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Combining Ability Estimates and Heterosis for Yield and Fiber Quality of Cotton in Line x Tester Design

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Abstract

The objective of this study was to facilitate the selection in cotton breeding program and estimate the general combining ability (GCA) of the parents and specific combining ability (SCA) of hybrids considered for the development of high yielding and better fiber quality in early generations. The study was carried out at the Southeastern Anatolia Agricultural Research Institute during 2006 and 2007 cotton growing season. Seven cotton lines (which are known as high quality) and three testers (which are known as well adapted and high yielding) were crossed in a line x tester mating design in 2006. Ten genotypes and 21 F_1 hybrids were planted in the randomized complete block design with three replications at the same experimental area in 2007. The variance due to GCA and SCA were highly significant for all the traits studied. This indicated that both additive and non-additive gene effects were responsible for the investigated characters. From the trial it was found that in the population, fiber length, fiber fineness and fiber elongation were influenced by additive gene effects while seed cotton yield, fiber yield, ginning percentage, fiber strength and fiber uniformity were influenced by non-additive gene effects. Among the parents FiberMax 832, Teks, Stoneville 453 and Maraş 92 for seed cotton yield and fiber yield; Aşkabat 71 and Giza 45 for fiber length and fiber strength; Aşkabat 71 for fiber fineness and fiber uniformity were detected with higher general combining ability. Most of the parents except Aşkabat 71, Giza 45 and Maraş 92 exhibited GCA for ginning percentage. SCA was significant for FiberMax 832 x Stoneville 453, Tam 94 L 25 x Maraş 92 and Teks x Stoneville 453 hybrid combinations for yield with acceptable fiber quality.

Keywords: cotton, general and specific combining ability, heterosis, line x tester analysis

Introduction

Breeders rely on genetic variation between parents to create unique gene combinations necessary for new superior cultivars. Genetically distant parents should be used in the cotton improvement program for higher yield and best fiber quality. Although the choice of parents is often the most important decision in a breeding program, little is known about the importance of parental genetic distance to successful cotton cultivar development (Esbrocck and Bowman, 1998). Meredith and Brown (1998) found that region of adaptation was an important factor in choosing parents, one parent needed to be a well adapted genotype from the region in which it was to be grown. At least one parent should have above average fiber quality. Cheatham *et al.*, 2003 reported that Australian cotton varieties and wild cotton varieties have the genes to improve fiber quality and fertility; yield and fiber quality could be improved by using these varieties in the U.S.A breeding studies.

The line x tester analysis method can be used to estimate general and specific combining abilities in both self and cross-pollinated plants (Kempthorne, 1957). Line x tester analysis provides for the detection of appropriate parents and crosses superior in terms of the investigated characters so application of the analysis has been widely used by plant breeders to selection in early generations (Pathak and Kumar, 1975; Kaushik *et al.*, 1984; Jagtap, 1986; El-Feki *et al.*, 1995, Bhardwaj and Kapoor, 1998; Ganapathy *et al.*, 2005; Ahuja and Dhayal, 2007).

Combining ability describes the breeding value of parental lines to produce hybrids, general and specific combining ability as defined by Spraque and Tatum (1942) who stated that GCA effects were due to additive type of gene action but SCA effects were due to genes which are non-additive (dominant and epistatic) type of gene action.

Previous studies showed that variation in seed cotton yield and fiber quality traits were influenced by additive and non-additive gene action. Myers and Lu (1998) reported that GCA effects were more significant than SCA effects for micronaire, upper-half mean length, fiber strength and elongation suggesting that additive gene action is important for these traits. Bhardwaj and Kapoor (1998) revealed that seed cotton yield and lint index were controlled by additive genetic variance and non-additive genetic variance, on the other hand ginning percentage were controlled by additive genetic variances. Green and Culp (1990) found that GCA effects were significant for all fiber properties except uniformity index. Cheatham *et al.* (2003) reported that fineness and length exhibited primarily dominance genes effects, fiber percentage and fiber strength are controlled by additive genes effects; fiber yield and fiber elongation extension are controlled equal by additive and dominant genes effects. Ahuja and Dhayal (2007) revealed that GCA and SCA effects for all the traits except fiber elongation, preponderance of non-additive gene action was obtained for seed cotton yield per plant and majority of its component traits including fiber traits.

