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Determination of Superior Parents and Hybrid Combinations in Respect to Lint Yield and Yield Components in Cotton (*Gossypium hirsutum* L.)

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Abstract: The purpose of this study was to determine estimates of the general combining ability of parents and the specific combining ability of hybrids needed to develop high yielding cotton cultivars. Five cotton lines (Sure Grow 125, Sure Grow 404, Sure Grow 501, Sure Grow 1001 and Çukurova 1518) and 7 testers (PAUM 400, PAUM 401, PAUM 402, PAUM 403, PAUM 404, PAUM 405 and PAUM 406) were crossed in a line x tester mating system at Çukurova University, Cotton Research and Application Center, Adana, Turkey, in 2000. Twelve genotypes and 35 F_1 hybrids were sown in a randomized complete block design with 3 replications at the same center in 2001. The general combining ability variance of parents and the specific combining ability variance of hybrids in respect to lint yield and yield components were estimated via line x tester analysis. Line x tester analysis revealed significant general and specific combining ability effects for lint yield, 100-seed weight, seed cotton weight per boll, lint percentage and boll number per plant. The following lines had higher general combining abilities than the others: PAUM 403 for boll number per plant; Çukurova 1518, PAUM 400, PAUM 403, PAUM 405 and PAUM 406 for lint yield; Sure Grow 501, Çukurova 1518, PAUM 401 and PAUM 405 for lint percentage; Sure Grow 125, PAUM 400, PAUM 403 for 100-seed weight; and Çukurova 1518, PAUM 400, PAUM 405 and PAUM 406 for seed cotton weight per boll. Only Sure Grow 501 x PAUM 400 F_1 showed significant specific combining ability effects for bolls/plant. It yielded more total lint than the others. This F_1 achieved its high yield by producing many boll numbers per plant, while the others produced fewer.

Key Words: Cotton, *Gossypium hirsutum* L., general combining ability, specific combining ability, lint yield, yield components

Pamukta (*Gossypium hirsutum* L.) Lif Verimi ve Verim Öğeleri Bakımından Üstün Anaç ve Melez Kombinasyonların Belirlenmesi

Özet: 2000 yılında, *Gossypium hirsutum* L. türünden 5 çeşit (Sure Grow 125, Sure Grow 404, Sure Grow 501, Sure Grow 1001 and Çukurova 1518) ana, 7 hat ise (PAUM 400, PAUM 401, PAUM 402, PAUM 403, PAUM 404, PAUM 405 ve PAUM 406) baba olacak şekilde, line x tester melezleme yöntemine göre Çukurova Üniversitesi, Pamuk Araştırma ve Uygulama Merkezinde birbirleriyle melezlenmiştir. Elde edilen 35 F_1 melezi ve 12 anaç, 2001 yılında tesadüf blokları deneme desenine göre üç tekerrürlü olarak ekilmiş ve lif verimi ve verim öğeleri bakımından değerlendirilmiştir. Elde edilen verilere, line x tester analizi uygulanmıştır. Çalışmada anaçların genel, melezlerin özel uyum yeteneklerinin belirlenmesi, ve böylece erken generasyonlarda lif verimi ve verim öğeleri yönünden üstün anaçların ve melez kombinasyonların seçilmesi amaçlanmıştır. Sonuç olarak, ebeveyn ve hibridlerin genel ve özel uyum yetenekleri, lif verimi ve verim öğeleri bakımından önemli farklılıklar oluşturmuştur. Ebeveynler arasında, PAUM 403 koza sayısı; Çukurova 1518, PAUM 400, PAUM 403, PAUM 405 ve PAUM 406 lif verimi; Sure Grow 501, Çukurova 1518, PAUM 401 ve PAUM 405 çırçır randımanı; Sure Grow 125, PAUM 400 ve PAUM 403 100 tohum ağırlığı; Çukurova 1518, PAUM 400, PAUM 405 ve PAUM 406 koza kütlü pamuk ağırlığı yönünden en yüksek genel uyum yeteneğine sahip olmuşlardır. Sure Grow 501 x PAUM 400 koza sayısı yönünden özel kombinasyon kabiliyeti önemli tek melez kombinasyon olarak tespit edilmiştir. Ayrıca, bu melez kombinasyon en yüksek lif verimine de sahiptir. Elde edilen bu sonuç, ileriki generasyonlarda amaca yönelik bitkilerin, bu melez kombinasyondan seçilme şansının daha yüksek olduğunu göstermektedir.

