et al. (2008). Taleei and Beigi (1996), Soylu (1998) and

Dagüstü (2008) have determined that both additive and non-additive gene effects play a role on these traits analyzed.

Since for most of the analyzed traits line number 3 (15-10) and cultivar number 6 (Saraybosna) had significant general combining abilities, they can be recommended parents for use in bread wheat improvement programs. Significant specific combining abilities in both generations were shown by 1×6 cross for spike length and 1000 grain weight, 5×8 cross for spike length and number of spikelets per spike and 1×8 cross for 1000 grain weight. Also since appropriate crosses and parents were determined for all the traits, this shows that this cross population can be used to obtain desired bread wheat for future generations.

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