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Heterosis and Estimation of General and Specific Combining Ability as Base for Selected Superior Recombination of the Some Crossed Cotton Genotypes

W. M. B. Yehia [a*], A. M. Abdelbary [a], A. A. Mohamed [a], H. M. K. Kotb [a] and M. M. Sherif [b]

[a] *Cotton Breeding Section, Cotton Research Institute, Agricultural Research Center, 12619, Egypt.*
[b] *Water Studies Research Complex (WSRC), Toshka -Abu Simble City -National Water Research Center – Egypt.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this study was to determine the general and specific combining abilities and heterosis of some cotton genotypes for yield, its components and fiber traits using line x tester mating design. Nine parents (six line and three testers) were crossed in a line x tester mating design in 2020 season. Nine parents along with their eighteen F_1 crosses were studied in a randomized complete block design (RCBD) with three replications during 2021 at Sakha. Agricultural. Research. Station. Kafr El-Sheikh, Governorate, Egypt. Based on line x tester analysis, the variance due to

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**Corresponding author: E-mail: waleed.yehia@arc.sci.eg;*

genotypes, parents, crosses and parent vs. cross exhibited significant differences (P. 0.01) for most yield, yield components and fiber traits. The variance due to GCA of lines x testers and SCA of line x tester interactions were highly significant for most studied traits, indicating the importance of both additive and non-additive gene actions in controlling these traits. The estimates of GCA and SCA effects revealed that the parent and some crosses were having desirable and significantly GCA and SCA effects, respectively. High mean performances and significantly GCA effects values were observed of line Giza 92, Giza 75 and tester Giza 97 for most studied traits, hence, these parents can be used as for generation superior cotton hybrids. The best values of mean performances, SCA effects and heterosis were found in the combinations Giza 94 x Giza 92, Giza 97 x Suvin for most yield and yield components and the cross Giza 97 x (Giza 75 x Sea) for yield and fiber traits. These crosses are considered as the promising crosses to be used in breeding programs for produce hybrid cotton and improvement for these traits in Egypt.

Keywords: Cotton; heterosis; general combining ability; specific combining ability; hybrids.

1. INTRODUCTION

The primary objectives of cotton breeding program are high yield with suitable fiber quality parameters. Breeding depends on genetic variation between parents to create unique gene combinations necessary for new superior cultivars. The information on heritability, combining ability and heterosis effects for yield and its components, quality parameters direct to suitable parents and promising cross combination in a breeding program. The result of various studies revealed that parents and cross combination should be selected by their combining ability and gene action according the efficacy of phenotypic performance. “Although, selection of parents based on mean performance, adaptation and genetic diversity does not lead necessarily to desirable result this is due to the differential ability of the parents, which depended on the complex interaction among the genes and judged by the mean performance insert” [1]. Egyptian cotton breeders seek the most appropriate materials or breeding way to present clearly the result of experimental scientific studied Meredith and Broun [2] found that, “region of adaptation was an important factor in choosing, parents one parent needed to be well-adapted genotype from the region in which it was to be grown. At least one parent should have above average fiber quality”. The line x tester analysis is one of the most statistics - genetic method which provides available knowledge about general and specific combing abilities of parents (GCA) and crosses (SCA) Usharani et al. [3]. The number of evaluated genotypes using line x tester methods is more than those of diallel analysis, scaling test etc. “The general (GCA) and specific (SCA) combining ability have significant impact on evaluation of genotypes and population improvement. The (GCS) is the average performance of a genotype in hybrid combinations with number of genotypes [4]. The (SCA) is the average performance of specific cross combination expressed as deviation from the population means. Combining ability can be used to determine the use fullness of the parents in hybrid combination and to develop best hybrid adapted to different environment” Sprague and Tatum [5]. The ratio could be useful in order to estimate the behavior of a segregating generation many research reported that seed cotton yield, fiber strength and ginning percentage controlled by non-additive gene effects Khokhar et al. [6] and Patil and Patile [7]. Therefore, selectionfor improvement should be delayed to late generation (F_4-F_5).Reflectance degree exhibited moderate heritability estimates Lingaraja et.al.2017, reported that, moderately high and positive heterosis value for cotton seed yield, whereas mostly low and negative values for ginning percentage and fiber quality parameters were determined by El-Hashash [8]. Heresies is to estimate the performance of an F1- produce by crossing of two varieties or pure line but the use of heterosis in cotton has not yet reached the successive level.In conventional breeding programs. Heterosis effects are used to determine the dominance or/and epispastic variance and the promising cross combinations Ahuja and Dhayal [9] and Karademer et al. [10] 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 /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 consisting of six lines and three testers and selecting the superior hybrids that can be used in breeding program of cotton.

