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HETEROSIS AND COMBINING ABILITY FOR YIELD AND FIBER QUALITY IN COTTON (GOSSYPIUM BARBADENSE L.) USING HALF DIALLEL MATING SYSTEM

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ABSTRACT: The present study was carried out at Sakha Agricultural Research Station, Cotton Research Institute, Agricultural Research Center, Egypt, during the two *successive* seasons 2018 and 2019. Six cotton varieties belong to *(Gossypium barbadense* L.*)*. Three of them are Egyptian cotton varieties; Giza 89, Giza 93 and Giza 96. The other three varieties are Pima S_4, Pima S_6 and Suvin. They were crossed in a half diallel mating to produce 15 F_1 hybrids in 2018 season. The F_1 hybrids and six cotton varieties were growing in 2019 season in a randomized complete blocks design with three replications. The Results showed that the mean squares of the genotypes, parents, crosses and parents versus crosses were significant and highly significant for all studied traits except No. of bolls/plant at parents and micronaire reading at parents versus crosses. The results illustrated that the mean squares of general combining ability (GCA) and specific combining ability (S.C.A.) were significant and highly significant for all studied traits except micronaire reading at specific combining ability (S.C.A.). The parental genotypes Giza 96 and Giza 89 gave significant (desirable) GCA effects for most yield traits. Giza 96 and Suvin exhibit significant and positive (desirable) GCA effects of some fiber properties. The crosses Giza 89 x Pima S_4, Giza 96 x Pima S_6 and Giza 96 x Suvin recorded significant and positive (desirable) SCA effects for most yield traits, while the crosses Giza 89 x Giza 96, Giza 96 x Suvin and Giza 89 x Suvin showed significant (desirable) SCA effects for some fiber properties. following crosses Giza 89 x Giza 96, Giza 93 x Giza 96, Giza 96 x Pima S_4, Giza 96 x Pima S_6 and Giza 96 x Suvin demonstrated desirable heterosis relative to mid- and better-parent for most studied yield traits, also the crosses Giza 89 x Giza 96 and Giza 89 x Suvin indicated desirable heterosis relative to mid- and better-parent for some fiber properties. The results indicated that the non-additive of genetic variances were larger than the additive genetic variance with respect to all studied traits except, lint percentage, boll weight, upper half mean and micronaire reading traits. Generally, Giza 96 and Giza 89 could be used in breeding programs for improving high yielding varieties, while Giza 96 and Suvin could be considered as excellent parents for breeding programs to produce new varieties characterized with best fiber properties.

Key words: ***Cotton, half diallel analysis, combining ability, Heterosis, Heritability, Gene action.***

INTRODUCTION

Plant breeders are looking for desirable genes and gene complexes, and identification of promising individuals is very important in any breeding program. Diallel mating design is one of the tools which help the breeder to identify the potential genotypes and the promising recombination procedure by combining the parental individuals through GCA and SCA.

In diallel mating design the parents are crossed in all possible combinations to identify parents as the best/poor general combiners through GCA and the specific crosses combinations through SCA. In combining ability, the entire genetic

variability of each trait can be partitioned into GCA and SCA as defined by Griffing (1956), he stated that GCA effects a administer the additive type of gene action whereas SCA effects are showed due to genes which are non- additive (dominant or epistasis) in nature reported the importance of non-additive type of gene action for different cotton traits.

Arain *et al.,* (2015) their revealed that, the variances due to GCA and SCA were significant for all the traits except that GCA was non-significant for boll weight only whereas, SCA was non-significant for boll weight, seed index and ginning out turn percentage. The significance of GCA indicated the importance of additive genes advocating the traits while, the involvement of non-additive genes was evident from the significance of SCA variances. The GCA variances were greater than SCA for bolls per plant, seed cotton yield and lint percentage while, SCA variances were higher than GCA for fiber length. Khan *et al.,* (2015) showed that significant (p≤0.01) differences were observed among the genotypes for bolls per plant, boll weight, seed cotton yield per plant, lint% and lint index. F_1 hybrids showed significant increase over parental means for all the traits. Mean squares due to GCA and SCA were highly significant for all the traits. The GCA mean squares were higher than SCA for majority traits which revealed that additive genes controlled the inheritance. Sultan *et al.,* (2018) cleared that the cross combinations Pima x Giza 67, Pima x Giza 86 and Pima x Giza 68 exhibited mean values and exceeded other combinations for yield and its components traits. The cross combination Pima x Giza 68 recorded significant desirable values over better parents heterosis for seed cotton yield/ plant, lint yield and lint percentage. AL-Hibbiny *et al.,* (2019-b) found that the crosses Giza 96 x Giza 94, Giza 96 x Australy 13 and Giza 96 x karshenky demonstrated the best heterosis relative to mid- and better-parent for most studied yield traits in F_1 crosses, while the crosses Giza 96 x pima S_7, Giza 92 x Australy 13 and Giza 92 x pima S_7 indicated best heterosis relative to mid-parent and better-parent for some studied fiber quality traits in F_1 crosses. AL-Hibbiny *et al.,* (2020-a) cleared that highly significant and positive (desirable) heterosis relative to mid- and better-parents for most traits studied was found in the crosses Giza 89 x 10229 and Giza 96 x 10229. On the other hand, the heterosis relative to mid- and better-parent was highly significant and negative (useful) for micronaire reading of the same crosses. High heritability in broad-sense estimates (>50%) were detected for all the traits studied at the two crosses except seed cotton yield/plant at cross (Giza 89 x 10229) and boll weight of cross (Giza 96 x 10229). The heritability in narrow-sense estimates ranged from 3.29% to 35.70% for boll weight and uniformity index of cross (Giza 96 x 10229), respectively. Chapara *et al.,* (2020) noticed that the ratio of σ^2 GCA/σ^2 SCA was smaller than zero for all the characters indicating predominance of non-additive gene action (dominant or epistasis) in the inheritance of investigated traits except lint index.