The general objectives of this study were to evaluate general combining ability of parents and specific combining ability of hybrids and estimate gene action in cotton and selecting the superior hybrids that can be used in breeding program of cotton.

Material and methods

Ten cotton genotypes were selected as parents based on their agronomic and technological performance which seven cotton varieties for high quality and three cotton varieties for well adaptation and high yielding capacities. FiberMax 832, Tam 94 L 25, Teks, Aşkabat 71, Giza 45, Bahar 14 and Gedera 236 were used as line; Stoneville 453, Sayar 314 and Maraş 92 were used as tester and crossed in a line x tester mating design at the Southeastern Anatolia Agricultural Research Institute's experimental area in 2006. Ten genotypes and 21 F_1 hybrids were grown in the randomized complete block design with three replications at the same experimental area in 2007. Each plots contained two rows, of 12 m length at planting and 10 m length at harvest. The distance between and within the rows spacing were 0.70 m and 0.15 m, respectively. Sowing was made with combine cotton drilling machine on 21 May 2007; all plots received 120 kg ha^{-1} N and 60 kg ha^{-1} P_2O_5. Half of the N and all P_2O_5 were applied at sowing time and the remaining N was given at the square stage as ammonium nitrate. The experiment was thinned and hoed twice by hand and three times with machine and only once herbicides were used before sowing. Insects were monitored throughout the experiment and insect control was not needed during cotton growing season. Experimental plots were irrigated seven times by furrow, first irrigated was done in 29 June, and repeatedly six times at ten or twenty days intervals, totally 750 mm water were used. The plots were harvested by hand for yield determination on 22 October 2007 and second on 16 November 2007 and the seed cotton yields was calculated base on the hand-harvest date. After ginning lint yields were calculated by multiplying seed cotton yield by lint percentage. Fiber samples were analyzed for fiber analysis by HVI Spectrum.

In the study seed cotton yield, fiber yield, ginning percentage, fiber length, fiber fineness, fiber strength, fiber elongation and fiber uniformity traits were analyzed with the TarPopGen computer program which developed by Ozcan and Açıkgöz (1999) and differences were scrutinized for significance using LSD 0.05. The GCA variance effects of the parents and the SCA variance effects of the hybrids were estimated by the using of the line x tester analysis method described by Kempthorne (1957) and adopted by Sing and Chaudhary (1985). The first step in the line x tester analysis is to perform analysis of variance as per design used and test the significance of differences among the genotypes including crosses and parents. If these differences are found significant, line x tester analysis is done. Regarding statistical analysis, the combined analysis of parents and crosses was done as suggested by Arunachalam (1974) and for combining ability analysis, the following model was used:

$$y_{ijk} = \mu + f_i + m_j + (mf)_{ij} + b_k + e_{ijk}$$

where, y_{ijk} = value of the observation recorded on the (i x j) th cross in the k th replication; μ is the general effect; f_i is the effect of the i th line; m_j is the effect of the j th tester; mf_{ij} is the specific combining ability (sca) effect of the (ixj) th cross; b_k is the k th block effect and e_{ijk} is the environmental effect associated with the ijk th observation which is assumed to be normally and independently distributed with a mean of zero and variance (σ^2).

Magnitude of heterosis in terms of percentage of increase or decrease of F1 hybrids over mid-parent (MP) for each character was computed according to Hallauer and Miranda (1981).

$$Ht = \frac{\overline{F}_1 - \overline{MP}}{\overline{MP}} \times 100$$

Ht : Heterosis, $\overline{F}_1$: Mean of F_1, $\overline{MP}$: Mean of Parent

Results and discussion

The analysis of variance (Tab. 1) indicated that the mean squares of genotypes for all characters investigated were significantly different ($p<0.01$), indicating the presence of variability among hybrids and their parents, hence later analysis for combining ability was possible. The total genetic variability was partitioned to general combining ability and specific combining ability.

