Combining Ability, Heterosis and Genetic Parameters Estimates for Yield and Its Related Traits Using Line × Tester Mating Design in Egyptian Cotton (*Gossypium barabadense* L.)

Elsayed I.M. Mansour[1]; Samy Sh. El-Tabbakh[2]; Waleed M.B. Yehia[1]; and Mona M. Hemeid[2]

ABSTRACT

This investigation was carried out at the experimental farm of Faculty of Agriculture, Alexandria University, during 2018 and 2019 summer growing seasons. The objectives of this study were to determine some genetic parameters of some cotton genotypes for yield and yield components traits under two levels of nitrogen fertilizer through line x tester mating design. Ten parental genotypes (seven lines and three testers) along with their 21 F_1 crosses were arranged in two experiments of randomized complete block design (RCBD) with three replications. Genotypic, parental, crosses, parent vs crosses, lines, testers and line x tester variances were significant or highly significant for all the studied traits under both nitrogen fertilizer levels. The variance due to General combining ability (GCA) of parents (lines and testers) and specific combining ability (SCA) of crosses was significant for most of the studied traits, indicating the importance of both additive and dominance effects in controlling these traits. Values of GCA and SCA effects showed that the parents and some crosses gave desirable and significant GCA and SCA effects under two levels of nitrogen fertilizer. The high mean performance estimates and significant GCA effects were observed for the (G94 and G97) lines and (G90 x Aust.) tester for most of yield and yield components traits, so these parents can be used for generating good cotton hybrids. The highest values of mean performance, desirable SCA effects and highest heterosis values were detected in the combinations (G97 x (G90 x Aust.), G93 x (G90 x Aust.), G96 x (G90 x Aust.), (G92 x G86) and (G94 x G86) for the most studied traits under the two levels of nitrogen fertilizer (30 and 60 kg N/ feddan) and these crosses can be considered the promising crosses to be used in breeding program to produce new cotton hybrids and improve of yield and yield component traits.

Keywords: cotton, combining ability, heterosis, genetic parameters and yield.

INTRODUCTION

Cotton is considered the most important fiber crop all over the world, cotton seeds are an important source of vegetable oil in Egypt, and it is the best agricultural national income crop. However, in recent years, the area of cotton in Egypt has been subjected to a steady decline for many reasons such as high production cost which led to the reluctance of farmers to cultivate it and a decline in Egypt's global share of excellent long-staple cotton. Therefore, efforts are being made to increase production capacity, improve technological quality and reduce production costs. Combining ability studies is one such technology to select the superior genotypes. It helps in identifying the best combiners that may be used in crosses either to exploit heterosis or to accumulate fixable genes and obtain desirable segregants. Line x tester mating design provides reliable information about the general and specific combining ability (GCA) and (SCA) of parents and their crosses combinations and helps estimate various types of gene effects (Kempthorne, 1957). The important step of promising new hybrids production is to select specific parents (Reddy *et al*., 2017; Sultan, *et al.*, 2018 and Yehia & El-Hashash, 2019). Many plant breeders have been used the line x tester analysis in the investigation of general and specific combining ability effects, heterosis and to divide the genetic variance into its components (Guven & Sadet, 2021 and Hamed & Said, 2021). The goal of this research was to assess heterosis, combining ability, gene action for yield and its components in some crosses belong to *Gossypium barbadense* L. to determine the good combiner from parents to starting a breeding program and select the crosses has a good specific combining ability to use it as a promising crosses or use this crosses in the breeding program to produce a new genetic recombination's.

MATERIALS AND METHODS

Genetic materials:

The genetic materials used in this investigation included ten parental genotypes belong to (*Gossypium barbadense* L.). Seven lines (G87, G88, G92, G93, G94, G96 and G97) and three testers (G45, G86 and G90 x

---

DOI: 10.21608/asejaiqjsae.2025.466811

[1]Cotton Research Institute, Agriculture Research Center (ARC), Giza 12619, Egypt.

[2]Department of Crop Science, Faculty of Agriculture, Alexandria University, Alexandria, Egypt.

Received, October 9, 2025, Accepted, November 19, 2025.

Aust.) were involved in a series of hybridization according to line x tester mating design in the first season 2018 to generate 21 single crosses. In 2019 season, two field experiments were conducted in two nitrogen fertilizer levels, i.e. 60 kg/feddan (N1) and 30 kg/feddan (N2). Both experiments were arranged in a randomized complete block design (RCBD) with three replications for each level. Each plot was represented by one row of 4meter long and 0.7 meter wide. Plants within rows were 0.4 m (Area = 2.8 m^2). Hills were thinned to one plant per hill; allowing of 10 plants per plot. Data were recorded on individual five plants randomly chosen from each plot in the middle of the row for F1 and their parents. The studied traits were seed cotton yield (g) /plant (S.C.Y. /P.), Lint cotton yield (g)/plant (L.C.Y. /P.), Boll weight (g) (B.W.), Number of bolls /plant (N. B. /P), Lint percentage (L.P. %), Seed index (g) (S.I.), Lint index (L. I.) and Number of seeds /boll (N. S. /B.).

Statistical analysis:

The analysis of variance was carried out according to Gomez and Gomez (1984) for determining differences among the genotypes, whereas combining ability variances and effects were determined according to statistical methods developed by Kempthorne (1957) and heterosis by Fehr (1987). Heritability was computed in both broad (h^2_b) and narrow (h^2_n) senses according to Burton (1952).

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance of all studied traits for the ten parents and their 21 F_1crosses under the two levels of nitrogen fertilizer is presented in Table (1). The results showed that genotypes, parents, crosses, parents *vs.* crosses, lines, testers and line x tester recorded highly significant for all studied traits except for lint percent of parent vs. crosses under the N1 and N2 levels, as well as number of seeds per boll of parent vs. crosses and testers under N1 level. These results of mean squares for the yield traits refer to that these parental genotypes were properly selected in order to improve yield and yield component traits, and the great number of variances among the parental genotypes would generate a great value of heterosis in the F_1 hybrids, that enrich the selection process of new superior genotypes. Results also showed that GCA/SCA values were less than unity and which referred to the importance of SCA for all the studied traits. Similar results were obtained by Baloch *et al.* (2014); Balcha *et al.* (2019); Samak *et al.* (2022); Yehia & El-Hashash (2022) and Farooq *et al*. (2023).

The mean performance of genotypes:

Mean performance of the parents (lines and testers) and twenty-one F1 hybrids for yield and yield component traits under the two nitrogen fertilizer levels (N1 and N2) is presented in Tables (2 and 3). The data regarding the average performance of twenty-one F1 hybrids along with their ten parents indicated that the F1 hybrids gave higher and some hybrids showed higher mean values than their parents (lines and testers) for all the traits studied.

The parents G.97and G.94 gave the highest mean value for most traits under the two levels of nitrogen fertilizer N1 and N2.

Table 1. Mean squares of yield and yield component traits under the two nitrogen fertilizer levels.

S.O. V	d.f	Seed cotton yield /plant		Lint cotton yield /plant		Boll weight		Number of bolls / plant	
		N1	N2	N1	N2	N1	N2	N1	N2
Replications	2	767.62**	1961.26**	197.57**	235.02**	0.10**	0.17**	25.38*	103.77**
Genotypes	30	1933.05**	1878.80**	427.84**	327.29**	0.20**	0.19**	106.53**	115.06**
Parents	9	2289.13**	2283.72**	475.67**	420.35**	0.39**	0.31**	105.47**	124.10**
Crosses	20	1562.21**	1491.68**	374.86**	273.15**	0.09**	0.14**	96.71**	90.08**
Par. vs. crosses	1	6145.01**	5976.78**	1056.85**	572.70**	0.56**	0.15**	312.55**	533.26**
Lines	6	336.56**	569.61**	262.57**	123.30**	0.03**	0.08**	19.89**	71.48**
Testers	2	10487.6**	9016.78**	1911.78**	1433.79**	0.19**	0.57**	729.83**	517.06**
Lines x testers	12	687.47**	698.54**	174.86**	154.63**	0.10**	0.10**	29.60**	28.21**
Error	60	40.17	40.98	6.32	5.63	0.01	0.01	5.48	5.75
δ2 G C A		22.78	20.65	5.21	3.09	-0.0004	0.0011	1.7477	1.611
δ2 S C A		215.77	219.19	56.18	49.67	0.032	0.03	8.04	7.49
δ2 G C A / δ2 S C A		0.105	0.094	0.092	0.062	-0.013	0.037	0.217	0.215

N1 (60 kg N/fed.) and N2 (30 kg N/fed.) the two nitrogen levels, *, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively.

