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HETEROSIS AND COMBINING ABILITY OF SEED COTTON YIELD AND ITS CONTRIBUTING TRAITS UNDER DROUGHT CONDITIONS

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ABSTRACT

A half diallel set of crosses involving eight cotton parental cultivars, six of them belonging to Gossypium barbadense, Giza 45, Giza 70, Giza 83, Giza 85, Pima S-7 and Sea island as well as two Upland cultivars (G.hirsutum), Tamcot and Deltapine 703, were evaluated under three irrigation intervals 15, 25 and 35 days. The results revealed that irrigation regimes mean squares were found to be highly significant for all studied traits. Highly significant differences among genotypes, parents and F_1 crosses were observed for all studied traits under the three irrigation regimes and their combined analysis. The interactions of irrigation regimes with each of genotypes, parents and crosses were found to be highly significant for all studied traits. Heterobeltiosis was generally pronounced and existed for all studied characters except boll number .Both general and specific combining ability (GCA and SCA) variances were found to be highly significant for all studied traits under the three irrigation regimes and the combined data, suggesting that both additive and non-additive gene effects were operative for these traits. The GCA/SCA ratios indicated that additive and additive by additive types of gene action were of greater importance in the inheritance of all studied traits either under normal irrigation or water stress conditions. The best general combiners under normal irrigation were: Tamcot and Deltapine 703 for earliness, boll weight, seed index and seed cotton yield/plant, Giza 70 for boll number, lint percentage and seed cotton yield, Giza 45 for boll number, Giza 83 and Giza 85 for boll number, lint percentage and seed index and Pima S-7 and Sea island for boll number and lint percentage. On the other hand, the four exotic varieties Pima S-7, Sea island, Tamcot and Deltapine 703 were good general combiners for seed cotton yield and some of its components under the relatively water stress conditions. Some cross combinations revealed desirable SCA effects for yield under normal irrigation and water stress conditions. The best cross-combinations were Giza 45 x Giza 85, Giza 70 x Sea island, Giza 83 with both of Pima S-7 and Tamcot and Pima S-7 x Tamcot under normal irrigation condition and the two crosses Giza 45 x Giza 83 and Sea island x Deltapine 703 under drought condition. Moreover, the four cotton genotypes Giza 85, Pima S-7, Tamcot and Deltapine and three crosses Pima S-7 x Tamcot, Giza 85 x Sea island and Tamcot x Deltapine 703 showed the lowest drought susceptibility index (most drought tolerance).

Key words: *Cotton, Heterobeltiosis, Combining ability, Susceptibility index, Drought tolerance*

INTRODUCTION

Development of cotton cultivars tolerant to drought stress in Egypt becomes a vital objective in many breeding programs especially with the current interest in expanding cotton acreage in newly reclaimed desert lands, which is characterized by low water holding capacity, sandy soils and water scarcity. To achieve such objective the breeder must take an interdisciplinary approach toward the evaluation of cotton germplasm. One discipline is to enter the parental material into a crossing program and progenies were selected using an index based on yield under no stress and stress known as drought susceptibility index (Fischer and Maurer 1978). This index provides a measure of stress tolerance based on minimization of yield loss under stress compared to optimum conditions rather than on yield level under non-stress *per se*.

The diallel mating design has been used extensively by many geneticists and breeders to evaluate parental materials before taking any decisions concerning the breeding system to be used. The combining ability analysis is the most widely used biometrical tool for classifying parental genotypes for their potentialities in hybrid combinations. The parents having the best potential are those exhibiting the highest general combining ability effects. The hybrid combinations which possess the highest specific combining ability effects would be the reflection of the non-additive gene effects. Several researchers have studied the combining ability for different economic traits of cotton (Hendawy 1994, El-Gohary *et al*1981 and Rady *et al* 1996) in both intra- and interspecific crosses. There is continuous need, however, to evaluate the behavior of different varieties in new cross-combinations under stress conditions to provide plant breeders with essential information about their combining ability under such conditions before establishing any breeding program.

Therefore, the main objectives of the present study were to evaluate eight cotton genotypes and their 28 F_1 hybrids for heterosis as well as general and specific combining abilities under normal and stress conditions for earliness, seed cotton yield and yield components.

MATERIALS AND METHODS

The field work of this study was conducted at the Experimental Farm of the Fac. of Agric., Ain Shams Univ., Shoubra El-Kheima, Cairo, in the first season (2002) and at the Agric. Res. Stat. of the Fac. of Agric., Ain Shams Univ., Shalakan, Kalubia Governorate, in the second season (2003).

Six Egyptian cotton (*Gossypium barbadense*, L) cultivars namely, Giza 45 (P_1), Giza 70 (P_2), Giza 83 (P_3), Giza 85 (P_4), Pima S-7 (P_5) and Sea island (P_6) as well as two American Upland cotton (*G. hirsutum*, L.) varieties, viz. Tamcot (P_7) and Deltapine 703 (P_8) were used as a breeding material for this study. The seeds of these genotypes were kindly provided by Cotton Breeding Section, Cotton Res. Institute (CRI), Agric. Res. Center (ARC), Ministry of Agriculture and Land Reclamation, Giza, Egypt. These parental varieties were chosen on the basis of the presence of wide diversity between them.

In 2002 growing season, the eight parents was hand crossed in a half diallel fashion excluding reciprocals to produce the hybrid seeds of all possible twenty-eight intra- and inter- specific cross combinations. In 2003 growing season, the eight parents and their 28 F_1's were evaluated under three different irrigation regimes as irrigation intervals, i.e. every 15 days (a well-watered control or treatment), 25 days (a moderate moisture stress or moderate water deficit treatment) and 35 days (a severe moisture stress or severe water deficit stress) in three separate adjacent experiments, respectively. The three irrigation regimes were begun when cotton plants were 32 days old after sowing where plants were established and constant amount of water per irrigation was given for all irrigation treatments. Each experiment was laid out as a randomized complete blocks design with three replicates. Wide borders (2 m width) were kept among the different water regimes to minimize the underground water permeability. Each experimental plot comprised a single ridge, 3 m long and 70 cm width. Cotton seeds were sown on 30^{th} of March in hills spaced at 20 cm and the seedlings were later thinned at two plants per hill. All other common agricultural practices of growing cotton were applied properly as recommended in the district.

Data were recorded on eight guarded plants from each plot for the following characteristics, days to the first flower (d), number of open bolls/plant, boll weight (g), seed cotton yield/plant (g), lint percentage (%) and seed index (g). The drought susceptibility index (SI) was used to characterize the relative stress tolerance of all genotypes. The susceptibility index was calculated only for seed cotton yield per plant using a generalized formula according to Fischer and Maurer (1978) as follows:

$$S = (1 - Yd/Yp)/ D$$

Where

S= An index of drought susceptibility.

Yd= Performance of a genotype under drought stress.

Yp= Performance of the same genotype under normal irrigation.

D= Drought intensity = 1 – (mean Yd of all genotypes/mean Yp of all genotypes)

An ordinary analysis of variance for each irrigation regime and the combined analysis over the three irrigation intervals was performed according to Snedecor and Cochran (1981). General and specific combining ability variances and effects were obtained by employing Griffing's (1956) diallel cross analysis, method 2 and model 1. Heterosis expressed as percentage deviation of F_1 performance from better parent value for the studied traits was also calculated.

RESULTS AND DISCUSSION

The analysis of variance for seed cotton yield and some of agronomic traits under three irrigation regimes and over all conditions is presented in Table (1). Irrigation regimes mean squares were highly significant for all studied traits, indicating that the genotypes performance differed under the three irrigation treatments. Highly significant mean squares due to genotypes, parents and crosses for all studied traits under the three irrigation treatments indicate the existence of sufficient genetic variability among these cotton genotypes for these traits. The parents vs. crosses mean squares as an indication to average heterosis over all hybrids were significant for lint percentage and seed index under the three irrigation regimes, for days to the first flower and number of bolls/plant under both mild and severe conditions as well as seed cotton yield/plant under normal condition, revealing that average heterosis over all hybrids was pronounced for these traits under such condition. However, other studied traits in all cases did not reach the significant level, suggesting that the average heterosis was less pronounced for these traits. Therefore, the evaluation of potential parents for heterotic expression would necessarily be conducted over several environmental conditions. These results are in accordance with those obtained by Esmail (1991 and 1996), Rady *et al* (1996) and Esmail and Abdel-Hamid (1999).

Significant mean squares due to genotypes, parents and crosses with irrigation interactions were observed for all studied traits, reflecting the fact that these genotypes were inconsistent in their response to environmental conditions. Moreover, mean square for parents *vs.* crosses x irrigation interaction was significant for days to the first flower and seed cotton yield/plant.

Table 1. Mean squares estimates for the studied traits at three irrigation intervals+ and their combined data.