Mean squares of GCA for lines were found significant for all of investigated characteristics revealing important role of additive type gene effects while SCA were observed significant for the seed cotton yield, fiber yield, ginning percentage, fiber length and fiber strength revealing that non-additive gene effects as dominant or epistatic.

From Tab. 1, The variance due to GCA was lower than SCA for seed cotton yield, fiber yield, ginning percentage, fiber strength and fiber uniformity expressed non-additive gene action (dominant or epistatic), which is in accordance with the previous results of El-Feki *et al*. (1995), Bhardwaj and Kapoor (1998), Green and Culp (1990), Kapoor (1998), Cheatham *et al.* (2003) , Ahuja and Dhayal (2007) and Ilyas *et al. (* 2007).

General combining ability variance (σ^2 GCA) was higher than specific combining ability variance (σ^2 SCA) for fiber length, fiber fineness and fiber elongation reflecting the role of additive type of gene action (Tab. 1). The results are in compromise with the findings of Meredith and Bridge (1972), Myers and Lu (1998) and Rauf *et al.* (2006). Baker and Verhalen (1973) drew similar conclusions concerning to importance of additive type gene action with regards to fiber traits.

The GCA effects of parents were presented in Tab. 2. As regards the estimates for GCA effects, for seed cotton yield FiberMax 832, Teks, Stoneville 453 and Maraş 92 cotton varieties showed significant positive GCA effects, whereas negative GCA effects for seed cotton yield were predicted from Gedera 236, Bahar 14, Giza 45 and Sayar 314. For seed cotton yield improvement FiberMax 832, Teks, Stoneville 453 and Maraş 92 appeared to be a good general combiner. It can be seen that on Tab. 2, similar results were obtained for fiber yield. Positive GCA effects for fiber yield were observed for FiberMax 832, Teks, Stoneville 453 and Maraş 92 cotton varieties, while negative GCA effects were observed for Giza 45, Gedera 236 and Sayar 314.

Among the ten parents six parents had the significant and positive GCA for ginning percentage, Fiber Max 832, Tam 94 L 25, Teks, Bahar 14, Gedera 236 and Sayar 314, while the negative and significant GCA for ginning percentage were observed from Giza 45, Aşkabat 71 and Maraş 92. Except Giza 45, Aşkabat 71 and Maraş 92 all of the parents seem to be a good combiner for ginning percentage.

Parental lines Aşkabat 71 and Giza 45 were predicted to be best general combiners for fiber length and fiber strength, but crosses with this parent showed reduced ginning percentage and fiber yield. Significant and negative GCA effects for fiber fineness were predicted from Aşkabat 71, while positive GCA effect were observed from

Tab. 1. Analysis of variance for line x tester and combining ability for yield and fiber properties

Source of variation	DF	SCY (kg ha^{-1})	FY (kg ha^{-1})	GP (%)	FL (mm)	FF (mic.)	FS (g/tex)	ELG (%)	UNF (%)
Replication	2	11789.6	2560.7	1.35	0.31	0.51*	0.58	0.36*	2.89
Genotypes	30	119499.4 **	23810.3 **	31.00**	28.32**	0.28*	49.52**	0.39**	4.14**
Parents	9	181137.5 **	41239.6 **	54.54**	18.57**	0.26	60.22**	0.30*	7.28**
Parents vs Hybrids	1	541.87	56.1	11.83**	0.94	0.48	2.50	0.02	0.00
Hybrids	20	97710.1 **	17154.8 **	21.36**	34.08**	0.28*	47.06**	0.45**	2.94*
GCA (Lines)	6	157541.5 *	32018.3 *	61.66**	110.41**	0.60*	141.02**	1.22**	7.28**
GCA (Testers)	2	226467.4 *	26207.3	7.73	1.09	0.25	0.49	0.16	1.95
SCA(Line xTester)	12	46334.8 **	8214.2 **	3.48*	1.41*	0.12	7.84*	0.12	0.93
Error	60	10994.4	1588.8	1.41	0.72	0.14	3.47	0.11	1.65
σ^2 (GCA)		1337.9	232.8	0.46	0.85	0.004	1.021	0.009	0.052
σ^2 (SCA)		11780.1	2208.4	0.69	0.22	-0.004	1.456	0.001	-0.24
σ^2GCA/Q^2 SCA		0.113	0.105	0.67	3.86	-1.00	0.70	9.00	-0.216