2. MATERIALS AND METHODS

This research was conduct at Sakha, Agriculture, Research station kafr El-Sheikh Governorate, Egypt, during 2020 and 2021 growing seasons. Experiment consists of six lines, viz, Giza 92, Giza85, Giza 75, Suvin, Pima S_6 and Giza 75 x Sea, and three testers, Giza94, Giza86 and Giza97. Those genotypes were crossed in 2020 season in line x tester mating design to produce eighteen F_1 crosses. All genotypes (six line + three tester +18 F_1crosses) were evaluated in randomized complete block design (RCBD)with three replications in 2021 season. In each replication include parents (lines and testers) and F1 crosses which sown in single row of 4 mm long with a spacing of 70 cm between rows and 40 cm between plants. All the cultural practice such as sowing date, fertilization and irrigation were applied as recommended for cotton production. Date was recorded on 10 guarded plants for the studied traits boll weight (B.W.gm.), seed cotton yield/plant (S.C.Y/P. gm,) lint cotton yield/plant (L.C.Y. /P gm.), lint percentage (L %), number of bolls/plant (No. B /P), seed index (S I gm.); fiber fineness (F.F. Mic.), fiber strength (F.S. Presly.); 2.5 % span length (2.5% SL.) in mm were recoded. Data recoded were subjective to analysis of variance according to Steel and Torrie [11], to determine significant differences manage genotypes. The combining ability effects of the parents (GCA) and the crosses (SCA) were estimated by using of the line x tester analysis method described by Kempthorne [12] and adopted by Singh and Chaudhary [13]. 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 a mange the genotypes including crosses and parents. If these differences are found significant, line x tester analysis is done. Heterosis relative to mid and better parents was estimated as per the formula given by Liang et al. [14] and the significance of heterosis was determined using the least significant difference value (L.S.D.) at 0.05 and 0.01 levels of probability according to Steel and Torrie [11].

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance

"Mean squares in line x tester analysis for yield, its components and fibers traits used in this study are shown in Table 1. Preliminary analysis of variance exhibited there are highly significant differences between genotypes for all studied traits these findings indicate the parent of considerable genetic variable between genotypes, hence, subsequent analysis combining ability was performed" [15]. The variances due to parents, crosses and parents vs. crosses should highly significance for most investigated traits. While parents vs. cross displayed no significant differences for boll weight trait. The sum of squares due to crosses is partitioned into general combining ability (line x testes). Mean squares of (GCA) for lines were significant for all studied traits expect boll weight, seed index, fiber fineness and fiber strengths, indicating important role of addition gene effect, while mean square of SCA of testes were observed significant for boll weight, line percentage, number of boll plant and seed index, revealing that non - additive gene effects as dominance or epistatic. This finding indicates that, the crosses were sufficiently different from each other for these traits and hence, selection is possible to identify those most desirable crosses.

This difference could be attributed to large difference between parental lines of difference studies. From Table 1, the variance due to GCA of line lower than SCA of testers for boll weight, lint percentage, seed index, fiber fineness and fiber strength, expressed, non - additive gene action (dominance or ecstatic), which is in accordance with the previous result EL-Feki et al. [16]; Bhadwinj and Kapoor [17]; Green and Culp [18]; Kapoor [19]; Cheatham et al. [20]; Ahuja and Dhagal [9] and Ilyas et al. [21]. On the other hand, GCS was higher than SCA for seed cotton yield /plant, lint cotton yield /plant, number of bolls /plant and 2.5% span length, reflecting the role of additive type gene action Table 1. The results are in compromise with findings of Maradith and Bridge (1972), Myers and Lu [22] and Rauf et al. [23]. Also, Baker and Verhalen [24] drew similar conclusions concerning to importance of additive type gene action with regards to fiber traits. The results indicated that pattern of appropriate line combinations may be varying depending on the tester mode. High magnitude of the mean squares of tester indicating greater diversity among the testers and these tester scan by pursued for developing plant heterosis groups with high combining ability [25]. Therefore, the choice of appropriate tester is crucial in developing high yielding hybrid cotton Karademir et al. [15] and Chinchane et al. [26] stated that, the GCS was highly significant for testers in terms of most traits, revealing important role of additive type of gene effects in these traits. On the other hand, there were non-significant differences of GCA for lines. The SCA was highly significant for hybrids (line*tester) for all traits except fiber strength and 2.5% span length, revealing non-additive gene effects as dominance or epistasis.