S. O. V	Single	Comb.	I_1	I_2	I_3	Comb.	I_1	I_2	I_3	Comb.
			Days to first flower				No. of open bolls/plant			
Replication / I	2	6	0.70	1.75	0.48	0.98	0.32	0.46	0.02	0.21
Irrigation (I)		2				1264.7**				723.52**
Genotypes (G)	35	35	41.89**	37.89**	34.57**	100.64**	12.07**	9.32**	3.43**	19.77**
Parents (P)	7	7	95.14**	90.99**	85.24**	254.81**	27.68**	15.57**	4.69**	37.75**
P vs. C	1	1	0.44	12.05**	15.27**	15.02**	3.12**	11.35**	5.56**	18.70**
Crosses (C)	27	27	29.62**	25.08**	22.15**	63.84**	8.37**	7.62**	3.03**	15.14**
GCA	7	7	188.37**	151.44**	129.54**	451.20**	49.32**	40.35**	12.21**	90.39**
SCA	28	28	5.25**	9.50**	10.84**	12.98**	2.77**	1.56**	1.23**	2.11*
G x I		70				6.86**				2.53**
P x I		14				8.28**				5.10**
P vs. C x I		2				6.38**				0.66*
C x I		54				6.50**				1.94**
GCA x I		14				9.08**				5.75**
SCA x I		56				6.31**				1.73**
Error	70	210	0.71	0.81	0.96	0.83	0.34	0.20	0.08	0.21
GCA/SCA			35.72	15.94	11.95	34.77	17.81	25.89	9.93	42.92
			Boll weight				Lint percentage %			
Replication / I	2	6	0.01	0.03	0.01	0.02	0.58	0.77	0.20	0.52
Irrigation (I)		2				3.15**				210.8**
Genotypes (G)	35	35	1.18**	1.07**	0.89**	3.00**	13.46**	15.43**	14.67**	32.04**
Parents (P)	7	7	3.10**	2.66**	1.31**	6.73**	13.05**	14.38**	12.83**	23.07**
P vs. C	1	1	0.36**	0.18**	0.89**	1.30**	39.40**	38.70**	36.34**	114.39**
Crosses (C)	27	27	0.71**	0.69**	0.78**	2.09**	12.60**	14.84**	14.35**	31.31**
GCA	7	7	5.39**	5.13**	3.94**	14.33**	25.99**	40.26**	14.88**	65.16**
SCA	28	28	0.12**	0.06**	0.13**	0.17**	10.33**	9.23**	14.62**	23.78**
G x I		70				0.07**				5.76**
P x I		14				0.18**				8.60**
P vs. C x I		2				0.07**				0.02
C x I		54				0.04**				5.23**
GCA x I		14				0.06**				7.99**
SCA x I		56				0.07**				5.20**
Error	70	210	0.02	0.01	0.01	0.01	0.42	0.37	0.36	0.38
GCA/SCA			43.85	89.93	30.75	85.32	2.52	4.36	1.02	2.74
			Seed index				Seed cotton yield/plant			
Replication / I	2	6	0.03	0.01	0.01	0.02	4.18	3.58	2.02	3.26
Irrigation (I)		2				21.10**				8763.7**
Genotypes (G)	35	35	4.97**	5.00**	5.99**	14.41**	28.23**	14.83**	9.86**	17.63**
Parents (P)	7	7	3.51**	2.38**	1.64**	6.65**	10.16*	30.93**	17.00**	23.89**
P vs. C	1	1	19.98**	10.93**	29.82**	58.40**	130.74**	0.24	0.81	46.76**
Crosses (C)	27	27	4.79**	5.47**	6.23**	14.79**	29.12**	11.20**	8.35**	14.93**
GCA	7	7	11.01**	13.15**	13.64**	36.38**	31.79**	29.22**	21.10**	35.53**
SCA	28	28	3.46**	2.97**	4.07**	8.91**	27.33**	11.23**	7.04**	13.14**
G x I		70				0.77**				17.64**
P x I		14				0.44**				17.10**
P vs. C x I		2				1.16**				42.52**
C x I		54				0.85**				16.86**
GCA x I		14				0.71**				23.29**
SCA x I		56				0.79**				16.23**
Error	70	210	0.08	0.03	0.05	0.05	3.90	1.58	1.65	2.38
GCA/SCA			3.19	4.43	3.35	4.08	1.16	2.60	3.00	2.70

* and ** denote significant at 0.05 and 0.01 levels of probability, respectively.
+ I_1, I_2 and I_3 denote irrigation at 15, 25 and 35 days intervals, respectively.

The mean values of the studied genotypes for six traits under three irrigation regimes and over all conditions are presented in Table (2).

Number of days to first flower for parents and crosses generally decreased as irrigation interval increased. The two *hirsutum* varieties were earlier about 12 days than *barbadense* varieties. Most hybrids were intermediate between their respective parents and interspecific hybrids were earlier than intra-*barbadense* hybrids.

Number of bolls/plant and boll weight were also decreased as irrigation interval increased. Number of bolls of *barbadense* parents is about two-folds that of *hirsutum* parents while, boll weight of *barbadense* parents is half that of *hirsutum* parents. Hybrids were intermediate in both traits. Interspecific hybrids tended to have lower number of bolls and heavier bolls than those of *barbadense* parents and hybrids.

Lint percentage and seed index were generally declined under stress. Hybrids have lower lint percentage and higher seed index under the three water regimes. Such results are expected since hybrids usually produce heavier seeds result in lower lint percentage. Nevertheless, some hybrids have lint percentage comparable to high respective parent.

Seed cotton yield/plant for parents and hybrids decreased as irrigation intervals increased. Under normal irrigation, the hybrids in general out-yielded parental varieties and 14 out of the 28 hybrids surpassed the higher yield respective parents. Meanwhile, under both drought stress environments, no superiority were detected for hybrids over parents. However, the reductions in yield and its components detected herein are supported by the findings of Radin *et al* (1992), El-Shahawy and Abdel-Malik (1999) and Esmail and Abdel-Hamid (1999).

The stress susceptibility index (SI) based on seed cotton yield per plant for parents and their F_1 hybrids is illustrated in Table (3). Drought tolerant entries with low relative reduction in seed cotton yield had (SI) values lower than unity (Fischer and Maurer 1978). The results concerning drought susceptibility index reveal that the four cotton varieties, i.e. Giza 85, Pima S-7, Tamcot and Deltapine 703 and three crosses, viz. Pima S-7 x Tamcot, Giza 85 x Sea island and Tamcot x Deltapine 703 had the lowest (SI) values proving to be more drought tolerance. The mean performance of seed cotton yield of these genotypes exceeded the average yield of all genotypes (31.66 and 19.77) under mild and severe drought conditions, respectively. So, the seven above-mentioned genotypes are considered the most tolerant to water stress conditions and should be exploited in cotton breeding for this objective.

Table 2. Mean performance for agronomic traits in 8 x 8 cotton half crosses under three irrigation intervals *.