Q2GCA : variance of general combining ability, σ2SCA: variance of specific combining ability, * and **:significant at P ≤ 0.05 and P ≤ 0.01 respectively.
DF: Degree of freedom, SCY: Seed cotton yield (kg ha^{-1}), FY: Fiber yield (kg ha^{-1}), GP: Ginning percentage (%), FL: Fiber length (mm), FF: Fiber fineness (Micronaire), FS: Fiber strength (g/tex), ELG: Elongation (%), UNF: Uniformity (%)

Tab. 2. Predicted GCA effects for yield and fiber properties of parents

Parent	SCY (kg ha^{-1})	FY (kg ha^{-1})	GP (%)	FL (mm)	FF (mic.)	FS (g/tex)	ELG (%)	UNF (%)
Lines (Female)								
FiberMax 832	519.84 **	237.16 **	1.284**	-1.528**	0.110	0.629	-0.233*	-0.136
Tam 94 L 25	62.17	59.22	1.298**	-1.400**	-0.028	-2.560**	-0.356**	-0.549
Teks	487.43 **	249.14 **	2.150**	-1.432**	-0.048	-1.049	0.233*	0.751
Aşkabat 71	91.93	-61.67	-3.360**	5.174**	-0.441**	6.151**	0.056	1.506**
Giza 45	-259.24 *	-204.59 **	-4.213**	4.697**	-0.145	4.206**	0.144	0.329
Bahar 14	-283.73 *	-80.57	1.23**	-4.030**	0.373**	-4.960**	0.600**	-0.727
Gedera 236	-618.40 **	-198.69 **	1.611**	-1.480**	0.179	-2.416**	-0.444**	-0.994*
SE ±	11.05	4.20	0.39	0.28	0.12	0.61	0.11	0.42
Tester (Male)								
Stoneville 453	176.11 *	67.33 *	0.016	0.221	-0.083	0.094	0.044	-0.300
Sayar 314	-378.88 **	-128.95 **	0.599*	-0.235	0.124	-0.178	0.059	-0.010
Maraş 92	202.77 **	61.62 *	-0.615*	0.014	-0.041	0.084	-0.103	0.310
SE ±	7.23	2.75	0.25	0.18	0.08	0.40	0.07	0.28

SE: Standard error, * and **:significant at P ≤ 0.05 and P ≤ 0.01 respectively. SCY: Seed cotton yield (kg ha^{-1}), FY: Fiber yield (kg ha^{-1}), GP: Ginning percentage (%), FL: Fiber length (mm), FF: Fiber fineness (Micronaire), FS: Fiber strength (g/tex), ELG: Elongation (%), UNF: Uniformity (%)

Tab. 3. Proportional contribution of lines, testers and their interactions to total variance for investigated characters

Source of variation	SCY (kg ha^{-1})	FY (kg ha^{-1})	GP (%)	FL (mm)	FF (mic.)	FS (g/tex)	ELG (%)	UNF(%)
Contribution of Lines	483.7	559.9	86.59	97.18	63.81	89.89	80.46	74.23
Contribution of Tester	231.7	152.7	3.62	0.321	8.90	0.106	3.69	6.62
Contribution of Line x Testers	284.5	287.3	9.78	2.453	27.28	9.997	15.83	9.13

SCY: Seed cotton yield (kg ha^{-1}), FY: Fiber yield (kg ha^{-1}), GP: Ginning percentage (%), FL: Fiber length (mm), FF: Fiber fineness (Micronaire), FS: Fiber strength (g/tex), ELG: Elongation (%), UNF: Uniformity (%)

Bahar 14. Among the parents Teks and Bahar 14 seems to be a good combiners for fiber elongation and Aşkabat 71 for fiber uniformity.