Anahtar Sözcükler: Pamuk, *Gossypium hirsutum* L., Genel Uyum Yeteneği, Özel Uyum Yeteneği, Lif Verimi, Verim Öğeleri

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Introduction

Yield increase in crops has occurred due to plant breeding and improved production and management techniques. In order to produce high yielding cotton varieties in Turkey, cotton improvement has been carried out by conventional breeding techniques for years. Seed cotton yield increased from 881 to 3371 kg / ha^{-1} in the last 40 years in Turkey (FAO, 2002). This increase cannot be attributed to management practices only. Most of the increase in seed cotton yield has come via cultivar improvement. Current cultivars show better yield stability and a greater response to favorable growing conditions than ancestral lines.

Exploiting heterosis is one of the methods used to increase cotton yields that have stagnated in recent years. The success of the hybridization is largely dependent on the correct selection of parents. Estimates of genetic variation and combining ability are useful in determining the breeding value of some populations and the appropriate procedures to use in a breeding program. The general combining ability effects are important indicators of the value of genotypes in hybrid combinations. Differences in general combining ability effects have been attributed to additive, additive x additive, and higher-order additive interactions, whereas differences in specific combining ability have been attributed to non-additive genetic variance (Falconer, 1960).

Miller and Marani (1963) reported significant general and specific combining ability effects for lint yield and boll weight. Lee et al. (1967) found a significant general combining ability for lint percentage and boll weight. El-Adl and Miller (1971) found significant general and specific combining abilities for lint yield and yield components, with the exception of lint percentage. Baloch et al. (1995) revealed the importance of specific combining ability for yield, 100-seed weight and lint percentage, and general combining ability for boll number per plant and lint percentage. Wilson (1991); Tang et al. (1993) and Nadeem et al. (1998) reported significant general and specific combining ability effects for lint yield, lint percentage, seed cotton weight per boll and boll number per plant.

One of the problems in using heterosis in cotton involves defining a strategy for the selection of parents that will ultimately produce productive hybrids. The present study evaluated parents and hybrids produced from line x tester mating. The objective of this study was to estimate parental general combining ability effects, to compare performance among F_1 hybrids, and to identify those superior for lint yield and yield components.

Materials and Methods

The plant materials used in the present study were obtained by line x tester crossing. According to this method, Sure Grow 125, Sure Grow 404, Sure Grow 501, Sure Grow 1001 and Çukurova 1518 were crossed as the lines with PAUM 400, PAUM 401, PAUM 402, PAUM 403, PAUM 404, PAUM 405 and PAUM 406 as the testers. The five cultivars used as lines were selected mainly from current commercial cultivars. They can be classed into 3 groups according to maturity: early (Sure Grow 125 and Sure Grow 404), mid-early (Sure Grow 501 and Çukurova 1518) and mid-late (Sure Grow 1001). The testers are general-purpose lines for both rainfed and irrigated conditions. The seeds of these were supplied by Dr. O. Gençer, Çukurova University, Cotton Research and Application Center (CRAC), Adana, Turkey. The crosses were performed at CRAC, under field conditions, Adana, Turkey, in 2000. Between 30 and 70 flowers were crossed depending on shedding in each hybrid combination. Seed setting rate usually ranged from 30 to 60%. The seeds of 35 F_1 hybrids, 5 female and 7 male parents were sown in a randomized block design with 3 replications at CRAC on 8 May 2001. The soil type of the experimental field was clay in texture. Seed of each entry was planted in 1-row plots, and the rows were 0.70 m by 5.02 m. Seeding rate was 18 seed m^{-1} of row. Plants were fertilized with 120 kg N, 60 kg P and 60 kg K ha^{-1}. Half of the N, and all P and K were applied at sowing, and the remaining N was applied at the square stage. Insects were monitored throughout the experiment. Insecticides were applied in a manner consistent with the recommendations of the Adana Agricultural Extension Service. Weeds were controlled by hand weeding and machine. The plants were irrigated 5 times throughout the growing season.