Table 1 Cont. Mean squares of yield and yield component traits under the two nitrogen fertilizer levels.

S.O. V	d.f	Lint percent (%)		Seed index		Lint index		No. of Seeds/Boll	
		N1	N2	N1	N2	N1	N2	N1	N2
Replications	2	15.12	0.29	1.71**	0.87**	3.09**	0.35*	3.21*	0.64
Genotypes	30	32.04**	19.33**	1.10**	1.39**	3.06**	1.68**	7.84**	9.42**
Parents	9	24.62**	18.32**	1.42**	1.51**	2.66**	1.86**	8.86**	8.94**
Crosses	20	35.94**	20.69**	0.75**	0.90**	3.06**	1.58**	7.74**	9.50**
Par. vs. crosses	1	20.93	1.3	5.20**	10.11**	6.82**	2.03**	0.52	12.13**
Lines	6	62.56**	40.75**	0.81**	0.91**	4.36**	3.03**	7.13**	6.88**
Testers	2	36.57**	20.98**	0.78**	2.01**	1.98*	0.58**	2.22	28.87**
Lines x testers	12	22.53**	10.62**	0.72**	0.72**	2.59**	1.03**	8.96**	7.59**
Error	60	5.836	1.753	0.041	0.072	0.412	0.096	0.91	0.641
δ2 G C A		0.349	0.262	0.001	0.005	0.012	0.015	-0.032	0.05
δ2 S C A		5.563	2.955	0.226	0.215	0.725	0.311	2.683	2.315
δ2 G C A / δ2 S C A		0.063	0.089	0.004	0.02	0.017	0.047	-0.01	0.02

N1 (60 kg.) and N2 (30 kg.) the two nitrogen levels, *, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively.

Table 2. Mean performance of ten genotypes (lines and testers) for yield and yield component traits under the two levels of nitrogen fertilizer

Character / Genotype	Seed cotton yield /plant(g)		Lint cotton yield /plant(g)		Boll weight (g)		Number of bolls / plants	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 87 (L1)	91.67	74.33	30.43	24.44	2.51	2.49	36.56	29.87
G. 88 (L2)	105.33	89.33	36.19	30.34	2.81	2.72	37.45	32.81
G. 92 (L3)	116	94.67	38.89	30.71	3.13	3.05	37.1	31.08
G. 93 (L4)	76.33	70	26.25	23.17	2.6	2.55	29.29	27.5
G. 94 (L5)	133.33	124.33	53.52	48.08	3.37	3.19	39.52	38.94
G. 96 (L6)	130.67	119	49.49	43.23	3.16	3.07	41.35	38.79
G. 97 (L7)	143	134	57.53	51.34	3.44	3.27	41.61	40.94
G. 45 (T1)	55.33	47.67	17.95	15.15	2.47	2.4	22.38	19.87
G. 86 (T2)	113	109	41.3	38.62	3.15	3.03	35.87	35.94
G 90 x Aust. (T3)	127	116.33	47.89	42.55	3.25	3.14	39.11	37.07
LSD 0.05	10.35	10.46	4.1	3.88	0.15	0.14	3.82	3.92
Character / Genotype	**Lint percent (%)**		**Seed index**		**Lint index**		**No. of Seeds/Boll**	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 87 (L1)	33.2	32.88	10.12	9.65	5.03	4.73	16.54	17.29
G. 88 (L2)	34.36	33.98	10	9.22	5.23	4.75	18.46	19.48
G. 92 (L3)	33.52	32.43	9.65	9.39	4.87	4.51	21.54	21.93
G. 93 (L4)	34.38	33.07	10.23	9.36	5.36	4.63	16.7	18.22
G. 94 (L5)	40.15	38.65	10.56	9.74	7.08	6.14	19.13	20.11
G. 96 (L6)	37.88	36.29	9.17	8.61	5.59	4.92	21.42	22.73
G. 97 (L7)	40.24	38.3	10.15	9.82	6.83	6.1	20.25	20.57
G. 45 (T1)	32.44	31.75	8.24	7.46	3.96	3.47	20.25	21.95
G. 86 (T2)	36.55	35.43	10.18	9.62	5.87	5.28	19.62	20.34
G 90 x Aust. (T3)	37.71	36.58	10.34	9.25	6.26	5.34	19.6	21.54
LSD 0.05	3.95	2.16	0.33	0.44	1.05	0.51	1.56	1.31

N1 and N2 are the two nitrogen levels (60 kg and 30 kg), respectively.

Table 3. Mean performance of F1 for yield and yield component traits under the two levels of nitrogen.

Characters / Genotypes	Seed cotton yield /plant (g)		Lint cotton yield /plant (g)		Boll weight (g)		Number of bolls / plants	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 87 x G. 45	101.00	87.7	34.27	29.09	3.29	2.82	30.7	31.1
G. 87 x G. 86	131.00	112.7	46.36	39.04	3.1	2.82	42.26	39.94
G. 87 x (G. 90 x Aust.)	133.70	118	48.79	41.94	3.1	2.82	43.33	41.87
G. 88 x G. 45	121.70	122.7	46.37	38.27	3.2	2.93	37.94	41.77
G. 88 x G. 86	124.00	119.7	47.46	38.31	3.15	2.79	39.38	42.87
G. 88 x (G. 90 x Aust.)	137.00	127	46.49	36.37	3.03	2.94	45.2	43.14
G. 92 x G. 45	94.70	93	31.67	30.63	3.12	2.71	30.36	34.29
G. 92 x G. 86	142.70	143.7	52.67	52.12	3.29	3.22	43.33	44.62
G. 92 x (G. 90 x Aust.)	127.70	118.3	36.74	37.55	3.03	2.88	42.09	41.22
G. 93 x G. 45	92.00	79.3	31.05	26.03	2.89	2.73	31.77	28.82
G. 93 x G. 86	112.00	99.7	41.11	36.44	2.96	2.99	37.81	33.35
G. 93 x (G. 90 x Aust.)	155.00	139	56.33	47.71	3.29	3.3	47.11	42.11
G. 94 x G. 45	104.00	96.3	40.1	33.8	2.86	2.65	36.37	36.19
G. 94 x G. 86	158.30	143.3	63.14	54.89	3.42	3.3	46.34	43.42
G. 94 x (G. 90 x Aust.)	141.30	138.3	62.28	53.04	3.33	3.25	42.42	42.58
G. 96 x G. 45	101.30	82.7	36.22	28.66	3.05	2.87	33.3	28.86
G. 96 x G. 86	115.30	106.3	49.23	39.09	3.15	2.97	36.66	35.77
G. 96 x (G. 90 x Aust.)	161.00	142	64.75	54.15	3.45	3.33	46.72	42.71
G. 97 x G. 45	100.00	84.7	35.65	29.6	2.94	2.85	34.05	29.58
G. 97 x G. 86	138.30	113	51.17	37.56	3.2	3.02	43.18	37.41
G. 97 x (G. 90 x Aust.)	165.70	148	68.47	57.22	3.41	3.3	48.54	44.86
LSD 0.05	10.35	10.46	4.1	3.88	0.15	0.14	3.82	3.92

N1and N2 are the two nitrogen levels (60 kg and 30 kg), respectively.

Table 3 Cont. Mean performance of F1 for yield and yield component traits under the two levels of nitrogen.