The proportional contributions of lines; testers and their interactions (line x testers) to the total variance for investigated characters were presented in Tab. 3. It was shown that in the Tab. 3, maximum contribution to total variance of most of the characters (seed cotton yield, lint yield, ginning percentage, fiber length, fiber fineness, fiber strength, fiber elongation and fiber uniformity) was made by female parents (lines) effect, on the other hand, line x tester interactions contributed for seed cotton yield, fiber yield and fiber fineness. It had small contributions on ginning percentage, fiber strength, fiber elongation and fiber uniformity. It's obvious that maximum contributions to the total variance for studied characters were made by the female (line) parents and line x tester interactions.

The SCA effects of the crosses for seed cotton yield, fiber yield and fiber quality traits were presented in Tab. 4. Positive and significant specific combining ability effects for seed cotton yield and fiber yield were predicted from FiberMax 832 x Stoneville 453, Tam 94 L 25 x Maraş 92, Teks x Stoneville 453 and Gedera 236 x Maraş 92 cross combinations; while negative SCA effects were predicted from FiberMax 832 x Maraş 92, Teks x Maraş 92 and Gedera 236 x Sayar 314.

For ginning percentage positive SCA effects were predicted from Giza 45 x Sayar 314, Gedera 236 x Stoneville 453, Gedera 236 x Maraş 92 and Tam 94 L 25 x Maraş 92 cross combinations, while negative and significant SCA effect were observed from Gedera 236 x Sayar 314. Twelve cross combinations exhibited positive estimates for SCA effects for fiber length, the maximum being in case of Aşkabat 71 x Maraş 92, followed by Gedera 236 x Sa-

Tab. 4. Predicted specific combining ability effects (SCA) for yield and fiber properties of hybrids

Hybrid Combinations	SCY (kg ha^{-1})	FY (kg ha^{-1})	GP (%)	FL (mm)	FF (mic.)	FS (g/tex)	ELG(%)	UNF (%)
FiberMax 832 x Stoneville 453	427.70 *	167.33 *	-0.106	0.087	-0.027	3.362**	0.233	0.278
FiberMax 832 x Sayar 314	2.56	23.04	0.834	0.273	0.063	-2.133	-0.048	0.421
FiberMax 832 x Maraş 92	-430.26 *	-190.37 *	-0.729	-0.359	-0.036	-1.229	-0.186	-0.698
Tam 94 L 25 x Stoneville 453	-309.06	-122.40	-0.086	0.399	-0.362	0.017	-0.144	0.178
Tam 94 L 25 x Sayar 314	-137.00	-78.75	-0.762	-0.558	0.090	-0.211	0.241	0.121
Tam 94 L 25 x Maraş 92	446.05 *	201.14 **	0.848	0.160	0.272	0.194	-0.097	-0.298
Teks x Stoneville 453	563.31 **	208.58 **	-0.661	0.171	-0.139	-0.827	-0.067	-0.522
Teks x Sayar 314	-101.96	-27.17	0.679	0.377	0.170	0.944	-0.081	0.421
Teks x Maraş 92	-561.35 **	-181.41 *	-0.017	-0.548	-0.032	-0.117	0.148	0.102
Aşkabat 71 x Stoneville 453	83.81	21.63	-0.118	-0.536	0.385	-1.160	0.011	-0.844
Aşkabat 71 x Sayar 314	15.77	30.77	0.489	-0.320	-0.200	0.444	0.030	0.132
Aşkabat 71 x Maraş 92	-99.58	-52.40	-0.371	0.855	-0.185	0.716	-0.041	0.713
Giza 45 x Stoneville 453	-191.98	-73.02	-0.068	0.512	0.098	0.351	-0.278	0.500
Giza 45 x Sayar 314	222.12	119.16	1.245	-1.028*	-0.050	-0.478	0.141	-0.724
Giza 45 x Maraş 92	-30.14	-46.15	-1.177	0.516	-0.048	0.127	0.137	0.224
Bahar 14 x Stoneville 453	-359.99	-138.61	-0.129	0.129	-0.010	0.684	0.267	-0.011
Bahar 14 x Sayar 314	248.60	80.17	-0.366	0.415	-0.051	-0.178	-0.148	-0.202
Bahar 14 x Maraş 92	111.39	58.43	0.495	-0.544	0.061	-0.506	-0.119	0.213
Gedera 236 x Stoneville 453	-213.79	-63.52	1.168	-0.761	0.055	-2.427*	-0.022	0.422
Gedera 236 x Sayar 314	-250.10	-147.24 *	-2.119**	0.842	-0.023	1.611	-0.137	-0.168
Gedera 236 x Maraş 92	463.89 *	210.75 **	0.951	-0.080	-0.032	0.816	0.159	-0.254
SE ±	19.14	7.27	0.68	0.49	0.21	1.07	0.19	0.74