Plots were harvested by hand for yield determination on 14 September 2001. Samples containing 20 bolls were hand-harvested from each plot prior to picking. The boll samples were weighed to determine seed cotton weight per boll values, and ginned on a roller using a laboratory gin for lint percentage (100 x lint weight/seed cotton weight) and 100-seed weight calculations. The ginned lint from each plot was weighed and divided by the number of plants within each plot to determine lint yield per plant. Ten plants were selected randomly from each genotype to find the boll number per plant. Measurements were performed according to Gençer (1978).

The general combining ability variance of parents and the specific ability variance of hybrids were estimated via line x tester variance analysis according to Singh and Chaudhary (1977). The Microsoft Excel computer program was used to analyze the data. The line x tester mating design can provide information regarding the usefulness of male and female inbreds as parents for hybridization to generate segregating populations, which is expected to give prodigious selections. The general (GCA) and specific combining ability (SCA) effects were estimated using a 2-way table with the following formulae:

$$GCA_{lines} = (X_{i..}/tr) - (X_{...}/ltr)$$

$$GCA_{testers} = (X_{.j.}/lr) - (X_{...}/ltr)$$

$$SCA = (X_{ij.}/r) - (X_{i..}/tr) - (X_{.j.}/lr) + (X_{...}/ltr)$$

where $X_{i..}$ is the sum of columns; $X_{.j.}$ is the sum of rows; $X_{ij.}$ is the total value of hybrids over replications; $X_{...}$ is the grand total; and *l*, *t* and *r* are the number of lines, testers and replications.

Results

Estimated mean squares of lint yield and yield components from the F_1 generation for all characters studied are presented in Table 1. The analysis of variance (Table 1) revealed that the mean squares of genotypes for all characters studied were significantly different ($P < 0.01$), indicating the presence of variability among hybrids and their parents. Within both parental lines and hybrids, differences in lint yield and yield components except for boll number per plant were also statistically significant ($P < 0.01$), indicating the possible presence of heterosis in all traits.

Mean squares of specific combining ability were relatively large in magnitude and significant for all characters studied (Table 1). In contrast, variances of general combining ability were much smaller in magnitude than those of specific combining ability and were significant in 4 cases: for lint yield, lint percentage, 100-seed weight and seed cotton weight per boll. Only the general combining ability effects of the lines were small and insignificant in terms of boll number per plant.

Lint Yield

Mean and general combining ability values of plants observed are shown in Table 2. The 5 parents with the largest negative general combining ability effects for lint yield were Sure Grow 125, Sure Grow 501, PAUM 401,

Table 1. Analysis of variance for combining ability for lint yield and yield components in cotton.

Source of variation	df	Mean squares: Boll number per plant	Lint yield per plant	Lint percentage	100-seed weight	Seed cotton weight per boll
Replication	2	11.07	13.53**	14.09**	11.18**	0.31**
Genotypes	46	23.75*	131.73**	8.04**	2.10**	1.48**
Parents	11	40.42**	217.02**	9.86**	3.47**	1.71**
Par. vs. Hyb.	1	5.84	9.36**	0.69	0.12	1.77**
Hybrids	34	18.89	107.74**	7.66**	1.72**	1.40**
GCA Lines	4	1.97	130.17**	10.81**	4.08**	4.83**
GCA Testers	6	41.88**	274.01**	8.71**	1.74**	1.73**
SCA	24	880.90**	2300.69**	6791.00**	453.40**	72.29**
Error	92	11.39	3.02	0.35	0.10	0.0002

* and ** $P < 0.05$ and 0.01, respectively.