Characters / Genotypes	Lint percent (%)		Seed index (g)		Lint index (%)		No. of Seeds/Boll	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 87 x G. 45	33.96	33.23	9.92	9.9	5.1	4.93	21.89	18.99
G. 87 x G. 86	36.3	34.72	10.01	9.15	5.94	4.87	19.75	20.1
G. 87 x (G. 90 x Aust.)	36.5	35.57	10.82	10.73	6.22	5.92	18.19	16.97
G. 88 x G. 45	38.42	31.35	10.76	10.3	6.74	4.72	18.34	19.57
G. 88 x G. 86	38.28	32.34	9.53	9.14	5.91	4.37	20.39	20.63
G. 88 x (G. 90 x Aust.)	33.94	28.65	9.66	9.27	4.96	3.72	20.77	22.68
G. 92 x G. 45	33.46	32.93	10.26	10.07	5.17	4.95	20.21	18.05
G. 92 x G. 86	36.88	36.26	10.58	9.53	6.19	5.42	19.64	21.53
G. 92 x (G. 90 x Aust.)	28.76	31.73	10.27	9.27	4.15	4.32	21.04	21.22
G. 93 x G. 45	33.79	32.82	10.97	10.26	5.6	5.01	17.45	17.87
G. 93 x G. 86	36.51	36.37	11.19	10.51	6.56	6.02	16.79	18.07
G. 93 x (G. 90 x Aust.)	36.32	34.32	10.64	10.26	6.08	5.36	19.72	21.14
G. 94 x G. 45	38.4	34.99	10.91	10.59	6.88	5.7	16.17	16.25
G. 94 x G. 86	39.89	38.36	9.41	9.01	6.25	5.62	21.83	22.59
G. 94 x (G. 90 x Aust.)	44.08	38.35	10.73	10.12	8.46	6.29	17.38	19.8
G. 96 x G. 45	35.74	34.67	10.49	10.59	5.83	5.62	18.67	17.72
G. 96 x G. 86	42.68	36.81	10.4	10.23	7.76	5.96	17.34	18.34
G. 96 x (G. 90 x Aust.)	40.23	38.13	10.67	10.19	7.18	6.28	19.34	20.21
G. 97 x G. 45	35.64	34.88	9.94	9.49	5.51	5.09	19.04	19.58
G. 97 x G. 86	37.08	33.26	9.92	9.44	5.9	4.7	20.33	21.35
G. 97 x (G. 90 x Aust.)	41.33	38.66	10.7	10.21	7.54	6.44	18.75	19.83
LSD 0.05	3.95	2.16	0.33	0.44	1.05	0.51	1.56	1.31

N1and N2 are the two nitrogen levels (60 kg and 30 kg), respectively.

Among the F1 hybrids, the crosses maximum values were G. 94x G. 86, G. 94 x (G 90 x Aust.), G. 96 x (G 90 x Aust.) and G. 97 x (G 90 x Aust.) for most traits under the two levels of nitrogen fertilizer N1 and N2.

Combining ability

General combining ability (GCA):

The general combining ability effect for yield and yield component traits under the two nitrogen fertilizer levels is calculated and the results are presented in Table (4). The line G. 94 recorded highly significant G.C.A effects for most of the traits viz, seed cotton yield (8.00**,10.98**), lint cotton yield (8.01**,7.17**), number of bolls per plant (1.76**, 2.33**) and lint percentage (3.73**, 2.55**) at the two levels of nitrogen fertilizer. Also, the tester G 90 x Aust. Exhibited highly significant positive (G C A) effect under the two nitrogen fertilizer levels for the traits (S. C. Y.), (L C Y/P), (B.W) and (No. B. /P.) In addition, the tester G.86 exhibited a highly significant positive GCA (desirable) for seed cotton yield, lint cotton yield, number of bolls per plant and lint percentage traits at the levels N1 and N2. These results agreed with Dewdar (2011); Dahiphale *et al.* (2015); Bourgou *et al.* (2023); Raiz *et al.* (2023) and Reddy *et al.* (2023).

Specific combining ability (SCA):

Estimates of specific combining ability effects for yield and yield component traits under the two nitrogen fertilizer levels are presented in Table (5). The cross combinations (G. 88 x G. 45), (G. 92 x G. 86), (G. 93 x G. 90 x Aust.), (G. 94 x G. 86) and (G. 97 x G. 90 x Aust.) showed positive and significant SCA effects for most yield components. Similar results are in accordance with Iqbal *et al.* (2005); Gopikrishnan *et al.* (2013); Yehia & El-Hashash (2021); Abdel-Aty *et al.* (2022); Balci *et al.* (2023) and Bourgou *et al.* (2023).

Heterosis relative to mid-parents (M.P):

The results of heterosis relative to mid-parents for yield and yield component traits under the two levels of nitrogen fertilizer are presented in Table (6). The results for seed cotton yield per plant showed that 17 and 17 crosses from the 21 studied crosses exhibited significant positive heterosis in the N1 and N2 levels, respectively. The results, also showed that the highest heterosis values were recorded by the cross (G. 93 x G. 90 x Aust.) under the first level N1, and the cross (G. 88 x G. 45) under the second level N2, with the values of heterosis 52.46 and 79.08 %, respectively.

Table 4. Estimates of general combining ability effects for yield and yield component traits under the two nitrogen fertilizer levels.

Lines	Seed cotton yield /plant		Lint cotton yield /plant		Boll weight		Number of bolls / plants	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 87 (L1)	-4.67*	-8.90**	-4.02**	-3.38**	0.01	-0.16**	-1.19	-0.77
G. 88 (L2)	1	8.10**	-0.38	-2.42**	-0.03	-0.09**	0.9	4.19**
G. 92 (L3)	-4. 89 n.s	3.32	-6.80**	0.03	-0.01	-0.04	-1.35	1.64 n.s
G. 93 (L4)	-6.89**	-9.02**	-4.33**	-3.35**	-0.11**	0.03	-1.05	-3.64**
G. 94 (L5)	8.00**	10.98**	8.01**	7.17**	0.05	0.09**	1.76 n.s	2.33**
G. 96 (L6)	-0.67	-4.68 n.s	2.91**	0.56	0.06 n.s	0.08 n.s	-1.05	-2.62**
G. 97 (L7)	8.11**	0.21	4.60**	1.39	0.03	0.08 n.s	1.98 n.s	-1.12
LSD 0.05	4.23	4.27	1.68	1.58	0.06	0.06	1.56	1.6
LSD 0.05(gi-gj)	5.98	6.04	2.37	2.24	0.09	0.09	2.21	2.26
Testers	**Seed cotton yield /plant**		**Lint cotton yield /plant**		**Boll weight**		**Number of bolls / plants**	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 45 (T1)	-24.46**	-22.68**	-10.68**	-9.20**	-0.11**	-0.18**	-6.45**	-5.46**
G. 86 (T2)	5.11**	4.75**	3.00**	2.42**	0.02	0.04 n.s	1.34 n.s	1.22 n.s
G 90 x Aust. (T3)	19.35**	17.94**	7.68**	6.78**	0.08**	0.14**	5.11**	4.24**
LSD 0.05	2.77	2.79	1.1	1.04	0.04	0.04	1.02	1.05
LSD 0.05(gi-gj)	3.91	3.95	1.55	1.46	0.06	0.06	1.45	1.48

N1 and N2 are the two nitrogen levels (60 kg and 30 kg), n.s, *, **: not significant, significant and highly significant at 0.05 and 0.01 probability levels, respectively.

Table 4 Cont. Estimates of general combining ability effects for yield and yield component traits under the two nitrogen fertilizer levels

Lines	Lint percent (%)		Seed index		Lint index		No. of Seeds/Boll	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 87 (L1)	-1.47	-0.18	-0.12	0.01	-0.43 n.s	-0.06	0.75 n.s	-0.96**
G. 88 (L2)	-0.18	-3.91**	-0.39**	-0.35**	-0.31	-1.03**	0.64 n.s	1.32**
G. 92 (L3)	-4.02**	-1.05 n.s	0	-0.29**	-1.02**	-0.40**	1.10**	0.62 n.s
G. 93 (L4)	-1.52	-0.18	0.56**	0.43**	-0.11	0.16	-1.20**	-0.61 n.s
G. 94 (L5)	3.73**	2.55**	-0.02	-0.01	1.01**	0.57**	-0.73 n.s	-0.1
G. 96 (L6)	2.49**	1.85**	0.15 n.s	0.42**	0.74**	0.65**	-0.74 n.s	-0.89**
G. 97 (L7)	0.96	0.91*	-0.18 n.s	-0.20 n.s	0.13	0.11	0.18	0.61 n.s
LSD 0.05	1.61	0.88	0.14	0.18	0.43	0.21	0.64	0.53
LSD 0.05(gi-gj)	2.28	1.25	0.19	0.25	0.61	0.29	0.90	0.75
Testers	**Lint percent (%)**		**Seed index**		**Lint index**		**No. of Seeds/Boll**	
	N1	**N2**	**N1**	**N2**	**N1**	**N2**	**N1**	**N2**
G. 45 (T1)	-1.43 n.s	-1.13**	0.09 n.s	0.25**	-0.35 n.s	-0.16 n.s	-0.37	-1.35**
G. 86 (T2)	1.18 n.s	0.76 n.s	-0.22**	-0.34**	0.17	-0.02	0.25	0.73**
G 90 x Aust. (T3)	0.25	0.37	0.13**	0.09	0.18	0.18 n.s	0.12	0.62**
LSD 0.05	1.05	0.58	0.09	0.12	0.28	0.13	0.42	0.35
LSD 0.05(gi-gj)	1.49	0.82	0.12	0.17	0.40	0.19	0.59	0.49

N1 and N2 are the two nitrogen levels (60 kg and 30 kg), n.s, *, **: not significant, significant and highly significant at 0.05 and 0.01 probability levels, respectively.