The mean performance of the parents (lines and testers) and crosses used in the research can be seen at Tables 2 and 3, respectively. The present performance was considered as the first important selection index in the choice of parents and with high mean performance will result in superior hybrids. The mean performances values of parents (line and testers) and F_1 crosses displayed highly significant differences for all traits. Significant differences were recorded between mean when compared with the L.S. D. values.

The superior parents in terms of genotype mean values were Giza86 for boll weight trait; Giza 97for seed cotton yield/plant, lint cotton yield/plant and number of bolls/plants; Giza75 for lint percentage; Giza94 for seed index; Giza92 for fiber fineness and fiber strength. While, the parent Giza75*Sea had the best 2.5% span length. The results exhibited some F_1 crosses were superior than stander check and grand means for all studied traits. There were relatively large variations in all genotypes for those traits. The cross Giza94 x Giza92 exhibited best mean values and excelled from other crosses for the traits i.e., seed cotton yield/plant 124.56 gm. and lint cotton yield/plant 48.30 gram. The best boll weight 3.50gm, lint percentage 39.37%, number of bolls/plant43.53, seed index 12.73gm, fiber fineness3.97, fiber strength10.63 and2.5% span length34.73 were produced by crosses Giza97 x PimaS_6, Giza97 x Giza92, Giza86 x (Giza75x Sea), Giza86 x Giza75, Giza97 x Suvin, Giza97 x Suvin and Giza94 x (Giza75 x Sea) respectively. Generally, these data indicate superiority of some F1crosses, with respect to their corresponding parent and standard check. These data showed that heterosis effects emerged highly in point for studied traits in these crosses. These viewpoints were kept in mind while selecting reciprocal selection for combining ability. The highest combinations indicating that importance of low and average parents in the exploitation of heterosis for studied traits. Consequently, the parents involved in the previous combinations showed be used in improving yield, its components and fiber traits and the best crosses should be used in initiated the breeding program.

Table 1. Mean squares in line*tester analysis for yield, yield components and fiber traits

S.O. V.	d.f	B.W.	S.C.Y./P	L.C.Y./P	L.%	No. B.\P.	S.I.	F.F.	F.S.	2.5%S. L
Replications	2	0.033	157.30	16.293	0.478	30.853	0.226	0.042	0.0108	0.045
Genotypes	26	0.243**	1145.43**	190.295**	8.399**	159.209**	2.623**	0.255**	0.171**	0.8207**
Parents (P)	8	0.258*	539.023**	92.196**	12.41**	48.609	3.313**	0.327**	0.1858*	1.410**
Crosses (C)	17	0.251**	587.75**	103.94**	5.760**	132.88**	1.862**	0.163*	0.171**	0.5115*
P. vs. C.	1	0.003	15477.4**	2443.083*	21.22**	1491.6**	10.050**	1.245**	1.227**	1.3631*
GCA (Lines)	5	0.148	559.37**	95.006**	4.700**	155.01**	1.038	0.062	0.0947	0.8874**
GCA (Testers)	2	0.580**	51.885	0.651	5.031*	118.13*	6.120**	0.144	0.1817	0.5706
SCA (Line* Tester)	10	0.236*	709.103**	129.071**	6.435**	124.76**	1.422**	0.217**	0.0897	0.3117
Error	52	0.093	127.068	18.93	1.3038	9.680	0.463	0.079	0.070	0.241

** and** Significant at 5% and 1% levels of probability, respectively*

Table 2. Mean performances values of lines and testers with respect to yield, yield components and fiber traits