Table 2. The means and estimates of general combining ability effects (GCA) for lint yield and yield components.

		Boll number per plant		Lint yield per plant		Lint percentage		100-seed weight		Seed cotton per weight	
Parents	Code	Mean (Unit)	GCA effect	Mean (g)	GCA effect	Mean (%)	GCA effect	Mean (g)	GCA effect	Mean (g)	GCA effect
Lines											
Sure Grow 125	1	17.67	-0.46	21.50	-2.06**	39.68	-0.37*	9.10	0.68**	3.07	-0.21**
Sure Grow 404	2	11.33	0.33	15.30	-0.18	37.60	-0.10	9.70	-0.11	3.59	-0.27**
Sure Grow 501	3	13.23	-0.06	19.20	-1.19**	39.88	1.00**	10.32	-0.41**	3.29	-0.35**
Sure Grow 1001	4	19.67	-0.04	34.18	-0.85	38.79	-0.88**	9.80	-0.33**	4.48	0.001
Çukurova 1518	5	12.50	0.23	16.10	4.30**	35.68	0.35*	10.10	0.17	3.61	0.83**
Testers											
PAUM 400	6	22.17	0.79	33.85	1.44**	38.27	-0.71**	8.95	0.60**	5.17	0.13**
PAUM 401	7	16.00	-2.13*	19.38	-3.92**	42.38	0.77**	10.35	-0.34**	2.86	-0.21**
PAUM 402	8	11.68	-1.28	19.66	-4.80**	40.51	-0.69**	11.45	0.10	4.15	-0.45**
PAUM 403	9	17.00	2.09*	23.45	3.19**	40.93	-0.26	13.00	0.27*	3.37	-0.18**
PAUM 404	10	12.00	-1.58	19.80	-4.12**	40.17	-0.63**	10.05	-0.28*	4.11	-0.16**
PAUM 405	11	12.50	1.73	26.25	6.14**	41.49	1.17**	10.40	-0.12	5.06	0.41**
PAUM 406	12	11.17	0.38	14.76	2.07**	39.46	0.35	9.90	-0.23*	3.35	0.46**
SE (for line)		0.74		0.38		0.13		0.07		0.003	
SE (for tester)		0.87		0.45		0.15		0.08		0.004	

* and ** $P < 0.05$ and 0.01, respectively.

PAUM 402 and PAUM 404, while 5 other parents (Çukurova 1518, PAUM 400, PAUM 403, PAUM 405 and PAUM 406) showed significant and positive general combining ability effects (Table 2). Those parents were better donors for lint yield than the others.

The crosses of Sure Grow 125 x PAUM 405 (1 x 11), Sure Grow 125 x PAUM 406 (1 x 12), Sure Grow 404 x PAUM 404 (2 x 10), Sure Grow 404 x PAUM 406 (2 x 12), Sure Grow 501 x PAUM 400 (3 x 6), Sure Grow 1001 x PAUM 402 (4 x 8), Sure Grow 1001 x PAUM 403 (4 x 9) and Çukurova 1518 x PAUM 401 (5 x 7) had the highest mean lint yield and specific combining ability effects for lint yield (Table 3).

Boll Number Per Plant

As shown in Table 2, a significant and positive general combining ability effect for boll number was exhibited by only 1 parental tester (PAUM 403), whereas a significant and negative general combining ability effect for boll number per plant was shown by 1 parental tester (PAUM 401).