Table 5. Estimates of specific combining ability effects for yield and yield component traits under the two nitrogen levels.

Characters / Genotypes	Seed cotton yield /plant		Lint cotton yield /plant		Boll weight		Number of bolls / plants	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 87 x G. 45	3.57	4.24	1.82	1.6	0.23**	0.18**	-1.62	-1.08
G. 87 x G. 86	4.00	1.81	0.21	-0.07	-0.09	-0.04	2.16	1.08
G. 87 x (G. 90 x Aust.)	-7.57*	-6.05	-2.03	-1.53	-0.14**	-0.14**	-0.55	0.00
G. 88 x G. 45	18.57**	22.24**	10.27**	9.82**	0.18**	0.23**	3.55*	4.64**
G. 88 x G. 86	-8.67*	-8.19*	-2.31	-1.76	-0.01	-0.14**	-2.79*	-0.95
G. 88 x (G. 90 x Aust.)	-9.90**	-14.05**	-7.96**	-8.06**	-0.18**	-0.09	-0.75	-3.69**
G. 92 x G. 45	-2.54	-2.65	1.99	-0.26	0.08	-0.04	-1.78	-0.29
G. 92 x G. 86	15.89**	20.59**	9.30**	9.60**	0.12*	0.24**	3.40*	3.35*
G. 92 x (G. 90 x Aust.)	-13.35**	-17.94**	-11.30**	-9.33**	-0.19**	-0.20**	-1.62	-3.06*
G. 93 x G. 45	-3.21	-3.98	-1.1	-1.49	-0.05	-0.1	-0.68	-0.48
G. 93 x G. 86	-12.78**	-11.08**	-4.72**	-2.70	-0.11*	-0.06	-2.42	-2.63
G. 93 x (G. 90 x Aust.)	15.98**	15.06**	5.82**	4.20**	0.16**	0.15**	3.10*	3.11*
G. 94 x G. 45	-6.1	-6.98	-4.39**	-4.24**	-0.24**	-0.24**	1.11	0.92
G. 94 x G. 86	18.67**	12.59**	4.96**	5.23**	0.19**	0.20**	3.30*	1.47
G. 94 x (G. 90 x Aust.)	-12.57**	-5.6	-0.57	-0.99	0.05	0.04	-4.40**	-2.39
G. 96 x G. 45	-0.1	-4.98	-3.16*	-2.77*	-0.06	0.00	0.85	-1.46
G. 96 x G. 86	-15.67**	-8.75*	-3.84*	-3.97**	-0.09	-0.12*	-3.57*	-1.23
G. 96 x (G. 90 x Aust.)	15.76**	13.73**	7.00**	6.74**	0.16**	0.13*	2.71*	2.69
G. 97 x G. 45	-10.21**	-7.87*	-5.43**	-2.66	-0.14**	-0.03	-1.43	-2.24
G. 97 x G. 86	-1.44	-6.97	-3.60*	-6.32**	-0.01	-0.08	-0.08	-1.09
G. 97 x (G. 90 x Aust.)	11.65**	14.84**	9.03**	8.98**	0.15**	0.10*	1.51	3.34*
LSD 0.05	7.32	7.39	2.90	2.74	0.10	0.10	2.70	2.77

N1 and N2 are the two nitrogen levels (60 kg and 30 kg), *, significant and highly significant at 0.05 probability level.

Table 5 Cont. Estimates of specific combining ability effects for yield and yield component traits under the two nitrogen levels.

Characters / Genotypes	Lint percent (%) N1	Lint percent (%) N2	Seed index N1	Seed index N2	Lint index N1	Lint index N2	No. of Seeds/Boll N1	No. of Seeds/Boll N2
G. 87 x G. 45	-0.2	-0.14	-0.42**	-0.28	-0.3	-0.15	2.31**	1.66**
G. 87 x G. 86	-0.46	-0.55	-0.02	-0.43**	0.02	-0.35	-0.44	0.68
G. 87 x (G. 90 x Aust.)	0.66	0.69	0.45**	0.71**	0.28	0.51**	-1.88**	-2.34**
G. 88 x G. 45	2.97*	1.70*	0.68**	0.47**	1.23**	0.60**	-1.13*	-0.04
G. 88 x G. 86	0.23	0.8	-0.23*	-0.08	-0.13	0.12	0.31	-1.06*
G. 88 x (G. 90 x Aust.)	-3.19*	-2.50**	-0.45**	-0.39*	-1.09**	-0.73**	0.81	1.10*
G. 92 x G. 45	1.85	0.42	-0.2	0.19	0.35	0.21	0.28	-0.86
G. 92 x G. 86	2.67	1.86*	0.43**	0.25	0.85*	0.55**	-0.91	0.53
G. 92 x (G. 90 x Aust.)	-4.53**	-2.28**	-0.23	-0.44**	-1.20**	-0.75**	0.63	0.33
G. 93 x G. 45	-0.32	-0.55	-0.06	-0.34*	-0.13	-0.3	-0.17	0.2
G. 93 x G. 86	-0.21	1.11	0.48**	0.51**	0.31	0.58**	-1.45*	-1.69**
G. 93 x (G. 90 x Aust.)	0.53	-0.55	-0.42**	-0.17	-0.18	-0.28	1.61**	1.49**
G. 94 x G. 45	-0.96	-1.11	0.47**	0.43**	0.04	-0.01	-1.92**	-1.94**
G. 94 x G. 86	-2.07	0.36	-0.72**	-0.55**	-1.12**	-0.23	3.12**	2.31**
G. 94 x (G. 90 x Aust.)	3.04*	0.74	0.25*	0.12	1.08**	0.25	-1.20*	-0.37
G. 96 x G. 45	-2.38	-0.74	-0.12	0	-0.74*	-0.18	0.59	0.31
G. 96 x G. 86	1.95	-0.49	0.1	0.24	0.66	0.03	-1.36*	-1.15*
G. 96 x (G. 90 x Aust.)	0.43	1.22	0.02	-0.24	0.07	0.15	0.77	0.84
G. 97 x G. 45	-0.95	0.41	-0.34**	-0.48**	-0.45	-0.17	0.04	0.68
G. 97 x G. 86	-2.11	-3.10**	-0.04	0.07	-0.59	-0.69**	0.71	0.37
G. 97 x (G. 90 x Aust.)	3.06*	2.69**	0.39**	0.41*	1.04**	0.85**	-0.74	-1.04*
LSD 0.05	2.79	1.53	0.23	0.31	0.74	0.36	1.1	0.92

N1 and N2 are the two nitrogen levels (60 kg and 30 kg), *, significant and highly significant at 0.05 probability level.

Table 6. Heterosis relative to mid-parents (M.P) for yield and yield component traits under the two nitrogen fertilizer levels.