Traits	B.W.	S.C.Y./P.	L.C.Y./P	L.%	No. B\P	S. I	F. F	F. S	2.5% S.L.
Lines									
Giza. 92	3.13	65.80	24.11	36.62	21.09	9.15	3.60	10.93	33.50
Giza. 85	3.11	68.46	22.33	32.61	22.12	9.79	4.40	10.27	32.87
Giza. 75	2.74	82.35	33.26	40.16	30.13	9.64	4.43	10.50	33.50
Suvin	3.13	71.94	26.85	36.94	22.89	10.65	4.37	10.57	33.64
Pima SI	2.97	70.24	23.58	34.62	23.67	10.03	4.17	10.90	32.93
Giza.75 x Sea	2.94	61.47	21.71	34.95	21.00	9.77	3.67	10.67	35.13
Testers									
Giza.94	3.51	89.27	32.32	35.96	26.53	12.04	4.40	10.35	33.90
Giza. 86	3.67	73.79	26.45	35.98	20.01	11.81	4.40	10.47	34.10
Giza. 97	3.37	104.21	37.54	36.00	30.92	11.45	4.00	10.90	33.30
L.S.D.0.05	0.498	18.41	7.105	1.865	5.081	1.111	0.459	0.432	0.802
L.S.D.0.01	0.662	24.48	9.450	2.480	6.757	1.478	0.610	0.575	1.066

** and** Significant at 5% and 1% levels of probability, respectively*

Table 3. Mean performances values of F1 crosses with respect to yield, yield components and fiber traits

S.L.	B.W.	S.C.Y./P	L.C.Y./P	L.%	No b\P	S. I	F. F	F. S	2.5% S.L.
Giza.94 x Giza.92	3.35	124.56	48.30	38.79	37.39	10.71	4.53	10.40	34.27
Giza.94 x Giza.85	3.30	114.81	41.43	36.10	34.74	10.97	4.87	10.07	33.87
Giza.94 x Giza.75	3.19	105.67	39.22	37.12	34.03	11.78	4.33	10.40	33.73
Giza.94 x Suvin	3.04	121.19	46.22	38.14	39.86	10.61	4.63	10.17	34.07
Giza.94 x Pima S_6	2.87	95.66	36.17	37.85	23.91	9.92	4.37	10.23	33.93
Giza.94 x (Giza. 75 x Sea)	3.37	70.95	25.12	35.45	20.37	11.48	4.40	10.30	34.73
Giza.86 x Giza.92	3.11	86.04	31.13	36.20	26.87	11.74	4.10	10.50	34.33
Giza.86 x Giza.85	2.92	116.26	42.39	36.45	39.82	12.38	4.27	10.27	33.13
Giza.86 x Giza.75	2.92	107.69	40.33	37.41	36.85	12.73	4.20	10.17	33.27
Giza.86 x Suvin	2.90	104.93	37.02	35.41	36.19	12.14	4.83	10.07	33.50
Giza.86 x Pima S_6	3.20	109.74	39.10	35.68	34.63	10.60	4.40	10.43	34.13
Giza.86 x (Giza. 75 x Sea)	2.78	120.45	45.42	37.70	43.53	11.81	4.30	10.63	34.10
Giza.97 x Giza.92	3.27	99.06	39.00	39.37	30.32	10.77	4.67	10.33	33.80
Giza.97 x Giza.85	3.15	122.35	47.10	38.51	38.99	10.03	4.43	10.33	33.97
Giza.97 x Giza.75	2.72	109.76	39.50	35.98	40.80	10.78	4.30	10.60	33.83
Giza.97 x Suvin	3.40	104.66	41.03	39.21	30.83	10.86	3.97	10.63	34.07
Giza.97 x Pima S_6	3.80	91.49	33.87	37.02	24.09	11.77	4.50	10.27	33.47
Giza.97 x (Giza. 75 x Sea)	3.62	97.58	33.68	34.85	27.34	11.00	4.50	10.60	34.50
L.S.D. 0.05	0.498	18.41	7.105	1.865	5.081	1.111	0.459	0.432	0.802
L.S.D .0.01	0.662	24.48	9.450	2.480	6.757	1.478	0.610	0.575	1.066

3.2 Combining Ability Effects

3.2.1 General Combining Ability (GCA) effects

The values of GCA effects for the parents (lines and testers) are presented in Table 4. Positive and negative GCA effects were observed between lines and testers for all studied traits. One lines for boll weight, seed cotton yield/plant, lint cotton yield/plant, lint percentage,and2.5% span length ,Also, two lines for number of bolls per plant and seed index were showed positive and highly significant GCA effects, indicating predominance of additive genes for these traits Rajeev and Patil [27].The line Giza75 x Sea had the highest negative and significant GCA effect for seed cotton yield/plant and lint percentage .while the other lines shown undesirable values for GCA effects and declare a poor general combiner for all studied traits. The genotypes Giza85 and Giza 86 showed significant GCA effects in positive direction and revealed as good among testers for number of bolls/plant and seed index, seed cotton yield/plant, lint cotton yield/plant and number of bolls/plants for genotypes Giza85and Giza86, also the genotype Giza97for boll weight. While the genotype Giza86 for boll weight and lint percentage, Giza97 for seed index. Those genotypes showed significant GCA effects in negative direction. Similar studies were reported by Yehia et al. [28]; EL-Hashash [29] and Usharani et al. [3].