This study was conducted to evaluate heterosis, combining ability, gene action, and heritability for yield, yield components and fiber properties among six parents and their fifteen cotton crosses.

MATERIALS AND METHODS

The genetic materials used in the present investigation included six cotton varieties belong to (Gossypium barbadense L.). Three of them are Egyptian cotton varieties; Giza 89, Giza 93 and Giza 96. while other three varieties i.e. Pima S_4 (American Egyptian variety), Pima S_6 (American Egyptian variety) and Suvin (Indian variety).

In the growing season of 2018, the six parents were *sown* and mated in half diallel to obtain 15 F_1 single crosses. The parental varieties were also self-pollinated to obtain enough seeds for further investigations.

In 2019 season, a randomized complete blocks design with three replications was carried out at Sakha Agricultural Research Station at Kafr El-Shiekh Governorate, Egypt, to evaluate 21 genotypes (six parents and their 15 half diallel crosses). Each plot was one row 4.0 m long, the distance between the rows were 0.6 m and plant to plant spacing of 0.4 m to insure 10 plants per row. Hills were thinned to keep a constant stand of one plant per hill at seedlings stage. Cultural practices were applied as usually recommended for ordinary cotton fields.

The studied traits

1- Number of bolls per plant (NB/P)
2- Boll weight (BW. g)
3-Seed cotton yield per plant (SCY/P. g)
4- Lint cotton yield per plant (LCY/P. g)
5- Lint percentage (L %)
6- 6- Seed index (SI. g)
7- Lint index (LI. g)
8- Upper half means (UHM).
9- Micronaire reading (Mic)
10- Fiber strength (FS)
11- Uniformity index (UI)

All fiber properties tests were measured in the laboratories of the Cotton Technology Research Division, Cotton Research Institute, *Egypt.*

Statistical analysis

Data of plot means were subjected to a regular statistical analysis of RCBD as outlined by Steel and Torrie (1980) to test the null hypothesis of no differences between various F_1 hybrids and their parental means. Least significant difference at 5 % level of probability (LSD at 5 %) was also used for means separation and comparison after significance.

The GCA effects of parents and SCA effects of F_1 crosses were calculated according to the method described by Griffing (1956) based on method 2, model 1 (fixed model) as also outlined by Singh and Chaudhary (1985).

Average heterosis for each F_1 cross was estimated as the deviation of F_1 mean from the mid-parents, and heterobeltosis was calculated as the deviation of F_1 mean from the better parent and expressed in percentages. Significance of heterosis was determined using the least significant difference value (LSD) at 0.05 and 0.01 levels of probability according to equation suggested by Steel and Torrie (1980).

Heritability was estimated in both broad (h^2_b%) and narrow (h^2_n%) senses from two formulas given by Allard (1960) and Mather (1949).

RESULTS AND DISCUSSION

- ## Analysis of variance

Results of the analysis of variance and the mean squares of all studied traits of the six parents and their 15 F_1 crosses are presented in Table (1). Results showed that the mean squares of the genotypes, parents, crosses and parents versus crosses were significant and highly significant for all studied traits except No. of bolls/plant at parents and micronaire reading at parents versus crosses. The results illustrated that the mean squares of general combining ability (GCA) and specific combining ability (S.C.A.) were significant and highly significant for all studied traits except micronaire reading at specific combining ability (S.C.A.). Karademir *et al.,* (2009) found that the variance due to GCA and SCA was highly significant for seed cotton yield, lint yield, fiber length, fiber fineness and fiber strength. Mahrous (2018) cleared that the analysis of variance indicated that

genotypes, parents, crosses and parents vs. crosses were significant or highly significant for all the studied traits, except lint percentage in parents and parents vs. crosses, which were insignificant. Sultan *et al.,* (2018) noticed that the analysis of variance indicated that the mean squares of genotypes for all studied characters were significant and highly significant, indicating the present of considerable amount of genetic variability among genotypes, parents and hybrids.

- **The mean performance of genotypes**

The mean performances of the six parents and their 15 F_1 crosses of all studied traits are presented in Table (2). The best mean performances were found for the parent Giza 93 for fiber strength, followed by the parents Giza 96 for No. of bolls/plant, seed cotton yield, lint cotton yield/plant, boll weight, seed index, upper half mean and uniformity index, pima S_6 for lint percentage and lint index and suvin for micronaire reading.

Table 1. Mean squares of analysis of variances for genotypes and combining abilities for yield components and fiber quality traits in cotton.

SOV	df	No.B/P	SCY/P	LCY/P	L%	BW	SI
Replications	2	52.03*	169.71	26.18	0.002	0.05	0.03
Genotypes	20	94.45**	2079.66**	304.01**	10.33**	0.18**	1.21**
Parents (P)	5	20.85	874.33*	94.34*	20.14**	0.22**	1.32**
Crosses (C)	14	90.02*	2108.01**	292.19**	6.54**	0.17**	0.75**
P VS. C	1	524.48**	7709.45**	1517.87**	14.42**	0.10*	7.06**
GCA	5	58.39**	1750.73**	217.21**	11.44**	0.19**	0.92**
SCA	15	22.51**	340.72**	62.71**	0.78**	0.02*	0.23**
Error	40	16.12	179.94	25.35	0.59	0.02	0.08

Table. 1 Cont.

SOV	df	LI	UHM	FS	MIC	UI
Replications	2	0.01	0.76	0.03	0.02	1.33
Genotypes	20	1.02**	8.55**	0.25**	0.25**	3.22**
Parents (P)	5	0.76**	11.96**	0.45**	0.53**	4.05*
Crosses (C)	14	0.68**	7.52**	0.13**	0.17**	2.04*
P VS. C	1	7.15**	5.96**	0.87**	0.03	15.61**
GCA	5	0.65**	10.27**	0.19**	0.30**	1.11*
SCA	15	0.24**	0.37*	0.05**	0.01	1.06**
Error	40	0.08	0.41	0.03	0.02	0.84

***, ** denote Significant and highly significant at 0.05 and 0.01 levels of probability, respectively.**

Table 2. Mean performances of 6 parents and 15 F_1's crosses for yield components and fiber quality traits in cotton.