Characters / Genotypes	Seed cotton yield /plant N1	Seed cotton yield /plant N2	Lint cotton yield /plant N1	Lint cotton yield /plant N2	Boll weight N1	Boll weight N2	Number of bolls / plants N1	Number of bolls / plants N2
G. 87 x G. 45	37.41**	43.72**	41.69**	46.95**	32.08**	15.36**	4.16	25.02**
G. 87 x G. 86	28.01**	22.91**	29.24**	23.82**	9.61**	2.1	16.68**	21.36**
G. 87 x (G. 90 x Aust.)	22.26**	23.78**	24.59**	25.19**	7.70**	0.39	14.51**	25.09**
G. 88 x G. 45	51.45**	79.08**	71.29**	68.26**	21.28**	14.73**	26.83**	58.57**
G. 88 x G. 86	13.59**	20.67**	22.49**	11.11*	5.55*	-3.07	7.43	24.70**
G. 88 x (G. 90 x Aust.)	17.93**	23.50**	10.59*	-0.21	0.07	0.5	18.09**	23.46**
G. 92 x G. 45	10.51*	30.68**	11.45	33.60**	11.38**	-0.43	2.1	34.61**
G. 92 x G. 86	24.60**	41.08**	31.35**	50.36**	4.83*	5.90**	18.76**	33.14**
G. 92 x (G. 90 x Aust.)	5.08	12.16**	-15.32**	2.51	-4.86*	-6.95**	10.46*	20.97**
G. 93 x G. 45	39.75**	34.84**	40.51**	35.83**	14.00**	10.49**	22.97**	21.68**
G. 93 x G. 86	18.31**	11.36*	21.71**	17.95**	2.87	7.06**	16.07**	5.14
G. 93 x (G. 90 x Aust.)	52.46**	49.19**	51.95**	45.16**	12.43**	16.21**	37.76**	30.42**
G. 94 x G. 45	10.25*	12.02*	12.21*	6.91	-2	-5.18*	17.51**	23.08**
G. 94 x G. 86	28.55**	22.86**	33.16**	26.62**	4.75*	6.05**	22.94**	15.97**
G. 94 x (G. 90 x Aust.)	8.58*	14.96**	22.81**	17.04**	0.65	2.67	7.9	12.03**
G. 96 x G. 45	8.96	-0.8	7.41	-1.79	8.30**	5.10*	4.5	-1.6
G. 96 x G. 86	-5.34	-6.73	8.43*	-4.47	-0.24	-2.59	-5.04	-4.26
G. 96 x (G. 90 x Aust.)	24.97**	20.68**	32.97**	26.26**	7.75**	7.22**	16.13**	12.61**
G. 97 x G. 45	0.84	-6.79	-5.55	-10.96*	-0.54	0.58	6.42	-2.72
G. 97 x G. 86	8.07*	-7.00	3.53	-16.49**	-2.73	-4.19*	11.46**	-2.68
G. 97 x (G. 90 x Aust.)	22.72**	18.24**	29.90**	21.88**	2.09	2.96	20.28**	15.01**

N1 and N2 the two nitrogen levels (60 kg and 30 kg.), *, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively

Table 6 Cont. Heterosis relative to mid-parents (M.P) for yield and yield component traits under the two nitrogen fertilizer levels

Characters / Genotypes	Lint percent (%)		Seed index		Lint index		No. of Seeds/Boll	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 87 x G. 45	3.47	2.84	8.01**	15.76**	13.46	20.28**	18.97**	-3.22
G. 87 x G. 86	4.11	1.65	-1.46	-5.08*	9.06	-2.73	9.23*	6.81*
G. 87 x (G. 90 x Aust.)	2.96	2.41	5.80**	13.55**	10.24	17.73**	0.66	-12.63**
G. 88 x G. 45	15.03**	-4.62	17.95**	23.47**	46.74**	14.85**	-5.25	-5.51*
G. 88 x G. 86	7.97	-6.84*	-5.53**	-3	6.5	-12.74**	7.10*	3.64
G. 88 x (G. 90 x Aust.)	-5.82	-18.81**	-5.04**	0.39	-13.66	-26.20**	9.13*	10.57**
G. 92 x G. 45	1.46	2.62	14.75**	19.58**	17.1	24.08**	-3.31	-17.74**
G. 92 x G. 86	5.27	6.86*	6.71**	0.24	15.38	10.83*	-4.6	1.86
G. 92 x (G. 90 x Aust.)	-19.24**	-8.05**	2.8	-0.53	-25.39**	-12.20**	2.31	-2.4
G. 93 x G. 45	1.15	1.25	18.80**	22.04**	20.15*	23.86**	-5.54	-11.00**
G. 93 x G. 86	2.93	6.19*	9.63**	10.71**	16.76*	21.58**	-7.57*	-6.28*
G. 93 x (G. 90 x Aust.)	0.77	-1.44	3.47*	10.32**	4.66	7.67	8.67*	6.36*
G. 94 x G. 45	5.8	-0.6	16.04**	23.15**	24.59**	18.73**	-17.87**	-22.71**
G. 94 x G. 86	4.02	3.54	-9.27**	-6.91**	-3.46	-1.58	12.66**	11.70**
G. 94 x (G. 90 x Aust.)	13.23**	1.94	2.69	6.58**	26.78**	9.69*	-10.25**	-4.91
G. 96 x G. 45	1.65	1.89	20.44**	31.86**	22.16*	34.03**	-10.38**	-20.68**
G. 96 x G. 86	14.68**	2.64	7.44**	12.26**	35.40**	16.89**	-15.52**	-14.83**
G. 96 x (G. 90 x Aust.)	6.45	4.64	9.34**	14.13**	21.21**	22.55**	-5.69	-8.67**
G. 97 x G. 45	-1.93	-0.43	8.11**	9.85**	2.2	6.25	-5.97	-7.89**
G. 97 x G. 86	-3.41	-9.79**	-2.4	-2.86	-7.07	-17.36**	1.97	4.39
G. 97 x (G. 90 x Aust.)	6.06	3.25	4.48**	7.11**	15.22*	12.56**	-5.89	-5.80*

N1 and N2 the two nitrogen levels (60 kg and 30 kg.), *, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively.

For lint cotton yield per plant, the results showed that 16 and 14 crosses of the F1 crosses had significant positive heterosis relative to mid-parents, and also that the highest positive heterosis was given by the cross (G. 88 x G. 45) under the two nitrogen levels N1 and N2 with the values 71.29 and 68.26 %, respectively. Results for the trait boll weight (B. W.) showed that the cross (G. 87 x G. 45) exhibited the highest positive significant heterosis values under the two levels of nitrogen fertilizer N1 and N2, with the mean values being 32.08% and 15.36%, respectively. Conversely, the lowest positive heterosis values were recorded by the cross (G. 94 x G. 86) and (G. 96 x G. 45) under the first and second nitrogen fertilizer levels with the values of heterosis 4.75 and 5.10 %, respectively. For number of bolls per plant (No. B. /P.), the results for heterosis relative to mid-parents indicated that the highest positive significant values were recorded by (G. 93 x G. 90 x Aust.) under the level N1, and the cross (G. 88 x G. 45) under the second level N2 with the values of heterosis were 37.76 and 58.57 %, respectively.

While the crosses (G. 92 x G. 90 x Aust.) and (G. 94 x G. 90 x Aust.) exhibited the lowest positive heterosis values under both levels of nitrogen fertilizer N1 and N2 with the heterosis values 10.46 and 12.03%, respectively. For lint percentage (%), the results of heterosis relative to mid-parents (M.P) ranged from 13.23% for the cross (G. 94 x G. 90 x Aust.) to 15.03% for the cross (G. 88 x G. 45) under the first nitrogen level N1, but under the N2 level the positive heterosis values (desirable) ranged from 6.19% for the cross (G. 93 x G. 86) to 6.86% for the cross (G. 92 x G. 86). For the seed index (S. I.) trait, the results showed that 14 and 14 crosses out of the 21 studied crosses exhibited significant positive heterosis (desirable) relative to mid-parents under N1and N2 levels, respectively.

The lint index (L.I) results showed that the highest significant positive heterosis was recorded by the cross (G. 88 x G. 45) under the first level N1, as well as the cross (G. 96 x G. 86) under the second level N2 of fertilizer, with the mean values of heterosis 46.74% and 34.03%, respectively. For the number of seeds per boll (No. S. /B.) trait, the results recorded that the highest positive and significant heterosis values given (G. 87 x G. 45) cross under the first level N1, and by the cross (G. 94 x G. 86) under the second level N2 also with the values 18.97% and 11.70%, respectively. Similar results agreed with those reported by Kaleri *et al.* (2015); Kanasagra *et al.* (2022); Abdel-Aty *et al.* (2023);

Hottigodar *et al.*(2023); Parmar *et al.,* (2023) and Yehia *et al.* (2024).

Heterosis relative to better parent (B.P):

Heterosis relative to better parent (B.P) for yield and yield component traits under the two nitrogen fertilizer levels N1 and N2 calculated, and the results are presented in Table (7). The results for the seed cotton yield trait indicated that 9 and 10 crosses from the 21 studied crosses exhibited positive and significant heterosis (desirable) in the N1and N2, respectively.