SE: Standard error, * and **:significant at P ≤ 0.05 and P ≤ 0.01 respectively. SCY: Seed cotton yield (kg ha^{-1}), FY: Fiber yield (kg ha -1), GP: Ginning percentage (%), FL: Fiber length (mm), FF: Fiber fineness (Micronaire), FS: Fiber strength (g/tex), ELG: Elongation (%), UNF: Uniformity (%)

Tab. 5. Heterosis of cross combinations for yield and fiber properties

Hybrids	SCY (kg ha^{-1})	FY (kg ha^{-1})	GP (%)	FL (mm)	FF (mic.)	FS (g/tex)	ELG (%)	UNF (%)
FiberMax 832 x Stoneville 453	177.2	177.0	0.26	2.81	-2.95	24.67	-2.77	0.41
FiberMax 832 x Sayar 314	-151.7	-132.1	2.24	1.69	3.03	6.42	-5.47	1.13
FiberMax 832 x Maraş 92	-160.7	-195.6	-4.11	1.44	-2.68	9.80	-11.58	-0.46
Tam 94 L 25 x Stoneville 453	75.0	71.1	-0.67	4.39	-14.80	0.45	-7.26	1.13
Tam 94 L 25 x Sayar 314	-118.4	-141.9	-2.68	-0.55	0.51	-0.99	1.79	1.61
Tam 94 L 25 x Maraş 92	237.4	226.7	-1.11	3.71	1.92	0.77	-8.21	0.83
Teks x Stoneville 453	214.3	198.1	-1.04	0.42	-11.59	-3.58	0.59	-0.20
Teks x Sayar 314	-189.3	-174.5	1.91	-0.59	-0.12	0.87	2.58	1.44
Teks x Maraş 92	-175.4	-193.4	-2.18	-1.84	-8.50	-1.73	2.46	0.79
Aşkabat 71 x Stoneville 453	243.7	141.8	-7.22	14.79	-3.06	12.21	2.09	1.01
Aşkabat 71 x Sayar 314	-49.9	-119.1	-5.86	13.82	-14.40	16.04	4.70	2.71
Aşkabat 71 x Maraş 92	45.8	-81.5	-10.75	19.38	-17.57	17.19	-0.53	3.10
Giza 45 x Stoneville 453	2.9	-45.7	-1.25	12.50	-7.94	16.61	-7.80	0.00
Giza 45 x Sayar 314	-93.2	-113.3	2.10	6.27	-7.94	13.50	1.08	-0.88
Giza 45 x Maraş 92	-43.1	-156.5	-7.63	12.72	-11.14	15.72	-2.79	-0.06
Bahar 14 x Stoneville 453	-96.9	0.5	14.08	-12.60	-5.25	-15.23	11.17	-1.73
Bahar 14 x Sayar 314	-111.0	-40.1	12.72	-13.28	-2.76	-18.25	6.54	-1.42
Bahar 14 x Maraş 92	-19.0	54.1	12.48	-14.69	-3.13	-18.66	3.03	-1.19
Gedera 236 x Stoneville 453	-318.2	-276.6	6.28	-2.36	-0.51	-8.97	-5.08	0.24
Gedera 236 x Sayar 314	-532.4	-544.7	-2.58	1.21	1.12	2.45	-4.91	0.08
Gedera 236 x Maraş 92	-168.9	-144.7	2.81	-0.03	-2.26	0.55	-3.50	-0.29