Genotypes		No.B/P	SCY/P	LCY/P	L%	BW	SI	LI	UHM	FS	MIC	UI
G 89		40.07	128.17	46.75	36.46	3.21	9.92	5.70	33.43	9.47	4.38	84.48
G 93		35.35	113.63	38.59	33.97	3.22	10.37	5.33	34.20	10.49	3.51	85.16
G 96		40.18	143.33	52.27	36.69	3.55	10.47	6.08	36.97	9.60	4.13	87.83
Pima S_4		35.44	118.35	47.44	40.07	3.34	9.34	6.25	32.09	10.04	3.54	86.50
Pima S_6		34.18	95.93	39.37	41.03	2.82	9.52	6.62	31.25	10.12	4.17	85.65
Suvin		35.47	103.50	39.67	38.34	2.92	8.72	5.42	32.88	10.22	3.38	85.78
G 89 x G 93		46.07	145.63	54.58	37.48	3.17	10.61	6.36	33.75	10.43	3.81	86.14
G 89 x G 96		50.14	182.37	68.64	37.60	3.63	10.97	6.61	36.57	10.09	4.05	87.96
G 89 x Pima S_4		46.16	152.93	61.62	40.27	3.31	10.37	7.00	33.21	10.05	3.91	87.39
G 89 x Pima S_6		44.16	131.23	53.43	40.72	2.97	10.23	7.03	33.36	10.11	4.18	87.27
G 89 x Suvin		39.68	121.47	47.11	38.80	3.07	9.99	6.33	33.49	10.41	3.53	88.08
G 93 x G 96		50.24	184.47	67.05	36.37	3.67	11.03	6.31	36.55	10.45	3.68	86.68
G 93 x Pima S_4		43.43	143.20	52.33	36.53	3.30	10.25	5.90	33.04	10.06	3.53	87.94
G 93 x Pima S_6		37.18	119.57	45.31	37.90	3.22	10.15	6.19	33.64	10.42	3.76	87.28
G 93 x Suvin		37.72	114.43	43.26	37.81	3.04	10.05	6.11	33.55	10.54	3.41	86.74
G 96 x Pima S_4		44.46	161.03	63.55	39.45	3.62	11.40	7.43	36.55	9.83	4.02	87.37
G 96 x Pima S_6		49.48	173.43	70.29	40.53	3.51	10.95	7.46	34.76	10.10	4.12	87.37
G 96 x Suvin		49.58	160.07	62.19	38.83	3.23	11.08	7.04	36.38	10.49	3.84	87.31
Pima S_4 x Pima S_6		36.90	113.07	45.77	40.51	3.07	10.01	6.82	32.30	10.09	3.97	85.56
Pima S_4 x Suvin		37.74	113.77	44.64	39.24	3.02	9.81	6.34	32.55	10.35	3.54	86.56
Pima S_6 x Suvin		34.57	107.93	43.43	40.27	3.15	10.04	6.78	32.60	10.29	3.69	85.36
LSD at	0.05	1.51	5.05	1.90	0.29	0.05	0.11	0.11	0.24	0.07	0.06	0.34
	0.01	2.02	6.76	2.54	0.39	0.07	0.14	0.14	0.32	0.09	0.08	0.46

Results revealed that the best F_1 cross performances were Giza 89 x Giza 96 for upper half mean, Giza 89 x pima S_6 for lint percentage, Giza 89 x Suvin for uniformity index, Giza 93 x Giza 96 for No. of bolls/plant, seed cotton yield /plant and boll weight, Giza 93 x Suvin for fiber strength and micronaire reading, Giza 96 x Pima S_4 for seed index and Giza 96 x Pima S_6 for lint cotton yield/plant and lint index.

- **Combining ability**

Estimates of GCA effects are shown in Table (3). The parental genotype Giza 89 showed significant and positive (desirable) GCA effects for No. of bolls/plant, seed cotton yield and lint cotton yield/plant. The parent Giza 93 exhibited significant and positive (desirable) GCA effects for seed index and fiber strength but, significant and negative (desirable) GCA effects for micronaire reading. Giza 96 showed significant and positive (desirable) GCA effects for all studied traits except lint percentage and fiber strength. The parent Pima S_4 recorded significant and positive (desirable) GCA effects for lint percentage and lint index, while significant and negative (desirable) GCA effect for micronaire reading were determined for this parent. The parent Pima S_6 revealed significant and positive (desirable) GCA effects for lint percentage and lint index characters. Suvin showed significant and positive (desirable) GCA effects for fiber strength and negative (desirable) GCA effects for micronaire reading.

Table 3. General combining ability effects of parental genotypes for yield components and fiber quality traits in cotton.

Genotypes	No.B/P	SCY/P	LCY/P	L%	BW	SI
G 89	2.12**	5.93*	2.06*	-0.23	-0.01	0.03
G 93	-0.51	-0.99	-2.84**	-1.95**	0.02	0.13*
G 96	4.36**	25.69**	9.23**	-0.43**	0.26**	0.58**
Pima S_4	-1.23	-2.73	0.05	0.81**	0.04	-0.15**
Pima S_6	-2.34**	-13.18**	-3.18**	1.54**	-0.14**	-0.17**
Suvin	-2.40	-14.73**	-5.31**	0.25	-0.17**	-0.42**
LSD at 0.05	1.51	5.05	1.90	0.29	0.05	0.11
LSD at 0.01	2.02	6.76	2.54	0.39	0.07	0.14

Table. 3 Cont.