3.2.2 Specific Combining Ability (SCA) effects

The estimates of SCA effects for F_1 crosses are given in Table 5.Out of 18F_1 crosses studied, two crosses for seed cotton yield per plant, and number of bolls/plant and one cross for each of lint percentage, seed index and fiber fineness traits, showed significant or highly significant SCA effects in desired direction. The estimates of SCA effect reveled that none of the hybrids was consistently provide to be superior for all studied traits. On the other hand, the significant or insignificant SCA effects in undesired types in these combinations EL-Hashash [29]. The specific combining ability effect (SCA) provides information which is useful to classify new cross combination. The highest positive SCA values and best cross, namely Giza 86 x (Giza 75 x sea) for seed cotton yield plant, line cotton yield/plant, lint percentage and number of bolls /plant traits followed the cross Giza 94 x Giza 92 for traits seed cotton/ yield, lint cotton yield/ plant and number of bolls/plants, indicating the non-additive and additive x non- additive types of interaction were significantly higher among hybrids, thus non-additive gene action could be exploited by heterosis breeding Comparable findings were given by Khokhar et al. [6] and Rajeev and Patil [27]. High yielding hybrids also possessed high SCA effects, high heterosis as well as high presence performance for most of its yield contributing characters. This appeared appropriate as yield being a complex character depends on a number of its component traits Bilwal et al. [30]. Mentioned that the good general combining parents may not necessarily always produce good specific combinations for different traits. Most of crosses with high SCA have at least highest one GCS parent. Therefore, high x low, low x high and in some cases high x high GCS parents performed well in SCA determination and revealed general combiners have best mean performance El-Hashash [29]. The best general combiners best specific combination for seed cotton yield/plant Rajeev and Patil [27] and Yehia and EL-Hashash [31] only one cross. In this study, all crosses either involved poor x good, poor x poor or good x poor GCA combination. The good x good GCA combination could be due to additive and additive types of gene action which is fixable on nature which had significant SCA effects for studied traits. Yahia [32]; Sorour et al. [33], Chinchane et al. [26] and Yehia and EL-Hashash [34]. This study suggested that information of GCA effects of parent should be considered along with SCA effects and presence performance of hybrid for predicting the value of any hybrid. It is desirable to search out parental lines with high GCA effects and low sensitivity to environmental variation in a crop improvement program Bilwal et al. [30].

3.3 Heterosis

Heterosis estimates with respect to mid-parents and better patent for studied traits are given in Tables 6 and 7. Outside F_1;S crosses (18). 3 and 2 crosses for boll weight; 16 and 2 crosses for seed cotton yield/plant; 17and 13 crosses for lint cotton yield/plant; 10and 8 crosses for lint percentage; 14 and 13 crosses for number of bolls /plants; 10 and 2 crosses for seed index; 10 and 6 crosses for fiber fineness; 12 and 5 crosses for 2.5% span length showed positive and significant heterosis to mid-parents and better parent, respectively. As for fiber strength, 13 and 16 crosses had negative and significant heterosis relative to mid-parents and better parent, respectively. On the other hand, the other crosses had undesirable heterosis relative to mid-parents and better parent for all studied traits. The estimates of heterosis revealed that, none of hybrids was consistently proved to be superior for all traits. The present study confirms the findings of Bankar et al. [35] and Patil and Patil [7] who had reported significant heterosis for all studied traits. From the results we can concluded that, two crosses, Giza 94 x Giza92 and Giza 97 x Suvin for yield and its components traits and the two crosses Giza97 x Pima S_6 and 97 x (Giza 75 x Sea) for yield and fiber traits exhibited the best heterosis versus mid- parents and better parents Table 6 and 7 these crosses can be introduced into the cross-breeding program with multipurpose objectives to improve both yield and fiber quality traits for cotton in Egypt. The results indicate, the importance of low* average and high*high parents, combinations in the development of crosses exhibiting high level of hybrid vigor for yield and yield related traits.