Genotypes	Days to first flower				No. of open bolls/plant			
	I_1	I_2	I_3	Comb.	I_1	I_2	I_3	Comb.
Giza 45 (p_1)	80.67	75.00	74.00	76.56	15.64	11.70	9.42	12.25
Giza 70 (p_2)	81.33	77.33	74.00	77.56	15.10	12.96	7.03	11.7
Giza 83 (p_3)	79.33	77.33	75.00	77.22	12.05	13.14	7.39	10.86
Giza 85 (p_4)	81.00	77.67	73.33	77.33	14.13	12.51	8.33	11.66
Pima S-7 (p_5)	80.00	77.33	72.67	76.67	13.63	13.29	8.44	11.79
Sea Island (p_6)	83.33	76.67	69.33	76.44	14.42	12.56	8.73	11.9
Tamcot (p_7)	70.67	64.33	61.33	65.44	08.14	07.72	5.56	07.14
Deltapine (p_8)	67.67	66.00	63.00	65.56	07.89	08.06	6.77	07.57
Mean	78.00	73.96	70.33	74.10	12.63	11.49	7.71	10.61
P_1 x P_2	81.67	75.00	73.00	76.56	14.28	10.07	7.88	10.74
P_1 x P_3	80.67	77.00	71.67	76.44	12.57	11.11	7.95	10.54
P_1 x P_4	80.00	74.00	73.00	75.67	15.54	12.09	8.14	11.92
P_1 x P_5	80.67	77.00	72.67	76.78	12.44	12.41	8.78	11.21
P_1 x P_6	78.67	78.00	74.67	77.11	13.78	12.78	7.49	11.35
P_1 x P_7	74.67	72.67	69.00	72.11	09.91	09.16	6.15	08.41
P_1 x P_8	75.67	73.67	71.67	73.67	11.46	08.44	5.79	08.56
P_2 x P_3	82.00	77.33	74.00	77.78	12.43	12.23	7.86	10.84
P_2 x P_4	82.33	77.00	74.00	77.78	14.08	12.83	8.04	11.65
P_2 x P_5	81.33	76.33	72.00	76.56	13.81	11.90	8.36	11.36
P_2 x P_6	80.00	76.33	73.00	76.44	14.39	12.77	7.75	11.64
P_2 x P_7	77.33	72.00	73.00	74.11	11.98	09.38	6.43	09.26
P_2 x P_8	75.00	73.33	68.00	72.11	11.62	09.79	5.76	09.06
P_3 x P_4	79.33	74.67	72.33	75.44	12.21	11.76	7.98	10.65
P_3 x P_5	79.67	77.33	73.00	76.67	14.50	11.02	7.61	11.04
P_3 x P_6	81.00	73.33	74.00	76.11	11.50	11.84	6.55	09.96
P_3 x P_7	77.33	75.33	72.00	74.89	11.60	09.21	6.16	08.99
P_3 x P_8	74.00	75.00	68.33	72.44	11.70	08.81	6.79	09.10
P_4 x P_5	79.00	78.67	74.00	77.22	11.92	11.72	7.94	10.53
P_4 x P_6	76.33	78.33	70.00	74.89	12.83	12.11	9.08	11.34
P_4 x P_7	77.00	73.33	71.00	73.78	11.50	09.43	5.58	08.84
P_4 x P_8	75.33	74.67	68.33	72.78	10.71	09.42	6.21	08.78
P_5 x P_6	80.33	77.67	70.33	76.11	14.11	13.57	7.99	11.89
P_5 x P_7	75.67	71.00	69.00	71.89	09.75	09.88	6.56	08.73
P_5 x P_8	74.00	72.33	71.67	72.67	11.30	09.53	6.55	09.13
P_6 x P_7	75.67	73.00	70.00	72.89	10.86	09.52	6.47	08.95
P_6 x P_8	76.00	74.33	69.33	73.22	11.23	09.30	6.99	09.17
P_7 x P_8	69.00	64.67	61.67	65.11	08.05	07.88	5.78	07.24
Mean	77.85	74.76	71.24	74.62	12.22	10.71	7.17	10.03
Average	77.88	74.58	71.04	74.5	12.31	10.89	7.29	10.16
L.S. D. 5%	1.38	1.46	1.59	0.84	0.95	0.72	0.47	0.42
L.S. D. 1%	1.66	1.76	1.92	0.98	1.15	0.87	0.57	0.49

* I_1, I_2 and I_3 denote irrigation at 15, 25 and 35 days intervals, respectively

Table 2. Cont.

Genotypes	Boll weight				Lint percentage %			
	I_1	I_2	I_3	Comb.	I_1	I_2	I_3	Comb.
Giza 45 (p_1)	2.29	2.22	1.90	2.14	35.32	33.17	32.60	33.70
Giza 70 (p_2)	2.44	2.48	2.26	2.39	40.42	34.52	35.46	36.80
Giza 83 (p_3)	2.87	2.72	2.41	2.67	40.22	38.71	38.17	39.03
Giza 85 (p_4)	2.49	2.43	2.42	2.45	37.62	37.95	35.79	37.12
Pima S-7 (p_5)	2.46	2.43	2.41	2.43	39.71	38.47	32.56	36.91
Sea Island (p_6)	2.54	2.40	2.56	2.50	36.76	37.48	35.58	36.61
Tamcot (p_7)	4.74	4.63	3.97	4.45	40.34	39.58	35.99	38.64
Deltapine (p_8)	4.63	4.27	3.32	4.07	36.20	37.29	37.82	37.10
Mean	3.06	2.95	2.66	2.89	38.32	37.15	35.50	36.99
P_1 x P_2	2.86	2.72	2.49	2.69	37.82	35.05	33.19	35.35
P_1 x P_3	3.11	2.59	2.65	2.78	38.33	36.50	35.01	36.61
P_1 x P_4	2.77	2.67	2.46	2.63	36.12	34.24	33.42	34.59
P_1 x P_5	2.70	2.52	2.34	2.52	36.51	36.22	34.68	35.80
P_1 x P_6	2.59	2.60	2.54	2.58	35.89	33.59	34.35	34.61
P_1 x P_7	3.53	3.43	3.30	3.42	37.18	34.75	32.75	34.89
P_1 x P_8	3.73	3.52	3.46	3.57	33.30	31.33	31.23	31.95
P_2 x P_3	2.62	2.62	2.47	2.57	36.97	38.19	35.16	36.77
P_2 x P_4	2.92	2.69	2.42	2.68	39.47	37.56	37.61	38.21
P_2 x P_5	2.72	2.52	2.30	2.51	39.34	37.93	34.94	37.40
P_2 x P_6	2.97	2.62	2.33	2.64	37.25	35.88	32.02	35.05
P_2 x P_7	3.47	3.46	3.42	3.45	34.31	35.08	32.29	33.89
P_2 x P_8	3.46	3.36	3.29	3.37	33.96	31.11	30.80	31.96
P_3 x P_4	3.12	2.87	2.52	2.84	40.09	38.12	34.34	37.52
P_3 x P_5	2.73	2.63	2.54	2.63	39.36	38.89	39.95	39.40
P_3 x P_6	3.18	2.85	2.39	2.81	38.89	37.62	36.45	37.65
P_3 x P_7	3.55	3.50	3.40	3.48	35.71	35.85	34.99	35.52
P_3 x P_8	3.55	3.21	3.21	3.32	35.61	33.50	31.73	33.61
P_4 x P_5	2.81	2.66	2.41	2.63	38.78	36.42	30.77	35.32
P_4 x P_6	2.73	2.64	2.33	2.57	38.90	37.11	35.67	37.23
P_4 x P_7	3.52	3.47	3.27	3.42	36.77	35.96	33.10	35.28
P_4 x P_8	3.47	3.34	3.21	3.34	34.65	32.50	33.04	33.40
P_5 x P_6	2.60	2.48	2.23	2.44	40.22	38.28	34.20	37.57
P_5 x P_7	3.43	3.46	3.28	3.39	32.88	37.49	36.11	35.49
P_5 x P_8	3.58	3.59	3.50	3.56	35.62	35.72	33.12	34.82
P_6 x P_7	3.46	3.51	3.36	3.44	36.07	35.59	34.68	35.45
P_6 x P_8	3.62	3.49	3.51	3.54	35.39	31.48	31.77	32.88
P_7 x P_8	4.74	4.32	3.87	4.31	36.97	37.82	37.46	37.42
Mean	3.20	3.05	2.88	3.04	36.87	35.71	34.10	35.56
Average	3.17	3.03	2.83	3.01	37.19	36.03	34.41	35.88
L.S. D. 5%	0.21	0.18	0.11	0.10	1.05	0.99	0.97	0.57
L.S. D. 1%	0.25	0.22	0.13	0.12	1.27	1.19	1.17	0.66

* I_1, I_2 and I_3 denote irrigation at 15, 25 and 35 days intervals, respectively.

Table 2. Cont.