Genotypes	LI	UHM	FS	MIC	UI
G 89	-0.04	-0.06	-0.15**	0.19**	-0.13
G 93	-0.44**	0.15	0.21**	-0.19**	-0.21
G 96	0.25**	2.13**	-0.13**	0.16**	0.69**
Pima S_4	0.12*	-0.73**	-0.09*	-0.08*	0.13
Pima S_6	0.31**	-1.07**	0.004	0.17**	-0.33
Suvin	-0.20**	-0.42**	0.16**	-0.24**	-0.15
LSD at 0.05	0.11	0.24	0.07	0.06	0.34
LSD at 0.01	0.14	0.32	0.09	0.08	0.46

***, ** denote Significant and highly significant at 0.05 and 0.01 levels of probability, respectively.**

Amein *et al.,* (2013) found that the parent Giza 86 showed maximum and significant GCA effects for fiber strength, and it was also the 2nd best combiner for seed cotton yield and lint yield. The parent 10229 was the 2nd best combiner for fiber strength, boll weight and lint percentage. The parent (Giza 89 x Giza 86) was the best combiner for boll weight, while the parent (Giza 89 x Sea) was the best combiner for upper half mean. Sorour *et al.,* (2013) found that the best general combiner for most of studied traits was parent (10229 x G. 86). Also the best general combiners for most of studied traits were crosses (10229 x G. 86) x Pima S_1, G.45 x G.70, CB.58 x G.70 and CB.58 x G.93. The parent (10229 x G. 86) had the best general combining ability for boll weight, seed cotton yield, lint yield and lint percentage under two sowing dates and their combined. AL-Hibbiny *et al.,* (2019-a) showed that the line Giza 95 was significant and positive desirable GCA effects for all yield traits. Giza 92 had significant and positive desirable GCA effects for seed index and fiber strength and negative desirable for micronaire reading Giza 96 had significant and positive desirable GCA effects for fiber strength and negative desirable for micronaire reading. In this respect, the results of testers showed that Australy 13 had significant and positive desirable for No. of bolls/plant, seed cotton yield/plant and lint cotton yield/plant. Sultan *et al.,* (2018) cleared that the parent Giza 68 recorded significant positive general combining ability value for seed cotton yield/ plant. However, the parent Giza 85 followed by Dandra gave the best general combining values for lint yield/plant and lint percentage.

Significant and favorable specific combining ability (SCA) effects were shown by some crosses for yield and fiber quality traits in Table (4). The results indicated that specific combining ability (SCA) effects of No. of bolls/plant were significant and positive (desirable) for crosses Giza 89 x Giza 93, Giza 89 x Pima S_4, Giza 89 x Pima S_6, Giza 93 x Giza 96, Giza 93 x Pima S_4, Giza 96 x Pima S_4, Giza 96 x Pima S_6 and Giza 96 x Suvin. SCA effects of crosses Giza 89 x Giza 96, Giza 89 x Pima S_4, Giza 93 x Giza 96, Giza 93 x Pima S_4, Giza 96 x Pima S_4, Giza 96 x Pima S_6 and Giza 96 x Suvin were significant and positive (desirable) for seed cotton yield/plant and lint cotton yield/plant characters. SCA effects of crosses Giza 89 x Giza 93, Giza 89 x Pima S_4, Giza 89 x Pima S_6, Giza 93 x Suvin, Giza 96 x Pima S_6 and Giza 96 x Suvin were significant and positive (desirable) for lint percentage. SCA effects for crosses i.e. Giza 89 x Giza 96, Giza 93 x Giza 96, Giza 93 x Pima S_6, Giza 96 x Pima S_6 and Pima S_6 x Suvin were significant and positive (desirable) for boll weight. SCA effects of crosses Giza 89 x Giza 93, Giza 89 x Pima S_4, Giza 96 x Pima S_6, Giza 96 x Suvin and Pima S_6 x Suvin were significant and positive (desirable) for seed index. SCA effects of crosses Giza 89 x Giza 93, Giza 89 x Pima S_4, Giza 96 x Pima S_6, Giza 93 x Suvin, Giza 96 x Pima S_6, Giza 96 x Suvin and Pima S_6 x Suvin were significant and positive (desirable) for lint index. SCA effects of Giza 89 x Giza 96, Giza 89 x Pima S_6, Giza 93 x Pima S_6 and Giza 96 x Suvin were significant and positive (desirable) for upper half mean. SCA effects of crosses Giza 89 x Giza 93, Giza 89 x Giza 96, Giza 89 x Pima S_4, Giza 89 x Suvin, Giza 93 x Giza 96, Giza 96 x Suvin, and Pima S_4 x Suvin were significant and positive (desirable) for fiber strength. SCA effects of crosses Giza 89 x Giza 96, Giza 89 x Suvin and Giza 93 x Giza 96, were significant and negative (desirable) for micronaire reading. SCA effects of crosses Giza 89 x Giza 96, Giza 89 x Pima S_4, Giza 89 x Pima S_6, Giza 89 x Suvin, Giza 93 x Pima S_4, Giza 93 x Pima S_6 and Giza 96 x Pima S_4 were significant and positive (desirable) for uniformity index. Amein *et*

al., (2013) found that the cross combination Giza 86 x 10229 had the highest positive and significant SCA effects for seed cotton yield and lint yield followed by the cross combination (10229 x Giza 86) x (Giza 89 x Pima S_6) for seed cotton yield and lint yield. The cross (Giza 89 x Giza 86) x (Giza 75 x Sea) was the best combination for boll weight. Sorour *et al.,* (2013) revealed that the crosses CB.58 x G.93 and G.45 x G.70 showed highly significant desirable specific combining ability for boll weight, seed cotton yield, lint yield and number of bolls per plant at two sowing dates and their combined. Sultan *et al.,* (2018) cleared that the cross combination Pima x 67 followed by Pima x Dandra observed highest positive significant SCA effects for most yield characters. AL-Hibbiny *et al.,* (2019-a) noticed that the estimates of specific combining ability (SCA) effects for the crosses Giza 90 x Karshenky, Giza 95 x Pima S_7, Giza 92 x Karshenky and Giza 96 x Suvin were significant desirable SCA effects for some yield traits.

Table 4. Specific combining ability effects of each cross for yield components and fiber quality traits in cotton.