Table 4. Predicted General Combining Abilities (GCA) effects for lines and testers with respect to yield, yield components and fiber properties

Traits	B.W.	S.C.Y./P.	L.C.Y./P	L.%	N o B\P	S. I	F. F	F. S	2.5% S.L.
Lines									
Giza. 92	0.0804	-2.494	0.2543	1.051**	-1.839	-0.154	0.011	0.056	0.206
Giza. 85	-0.0374	12.099**	4.415**	-0.051	4.485*	-0.101	0.100	-0.133	-0.272
Giza. 75	-0.2163*	1.993	0.460ns	-0.231	3.861	0.536*	-0.144	0.033	-0.317
Suvin	-0.048	4.544	2.197	0.515	2.264	-0.024	0.055	-0.067	-0.05
Pima SI	0.127	-6.752	-2.841	-0.217	-5.820**	-0.462*	0.001	-0.044	-0.083
Giza.75 x Sea	0.0948	-9.385*	-4.485**	-1.067**	-2.951	0.204	-0.022	0.156	0.517**
SE	0.1019	3.7575	1.4503	0.381	1.927	0.2268	0.094	0.0879	0.1637
Testers									
Giza.94	0.0254	-0.243	0.185	0.172	-1.647	-0.313	0.1	-0.094	0.172
Giza. 86	-0.1907*	1.806	0.009	-0.593*	2.952*	0.673**	-0.072	-0.011	-0.183
Giza. 97	0.1654*	-1.563	-0.195	0.421	-1.305	-0.360*	-0.028	0.1056	0.011
SE	0.072	2.657	1.026	0.269	1.363	0.1604	0.066	0.062	0.1158

** and** Significant at 5% and 1% levels of probability, respectively*

Table 5. Predicted specific combining abilities (SCA) effects for yield, yield components and fiber properties of hybrids

F1 crosses	B.W.	S.C.Y./P.	L.C.Y./P	L.%	N o b\P	S. I	F. F	F. S	2.5% S.L.
Giza.94 x Giza.92	0.0791	21.5828**	8.6335**	0.499	7.5113*	-0.0456	0.001	0.0833	-0.0389
Giza.94 x Giza.85	0.1535	-2.7583	-2.3976	-1.09	-1.4598	0.1544ns	0.244	-0.0611	0.0389
Giza.94 x Giza.75	0.2224	-1.7972	-0.6487	0.113	-1.5487	0.3311	-0.044	0.1056	-0.05
Giza.94 x Suvin	-0.0954	11.1717	4.6113	0.381	5.8813	-0.2789	0.056	-0.0278	0.0167
Giza.94 x Pima S_6	-0.4476*	-3.0628	-0.3943	0.823	-1.9876	-0.5278	-0.156	0.0167	-0.083
Giza.94 x (Giza. 75 x Sea)	0.088	-25.1361**	-9.8043**	-0.727	-8.3965*	0.3667	-0.1	-0.1167	0.117
Giza.86 x Giza.92	0.0585	-18.9894**	-8.3537**	-1.326*	-7.607*	-0.0083	-0.261	0.1	0.383
Giza.86 x Giza.85	-0.017	-3.3506	-1.2548	0.022	-0.9815	0.585	-0.183	0.0556	-0.339
Giza.86 x Giza.75	0.1685	-1.8194	0.6407	1.167	-3.3304	0.295	-0.006	-0.2111	-0.161
Giza.86 x Suvin	-0.0226	-7.1339	-4.4126	-1.583*	-2.387	0.265	0.428*	-0.2111	-0.194
Giza.86 x Pima S_6	0.1019	8.975	2.7119	-0.574	4.1374	-0.8406*	0.05	0.1333	0.472
Giza.86 x (Giza. 75 x Sea)	-0.2893	22.3183**	10.6685**	2.296**	10.1685**	-0.2961	-0.028	0.1333	-0.161
Giza.97 x Giza.92	-0.1376	-2.5933	-0.2798	0.827	0.0957	0.0539	0.2611	-0.1833	-0.344
Giza.97 x Giza.85	-0.1365	6.1089	3.6524	1.068	2.4413	-0.7394	-0.061	0.0056	0.3
Giza.97 x Giza.75	-0.3909*	3.6167	0.008ns	-1.279	4.8791	-0.6261	0.05	0.1056	0.211
Giza.97 x Suvin	0.118	-4.0378	-0.1987	1.202	-3.4943	0.0139	-0.483**	0.2389	0.178
Giza.97 x Pima S_6	0.3457	-5.9122	-2.3176	-0.249	-2.1498	1.3683**	0.106	-0.15	-0.389
Giza.97 x (Giza. 75 x Sea)	0.2013	2.8178	-0.8643	-1.569*	-1.772	-0.0706	0.128	-0.0167	0.044
SE	0.1764	6.5081	2.5120	0.660	3.3375	0.3928	0.162	0.1523	0.284