Genotypes	Seed index				Seed cotton yield/plant			
	I_1	I_2	I_3	Comb.	I_1	I_2	I_3	Comb.
Giza 45 (p_1)	12.63	11.7	11.61	11.98	35.61	25.71	17.77	26.36
Giza 70 (p_2)	11.38	10.74	10.45	10.86	36.57	31.85	15.65	28.02
Giza 83 (p_3)	12.06	10.9	10.22	11.06	34.25	35.42	17.69	29.12
Giza 85 (p_4)	12.16	11.14	11.00	11.43	35.01	30.08	19.84	28.31
Pima S-7 (p_5)	9.71	9.65	9.47	9.61	31.66	32.08	20.15	27.96
Sea Island (p_6)	10.85	9.98	10.62	10.48	36.38	29.92	22.06	29.45
Tamcot (p_7)	10.9	10.97	11.16	11.01	37.77	35.23	21.61	31.54
Deltapine (p_8)	12.99	12.46	11.66	12.37	35.87	33.72	22.17	30.59
Mean	11.59	10.94	10.77	11.10	35.39	31.75	19.62	28.92
P_1 x P_2	11.50	11.30	11.19	11.33	40.58	27.08	19.29	28.98
P_1 x P_3	11.88	10.66	11.37	11.30	38.75	28.52	20.80	29.36
P_1 x P_4	12.00	12.13	12.12	12.08	42.69	31.87	19.79	31.45
P_1 x P_5	11.78	11.03	10.75	11.19	33.16	30.83	20.26	28.08
P_1 x P_6	11.48	10.91	11.07	11.15	35.34	32.94	18.72	29.00
P_1 x P_7	13.08	11.91	12.3	12.43	34.63	31.20	19.79	28.54
P_1 x P_8	14.23	13.52	14.49	14.08	42.15	29.17	19.64	30.32
P_2 x P_3	11.58	9.23	10.66	10.49	32.45	31.67	19.17	27.76
P_2 x P_4	12.29	9.83	11.09	11.07	40.70	34.30	19.22	31.41
P_2 x P_5	10.81	11.68	11.08	11.19	37.28	29.75	18.95	28.66
P_2 x P_6	12.19	10.77	10.35	11.10	42.46	33.11	17.95	31.17
P_2 x P_7	14.18	11.91	12.66	12.92	41.07	32.10	20.92	31.36
P_2 x P_8	13.77	13.37	14.70	13.95	39.77	32.55	18.55	30.29
P_3 x P_4	12.16	10.27	10.78	11.07	37.75	33.38	19.93	30.35
P_3 x P_5	11.75	10.56	10.49	10.93	39.34	28.65	19.10	29.03
P_3 x P_6	12.83	10.52	10.86	11.40	36.23	33.34	15.46	28.34
P_3 x P_7	13.73	13.56	13.26	13.52	40.88	31.84	20.54	31.09
P_3 x P_8	13.77	13.36	14.15	13.76	41.04	27.87	21.25	30.05
P_4 x P_5	11.13	11.00	11.20	10.78	32.97	30.98	19.65	27.87
P_4 x P_6	11.24	10.65	11.52	11.14	34.73	31.64	20.19	28.85
P_4 x P_7	14.41	12.45	12.85	13.24	40.07	32.26	17.84	30.06
P_4 x P_8	15.57	14.41	14.56	14.85	36.92	31.15	19.50	29.19
P_5 x P_6	11.77	10.53	10.43	10.91	36.34	33.37	17.74	29.15
P_5 x P_7	11.63	10.9	11.47	11.33	32.92	33.81	21.03	29.25
P_5 x P_8	13.21	12.92	13.91	13.35	40.06	33.77	22.60	32.14
P_6 x P_7	12.67	12.61	12.29	12.52	37.25	32.93	21.22	30.47
P_6 x P_8	14.93	13.98	14.37	14.43	40.20	32.16	24.10	32.15
P_7 x P_8	11.78	11.87	11.05	11.57	37.28	33.47	21.91	30.89
Mean	12.62	11.71	12.04	12.12	38.04	31.63	19.82	29.83
Average	12.39	11.54	11.76	11.88	37.45	31.66	19.78	29.63
L.S. D. 5%	0.46	0.26	0.37	0.21	3.22	2.05	2.09	1.43
L.S. D. 1%	0.55	0.31	0.45	0.25	3.88	2.47	2.52	1.67

* I_1, I_2 and I_3 denote irrigation at 15, 25 and 35 days intervals, respectively.

Table 3. Drought susceptbility index for seed cotton yield per plant in 8 x 8 diallel crosses

Genotypes	Drought Sceptibility Index I	Drought Sceptibility Index II	Genotypes	Drought Susceptibility Index I	Drought Susceptibility Index II
Giza 45 (p_1)	1.0	1.06	P_3 x P_4	0.74	1.00
Giza 70 (p_2)	0.3	1.21	P_3 x P_5	1.76	1.09
Giza 83 (p_3)	-0.2	1.03	P_3 x P_6	0.52	1.22
Giza 85 (p_4)	0.1	0.92	P_3 x P_7	1.43	1.05
Pima S-7 (p_5)	-0.9	0.77	P_3 x P_8	2.07	1.02
Sea Island (p_6)	1.5	0.83	P_4 x P_5	0.39	086
Tamcot (p_7)	0.4	0.91	P_4 x P_6	0.58	0.89
Deltapine (p_8)	0.9	0.81	P_4 x P_7	1.26	1.18
Mean	0.6	0.94	P_4 x P_8	1.01	1.00
P_1 x P_2	2.5	1.11	P_5 x P_6	0.53	1.09
P_1 x P_3	1.1	0.98	P_5 x P_7	-0.18	0.77
P_1 x P_4	1.4	1.14	P_5 x P_8	1.02	0.92
P_1 x P_5	0.6	0.83	P_6 x P_7	0.75	0.91
P_1 x P_6	0.4	1.00	P_6 x P_8	1.29	0.85
P_1 x P_7	0.6	0.91	P_7 x P_8	0.66	0.87
P_1 x P_8	1.9	1.13	Mean	1.05	1.01
P_2 x P_3	0.5	0.87	Average	0.96	0.99
P_2 x P_4	1.2	1.12	L.S. D. 5%	0.57	0.17
P_2 x P_5	1.1	1.04	L.S. D. 1%	0.40	0.12
P_2 x P_6	1.2	1.22	r (normal)	0.80**	0.62**
P_2 x P_7	1.1	1.04	r (water stress)	-0.69**	-0.71**
P_2 x P_8	1.7	1.13			

r denote simple correlation coeficient between (SI) value and mean performances of seed cotton yield/plant under normal and drought conditions.

Significant positive correlation was observed between (SI) values and mean of seed cotton yield under normal irrigation condition for genotypes (r=0.795** and 0.618**), suggesting that low yield potential may be related to drought tolerance. On the other hand, significant negative correlation was detected between (SI) values and mean of seed cotton yield under water stress conditions for genotypes (r = -0.690** and -0.712**), revealing that drought tolerance (lowest SI) was associated with high yield under water stress conditions. These results ascertain that both low (SI) and high yield under drought conditions would be useful selection criterion to improve drought tolerance in cotton. Therefore, selection for drought tolerance will be effective only when the cotton plants are subjected to water stress during growth stages. Similar results were found by Fischer and Maurer (1978) and Esmail and Abdel-Hamid (1999).

Partitioning the sum of squares due to crosses into general (GCA) and specific (SCA) combining abilities for the studied traits under the three irrigation treatments and their combined analysis is shown in Table (1). Highly significant mean squares due to both GCA and SCA were observed for all studied traits under the three irrigation regimes and their combined analysis, indicating that both additive and non-additive genetic effects were involved in the inheritance of traits studied under both normal and drought conditions. The ratios of GCA/SCA variances exceeded the unity, which led to the conclusion that the additive and additive by additive types of gene action had important role in the inheritance of these traits under all irrigation regimes. Such results suggest the potential for obtaining further improvements for yield and its components. Also, selection procedures based on the accumulation of additive effect would be successful in improving these traits. In this connection, El-Gohary *et al* (1981) found that the additive genetic variance was more important in the inheritance of number of bolls/plant, boll weight and lint percentage. Also, Esmail (1991) found that both GCA and SCA variances were found to be highly significant for seed cotton yield and its components. He mentioned also that the GCA/SCA ratio indicted the greater importance of additive and additive by additive types of gene action in the inheritance of seed cotton yield and its components, except seed index at the normal plant density. Hendawy (1994), Rady *et al.* (1996), Hassan and Awad (1997) and Esmail and Abdel-Hamid (1999) came to similar conclusion.

The mean squares of interactions of both types of gene action (GCA & SCA) with irrigation regimes were significant for all studied traits, indicating existence of sensitivity of both kinds of genetic effects to the variation under various irrigation regimes. Therefore, the irrigation interval is considered as an effective factor for declaring GCA and SCA variances. Furthermore, the magnitudes of the interactions for GCA x irrigation were higher than those of SCA for all studied traits, suggesting that additive and additive x additive types of gene action appeared to be more influenced by irrigation regimes than non-additive ones. These results are in coincidence with those found by Esmail (1991), Abo El- Zahab *et al* (1992), Rady *et al* (1996) and Esmail and Abdel-Hamid (1999). However, Hendawy (1994) mentioned that both types of gene action were found to interact in a similar way with environments.

Estimates of GCA effects for each parental variety in each trait under the three irrigation regimes are presented in Table (4). High positive GCA values would be of interest in all studied traits except days to first open flower where high negative values would be useful from the breeder's point of view. For earliness criterion, the two Upland cotton genotypes, viz. Tamcot and Deltapine 703 showed highly significant negative estimates of GCA effects toward earliness under the three irrigation regimes. This would indicate that these genotypes could be considered as good combiners for developing early genotypes under such conditions of transferring earliness could be feasible in future.

Table 4. General combining ability effects of parental cultivars evaluated under three irrigation intervals+ for the studied traits.