Genotypes	No.B/P	SCY/P	LCY/P	L%	BW	SI
G 89 x G 93	3.12*	6.05	3.59*	1.14**	-0.08*	0.19*
G 89 x G 96	2.32	16.10**	5.58**	-0.25	0.15**	0.11
G 89 x Pima S_4	3.93**	15.08**	7.74**	1.16**	0.05	0.24**
G 89 x Pima S_6	3.04*	3.83	2.78	0.88**	-0.11**	0.11
G 89 x Suvin	-1.39	-4.38	-1.41	0.26	0.01	0.13
G 93 x G 96	5.05**	25.12**	8.88**	0.23	0.15**	0.07
G 93 x Pima S_4	3.83**	12.27**	3.35*	-0.85**	0.004	0.02
G 93 x Pima S_6	-1.31	-0.91	-0.45	-0.21	0.10*	-0.07
G 93 x Suvin	-0.72	-4.49	-0.37	0.99**	-0.05	0.08
G 96 x Pima S_4	3.83**	12.27**	3.35*	-0.85**	0.004	0.02
G 96 x Pima S_6	6.13**	26.27**	12.47**	0.90**	0.15**	0.29**
G 96 x Suvin	6.27**	14.46**	6.49**	0.50*	-0.10*	0.67**
Pima S_4 x Pima S_6	-0.87	-5.68	-2.87	-0.37	-0.07	0.08
Pima S_4 x Suvin	0.02	-3.42	-1.87	-0.34	-0.09*	0.13
Pima S_6 x Suvin	-2.03	1.20	0.15	-0.05	0.22**	0.38**
LSD at 0.05	2.34	7.83	2.94	0.45	0.08	0.16
LSD at 0.01	3.13	10.47	3.93	0.60	0.10	0.22

Table. 4 Cont.

Genotypes	LI	UHM	FS	FF	UI
G 89 x G 93	0.40**	-0.31	0.20**	-0.01	-0.20
G 89 x G 96	-0.03	0.54**	0.20**	-0.11*	0.71*
G 89 x Pima S_4	0.48**	0.04	0.12*	-0.01	0.70*
G 89 x Pima S_6	0.32**	0.53**	0.08	0.003	1.04**
G 89 x Suvin	0.14	0.01	0.22**	-0.24**	1.67**
G 93 x G 96	0.06	0.31	0.20**	-0.11*	-0.49
G 93 x Pima S_4	-0.21*	-0.34	-0.22**	-0.02	1.34**
G 93 x Pima S_6	-0.11	0.59**	0.04	-0.03	1.14**
G 93 x Suvin	0.31**	-0.14	0.004	0.02	0.42
G 96 x Pima S_4	-0.21*	-0.34	-0.22**	-0.02	1.34**
G 96 x Pima S_6	0.47**	-0.26	0.05	-0.02	0.32
G 96 x Suvin	0.56**	0.71**	0.28**	0.11*	0.08
Pima S_4 x Pima S_6	-0.05	0.15	0.003	0.07	-0.92**
Pima S_4 x Suvin	-0.01	-0.26	0.11*	0.05	-0.11
Pima S_6 x Suvin	0.23**	0.13	-0.05	-0.05	-0.84**
LSD at 0.05	0.16	0.37	0.11	0.09	0.53
LSD at 0.01	0.22	0.50	0.14	0.12	0.71

***, ** dente Significant and highly significant at 0.05 and 0.01 levels of probability, respectively**

- **Heterosis:**

The amounts of heterosis for all *traits studied* over the mid-parent (M.P) and better-parent (B.P) are presented in Tables (5) and (6) respectively. For the No. of bolls/plant character, 9 out of 15 studied crosses were found to be detect significant and positive desirable heterosis relative to mid-parent which ranged from 17.42% of Giza 93 x Pima S_4 to 36.51% of Giza 89 x Suvin, five crosses showed significant and positive desirable heterosis relative to better-parent i.e. Giza 89 x Giza 96, Giza 93 x Giza 96, Giza 93 x Pima S_4, Giza 96 x Pima S_6 and Giza 96 x Suvin with value of 24.78%, 25.03%, 22.55%, 23.14% and 23.38%, respectively. With respect to seed cotton yield/plant, seven crosses out of 15 crosses showed significant and positive desirable heterosis relative to mid-parent which were ranged from 20.46% for Giza 89 x Giza 96 to 45.49% for Giza 96 x Pima S_6, seven crosses showed significant and positive desirable heterosis relative to better-parent were ranged from 11.67% for Giza 96 x Suvin to 28.70% for Giza 93 x Giza 96. For lint cotton yield/plant, the results showed that eight crosses out of 15 crosses were significant and positive desirable heterosis relative to mid-parent which ranged from 19.04% for Giza 89 x Pima S_6 to 51.62% for Giza 96 x Pima S_6, six crosses showed significant and positive desirable heterosis relative to better-parent which ranged from 18.98% for Giza 96 x Suvin to 34.49% for Giza 96 x Pima S_6.

Regarding to lint percentage five crosses out of 15 crosses were found to be significant and positive desirable heterosis relative to mid-parent which ranged from 3.23% for Giza 96 x Pima S_6 to 9.42% for Giza 89 x Pima S_6. With

respect to boll weight five crosses out of 15 crosses were found to be significant and positive desirable heterosis relative to mid-parent which ranged from 5.00% for Giza 96 x Pima S_4 to 9.70% for Pima S_6 x Suvin, one cross showed significant and positive desirable heterosis relative to better-parent, it was Pima S_6 x Suvin with value of 7.89%. Regarding to seed index nine crosses out of 15 crosses were found to be significant and positive desirable heterosis relative to mid-parent which ranged from 4.59% for Giza 89 x Giza 93 to 16.53% for Giza 96 x Suvin, eight crosses showed significant and positive desirable heterosis relative to better-parent which ranged from 4.59% for Giza 96 x Pima S_6 to 8.92% for Giza 96 x Pima S_4. For lint index ten crosses out of 15 crosses were found to be significant and positive desirable heterosis relative to mid-parent which ranged from 7.33% for Giza 89 x Suvin to 20.49% for Giza 96 x Pima S_4, eight crosses showed significant and positive desirable heterosis relative to better-parent which ranged from 8.86% for Giza 89 x Giza 96 to 18.80% for Giza 96 x Pima S_4. Regarding to upper half mean five crosses out of 15 crosses were found to be significant and positive desirable heterosis relative to mid-parent which ranged from 2.93% of Giza 93 x Giza 96 to 9.25% of Giza 96 x Suvin.