The highest heterosis values were recorded by the crosses (G.96 x G.90 x Aust.) under the level N1, and by the cross (G.88 x G.45) under the second level N2. With the values of heterosis 23.21% and 37.31%, respectively. For lint cotton yield per plant the heterosis values ranged from 12.23% for the cross (G.87 x G 86) to 30.82% for the cross (G.96 x G.90 x Aust.) under the first level of fertilizer N1, and from 10.30% for the cross (G.94 x G.90 x Aust.) to 34.95% for the cross (G.92 x G.86) under the second level N2. For the trait boll weight (B.W.) the results of heterosis relative to the better parent showed that the highest values of significant positive heterosis were recorded by the cross (G.87 x G.45) under the two levels of nitrogen fertilizer N1and N2 with the values of heterosis were 31.12% and 13.27%, respectively.

For the number of bolls per plant trait, the results of heterosis relative to the better parent showed that the highest positive and significant heterosis was produced by the crosses (G.93 x G.90 x Aust.) under the first level N1 and the cross (G.88 x G.45) under the second level N2. With the values of heterosis 20.46% and 27.31%, respectively. For the trait lint percentage, the results showed that the highest positive significant heterosis value was given by the cross (G. 96 x G. 86) under the first level N1 with the heterosis value 12.66 %. The results for the trait seed index (S. I.) showed that the highest values of positive significant heterosis relative to the better parent were recorded by the cross (G. 96 x G. 45) with values were 14.31 and 23.06 % under N1 and N2, respectively. While lint index trait cleared that the heterosis values relative to better parent under the first nitrogen level N1 ranged from 19.42% for the cross (G. 94 x G. 90 x Aust.) to 32.23% for the cross (G. 96 x G. 86), also ranged from 11.03% for the cross (G. 87 x G. 90 x Aust.) to 17.75% for the cross (G. 96 x G. 90 x Aust.) under the second level of nitrogen (N2).

Table 7. Heterosis relative to better- parent (B.P) for yield and yield component traits under the two nitrogen fertilizer levels

Characters / Genotypes	Seed cotton yield /plant		Lint cotton yield /plant		Boll weight		Number of bolls / plants	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 87 x G. 45	10.18	17.94*	12.62*	19.01*	31.12**	13.27**	-16.05**	4.1
G. 87 x G. 86	15.93**	3.36	12.23*	1.09	-1.59	-7.06**	15.58**	11.11*
G. 87 x (G. 90 x Aust.)	5.25	1.43	1.88	-1.45	-4.62*	-10.03**	10.79*	12.94*
G. 88 x G. 45	15.51**	37.31**	28.11**	26.12**	13.89**	7.92**	1.31	27.31**
G. 88 x G. 86	9.73*	9.79*	14.91**	-0.8	-0.11	-8.05**	5.16	19.27**
G. 88 x (G. 90 x Aust.)	7.87	9.17*	-2.92	-14.53**	-6.67**	-6.20**	15.59**	16.37**
G. 92 x G. 45	-18.39**	-1.76	-18.56**	-0.25	-0.32	-11.05**	-18.15**	10.34
G. 92 x G. 86	22.99**	31.80**	27.52**	34.95**	4.44	5.62*	16.79**	24.14**
G. 92 x (G. 90 x Aust.)	0.52	1.72	-23.28**	-11.76*	-6.67**	-8.31**	7.63	11.19*
G. 93 x G. 45	20.52**	13.33	18.28*	12.31	11.06**	7.22*	8.46	4.81
G. 93 x G. 86	-0.88	-8.56	-0.46	-5.64	-6.03*	-1.47	5.42	-7.21
G. 93 x (G. 90 x Aust.)	22.05**	19.48**	17.62**	12.11*	1.27	5.27*	20.46**	13.58*
G. 94 x G. 45	-22.00**	-22.52**	-25.08**	-29.70**	-15.12**	-17.00**	-7.98	-7.05
G. 94 x G. 86	18.75**	15.28**	17.96**	14.16**	1.28	3.36	17.26**	11.51*
G. 94 x (G. 90 x Aust.)	6	11.26**	16.35**	10.30*	-1.19	1.8	7.33	9.35
G. 96 x G. 45	-22.45**	-30.53**	-26.82**	-33.69**	-3.52	-6.39**	-19.47**	-25.59**
G. 96 x G. 86	-11.73**	-10.64*	-0.54	-9.56*	-0.4	-3.17	-11.34*	-7.77
G. 96 x (G. 90 x Aust.)	23.21**	19.33**	30.82**	25.28**	6.26**	6.01*	12.98**	10.12*
G. 97 x G. 45	-30.07**	-36.82**	-38.05**	-42.34**	-14.53**	-12.89**	-18.18**	-27.74**
G. 97 x G. 86	-3.26	-15.67**	-11.07**	-26.84**	-6.79**	-7.74**	3.77	-8.62
G. 97 x (G. 90 x Aust.)	15.85**	10.45**	19.01**	11.45**	-0.68	0.84	16.67**	9.58*

N1 and N2 the two nitrogen levels (60 kg and 30 kg.), *, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively.

Table 7 Cont. Heterosis relative to better- parent (B.P) for yield and yield component traits under the two nitrogen fertilizer levels

Genotypes \ Characters	Lint percent (%)		Seed index		Lint index		No. of Seeds/Boll	
	N1	N2	N1	N2	N1	N2	N1	N2
G. 87 x G. 45	2.29	1.08	-2.04	2.59	1.34	4.27	8.08*	-13.48**
G. 87 x G. 86	-0.67	-2.01	-1.75	-5.23*	1.29	-7.81	0.66	-1.19
G. 87 x (G. 90 x Aust.)	-3.19	-2.77	4.70**	11.15**	-0.58	11.03*	-7.18	-21.24**
G. 88 x G. 45	11.83*	-7.75*	7.57**	11.65**	28.83**	-0.6	-9.44*	-10.82**
G. 88 x G. 86	4.73	-8.74**	-6.38**	-5.02*	0.76	-17.15**	3.92	1.44
G. 88 x (G. 90 x Aust.)	-10	-21.69**	-6.58**	0.27	-20.73*	-30.28**	5.97	5.28
G. 92 x G. 45	-0.18	1.55	6.38**	7.27**	6.17	9.8	-6.21	-17.77**
G. 92 x G. 86	0.91	2.33	3.90*	-0.98	5.53	2.7	-8.85*	-1.83
G. 92 x (G. 90 x Aust.)	-23.72**	-13.27**	-0.62	-1.29	-33.70**	-19.03**	-2.32	-3.26
G. 93 x G. 45	-1.71	-0.77	7.24**	9.62**	4.41	8.36	-13.81**	-18.56**
G. 93 x G. 86	-0.12	2.66	9.38**	9.21**	11.74	14.06**	-14.45**	-11.17**
G. 93 x (G. 90 x Aust.)	-3.67	-6.16*	2.94	9.63**	-2.84	0.52	0.65	-1.85
G. 94 x G. 45	-4.36	-9.47**	3.30*	8.70**	-2.9	-7.11	-20.14**	-25.95**
G. 94 x G. 86	-0.64	-0.77	-10.88**	-7.49**	-11.74	-8.48*	11.25**	11.06**
G. 94 x (G. 90 x Aust.)	9.79	-0.79	1.61	3.85	19.42*	2.49	-11.31**	-8.08**
G. 96 x G. 45	-5.65	-4.49	14.31**	23.06**	4.29	14.29**	-12.84**	-22.04**
G. 96 x G. 86	12.66*	1.42	2.11	6.32**	32.23**	12.88**	-19.07**	-19.30**
G. 96 x (G. 90 x Aust.)	6.21	4.23	3.19	10.19**	14.75	17.75**	-9.72**	-11.05**
G. 97 x G. 45	-11.44*	-8.94**	-2.04	-3.36	-19.30*	-16.68**	-5.98	-10.78**
G. 97 x G. 86	-7.83	-13.16**	-2.58	-3.83	-13.63	-22.94**	0.4	3.81
G. 97 x (G. 90 x Aust.)	2.72	0.93	3.51*	3.98	10.4	5.47	-7.4	-7.93*

N1 and N2 the two nitrogen levels (60 kg and 30 kg.), *, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively

Table 8. Genetic variance components and heritability for yield and yield component traits under the two nitrogen fertilizer levels

Genetic components/ Heritability	Seed cotton yield /plant		Lint cotton yield /plant		Boll weight		Number of bolls / plants	
	N1	N2	N1	N2	N1	N2	N1	N2
A	45.56	41.31	10.42	6.17	-0.001	0.0021	3.5	3.22
D	215.77	219.19	56.18	49.67	0.032	0.032	8.04	7.49
G	261.33	260.5	66.6	55.84	0.031	0.0341	11.54	10.71
E	13.39	13.66	2.11	1.88	0.003	0.0027	1.83	1.92
Ph.	274.72	274.16	68.71	57.72	0.03	0.04	13.37	12.63
h^2_b	95.13%	95.02%	96.93%	96.75%	92.08%	92.75%	86.33%	84.82%
h^2_n	16.58%	15.07%	15.17%	10.69%	-2.97%	5.71%	26.18%	25.50%
Genetic Components/ Heritability	**Seed cotton yield /plant**		**Lint cotton yield /plant**		**Boll weight**		**Number of bolls / plants**	
	N1	**N2**	**N1**	**N2**	**N1**	**N2**	**N1**	**N2**
A	0.7	0.52	0	0.01	0.02	0.03	-0.06	0.1
D	5.56	2.95	0.23	0.22	0.73	0.31	2.68	2.31
G	6.26	3.47	0.23	0.23	0.75	0.34	2.62	2.41
E	1.95	0.58	0.01	0.02	0.14	0.03	0.30	0.21
Ph.	8.21	4.05	0.24	0.25	0.89	0.37	2.92	2.62
h^2_b	76.28%	85.61%	94.52%	90.79%	84.59%	91.07%	89.62%	91.87%
h^2_n	8.53%	12.83%	0.00%	3.95%	2.26%	8.04%	-2.05%	3.81%

N1 and N2 are the two nitrogen levels.

For the number of seeds per boll trait, the results showed that the highest positive and significant heterosis was recorded by the cross (G. 94 x G. 86) with the values 11.25% and 11.06%, under N1 and N2, respectively. Similar results were obtained by Gohil *et al.* (2017); Malathi *et al.* (2019); Mokadem *et al*. (2019) and Hamed & Said (2021).

Genetical parameters:

The results of genetic variance components and heritability for the studied traits under the two-nitrogen fertilizer levels are presented in Table (8). The results showed that the non-additive genetic variances (dominance) were greater than the additive genetic variance for all studied traits and played the main role of the inheritance of these traits, also the results showed that the genetic variance was greater than the environmental variance for all the studied traits.

These results would be useful if we need to produce new hybrids with high-yielding properties but in our case, we need to produce genetically stable varieties, so we have to conduct more self-pollenated generations to get the genetic stability of yield traits and generate new varieties. For the heritability estimation, the results showed that the heritability in broad sense was greater than the heritability in narrow sense for all studied traits, heritability in narrow sense estimates ranged from -2.97% for the trait boll weight under the N1 to 26.18% for number of bolls per plant under the same level of nitrogen fertilizer. In addition, the results indicated that the heritability in broad sense ranged from 76.28 % for lint percentage under the N1 to 96.93% for lint cotton yield per plant under the N1. Similar results were obtained by Sabir *et al.* (2017); Kumar *et al.* (2019); Vaghela *et al.* (2019) and Elfeki *et al.* (2024).

CONCLUSION

This investigation is carried out to estimate combining ability, heterosis and gene action for some of Egyptian cotton crosses and its parents, the results cleared that the line G.94, G.97 and the tester (G.90 x Aust.) were the good combiner for most of studied traits and also the results indicated that the crosses i.e.: G97 x(G90 x Aust.), G93 x (G90 x Aust.), G96 x (G90 x Aust.), (G92 x G86) and (G94 x G86) were the best and superior crosses for most of studied traits.

REFERENCES

Abdel-Aty, M. S., A. Youssef-Soad, W. M. B. Yehia, R. T. E. El-Nawsany, H. M. K. Kotb, G. A. Ahmed, M. E. Hasan, E. A. A. Salama, S. F. Lamlom, F. H. Saleh, A. N. Shah and N. R. Abdelsalam. 2022. Genetic analysis of yield traits in Egyptian cotton crosses (*Gossypium barbadense* L.) under normal conditions. BMC Plant Biol. 22, 462.

Abdel-Aty, M. S., F. A. Sorour, W. M. B. Yehia, H. M. K. Kotb, A. M. Abdelghany, S.F. Lamlom, A. N. Shah and N. R. Abdelsalam. 2023. Estimating the combining ability and genetic parameters for growth habit, yield, and fiber quality traits in some Egyptian cotton crosses. BMC Plant Biol. 23: 4 – 21.

Balcha, M., W. Mohammed and Z. Desalegn. 2019. Combining ability and heritability for yield, yield related and fiber quality traits in cotton (*Gossypium* spp.) at Werer, Ethiopia. Inter. J. Plant Breed. Genet. 6: 1-14.

Balci, S., V. M. Cinar and A. Unay. 2023. Estimating gene action and combining ability for yield and fiber quality in cotton (*Gossypium hirsutum* L.). Genet. 55: 61-69.

Baloch, M. J., J. A. Solangi, W. A. Jatoi, I. H. Rind and F. M. Halo. 2014. Heterosis and specific combining ability estimates for assessing potential crosses to develop F1 hybrids in upland cotton. Pak. J. Agric. Agric. Eng. Vet. Sci. 30: 8-18.

Bourgou, L., J. K. Dever, M. Sheehan, C. M. Kelly, S. K. Diané and M. Sawadogo. 2023. Diallel crosses of cotton (*Gossypium hirsutum* L.)—enhancement of fiber properties in future cultivars for Burkina Faso. Agron. 13, 2864.

Burton, G. W. 1952. Quantitative inheritance in grass-proc. 6th Int. Grassld Conf. 1: 227-283.

Dahiphale, K. D., J. D. Deshmukh, A. B. Jadhav and A. B. Bagade. 2015. Genetic variability, correlation and path coefficient analysis for yield and its attributing traits in cotton (*Gossypium hirsutum* L.). Int. J. Trop. Agric. 33: 15-22.

Dewdar, M. D. H. 2011. Nature of combining abilities and genetic interpretation for some quantitative traits in Egyptian cotton. Bull. Fac. Agric. Cairo Univ. 62: 418-424.

Elfeki, F. E., M. F. Hamed and R. M. El-Twab. 2024. Estimation of genetic parameters for some agronmic and technological quantitative traits in cotton using line x tester analysis. Menoufia J. Plant Product. 9: 229-240.

Farooq, A., A. Shakeel, A. Saeed, J. Farooq, M. Rizwan, W. S. Chattha, G. Sarwar and Y. Ramzan. 2023. Genetic variability predicting breeding potential of upland cotton (*Gossypium hirsutum* L.) for high temperature tolerance. J. Cotton Res. 6: 1-17.

Fehr, W. R. 1987. Principles of cultivar development theory and technique. Macmillan Pub. Comp. Inc., New York, pp. 115-119.

Gohil, S. B., M. B. Parmar and D. Chaudhari. 2017. Study of heterosis in interspecific hybrids of cotton (*Gossypium hirsutum* L. × *Gossypium barbadense* L.). J. Pharmacogn. Phytochem. 6: 804-810.

Gomez, K. A. and A. A. Gomez. 1984. Statistical procedures for agricultural research. John Wiley and Sons, Inc., New York, p. 680.

Gopikrishnan, P., N. Shunmugavalli and G. Anand. 2013. Genetic variability studies in interspecific cotton (*Gossypium* Spp.) hybrids. Electron. J. Plant Breed. 4: 1251-1254.

Guven, B. and R. Sadet. 2021. Combining ability and hybrid power in interspecific (*Gossypium hirsutum* L. x *Gossypium barbadense* L.) line x tester hybrids of cotton. Turkey J. Field Crops 26: 96-100.

Hamed, H. H. E. and S. R. N. Said. 2021. Estimation of heterosis and combining ability for yield and fiber quality traits by using line x tester analysis in cotton (*Gossypium barbadense* L.). Menoufia J. Plant Prod. 6: 35 – 51.