Parents	Days to first flower			No. of open bolls/plant			Boll weight		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
Giza 45	1.24**	0.61**	1.44**	1.05**	0.15**	0.55**	-0.26**	-0.27**	-0.24**
Giza 70	2.14**	1.07**	1.57**	1.20**	0.69**	0.06**	-0.26**	-0.23**	-0.22**
Giza 83	1.17**	1.34**	1.60**	-0.02	0.43**	0.01**	-0.09**	-0.15**	-0.14**
Giza 85	1.04**	1.48**	1.00**	0.63**	0.64**	0.41**	-0.22**	-0.20**	-0.20**
Pima S-7	0.98**	1.38**	0.87**	0.43**	0.86**	0.51**	-0.30**	-0.25**	-0.20**
Sea island	1.37**	1.31**	0.07*	0.68**	0.90**	0.42**	-0.23**	-0.22**	-0.16**
Tamcot	-3.29**	-4.06**	-3.10**	-2.08**	-1.81**	-1.13**	0.67**	0.72**	0.64**
Deltapine 703	-4.66**	-3.12**	-3.43**	-1.89**	-1.87**	-0.82**	0.69**	0.61**	0.53**
r	0.98**	0.99**	0.99**	0.99**	0.98**	0.92**	0.99**	0.99**	0.95**
L.S.D. 0.05 (gi)	0.28	0.30	0.33	0.20	0.15	0.10	0.04	0.04	0.02
L.S.D. 0.01 (gi)	0.37	0.40	0.43	0.26	0.20	0.13	0.06	0.05	0.03
L.S.D. 0.05 (gi-gj)	0.43	0.45	0.49	0.29	0.23	0.14	0.08	0.06	0.06
L.S.D. 0.01 (gi-gj)	0.57	0.59	0.65	0.39	0.31	0.18	0.10	0.08	0.08

Parents	Lint percentage %			Seed index			Seed cotton yield/plant		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
Giza 45	-0.90**	-1.62**	-0.99**	-0.03**	0.10**	0.07**	0.15	-2.19**	-0.42**
Giza 70	0.52**	-0.44**	-0.28**	-0.24**	-0.43**	-0.32**	1.04**	-0.07	-1.27**
Giza 83	1.07**	1.19**	1.43**	0.03**	-0.39**	-0.38**	-0.21	0.12*	-0.64**
Giza 85	0.53**	0.36**	-0.02	0.16**	-0.08**	0.03**	-0.12	0.09	-0.22**
Pima S-7	0.74**	1.37**	-0.08**	-1.00**	-0.59**	-0.75**	-2.16**	0.04	0.16**
Sea island	0.14**	0.03*	0.06**	-0.27**	-0.39**	-0.37**	-0.17	0.44**	0.15**
Tamcot	-0.42**	0.75**	0.37**	0.18**	0.33**	0.24**	0.26*	1.31**	0.85**
Deltapine 703	-1.68**	-1.62**	-0.49**	1.17**	1.45**	1.47**	1.21**	0.27**	1.39**
r	0.66	0.74*	0.59	0.81*	0.85**	0.81*	0.80*	0.80*	0.91**
L.S.D. 0.05 (gi)	0.22	0.20	0.20	0.10	0.05	0.08	0.66	0.42	0.43
L.S.D. 0.01 (gi)	0.28	0.27	0.26	0.13	0.07	0.10	0.87	0.56	0.57
L.S.D. 0.05 (gi-gj)	0.33	0.31	0.31	0.14	0.10	0.12	1.00	0.65	0.65
L.S.D. 0.01 (gi-gj)	0.44	0.41	0.41	0.18	0.13	0.16	1.32	0.85	0.85

*** and ** denote significant at 0.05 and 0.01 levels of probability, respectively.**
+ I_1, I_2 and I_3 denote irrigation at 15, 25 and 35 days intervals, respectively.
r denote simple correlation coefficient of parental mean performances with their general combining ability effects.

Concerning seed cotton yield and its components, the data revealed that the best general combiners under normal irrigation condition were the Egyptian cultivar Giza 70 for boll number, lint percentage and seed cotton yield, Giza 45 for boll number, Giza 83 for lint percentage and seed index, Giza 85 for boll number, lint percentage and seed index, Pima S-7 and Sea island for boll number and lint percentage and the two Upland cotton genotypes Tamcot and Deltapine 703 for boll weight, seed index and seed cotton yield/plant. On the contrary, the estimates for yield and its components under water stress conditions revealed that the cultivar Giza 45 exhibited significant positive GCA effects only for boll number and seed index, providing to be the best combiner for these traits under drought conditions. All *barbadense* cotton genotypes were the best general combiners for boll number, where they showed significant desirable GCA effects for this trait. Also, Sea island for lint percentage and seed cotton yield/plant, Pima S-7 for seed cotton yield, Tamcot and Deltapine 703 for boll weight, seed index and seed cotton yield and Tamcot for lint percentage are considered the best combiners under water stress conditions. Once identified the best parental combiners can be crossed to identify optimal hybrid combinations with the intent of selecting promising genotypes within the segregating generations of feasible.

The correlation coefficient between the parental mean performance and their corresponding GCA effects indicated significant positive values for days to first open flower, boll number, boll weight, seed index and seed cotton yield under both well-watered and drought condition and lint percentage under water stress condition. Such results indicated that the mean performance of a parental genotype could be considered as a good indication for its GCA effects. These findings are supported by the results found by other workers (Esmail 1991 and 1996, Hendawy1994, Hassan and Awaad 1997, Esmail and Abdel-Hamid 1999 and Ismail *et al* 2005).

Estimates of the specific combining ability effects for the hybrid combinations under the three irrigation regimes are illustrated in Table (5). For the earliness character, the negative SCA values of any cross would be preferred, indicating that the F_1 hybrid would produce lower means than the mid parent performance. Under normal irrigation condition, significant negative SCA effects were detected in eight crosses for days to the first open flower. On the other hand, ten crosses showed significant negative SCA values for this trait under drought condition. The two hybrids: Giza 83 x Giza 85 and Tamcot x Deltapine 703 have highest negative and significant SCA values under the three irrigation regimes and consequently considered to be the best hybrid-combinations for earliness trait. Regarding seed cotton yield and its components, significant positive SCA effects were observed in nine crosses for boll number, thirteen crosses for boll weight, twelve crosses for lint percentage, seventeen crosses for seed index and ten crosses for seed cotton yield/plant under well watered condition. Whereas, under water stress condition (severe condition), significant positive SCA effects were found in eleven crosses for boll number, eighteen crosses for boll weight, nine crosses for lint percentage, sixteen crosses for seed index and eight crosses for seed cotton yield/plant. Briefly, potential cross combinations were identified for giving good yields and highest desirable SCA effects such as Giza 45 x Giza 85, Giza 70 x Sea island, Giza 83 with both of Pima S-7 and Tamcot and Pima S-7 x Deltapine 703 under normal irrigation condition.

Table 5. Estimates of specific combining ability effects of the 28 crosses evaluated for the studied traits under three irrigation intervals+.