As with boll number per plant, most of the specific combining ability effects of F_1 hybrids were not significant (Table 3). The Sure Grow 501 x PAUM 400 (3 x 6) cross showed significant and positive specific combining ability effects for boll number per plant (19.67 units), and also specific combining ability effects for seed cotton weight per boll, which led to specific combining ability effects for high lint yield. The cross of Sure Grow 404 x PAUM 403 had the largest negative specific combining ability effects and the least mean boll number per plant (10.00 unit plant-1).

Lint Percentage

Four lines showed significant positive general combining ability effects and 5 showed significant negative effects for lint percentage (Table 2). The positive and negative general combining ability effects of the parents were major contributors to lint percentage in F_1 cotton hybrids. For example, hybrids with Sure Grow 501 (39.88%) as the female parent generally had higher lint percentages than did hybrids with any of the other female parents. Furthermore, hybrids with Sure Grow 1001 (38.78%) had lint percentages lower than many other hybrids.

Significant and positive specific combining ability effects for lint percentage were observed for Sure Grow

Table 3. The means and estimates of specific combining ability effects (SCA) for lint yield and yield components.

Hybrids	Characters									
	Boll number per plant		Lint yield per plant weight per boll		Lint percentage		100-seed weight		Seed cotton	
	Mean	SCA effect	Mean (g)	SCA effect	Mea (%)	SCA effect	Mean (g)	SCA effect	Mean (g)	SCA effect
1 x 6	12.17	-2.44	17.98	-4.77**	37.10	-1.23**	11.45	-0.02	3.98	-0.05**
1 x 7	11.77	0.08	19.16	1.76	39.87	0.07	10.69	0.15	3.82	0.13**
1 x 8	11.67	-0.88	15.21	-1.31	38.39	0.04	12.15	1.18**	3.40	-0.05**
1 x 9	17.33	1.43	24.97	0.47	37.00	-1.78**	11.38	0.24	3.00	-0.72**
1 x 10	11.67	-0.58	15.30	-1.89	37.74	-0.67	9.40	-1.19**	3.48	-0.26**
1 x 11	17.37	1.82	30.18	2.72*	41.38	1.19**	10.72	-0.04	4.69	0.39**
1 x 12	14.77	0.57	26.41	3.03**	41.77	2.39**	10.32	-0.32	4.92	0.57**
2 x 6	15.83	0.44	24.90	0.27	39.18	0.58	10.10	-0.58**	4.02	0.05**
2 x 7	11.00	-1.48	17.86	-1.42	40.05	-0.03	9.56	-0.19	4.07	0.45**
2 x 8	14.83	1.51	19.33	0.93	40.73	2.11**	10.25	0.07	3.20	-0.19**
2 x 9	10.00	-4.52*	21.23	-5.16**	38.31	-0.74	10.66	0.31	3.94	0.28**
2 x 10	16.00	2.97	22.77	3.70**	38.64	-0.04	10.25	0.45*	3.68	0.01
2 x 11	15.53	-0.80	26.18	-3.16**	39.81	-0.66	9.61	-0.35	3.49	-0.75**
2 x 12	16.87	1.89	30.11	4.84**	38.45	-1.21**	10.15	0.29	4.42	0.14**
3 x 6	19.67	4.66*	35.64	12.01**	38.83	-0.87	11.85	1.47**	4.67	0.79**
3 x 7	10.67	-1.42	11.85	-6.42**	40.04	-1.14**	8.95	-0.50*	2.77	-0.76**
3 x 8	12.17	-2.94	11.08	-6.31**	36.31	-3.41**	9.00	-0.88**	3.05	-0.25**
3 x 9	18.67	2.37	25.98	0.61	41.92	1.77**	9.05	-0.10**	3.32	-0.25**
3 x 10	12.33	-0.30	18.85	0.79	41.89	2.11**	9.60	0.10	3.65	0.07**
3 x 11	14.33	-1.61	30.26	1.93	42.25	0.68	9.80	0.14	5.00	0.84**
3 x 12	13.83	-0.76	21.65	-2.61*	41.64	0.88*	10.20	0.65**	3.76	-0.44**
4 x 6	15.00	-0.03	20.13	-3.83**	37.76	-0.06	10.15	-0.32	3.56	-0.68**
4 x 7	12.67	0.56	19.04	0.43	39.80	0.51	10.00	0.46*	3.78	-0.12**
4 x 8	15.83	2.87	21.85	4.12**	37.55	-0.29	9.65	-0.32	3.68	0.02
4 x 9	16.83	0.51	29.11	3.39**	39.31	1.04**	10.20	0.06	4.40	0.48**
4 x 10	12.17	-0.50	19.28	0.88	38.27	0.37	10.10	0.51*	4.14	0.20**
4 x 11	15.50	-0.47	28.83	0.16	39.29	-0.39	10.15	0.40	4.73	0.23**
4 x 12	11.67	-2.95	19.45	-5.15**	37.70	-1.18**	8.85	-0.79**	4.42	-0.13**
5 x 6	12.67	-2.63	25.43	-3.68**	40.63	1.58**	10.40	-0.56**	4.94	-0.12**
5 x 7	14.63	2.26	29.41	5.66**	41.12	0.59	10.11	0.08	5.02	0.30**
5 x 8	12.67	-0.56	25.43	2.57*	40.63	1.56**	10.40	-0.06	4.94	0.46**
5 x 9	16.80	0.21	31.54	0.69	39.23	-0.28	11.02	0.39*	4.96	0.22**
5 x 10	11.33	-1.60	20.07	-3.47**	37.37	-1.77**	10.20	0.12	4.74	-0.02
5 x 11	17.30	1.07	32.15	-1.65	40.10	-0.81*	10.09	-0.15	4.62	-0.71**
5 x 12	16.13	1.25	29.61	-0.12	39.24	-0.87*	10.30	0.17	5.24	-0.13**
SE		1.95		1.003		0.343		0.190		0.01