** and** Significant at 5% and 1% levels of probability, respectively*

Table 6. Mid parent heterosis values for yield, yield components and fiber traits

F_1 crosses	B.W.	S.C.Y./P	L.C.Y./P	L.%	N o B\P	S. I	F. F	F. S	2.5% S.L.
Giza.94 x Giza.92	0.8	60.64**	71.16**	6.9**	57.05**	1.15	13.33**	-2.27**	1.68**
Giza.94 x Giza.85	-0.2	45.57**	51.6**	5.3**	42.85**	0.NS	10.61**	-2.34**	1.45**
Giza.94 x Giza.75	2.13	23.14**	19.6**	-2.46**	20.12**	8.71**	-1.89	-0.24	0.1NS
Giza.94 x Suvin	-8.33**	50.34**	56.22**	4.64**	61.35**	-6.46**	5.7**	-2.79**	0.88*
Giza.94 x Pima S_6	-11.52**	19.94**	29.42**	7.25**	-4.73NS	-10.05**	1.95	-3.69**	1.55**
Giza.94 x (Giza. 75 x Sea)	4.44	-5.86	-7.01	-0.02	-14.27*	5.32**	9.09**	-1.98**	0.63
Giza.86 x Giza.92	-8.53***	23.27**	23.15**	-0.28	30.75**	12.01**	2.5	-1.87**	1.58**
Giza.86 x Giza.85	-13.96**	63.47**	73.81**	6.27**	89.05**	14.68**	-3.03*	-0.96	-1.05**
Giza.86 x Giza.75	-8.84***	37.95**	35.1**	-1.74*	46.97**	18.71**	-4.91**	-3.02**	-1.58**
Giza.86 x Suvin	-14.71**	44.01**	38.91**	-2.89**	68.75**	8.1**	10.27**	-4.28**	-1.09**
Giza.86 x Pima S_6	-3.61	52.4**	56.33**	1.08	58.58**	-2.95	2.72	-2.34**	1.84**
Giza.86 x (Giza. 75 x Sea)	-16.03**	78.12**	88.62***	6.3**	112.32**	9.42**	6.61**	0.63	-1.49**
Giza.97 x Giza.92	0.56	16.54**	26.52**	8.42**	16.57**	4.56**	22.81**	-5.34**	1.2**
Giza.97 x Giza.85	-2.72	41.72**	57.31**	12.24**	47.01**	-5.56**	5.56**	-2.36**	2.67**
Giza.97 x Giza.75	-11.06**	17.67**	11.56**	-5.52**	33.65**	2.23	-3.01	-0.93	1.3**
Giza.97 x Suvin	4.46*	18.83**	27.43**	7.5**	14.59**	-1.73	-9.16**	-0.93	1.78**
Giza.97 x Pima S_6	19.81**	4.89	10.83**	4.85**	-11.75*	9.66**	8**	-5.81**	1.06**
Giza.97 x (Giza. 75 x Sea)	14.72**	17.8**	13.68**	-1.76*	5.3	3.69*	12.5**	-1.7**	0.83*
L.S.D. 0.05	0.610	15.94	6.153	1.615	26.400	0.962	0.397	0.374	0.694
L.S.D .0.01	0.811	21.20	8.184	2.148	35.112	1.280	0.529	0.498	0.923

** and** Significant at 5% and 1% levels of probability, respectively*

Table 7. Better parent heterosis values for yield, yield components and fiber traits