Crosses	Days to first flower			No. of open bolls/plant			Boll weight		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
P_1 x P_2	0.41*	-1.27**	-1.04**	-0.28**	-1.66**	-0.01	0.22**	0.20**	0.12**
P_1 x P_3	0.37*	0.47*	-2.40**	-0.77**	-0.35**	0.11**	0.30**	-0.01**	0.21**
P_1 x P_4	-0.16	-2.67**	-0.47	1.56**	0.42**	-0.10**	0.09**	0.12**	0.07**
P_1 x P_5	0.57**	0.43*	-0.67*	-1.35**	0.51**	0.44**	0.10**	0.02**	-0.05**
P_1 x P_6	-1.83**	1.50**	2.13**	-0.25**	0.84**	-0.76**	-0.09**	0.07**	0.12**
P_1 x P_7	-1.16**	1.54**	-0.37	-1.36**	-0.07	-0.55**	-0.04**	-0.04**	0.07**
P_1 x P_8	1.20**	1.60**	2.63**	-0.01	-0.73**	-1.22**	0.14**	0.16**	0.35**
P_2 x P_3	0.81**	0.33	-0.20	-1.06**	0.22**	0.51**	-0.20**	-0.02**	0.01**
P_2 x P_4	1.27**	-0.13	0.40	-0.06	0.61**	0.29**	0.23**	0.10**	0.01**
P_2 x P_5	0.34	-0.70**	-1.47**	-0.13	-0.54**	0.51**	0.12**	-0.03**	-0.11**
P_2 x P_6	-1.39**	-0.64**	0.33	0.20*	0.29**	-0.01	0.29**	0.04**	-0.11**
P_2 x P_7	0.60**	0.40	3.50**	0.55**	-0.39**	0.22**	-0.10**	-0.06**	0.17**
P_2 x P_8	-0.36	0.80**	-1.17**	0.00	0.08	-0.77**	-0.14**	-0.05**	0.16**
P_3 x P_4	-0.76**	-2.73**	-1.31**	-0.71**	-0.20**	0.28**	0.26**	0.20**	0.04**
P_3 x P_5	-0.36	0.03	-0.50	1.78**	-1.16**	-0.20**	-0.05**	0.01*	0.06**
P_3 x P_6	0.57**	-3.90**	1.30**	-1.47**	-0.38**	-1.17**	0.33**	0.20**	-0.13**
P_3 x P_7	1.57**	3.47**	2.46**	1.39**	-0.30**	-0.00	-0.19**	-0.09**	0.08**
P_3 x P_8	-0.40*	2.20**	-0.87**	1.30**	-0.64**	0.31**	-0.22**	-0.29**	0.00
P_4 x P_5	-0.90**	1.24**	1.10**	-1.45**	-0.67**	-0.26**	0.16**	0.09**	-0.02**
P_4 x P_6	-3.96**	0.96**	-2.10**	-0.78**	-0.32**	0.97**	0.00	0.04**	-0.14**
P_4 x P_7	1.37**	1.33**	2.07**	0.65**	-0.29**	-0.98**	-0.10**	-0.07**	0.00
P_4 x P_8	1.07**	1.74**	-0.27	-0.33**	-0.24**	-0.67**	-0.17**	-0.10**	0.06**
P_5 x P_6	0.10	0.40	-1.64**	0.69**	0.92**	-0.23**	-0.04**	-0.07**	-0.23**
P_5 x P_7	0.11	-0.90**	0.20	-0.91**	-0.06	-0.10**	-0.11**	-0.03**	0.02**
P_5 x P_8	-0.20	-0.50*	3.20**	0.45**	0.35**	-0.43**	0.02**	0.20**	0.35**
P_6 x P_7	-0.29	1.17**	2.00**	-0.04	-0.46**	-0.10**	-0.15**	-0.01*	0.05**
P_6 x P_8	1.40**	1.56**	1.66**	0.14	-0.62**	0.10**	-0.01*	0.08**	0.32**
P_7 x P_8	-0.93**	-2.73**	-2.83**	-0.28**	0.67**	0.44**	0.22**	-0.04**	-0.12**
L. S. D. 0.05	0.87	0.92	1.00	0.60	0.46	0.29	0.13	0.12	0.06
L. S. D. 0.01	1.14	1.21	1.32	0.79	0.60	0.39	0.17	0.15	0.08
r	0.20	0.34	0.39*	0.35	0.81**	0.61**	-0.09	-0.22	0.52**

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

+ I_1, I_2 and I_3 denote irrigation at 15, 25 and 35 days intervals, respectively.

r denote simple correlation coefficient between hybrid mean performances and specific combining ability effects.

P_1, P_2, P_3, P_4, P_5, P_6, P_7 and P_8 denote Giza 45, Giz 70, Giza 83, Giz 85, Pima S-7, Sea island, Tamcot and Deltapine 703, respectively.

Table 5. Cont.

Crosses	Lint percentage %			Seed index			Seed cotton yield/plant		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
$P_1 \times P_2$	1.00**	1.08**	0.04	-0.62**	0.09**	-0.32**	1.94	-2.32**	1.20**
$P_1 \times P_3$	0.97**	0.91**	0.16	-0.51**	-0.59**	-0.08**	1.36	-1.07*	2.08**
$P_1 \times P_4$	-0.71**	-0.52**	0.01	-0.52**	0.57**	0.26**	5.21**	2.32**	0.65
$P_1 \times P_5$	-0.53**	0.45**	1.34**	0.42**	-0.02*	-0.32**	-2.27*	1.32**	0.74
$P_1 \times P_6$	-0.55**	-0.84**	0.87**	-0.61**	-0.34**	-0.39**	-2.09	3.03**	-0.79
$P_1 \times P_7$	1.30**	-0.40**	-1.04**	0.54**	-0.06**	0.23**	-3.23**	0.42	-0.42
$P_1 \times P_8$	-1.32**	-1.46**	-1.70**	0.70**	0.43**	1.19**	3.34**	-0.57	-1.11*
$P_2 \times P_3$	-1.81**	1.42**	-0.40**	-0.60**	-1.49**	-0.40**	-5.83**	-0.04	1.30**
$P_2 \times P_4$	1.23**	1.62**	3.49**	-0.02	-1.20**	-0.38**	2.33*	2.62**	0.93*
$P_2 \times P_5$	0.89**	0.98**	0.89**	-0.34**	1.16**	0.39**	0.95	-1.88**	0.28
$P_2 \times P_6$	-0.61**	0.27**	-2.17**	0.31**	0.05**	-0.72**	4.14**	1.08*	-0.71
$P_2 \times P_7$	-2.99**	-1.25**	-2.21**	1.86**	0.47**	0.98**	2.32*	-0.80	1.56**
$P_2 \times P_8$	-2.07**	-2.86**	-2.84**	0.45**	0.81**	1.79**	0.07	0.69	-1.35**
$P_3 \times P_4$	1.30**	0.55**	-1.48**	-0.42**	-0.80**	-0.63**	0.63	1.52**	1.01*
$P_3 \times P_5$	0.36**	0.31**	4.19**	0.33**	0.00	-0.13**	4.27**	-3.16**	-0.20
$P_3 \times P_6$	0.49**	0.38**	0.55**	0.68**	-0.24**	-0.15**	-0.84	1.13**	-3.83**
$P_3 \times P_7$	-2.13**	-2.11**	-1.21**	1.13**	2.08**	1.64**	3.38**	-1.25**	0.55
$P_3 \times P_8$	-0.97**	-2.09**	-3.62**	0.18**	0.76**	1.30**	2.59*	-4.18**	0.72
$P_4 \times P_5$	0.32**	-1.33**	-3.54**	-0.42**	0.14**	0.17**	-2.20*	-0.80	-0.07
$P_4 \times P_6$	1.04**	0.70**	1.22**	-1.04**	-0.41**	0.11**	-2.43*	-0.55	0.48
$P_4 \times P_7$	-0.54**	-1.17**	-1.66**	1.68**	0.66**	0.82**	2.48*	-0.80	-2.56**
$P_4 \times P_8$	-1.39**	-2.26**	-0.86**	1.85**	1.50**	1.30**	-1.62	-0.80	-1.45**
$P_5 \times P_6$	2.15**	0.86**	-0.19	0.65**	-0.02**	-0.21**	1.23	1.23**	-2.35**
$P_5 \times P_7$	-4.64**	-0.65**	1.41**	0.06**	-0.38**	0.23**	-2.63*	0.80	0.24
$P_5 \times P_8$	-0.63**	-0.05	-0.72**	0.65**	0.52**	1.43**	3.56**	1.80**	1.27**
$P_6 \times P_7$	-0.85**	-1.21**	-0.16	0.37**	1.13**	0.66**	-0.29	-0.48	0.45
$P_6 \times P_8$	-0.26*	-2.95**	-2.21**	1.64**	1.38**	1.51**	1.71	-0.21	2.78**
$P_7 \times P_8$	1.88**	2.67**	3.17**	-1.96**	-1.45**	-2.42**	-1.64	0.23	-0.10
L. S. D. 0.05	0.66	0.62	0.61	0.29	0.17	0.23	2.03	1.29	1.32
L. S. D. 0.01	0.88	0.82	0.81	0.38	0.22	0.3	2.67	1.70	1.74
r	0.83**	0.77**	0.92**	0.81**	0.81**	0.84**	0.91**	0.78**	0.78**

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

+ I_1, I_2 and I_3 denote irrigation at 15, 25 and 35 days intervals, respectively.

r denote simple correlation coefficient between hybrid mean performances and specific combining ability effects.

P_1, P_2, P_3, P_4, P_5, P_6, P_7 and P_8 denote Giza 45, Giz 70, Giza 83, Giz 85, Pima S-7, Sea island, Tamcot and Deltapine 703, respectively.

On the other hand, Giza 45 x Giza 83 and Sea island x Deltapine 703 exhibited the highest positive SCA effects under water stress condition (severe condition). It is of interest to mention that the Egyptian cotton cultivar Giza 70 was considered to be best combiner for seed cotton yield, boll number and lint percentage as well as the two cross combinations Giza 70 x Tamcot and Sea island x Deltapine 703 under both normal irrigation and water stress conditions. The three crosses, i.e. Giza 45 x Giza 85, Giza 70 x Sea island and Giza 83 x Pima S-7 under normal condition and the two crosses, viz. Giza 45 x Giza 83 and Sea island x Deltapine 703 under water stress conditions were identified as potential which could valuable in future breeding programs. The results concerning GCA and SCA effects indicated that the best cross combinations were obtained from the possible combinations between the parents with high and/or poor GCA effects. Consequently, it could be concluded that GCA effects of the parents were generally not strongly related to the SCA effects of their respective crosses. Such results agreed with those obtained by Esmail (1991), Hendawy (1994), Rady *et al.* (1996), Esmail and Adel-Hamid (1999) and Ismail *et al* (2005).