Hottigodar, Y., H. V. Kalpande and V. N. Chinchane. 2023. Heterosis study on yield, yield contributing and fibre quality traits in desi cotton (*Gossypium arboreum* L.). Pharm. Innov. J. 12: 491-495.

Iqbal, M., R. S. A. Khan, H. Khezir and K. Noor-Ul-Islam. 2005. Genetic variation and combining ability for yield and fiber traits among cotton F1 hybrid population. J. Biol. Sci. 5: 713-716.

Kaleri, F. N., M. A. R. Rashid, S. A. Channa, M. Shahnawaz and Z. A. Soomro. 2015. Gene action for yield and important yield components in (*Gossypium hirsutum* L.) using half diallel system. Am.-Eurasian J. Agric. Environ. Sci. 15: 470-477.

Kanasagra, J. R., M. G. Valu, L. J. Raval and S. Rupapara. 2022. Heterosis, combining ability and gene action for seed cotton yield and its contributing characters in cotton (*Gossypium hirsutum* L.). Pharm. Innov. J. 11: 2050-2056.

Kempthorne, O. 1957. An Introduction to genetic statistics. John Wiley and Sons, Inc., New York, USA, pp. 458 – 471.

Kumar, C. P. S., S. Raju, R. E. B. Rajan, A. Muraleedharan and D. B. Suji. 2019. Studies on genetic variability, heritability and genetic advance in cotton (*Gossypium hirsutum* L.). Plant Arch. 19: 618-620.

Malathi, S., R. S. Patil and H. S. Saritha. 2019. Heterosis studies in interspecific cotton hybrids (G. *hirsutum* L. x G. *barbadense* L.) under irrigated condition. Electron. J. Plant Breed. 10: 852-861.

Mokadem, S. A., A. L. A. Mawgood, H. S. Khalifa and T. M. E. Salem. 2019. Diallel analysis for earliness and yield components traits in some Egyptian cotton crosses (*Gossypium barbadense*, L.). Fayoum J. Agric. Res. Dev. 33: 723-727.

Parmar, N., G. O. Faldu, A. O. Sanghani, R. R. Patel and H. R. Ramani. 2023. Determination of gene action and combining ability for yield, its Attributes, Fiber quality and biochemical parameter in upland cotton [*Gossypium hirsutum* (L.)]. Pharm. Innov. J. 12: 389-395.

Raiz, A., F. Ullah, S. M. Chohan, A. Saeed, M. Aqeel, A. Sher, A. Nadeem, H. Akram, M. Shahid, H. Hussain and M. N. Khalid. 2023. Estimation of heterosis and combining ability effects for yield and fiber quality traits in cotton (*Gossypium hirsutum* L.). Biol. Clin. Sci. Res. J. 1-7.

Reddy, K. B., V. C. Reddy, M. L. Ahmed, T. C. M. Naidu and V. Srinivasarao. 2017. Combining ability analysis for seed cotton yield and quality traits in upland cotton (*Gossypium hirsutum* L.). Electron. J. Plant Breed. 8: 142-152.

Reddy, K. V. S., R. Chapara, M. S. Rani, B. S. Lakshmi and J. Pranaya. 2023. Estimation of combining ability and heterosis on seed cotton yield and its attributing traits in American cotton *Gossypium hirsutum* L. genotypes. Ecol. Environ. Conserv. 29: 225-235.

Sabir, H. K., A. A. Kaleri, A. W. Baloch, S. N. Mari, S. H. Kaleri, N. Gandahi, W. A. Jatoi, T. F. Abro and M. Khan. 2017. Genetic studies in upland cotton (*Gossypium hirsutum* L.) for earliness and yield contributing traits. Pure Appl. Biol. 6: 153-158.

Samak, A., S. Rajeswari, R. Ravikesavan, S. Lokanadhan, N. Ganapathy and A. V. Kini. 2022. Effect of environment on combining ability, heterosis for seed cotton yield in *Bt* introgressed lines of upland cotton. Agron. J. 114: 935–947.

Sultan, M. S., M. A. Abdel-Moneam, Y. M. EL-Mansy and H. S. El-Morshidy. 2018. Estimating of heterosis and combining ability for some Egyptian cotton genotypes using line x tester mating design. J. Plant Prod. 9: 1121 - 1127.

Vaghela, U. U., G. O. Faldu, R. J. Panchal and K. N. Patel. 2019. Determination of combining ability for seed cotton yield and its attributes in American cotton (*Gossypium hirsutum* L.). Int. J. Chem. Stud. 7: 1118-1122.

Yehia, W. M. B. and E. F. El-Hashash. 2019. Combining ability effects and heterosis estimates through line x tester analysis for yield, yield components and fiber traits in Egyptian cotton. Elixir Agric. 131: 53238-53246.

Yehia, W. M. B. and E. F. El-Hashash. 2021. Correlation and multivariate analysis across non-segregation and segregation generations in two cotton crosses. Egypt. J. Agric. Res. 99: 354-364.

Yehia, W. M. B. and E. F. El-Hashash. 2022. Estimates of genetic parameters for cotton yield, its components and fiber quality traits based on line x tester mating design and principal component analysis. Egypt. J. Agric. Res. 100: 302-315.

Yehia, W. M. B., E. E. D. I. Zaazaa, E. F. El-Hashash, M. M. Abou El-Enin and A. Shaaban. 2024. Genotype-by-environment interaction analysis for cotton seed yield using various biometrical methods under irrigation regimes in a semi-arid region. Arch. Agron. Soil Sci. 70: 1-23.

الملخص العربي

تقدير القدرة علي الآتلاف وقوة الهجين وبعض المقاييس الوراثية لصفات المحصول ومكوناته باستخدام نظام السلالة في القطن المصري x الكشاف

السيد ابراهيم منصور، سامي شعبان الطباخ، وليد محمد بسيوني يحيي، مني محمد حميد

أجريت هذه الدراسة في المزرعة التجريبية بكلية الزراعة بجامعة الإسكندرية خلال موسمي الصيف ٢٠١٨ و٢٠١٩. وتهدف هذه الدراسة إلى تقدير بعض المقاييس الوراثية لبعض التراكيب الوراثية للقطن لصفات المحصول ومكوناته تحت مستويين من الأسمدة النيتروجينية من خلال تصميم السلالة x الكشاف. عشرة تراكيب وراثية استخدمت كاباء (سبعة سلالات وثلاثة كشافات) مع ٢١ هجينا ناتجة من الجيل الأول (F1) في تجربتين بتصميم قطاعات العشوائية الكاملة (RCBD) فى ثلاث مكرارات. كانت التباينات الوراثية وتباينات الآباء والهجن والآباء باستثناء الهجن والسلالات والكشافات والسلالة × الكشاف ذات ذات نتائج معنوية أو عالية المعنوية لجميع الصفات المدروسة تحت مستويين من الأسمدة النيتروجينية. كان التباين الناتج عن GCA للآباء (السلالات والكشافات) و SCA للهجن معنويا بالنسبة لمعظم الصفات تحت الدراسة، مما يشير إلى أهمية كل من التأثيرات الإضافية والتأثيرات السائدة في التحكم في هذه الصفات. أظهرت قيم تأثيرات GCA و SCA أن الآباء وبعض الهجن أعطت تأثيرات GCA و SCA معنوية وهامة تحت مستويين من الأسمدة النيتروجينية. لوحظت تقديرات متوسطات الأداء وتأثيرات GCA اهمية كبيرة معنوية مرتفعة للآباء (G94) و (G97) والكشاف (G90 x Aust.) لمعظم صفات المحصول ومكوناته. بحيث يمكن استخدام هذه التراكيب الأبوية لانتاج هجن جديدة من القطن ذات قدرة إنتاجية مرتفعة. وقد أظهرت النتائج لقيم SCA، أن أفضل الهجن تحت الدراسة كانت (G97 x(G90 x Aust.)، (G93 x (G90 x Aust.)، G96 x (G90 x Aust.)، (G92 x G86)و (G94 x G86) بالنسبة لمعظم الصفات تحت الدراسة تحت مستويين من الأسمدة النيتروجينية، ويمكن اعتبار أن هذه الهجن واعدة لاستخدامها في برنامج التربية لإنتاج أصناف جديدة من القطن وتحسين الصفات المتعلقة بالمحصول ومكونات المحصول.

الكلمات المفتاحية: القطن، القـدرة علـى الآتـلاف، قـوة الهجين، مقاييس وراثية، المحصول.