SCY: Seed cotton yield (kg ha $^{-1}$), FY: Fiber yield (kg ha $^{-1}$), GP: Ginning percentage (%), FL: Fiber length (mm), FF: Fiber fineness (Micronaire), FS: Fiber strength (g/tex), ELG: Elongation (%), UNF: Uniformity (%)

yar 314, Giza 45 x Maraş 92, Giza 45 x Stoneville 453 and Bahar 14 x Maraş 92. Negative and significant SCA effects were predicted from Giza 45 x Sayar 314. Thirteen cross combinations among the twenty- one cross combinations had negative specific combining ability for fiber fineness these hybrid combinations seems to be desirable for this traits. FiberMax 832 x Stoneville 453, Gedera 236 x Sayar 314, Teks x Sayar 314, Gedera 236 x Maraş 92 and Aşkabat 71 x Maraş 92 cross combinations exhibited higher SCA effects for fiber strength. Nine cross combinations had positive SCA effects for fiber elongation, maximum SCA effects were predicted for Bahar 14 x Stoneville 453, Tam 94 L 25 x Sayar 314 and FiberMax 832 x Stoneville 453 cross combinations, respectively.

Twelve cross combinations showed positive SCA effects in terms of fiber uniformity, while others were negative. Maximum SCA effects were observed from Aşkabat 71 x Maraş 92, Giza 45 x Stoneville 453, Gedera 236 x Stoneville 453, FiberMax 832 x Sayar 314 and Teks x Sayar 314.

Heterosis estimates of hybrid combinations are presented in Tab. 5. It is indicated that Aşkabat 71 x Stoneville 453, Tam 94 L 25 x Maraş 92 and Teks x Stoneville 453 crosses had maximum and positive heterosis values in terms of seed cotton yield and fiber yield. These results conform to the findings of El-Feki *et al.* (1995), Ganapathy *et al.*(2005) and Rauf *et al*. (2005), who reported significant heterosis for seed cotton yield. As regards ginning percentage Bahar 14 x Stoneville 453, Bahar 14 x Sayar 314 and Bahar 14 x Maraş 92 had significant heterosis, for ginning percentage hybrid vigour being also observed from Meredith and Brown (1998), Ganapathy *et al* (2005) and Rauf *et al* (2005). For fiber length, Aşkabat 71 x Maras 92 (19.38%), Aşkabat 71 x Stoneville 453 (14.79%) and Aşkabat 71 x Sayar 314 (13.82%) showed highest heterosis value. For fiber fineness, Aşkabat 71 x Maraş 92 (-17.57%), Aşkabat 71 x Sayar 314 (-14.40%) and Teks x Stoneville 453 (-11.59%) showed negative heterosis value which indicates greater the micronaire value, lower is the fineness. The results are in the agreement with earlier research findings El-Debaby *et al*. (1997) and Rauf *et al*. (2005). For fiber strength FiberMax 832 x Stoneville 453 (24.67%), Aşkabat 71 x Maraş 92 (17.19%), Giza 45 x Stoneville 453 (16.61%) and Aşkabat 71 x Sayar 314 (16.04%) showed highest heterosis value. Bahar 14 x Stoneville 453 (11.17%) and Bahar 14 x Sayar 314 (6.54%) exhibited maximum heterosis for fiber elongation and Aşkabat 71 x Maraş 92 (3.10%) for fiber uniformity. The values of heterosis for fiber quality characters were usually lower than yield. but it's important for the textile industry.

Conclusions

Cotton textile sector demands better yield and high quality cotton, for this reason improvement of yield and fiber quality is one of the important targets of all cotton breeders. The present study aimed to facilitate the selection in cotton breeding program and development of cotton with high yielding and better fiber quality. In this study, additive variances were significant for fiber length, fiber fineness and fiber elongation and non-additive gene effects for seed cotton yield, fiber yield, ginning percentage, fiber strength and fiber uniformity. Among the parents FiberMax 832, Teks, Stoneville 453 and Maraş 92 for seed cotton yield and fiber yield, Aşkabat 71 and Giza 45 for fiber length and fiber strength, also Aşkabat 71 for fiber fineness and fiber uniformity were detected with higher GCA. Most of the parents except Aşkabat 71, Giza 45 and Maraş 92 exhibited significant GCA for ginning percentage. Specific combining ability was significant for FiberMax 832 x Stoneville 453, Tam 94 L 25 x Maraş 92 and Teks x Stoneville 453 hybrid combinations for yield with acceptable fiber quality.

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