Table (6) represents percentages of heterosis relative to better parent under normal, mild and severe conditions. Earliness is important objective for the breeder, thus, negative value of heterosis for days to the first flower is the desired one. It could be observed that fourteen, fourteen and thirteen hybrids were earlier than their respective earlier parents under normal, mild and severe conditions, respectively. Regarding number of bolls/plant, only one hybrid (Giza 70 X Giza 83) showed significant positive heterobeltiosis under severe condition.

For seed cotton yield/plant, ten, two and one hybrids exhibited significant positive heterobeltiosis under normal, mild and severe conditions, respectively. With respect to seed index, thirteen, thirteen and fourteen out of 28 hybrids had significant positive heterobeltiosis under the three irrigation regimes, respectively. Other crosses showed little or no heterotic effects. For lint percentage, one and three hybrids exhibited significant positive heterobeltiosis under normal and severe conditions for this trait, respectively. From the previous results, it could be indicated that the three crosses, viz. Giza 45 x Giza 83, Giza 45 x Sea island and Giza 45 x Giza 85 exhibited heterobeltiosis for more of traits studied contributing seed cotton yield under favorable and stress condition. These findings agreed with general trend where the expression of heterosis for a quantitative trait is always a function of its components. Therefore, it could be concluded that these hybrids would be efficient and prospective in cotton breeding programs for improving seed cotton yield. Heterotic effect has been

Table 6. **Heterobeltiosis for the studied traits under three irrigation intervals+.**

Crosses	Days to first flower			No. of open bolls/plant			Boll weight		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
P_1 x P_2	1.24	0.00	-1.35	-8.68**	-22.31**	-16.34**	16.98**	9.59*	10.28**
P_1 x P_3	1.69	2.67**	-3.15**	-19.61**	-15.47**	-15.67**	8.37*	-4.77	9.74**
P_1 x P_4	-0.83	-1.33	-0.45	-0.64	-3.36	-13.66**	11.25**	10.01**	1.65
P_1 x P_5	0.84	2.67**	0.00	-20.46**	-6.62*	-6.79**	9.82*	3.62	-3.15
P_1 x P_6	-2.48**	4.00**	7.70**	-11.91**	1.75	-20.51**	1.85	8.08*	-0.90
P_1 x P_7	5.66**	12.96**	12.51**	-36.64**	-21.71**	-34.73**	-25.49**	-25.84**	-16.85**
P_1 x P_8	11.82**	11.62**	13.24**	-26.75**	-27.88**	-28.60**	-19.58**	-17.66**	4.31*
P_2 x P_3	3.37**	0.00	0.00	-17.68**	-6.95*	6.46*	-8.62*	-3.82	2.32
P_2 x P_4	2.91**	-0.43	0.91	-6.75*	-0.95	-3.48	17.20**	8.34*	0.04
P_2 x P_5	1.66	-1.29	-0.92	-8.59**	-10.44**	-0.98	10.88*	1.49	-4.56
P_2 x P_6	-1.64	-0.44	5.29**	-4.75	-1.44	-11.15**	16.72**	5.28	-8.83**
P_2 x P_7	9.42**	11.92**	19.03**	-20.66**	-27.58**	-8.57*	-26.78**	-25.35**	-13.77**
P_2 x P_8	10.83**	11.11**	7.94**	-23.08**	-24.47**	-18.16**	-25.26**	-21.27**	-0.87
P_3 x P_4	0.00	-3.44**	-1.36	-13.61**	-10.55**	-4.28	8.96*	5.25	4.34
P_3 x P_5	0.43	0.00	0.45	6.36	-17.08**	-9.87**	-4.74	-3.52	5.34*
P_3 x P_6	2.11*	-4.36**	4.85**	-20.25**	-9.94**	-24.98**	10.99**	4.59	-6.45**
P_3 x P_7	9.42**	17.10**	17.40**	-3.71	-29.93**	-16.56**	-24.96**	-24.42**	-14.33**
P_3 x P_8	9.35**	13.64**	8.46**	-2.93	-32.97**	-8.08*	-23.42**	-24.92**	-3.40
P_4 x P_5	-1.25	1.73	1.83	-15.64**	-11.76**	-5.96*	12.78**	9.68*	-0.54
P_4 x P_6	-5.77**	2.17*	0.97	-10.98**	-3.58	4.09	7.20	8.90*	-9.14**
P_4 x P_7	8.96**	13.99**	15.77**	-18.61**	-24.62**	-33.09**	-25.66**	-24.96**	-17.50**
P_4 x P_8	11.32**	13.14**	8.46**	-24.20**	-24.68**	-25.53**	-25.02**	-21.74**	-3.22
P_5 x P_6	0.41	1.30	1.44	-2.15	2.16	-8.40**	2.44	2.27	-13.56**
P_5 x P_7	7.08**	10.37**	12.51**	-28.47**	-25.61**	-22.31**	-27.67**	-25.28**	-17.18**
P_5 x P_8	9.35**	9.59**	13.76**	-17.07**	-28.25**	-22.43**	-22.78**	-15.86**	5.42**
P_6 x P_7	7.08**	13.48**	14.14**	-24.65**	-24.23**	-25.82**	-26.97**	-24.20**	-15.41**
P_6 x P_8	12.31**	12.62**	10.05**	-22.11**	-25.93**	-19.86**	-21.78**	-18.25**	5.66**
P_7 x P_8	1.97	0.51	0.55	-1.11	-2.32	-14.62**	0.17	-6.72**	-2.47
Average	4.19	5.55	6.07	-6.24	-1.34	-0.05	-6.18	-7.55	-3.68
L.S.D. 0.05	1.38	1.46	1.59	0.95	0.72	0.47	0.21	0.18	0.11
L.S.D. 0.01	1.83	1.94	2.12	1.27	0.96	0.62	0.28	0.24	0.15

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

+ I_1, I_2 and I_3 denote irrigation at 15, 25 and 35 days intervals, respectively.

P_1, P_2, P_3, P_4, P_5, P_6, P_7 and P_8 denote Giza 45, Giz 70, Giza 83, Giz 85, Pima S-7, Sea island, Tamcot and Deltapine 703, respectively.

Table 6. Cont.

Crosses	Lint percentage %			Seed index			Seed cotton yield/plant		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
P_1 x P_2	-6.43**	1.56	-6.40**	-8.95**	-3.39**	-3.64*	10.99*	-14.97**	8.55
P_1 x P_3	-4.70**	-5.72**	-8.29**	-5.94**	-8.92**	-2.07	8.83	-19.48**	17.05**
P_1 x P_4	-3.99**	-9.76**	-6.63**	-4.93**	3.65**	4.39**	19.88**	5.95	-0.25
P_1 x P_5	-8.07**	-5.86**	6.37**	-6.71**	-5.75**	-7.47**	-6.87	-3.90	0.55
P_1 x P_6	-2.39	-9.49**	-3.46*	-9.05**	-6.78**	-6.40**	-2.87	10.10**	-15.15**
P_1 x P_7	-7.83**	-12.19**	-9.00**	3.62	1.82	8.76**	-8.33	-11.43**	-8.42
P_1 x P_8	-8.01**	-15.98**	-17.45**	9.55**	8.51**	24.80**	17.52**	-13.47**	-11.43*
P_2 x P_3	-8.54**	-1.34	-7.89**	-3.92*	-15.29**	2.04	-11.26*	-10.59**	8.37
P_2 x P_4	-2.36	-1.03	5.09**	1.02	-12.00**	0.75	11.31*	7.70*	-3.13
P_2 x P_5	-2.67*	-1.41	-1.47	-5.04*	8.78**	6.06**	1.94	-7.28*	-5.96
P_2 x P_6	-7.84**	-3.38*	-10.00**	7.12**	0.31	0.66	16.12**	3.97	-18.63**
P_2 x P_7	-15.11**	-11.35**	-10.28**	24.61**	8.54**	13.41**	8.72*	-8.87**	-3.18
P_2 x P_8	-15.99**	-16.57**	-18.56**	6.01**	7.25**	26.14**	8.75	-3.45	-16.32**
P_3 x P_4	-0.31	-1.53	-10.04**	-0.03	-8.08**	-1.70	7.82	-5.74	0.45
P_3 x P_5	-2.12	0.45	4.65**	-2.55	-3.09*	2.67	14.88**	-19.10**	-5.21
P_3 x P_6	-3.31*	-2.82*	-4.51**	6.41**	-3.51**	2.29	-0.42	-5.853*	-29.95**
P_3 x P_7	-8.16**	-9.42**	-8.34**	13.85**	23.54**	18.79**	8.22	-10.11**	-4.94
P_3 x P_8	-11.45**	-13.46**	-16.87**	5.98**	7.22**	21.39**	14.41**	-21.32**	-4.14
P_4 x P_5	-2.34	-5.33**	-14.03**	-8.49**	-1.28	2.15	-5.83	-3.43	-2.48
P_4 x P_6	3.40*	-2.20	-0.34	-7.56**	-4.61**	5.06**	-4.54	5.20	-8.48
P_4 x P_7	-8.84**	-9.13**	-8.03**	18.50**	11.55**	15.14**	6.93	-8.43**	-17.46**
P_4 x P_8	-7.90**	-14.36**	-12.63**	19.89**	15.65**	24.88**	2.93	-7.60*	-12.06*
P_5 x P_6	1.28	-0.49	-3.89**	8.45**	5.48**	-1.72	-0.11	4.01	-19.58**
P_5 x P_7	-18.48**	-5.26**	0.16	6.70**	-0.64	2.71	-12.85**	-4.01	-2.67
P_5 x P_8	-10.30**	-7.16**	-12.43**	1.67	3.69**	19.33**	11.69*	0.16	1.94
P_6 x P_7	-10.57**	-10.08**	-3.64**	16.23**	14.95**	10.10**	-1.39	-6.51*	-3.81
P_6 x P_8	-3.73*	-15.51**	-15.10**	14.91**	12.17**	23.31**	10.51*	-4.61	8.72
P_7 x P_8	-8.35**	-4.44**	-0.95	-9.32**	-4.76**	-5.26**	-1.32	-4.98	-1.16
Average	-6.61	-6.90	-6.93	3.29	1.96	7.38	4.49	-5.64	-5.31
L.S.D. 0.05	1.05	0.99	0.97	0.47	0.26	0.37	3.21	2.05	2.09
L.S.D. 0.01	1.40	1.21	1.29	0.62	0.34	0.49	4.27	2.72	2.78