Table 5. Heterosis relative to the mid-parent (M.P.) for yield components and fiber quality traits in the studied cotton hybrids.

Genotypes		No.B/P	SCY/P	LCY/P	L%	BW	SI
G 89 x G 93		22.19**	20.46*	27.90**	6.42**	-1.42	4.59*
G 89 x G 96		30.12**	42.05**	49.65**	5.31**	9.17**	7.04**
G 89 x Pima S_4		22.25**	21.50**	33.20**	9.42**	-0.55	3.47
G 89 x Pima S_6		19.20*	9.47	19.04*	8.16**	-7.93**	3.06
G 89 x Suvin		7.87	3.68	7.04	2.74	-3.48	2.75
G 93 x G 96		33.03**	43.57**	47.58**	2.93	8.30**	5.92**
G 93 x Pima S_4		17.42*	14.46	13.51	-1.02	-2.23	1.90
G 93 x Pima S_6		2.47	1.49	2.00	-0.10	-0.57	2.25
G 93 x Suvin		4.43	-0.45	-0.49	-0.54	-4.14	3.76
G 96 x Pima S_4		17.58*	23.07**	27.47**	2.78	5.00*	15.09**
G 96 x Pima S_6		35.20**	45.49**	51.62**	3.23*	8.28**	11.98**
G 96 x Suvin		36.51**	38.85**	39.16**	-0.51	2.28	16.53**
Pima S_4 x Pima S_6		5.99	5.53	5.45	-0.11	-0.25	6.18**
Pima S_4 x Suvin		7.74	7.40	5.89	-1.44	-0.21	6.72**
Pima S_6 x Suvin		-0.72	8.24	9.91	1.46	9.70**	10.18**
LSD at	0.05	5.74	19.17	7.20	1.09	0.19	0.40
	0.01	7.68	25.65	9.63	1.46	0.25	0.53

Table. 5 Cont.

Genotypes	LI	UHM	FS	FF	UI
G 89 x G 93	15.30**	-0.21	4.53**	-3.32	1.56*
G 89 x G 96	15.99**	4.88**	2.42	1.06	2.49**
G 89 x Pima S_4	19.78**	-2.83*	1.53	0.51	1.63*
G 89 x Pima S_6	17.17**	-0.69	1.72	5.86*	1.57*
G 89 x Suvin	7.33*	0.05	4.23**	-8.44**	2.54**
G 93 x G 96	10.54**	2.73*	4.00**	-3.81	0.21
G 93 x Pima S_4	0.27	-4.01**	0.21	-5.39	1.67*
G 93 x Pima S_6	2.00	0.03	3.60**	-1.93	1.15
G 93 x Suvin	2.82	0.22	4.44**	-8.99**	0.64
G 96 x Pima S_4	20.49**	5.84**	0.14	4.71	0.24
G 96 x Pima S_6	18.09**	3.97**	1.80	4.40	0.82
G 96 x Suvin	15.49**	9.25**	4.94**	0.82	1.01
Pima S_4 x Pima S_6	5.91	1.99	0.09	2.96	-0.60
Pima S_4 x Suvin	3.93	1.47	2.26	-4.14	0.68
Pima S_6 x Suvin	12.50**	1.65	1.21	-2.16	-0.41
LSD at 0.05	0.40	0.91	0.26	0.22	1.31
LSD at 0.01	0.53	1.22	0.35	0.29	1.75

***, ** denote Significant and highly significant at 0.05 and 0.01 levels of probability, respectively.**

Table 6. Heterosis relative to the better-parent (B.P.) for yield components and fiber quality traits in the studied cotton hybrids.

Genotypes		No.B/P	SCY/P	LCY/P	L%	BW	SI
G 89 x G 93		14.99	13.63*	16.74	2.78	-1.69	2.35
G 89 x G 96		24.78**	27.23**	31.32**	2.48	2.25	4.84*
G 89 x Pima S_4		15.20	19.32**	29.89**	0.49	-0.86	4.55
G 89 x Pima S_6		10.20	2.39	14.29	-0.76	-7.28*	3.07
G 89 x Suvin		-0.98	-5.23	0.78	1.18	-4.37	0.68
G 93 x G 96		25.03**	28.70**	28.27**	-0.89	3.28	5.41*
G 93 x Pima S_4		22.55*	21.00	10.30	-8.82**	-1.32	-1.13
G 93 x Pima S_6		5.20	5.22	15.07	-7.63**	-0.24	-2.12
G 93 x Suvin		6.36	0.70	9.05	-1.38	-5.72	-3.09
G 96 x Pima S_4		10.64	12.35**	21.59**	-1.55	1.88	8.92**
G 96 x Pima S_6		23.14**	21.00**	34.49**	-1.21	-1.31	4.59*
G 96 x Suvin		23.38**	11.67**	18.98*	1.28	-9.10**	5.89**
Pima S_4 x Pima S_6		4.10	-4.46	-3.52	-1.27	-8.05**	5.22*
Pima S_4 x Suvin		6.40	-3.87	-5.90	-2.07	-9.64**	4.98*
Pima S_6 x Suvin		-2.53	4.28	9.50	-1.86	7.89*	5.55*
LSD at	0.05	6.63	22.14	8.31	1.26	0.21	0.46
	0.01	8.87	29.62	11.12	1.69	0.29	0.62

Table. 6 Cont.