* and ** $P < 0.05$ and 0.01, respectively.

125 x PAUM 405 (1 x 11), Sure Grow 125 x PAUM 406 (1 x 12), Sure Grow 404 x PAUM 402 (2 x 8), Sure Grow 501 x PAUM 403 (3 x 9), Sure Grow 501 x PAUM 404 (3 x 10), Sure Grow 501 x PAUM 406 (3 x 12), Sure Grow 1001 x PAUM 403 (4 x 9), Çukurova 1518 x PAUM 400 (5 x 6) and Çukurova 1518 x PAUM 402 (5 x 8) F_{1s} (Table 3). In contrast, Sure Grow 125 x PAUM 400 (1 x 6), Sure Grow 125 x PAUM 403 (1 x 9), Sure Grow 404 x PAUM 406 (2 x 12), Grow 501 x PAUM 401 (3 x 7), Grow 501 x PAUM 402 (3 x 8), Sure Grow 1001 x PAUM 406 (4 x 12), Çukurova 1518 x PAUM 404 (5 x 10), Çukurova 1518 x PAUM 405 (5 x 11) and Çukurova 1518 x PAUM 406 (5 x 12) crosses showed significant and negative specific combining ability effects, indicating unfavorable combinations.

100-Seed Weight

Three parental genotypes showed significant positive general combining ability effects for 100-seed weight, whereas 5 parental genotypes showed significant negative general combining ability effects (Table 2).

The estimates of specific combining ability effects for each individual cross are presented in Table 3. The crosses Sure Grow 125 x PAUM 402 (1 x 8), Sure Grow 404 x PAUM 404 (2 x 10), Sure Grow 501 x PAUM 400 (3 x 6), Sure Grow 501 x PAUM 406 (3 x 12), Sure Grow 1001 x PAUM 401 (4 x 7), Sure Grow 1001 x PAUM 404 (4 x 10) and Çukurova 1518 x PAUM 403 (5 x 9) had significant and favorable specific combining ability effects for 100-seed weight. The crosses Sure Grow 125 x PAUM 404 (1 x 10), Sure Grow 404 x PAUM 400 (2 x 6), Sure Grow 501 x PAUM 401 (3 x 7), Sure Grow 501 x PAUM 402 (3 x 8), Sure Grow 501 x PAUM 403 (3 x 9), Sure Grow 1001 x PAUM 406 (4 x 12) and Çukurova 1518 x PAUM 400 (5 x 6) exhibited significant and negative specific combining ability effects for 100-seed weight.