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

+ I_1, I_2 and I_3 denote irrigation at 15, 25 and 35 days intervals, respectively.

P_1, P_2, P_3, P_4, P_5, P_6, P_7 and P_8 denote Giza 45, Giz 70, Giza 83, Giz 85, Pima S-7, Sea island, Tamcot and Deltapine 703, respectively.

extensively investigated in cotton by many researches (Hendawy 1994, Singh and Singh 1993, Esmail and Abdel-Hamid1999, Singh and Singh 2001,Abdel-Galil 2001, El-Disouqi and Ziena 2001, Singh *et al* 2003 and Ismail *et al* (2005).

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قوة الهجين والقدرة على التآلف لمحصول القطن الزهر ومكوناته تحت ظروف الجفاف

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أجرى هذا البحث بهدف دراسة قوة الهجين والقدرة على التآلف وتفاعلاتهما مع معاملات الري تحت الدراسة وذلك لبعض الصفات المحصولية. استخدم لهذا الغرض ثمانية أصناف من القطن منها ستة أصناف تتبع النوع المصري *G. barbadense L.* وهى جيزة ٤٥، جيزة ٧٠ ، جيزة ٨٣ ، جيزة ٨٥ ، بيما اس ٧ ، سي آيلند وصنفان يتبعان الأبلند الأمريكي *G hirsutum L.* وهما تامكوت ودلتابين ٧٠٣ .

زرعت هذه الآباء الثمانية في موسم ٢٠٠٢ بمزرعة كلية الزراعة – جامعة عين شمس بشبرا الخيمة وتم إجراء التهجينات بينها بجميع التوافيق الممكنة في اتجاه واحد للحصول على ٢٨ هجين وفى موسم ٢٠٠٣ تم تقييم الآباء والهجن الناتجة منها تحت ثلاثة فترات للري وهى الري كل ١٥ يوم (الري العادي)، ٢٥ يوم (الإجهاد المائي المعتدل)، ٣٥ يوم (ظروف الإجهاد المائي القاسي) في

ثلاثة تجارب منفصلة في تصميم القطاعات كاملة العشوائية في ثلاثة مكررات في محطة التجارب والبحوث الزراعية التابعة لكلية الزراعة بشلقان – محافظة القليوبية. أجرى تحليل التباين لكل تجربة (معاملة ري) على حدا، كما أجرى التحليل المشترك بعد اختبار تجانس التباين. قدرت قوة الهجين مقاسة للأب الأفضل. كما قدرت القدرة العامة والخاصة على التآلف باستخدام طريقة جريفنج ١٩٥٦ لتحليل الهجن التبادلية للنموذج الأول الطريقة الثانية، كما تم حساب معامل تحمل الجفاف بطريقة " فشر وموريز ١٩٧٨ "وذلك لصفة محصول النبات من القطن الزهر فقط.

ويمكن تلخيص أهم النتائج المتحصل عليها كما يلي:

١- كان التباين الراجع إلى فترات الري عالي المعنوية لكل الصفات تحت الدراسة وأعطى الري كل ١٥ يوم أعلى القيم لمعظم الصفات المدروسة .

٢- كان التباين الراجع إلى التراكيب الوراثية والآباء والهجن معنوياً لكل الصفات تحت معاملات الري المختلفة وكذلك التحليل المشترك بينهم. أعطى الهجين (جيزه ٤٥ × جيزه ٨٥) أعلى قيمه لمحصول النبات من القطن الزهر دون أن يتفوق معنوياً على الهجن (جيزه ٨٥ × جيزه ٧٠) ، (جيزه ٧٠ × تامكوت) ،(جيزه ٨٣ × دلتابين ٧٠٣) تحت ظروف الري العادي بينما تفوق الهجين (جيزه ٧٠ × جيزه ٨٥) تحت ظروف الإجهاد المائي المعتدل والهجين (سي آيلند × دلتابين ٧٠٣) تحت ظروف الإجهاد المائي القاسي .

٣- عموماً ظهرت قوه الهجين بالنسبة للأب الأفضل في بعض الهجن في كل الصفات المدروسة عدا صفة عدد اللوز المتفتح على النبات.

٤- كان التباين الراجع إلى القدرة العامة والخاصة على التآلف معنويا لكل الصفات تحت مستويات الري الثلاثة والتحليل المشترك بينهم مما يؤكد فعالية كل من الفعل الجيني المضيف وغير المضيف في وراثة هذه الصفات.

٥- تشير النسبة بين تبايني القدرة العامة والخاصة على التآلف إلى أهمية كل من الفعل الوراثي المضيف وأيضا التفاعل بين الفعل الوارثي المضيف × المضيف في وراثة كل الصفات المدروسة مما يؤكد إمكانية الحصول على تحسين وراثي في هذه الصفات في العشائر المدروسة تحت كل من ظروف الري العادي وظروف الإجهاد المائي.

٦- كان التباين الراجع للتفاعل بين كل من القدرة العامة والخاصة على التآلف ومعاملات الري معنويا لكل الصفات تحت الدراسة مما يشير إلى اختلاف كل من التباين المضيف وغير المضيف من معامله ري إلى أخرى.

٧- أظهرت النتائج أن أحسن الأصناف قدرة على التآلف تحت ظروف الري العادي هي تامكوت ودلتابين ٧٠٣ لصفات التبكير ووزن اللوزة ودليل البذرة ومحصول النبات من القطن الزهر، جيزة ٧٠ لعدد اللوز المتفتح على النبات وتصافى الحليج ومحصول النبات من القطن الزهر، وجيزة ٤٥

لعدد اللوز المتفتح على النبات، الصنفان جيزه ٨٣ ، جيزه ٨٥ لعدد اللوز المتفتح علـــى النبــات وتصافى الحليج ودليل البذرة وكذلك الصنفان بيما اس ٧، سي آيلند لعدد اللوز المتفتح على النبات وتصافى الحليج بينما تعتبر الأصناف الأربعة المستوردة بيما اس ٧ ، سي آيلند، تامكوت ، دلتابين ٧٠٣ من أحسن الأصناف قدرة على التالف تحت ظروف الإجهاد المائي النسبي .

٨- أظهرت الهجن (جيزه ٤٥ × جيزه ٨٥) ، (جيزه ٧٠ × سي آيلند) ، (جيزه ٨٣ × بيما اس ٧) ، (جيزه ٨٣ × تامكوت) ، (بيما اس ٧ × تامكوت) تحت ظروف الري العادي والـــهجن (جيزة ٤٥ × جيزة ٨٣) ، (دلتابين × سي آيلند) تحت ظروف الإجهاد المائي قدره خاصة عاليـــة مرغوبة لصفه محصول النبات من القطن الزهر.

٩- تشير النتائج أن الأصناف جيزه ٨٥ ، بيما اس ٧ ، والهجين (جيزه ٨٥ × سي آيلند) كانت لـــها قدره عالية على تحمل ظروف الجفاف ،لذلك يمكن الاستفادة بهذه التراكيب الوراثية في برامج تربية القطن لإنتاج أصناف جديدة تتحمل ظروف الإجهاد المائي .