Genotypes	LI	UHM	FS	FF	UI
G 89 x G 93	11.60**	-1.33	-0.56	-12.89**	1.16
G 89 x G 96	8.86*	-1.08	5.10**	-7.49*	0.15
G 89 x Pima S_4	11.90**	-0.68	0.11	-10.69**	1.03
G 89 x Pima S_6	6.08	-0.23	-0.03	-4.59	1.90*
G 89 x Suvin	11.14**	0.16	1.89	-19.44**	2.68**
G 93 x G 96	3.78	-1.12	-0.40	-11.05**	-1.31
G 93 x Pima S_4	-5.58	-3.39*	-4.06**	-0.35	1.66
G 93 x Pima S_6	-6.51	-1.65	-0.62	-9.68**	1.90*
G 93 x Suvin	12.68**	-1.89	0.49	-2.88	1.12
G 96 x Pima S_4	18.80**	-1.14	-2.05	-2.82	-0.52
G 96 x Pima S_6	12.63**	-5.96*	-0.20	-1.12	-0.53
G 96 x Suvin	15.81**	-1.59	2.64	-7.18*	-0.59
Pima S_4 x Pima S_6	2.93	0.65	-0.30	-4.80	-1.09
Pima S_4 x Suvin	1.39	-1.02	1.34	0.13	0.07
Pima S_6 x Suvin	2.29	-0.87	0.72	-11.36**	-0.49
LSD at 0.05	0.46	1.05	0.30	0.25	1.51
LSD at 0.01	0.62	1.41	0.40	0.34	2.02

***, ** denote Significant and highly significant at 0.05 and 0.01 levels of probability, respectively**

With respect to fiber strength six crosses out of 15 crosses were found to be significant and positive desirable heterosis relative to mid-parent which ranged from 3.60% for Giza 93 x Pima S_6 to 4.94% for Giza 96 x Suvin, one cross showed significant and positive desirable heterosis relative to better-parent, it was Giza 89 x Giza 96 with value of 5.10%. For micronaire reading, the results showed that tow crosses out of 15 crosses were significant and negative desirable heterosis relative to mid-parent i.e. Giza 89 x Suvin and Giza 93 x Suvin with value of -8.44% and -8.99%, respectively, eight crosses showed significant and negative desirable heterosis relative to better-parent which ranged from -7.18% for Giza 96 x Suvin to -19.44% for Giza 89 x Suvin. Regarding to uniformity index six crosses out of 15 crosses were found to be significant and positive desirable heterosis relative to mid-parent which ranged from 1.65% for Giza 89 x Giza 93 to 2.54% for Giza 89 x Suvin, three crosses showed significant and positive desirable heterosis relative to better-parent i.e. Giza 89 x Pima S_6, Giza 89 x Suvin and Giza 93 x Pima S_6 with value of 1.90%, 2.68% and 1.90%, respectively. Khan *et al.,* (2009) in a 6 x 6 diallel cross reported significant and positive heterosis for seed cotton yield, boll weight and lint percentage. The heterobeltiosis ranged from 3.13 to 65.63 % for bolls per plant, from 0.75 to 24.40 % for boll weight, from 0.82 to 115.22 % for seed cotton yield and from 0.27 to 3.88 % for lint percentage. Karademir and Gençer (2010) in 21 half diallel crosses of cotton reported significant and positive heterosis values for seed cotton yield, fiber fineness, fiber strength and lint

percentage. Sorour *et al.,* (2013) found that the positive heterotic effects relative to the mid-parent were found for most of the traits in the crosses (10229 x G.86) x G.45, G.45 x Suven, G.45 x G.70, TNB x G.70 and C.B 58 x G.93. Also positive heterotic effects relative to the better parent were found for most of the traits in the crosses (10229 x G.86) x TNB, G.45 x Suven and G.45 x G.70 over two planting dates and their combined. Al-Hibbiny (2015) found that, the following crosses demonstrated the best heterosis relative to mid- and better-parent, i.e., Giza 88 x Karshenky and Giza 88 x Pima S_6 for most studied traits, while the following crosses demonstrated the best heterosis relative to mid-parent for all studied yield traits, i.e. Giza 80 x Karshenky, Giza 90 x Pima S_6 and Giza 92 x Pima S_6. Lingaraja (2017) showed that range of economic heterosis varied from 1.58 to 32.91% of seed index, 11.15 to 31.85% of lint index, -11.06 to 3.37% of ginning outturn, -6.32 to 8.80% of 2.5 per cent span length, -2.73 to 18.27 of fibre strength, 17.69 to 21.23 of micronaire value, -2.08 to 1.66 of fibre uniformity and -60.38 to 48.32 of seed cotton yield per plant. AL-Hibbiny *et al.,* (2019-a) reported that the following crosses demonstrated the best heterosis relative to mid- and better-parent, i.e, Giza 95 x Karshenky, Giza 95 x Australy 13 and Giza 95 x Pima S7 for most traits studied, while the following crosses demonstrated the best heterosis relative to mid- and better-parent for most studied yield traits, i.e. Giza 90 x Australy 13 and Giza 86 x Karshenky. The crosses Giza 92 x Karshenky, Giza 92 x Australy 13, Giza 92 x Pima S7, Giza 96 x Suvin and Giza 96 x Pima S7 were the best heterosis relative to mid-parent for most studied fiber traits. AL-Hibbiny *et al.,* (2020-b) found that useful heterosis and desirable specific combining ability effects estimations and the promising recombination's i.e., Giza 95 x Suvin, Giza 87 x Karshenky, Giza 93 x 10229, Giza 93 x Karshenky and Giza 93 x 10229 were the highest values for most studied traits.

- **Genetic parameters**

The genetic variance components and dominance degree ratio were calculated for all studied traits and presented in Table (7). The results indicated that the non-additive of genetic variances were larger than the additive genetic variance with respect to all studied traits except, lint percentage, boll weight, upper half mean and micronaire reading traits. These results indicated that the non-additive effects play a major role in the expression of these traits, while additive effects had a minor role. Similar findings were reported by Basal *et al.,* (2009), Sorour *et al.,* (2013), Al-Hibbiny (2015), Mahrous (2018), Sultan *et al.,* (2018), AL-Hibbiny *et al.,* (2019-a) and AL-Hibbiny *et al.,* (2020-b).