F_1 crosses	B.W.	S.C.Y./P.	L.C.Y./P	L.%	N o b\P	S. I	F. F	F. S	2.5 S.L.
Giza.94 x Giza.92	-4.65	-4.65	49.43**	5.94**	40.95**	-10.99**	3.03	-4.88***	1.08**
Giza.94 x Giza.85	-5.89*	-5.89*	28.18**	0.4	30.98**	-8.89**	10.61**	-2.74***	-0.1
Giza.94 x Giza.75	-9.02**	-9.02**	17.91**	-7.57**	12.93*	-2.13	-2.26	-0.95	-0.49
Giza.94 x Suvin	-13.3**	-13.3**	43**	3.25**	50.28**	-11.85**	5.3**	-3.79***	0.49
Giza.94 x Pima S_6	-18.33**	-18.33**	11.92**	5.26**	-9.86	-17.56**	-0.76	-6.12***	0.1
Giza.94 x (Giza. 75 x Sea)	-3.99NS	-3.99	-22.28**	-1.42	-23.21**	-4.6**	0.001	-3.44***	-1.14**
Giza.86 x Giza.92	-15.26**	-15.26**	17.72**	-1.14	27.41**	-0.62	-6.82**	-3.96**	0.68
Giza.86 x Giza.85	-20.53**	-20.53**	60.3**	1.29	80.05**	4.85**	-3.03	-1.91**	-2.83**
Giza.86 x Giza.75	-20.35**	-20.35**	21.25**	-6.86**	22.28**	7.79**	-5.26**	-3.17**	-2.44**
Giza.86 x Suvin	-20.98**	-20.98**	37.86**	-4.14**	58.14**	2.79	9.85**	-4.73**	-1.76**
Giza.86 x Pima S_6	-12.81**	-12.81**	47.86**	-0.83	46.32**	-10.27**	0NS	-4.28**	0.1
Giza.86 x (Giza. 75 x Sea)	-24.34**	-24.34**	71.73**	4.78**	107.33**	-0.03	-2.27	-0.31	-2.94**
Giza.97 x Giza.92	-3.06	-3.06	3.89	7.51**	-1.96	-5.94**	16.67**	-5.49***	0.9*
Giza.97 x Giza.85	-6.52*	-6.52*	25.45**	6.95**	26.08**	-12.41**	0.76	-5.2***	2**
Giza.97 x Giza.75	-19.37**	-19.37**	5.2	-10.42**	31.94**	-5.85**	-3.01	-2.75***	1*
Giza.97 x Suvin	0.69	0.69	9.28**	6.15**	-0.3	-5.15**	-9.16**	-2.45***	1.27**
Giza.97 x Pima S_6	12.65**	12.65**	-9.78**	2.83**	-22.1**	2.85	8**	-5.81***	0.5
Giza.97 x (Giza. 75 x Sea)	7.41**	7.41**	-10.29**	-3.19**	-11.6*	-3.9*	12.5**	-2.75***	-1.8**
L.S.D. 0.05	0.610	15.94	6.153	1.615	26.400	0.962	0.397	0.374	0.694
L.S.D .0.01	0.811	21.20	8.184	2.148	35.112	1.280	0.529	0.498	0.923

** and** Significant at 5% and 1% levels of probability, respectively*

Thus, it can be concluded that the parents possessing only high values need not necessarily produce high yielding hybrids as indicated by the present study, Yehia, et al. [36] and El-Hashash [8] and Sorour et al. [33] reported that some crosses exhibited significant or highly significant positive heterosis over mid-parents for yield, yield components and fiber traits, While, the heterosis over better parent exhibited insignificant positive and desirable for all studied traits. The significant negative heterosis suggested the importance of additive genetic components EL-Hashash [8] and Yehia and EL-Hashash [31]. Useful and significant heterosis over mid- parents and better parent were observed for yield, and yield components by Babu et al. [37] and Bilwal et al. [30] and for fiber quality traits by Babu et al. [37].

4. CONCLUSIONS

Cotton textile sector demand better yield and high-quality cotton, for this reason improvement of yield and fiber quality is one of the improvement 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 variance was significant for most traits except boll weight, seed index, fiber fineness and fiber strength and non-additive gene effects for boll weight, lint percentage, number of bolls/plant and seed index. Among the parents, Giza 75 for cotton seed yield/plant, lint cotton yield/plant, lint percentage and number of bolls/plants, Giza97 for seed cotton yield/plant, lint cotton yield/plant and fiber fineness, Giza92 and Giza 75 x Sea for fiber traits. Also, Giza 85 and Giza 86 for yield and yield components were detected with higher GCA. Specific combining ability (SCA) was significant for Giza 86 x (Giza 75 x Sea) and Giza 94 x Giza 92 hybrid combinations for yield with acceptable fiber quality. Two crosses Giza 94 x Giza 92 and Giza 97 x Suvin exhibited the best heterosis versus mid-parent and better parent for yield and its components while, two crosses Giza 97 x Pima S_6 and Giza 97 x (Giza 75 x Sea) exhibited best heterosis versus mid-parent and better parent for yield fiber quality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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