Seed Cotton Weight per Boll

The line Çukurova 1518 and the testers PAUM 400, PAUM 405 and PAUM 406 showed the best general combining ability effects for seed cotton weight per boll (Table 2). The lines Sure Grow 125, Sure Grow 404 and Sure Grow 501 and the testers PAUM 401, PAUM 402, PAUM 403 and PAUM 404 showed the most negative general combining ability values for seed cotton weight per boll.

There were also significant differences among specific combining ability effects for seed cotton weight per boll. Seventeen crosses showed high and significant specific combining ability effects for seed cotton weight per boll (Table 3). In contrast, 15 crosses showed low and negative specific combining ability effects, indicating unfavorable combinations.

Discussion

In the present study, significant positive specific combining ability effects were observed for lint yield, lint percentage and seed cotton weight per boll for several hybrid combinations; specific combining ability effects for 100-seed weight were observed in a few hybrids; and specific combining ability effects for boll number per plant were also observed in only 1 hybrid. These results indicated that the epistasis and/or dominance effects for F_1 hybrids in cotton could be important to a certain extent. The presence of significant general and specific combining abilities in F_1 generations is a consequence of fluctuations in additive and dominance relationships, respectively, among the parents (Falconer, 1960; Tang et al., 1993).

According to Kerr (1966), boll number per plant is a primary yield component, whereas seed cotton weight per boll and lint percentage are secondary yield components. In this study, 12 parents showed significant positive general combining ability effects for at least 1 of 4 yield parameters. The presence of positive general combining ability effects indicated that continued progress should be possible through breeding for lint yield and yield components in cotton with these parents. Similar conclusions were also obtained for F_1 hybrids by Tang et al. (1993) and Meredith and Brown (1998).

Eight crosses had the highest mean lint yield and specific combining ability effects for lint yield (Table 3). The yield advantage of these crosses over the others was caused by an increase in seed cotton weight per boll and boll number per plant over those components in their parents, accompanied by 100-seed weight. Apart from those crosses, the others showed an unimpressive performance for other yield components in general, which led to negative or insignificant specific combining ability effects for lint yield. High lint yield levels were found in crosses in which Çukurova 1518, PAUM 400, PAUM 403, PAUM 405 and PAUM 406 were parents (Table 3). The yield increase of hybrids over the better parent or best commercial cultivars has been documented in numerous reviews (Tang et al. 1993; Basu, 1995; Meredith and Brown, 1998). The highest yielding F_1, Sure Grow 125 x PAUM 405 (1 x 11), Sure Grow 125 x PAUM 406 (1 x 12), Sure Grow 404 x PAUM 404 (2 x 10), Sure Grow 404 x PAUM 406 (2 x 12), Sure Grow 501 x PAUM 400 (3 x 6), Çukurova 1518 x PAUM 401 (5 x 7) and Çukurova 1518 x PAUM 402 (5 x 8) outyielded the parents. This increased yield was attained by a combination of an increase in bolls per plant plus an increase in seed cotton weight per boll. These results conclusively show that F_1 hybrids can produce significantly higher yields than the current best yielding parent or commercial cultivars. Similar conclusions were obtained by Miller and Lee (1964), and Meredith and Brown (1998).

In conclusion, the present study showed significant positive general combining ability effects for at least 1 yield parameter. Their usage as parents should allow useful yield in F_2 plants. If high-yielding hybrids are present in F_2 generations, this study indicates that sufficient general and specific combining abilities can be present in some parents to produce high-yielding F_2 plants.

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