- **Heritability**

The results of heritability in broad- and narrow-senses are illustrated in Table (7). The results revealed that the broad-sense heritability (h^2_b%) estimates were larger than the corresponding values of narrow sense heritability (h^2_n%) for all studied traits. The highest broad-sense heritability estimates was observed in case of upper half mean with value of 86.94% and the lowest value was for uniformity index with value of 48.63%, while the narrow-sense heritabilities were ranged from 0.73% for uniformity index to 79.30% for upper half mean, respectively. Similar findings were reported by Al-Hibbiny (2015), Mahrous (2018), AL-Hibbiny *et al.,* (2019-a), Mokadem *et al.,* (2020) and AL-Hibbiny *et al.,* (2020-b)

Table 7. Estimates of variance components of combining ability and heritabilities for yield components and fiber quality traits in cotton.

variance components and heritability	No.B/P	SCY/P	LCY/P	L%	BW	SI	LI	UHM	FS	MIC	UR
σ^2_{GCA}	4.48	176.25	19.31	1.33	0.02	0.09	0.05	1.24	0.02	0.036	0.006
σ^2_{SCA}	17.14	280.74	54.26	0.58	0.01	0.20	0.21	0.24	0.04	0.004	0.782
$\sigma^2_{GCA}/\sigma^2_{SCA}$	0.26	0.63	0.36	2.29	2.00	0.45	0.24	5.17	0.50	9.00	0.01
σ^2_{A}	8.97	352.50	38.63	2.67	0.04	0.17	0.10	2.48	0.04	0.073	0.012
σ^2_{D}	17.14	280.74	54.26	0.58	0.01	0.20	0.21	0.24	0.04	0.004	0.782
h^2b	61.82	77.87	78.56	84.72	76.05	82.93	80.13	86.94	68.27	76.64	48.63
h^2n	21.24	43.35	32.67	69.52	61.33	38.15	25.75	79.30	33.77	72.87	0.73

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قوة الهجين والقدرة علي التآلف للمحصول وصفات الجودة في قطن الباربادنس باستخدام نظام الهجن التبادلية

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الملخص العربى

أجريت هذه الدراسة في محطة البحوث الزراعية بسخا – معهد بحوث القطن – مركز البحوث الزراعية – مصر خلال موسمي الزراعة ٢٠١٨ و ٢٠١٩. تم استخدام ستة أصناف من القطن تنتمي جميعها إلي أقطان الباربادنس منها ثلاثة أصناف مصرية وهي جيزة ٨٩ و جيزة ٩٣ و جيزة ٩٦ وثلاثة أصناف أخري وهي بيما س٤ و بيما س٦ و سيوفين. تم التهجين بينهم بطريقة التزاوج التبادلي النصف دائري لانتاج ١٥ هجين للجيل الاول في موسم ٢٠١٨ وفي موسم ٢٠١٩ تم تقييم الستة أصناف والخمسة عشر هجين في تجربة قطاعات كاملة عشوائية في ثلاث مكررات بهدف تقدير قوة الهجين والقدرة العامة والخاصة علي التآلف وتقدير الكفاءة الوراثية لصفات المحصول وجودة التيلة. وكانت اهم النتائج المتحصل عليها:

أشارت نتائج تحليل التباين لكل من التراكيب الوراثية والأباء والهجن والاباء x الهجن وجود فروق معنوية لكل الصفات المدروسة ماعدا صفتي عدد اللوز المتفتح علي النبات وقراءة الميكرونير بالنسبة للآباء x الهجن. أما بالنسبة لتباين القدرة العامة و الخاصة علي التآلف فكانت عالية المعنوية لكل الصفات المدروسة ماعدا صفة قراءة الميكرونير بالنسبة للقدرة الخاصة علي التآلف.

أظهر الصنفين جيزة ٩٦ و جيزة ٨٩ أفضل قدرة عامة علي التآلف لمعظم الصفات المحصولية بينما أظهر الصنفين جيزة ٩٦ وسيوفين أفضل قدرة عامة علي التآلف لبعض صفات التيلة. كما أظهرت الهجن جيزة ٨٩ x بيما س٤ و جيزة ٩٦ x بيما س٦ و جيزة ٩٦ x سيوفين أفضل قدرة خاصة علي التآلف لمعظم الصفات المحصولية بينما أظهرت الهجن جيزة ٨٩ x جيزة ٩٦ و جيزة ٩٦ x سيوفين و جيزة ٨٩ x سيوفين أفضل قدرة خاصة علي التآلف لبعض صفات التيلة.

أشارت دراسة قوة الهجين الي وجود قوة هجين مرغوبة محسوبة بالنسبة لمتوسطات الابوين وأفضل الأباء وذلك لمعظم الصفات المدروسة، وقد أظهرت الهجن جيزة ٨٩ x جيزة ٩٦ و جيزة ٩٣ x جيزة ٩٦ و جيزة ٩٦ x بيما س٤ و جيزة ٩٦ x بيما س٦ و جيزة ٩٦ x سيوفين أعلي قيم لقوة الهجين بالنسبة لمتوسط الابوين وأفضل الأباء لمعظم الصفات المحصولية المدروسة. أيضا أظهرت الهجينان جيزة ٨٩ x جيزة ٩٦ و جيزة ٨٩ x سيوفين أعلي قيم لقوة الهجين لمتوسط الابوين وأفضل الأباء لبعض صفات التيلة.

عموما فانه يمكن استخدام الصنفين جيزة ٩٦ وجيزة ٨٩ في برامج التربية لتحسين وزيادة القدرة الانتاجية للاصناف الجديدة بينما يمكننا اعتبار الصنفين جيزة ٩٦ وسيوفين كأبين متفوقين في برامج التربية للحصول علي أصناف جديدة عالية الجودة.

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