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PROSPECTIVE FOR BREEDING SHORT SEASON COTTON. A SECOND LOOK. I. COMBINING ABILITY FOR YIELD AND YIELD RELATED TRAITS.

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ABSTRACT

This investigation was conducted with the objective of obtaining guidelines for efficient parental choice of cotton cultivars in cross breeding program for developing superior cultivars for conventional (full season environment, FSE) and late planting (short season environment, SSE) systems.

Three Pima (P_1=Eearlipima, P_2=Pima S-6 and P_3=Pima S-7) and six long-staple (P_4=Dandara, P_5=Giza 80, P_6=Giza 90, P_7=Giza 85, P_8=Giza 89, and P_9=Giza 83) Egyptian cotton genotypes were crossed in all possible combinations excluding reciprocals in 2003. Inbreeding for the resultant 36 F_1's to produce F_2's was done in 2004. In 2005, field evaluation of 81 entries (9 parents, 36 F_1's and 36 F_2's) was made at two planting dates, 17 March, designated as FSE and 1 May for late planting cropping system designated as SSE.

Five crosses in FSE ($P_1 \times P_4$, $P_2 \times P_5$, $P_3 \times P_9$, $P_4 \times P_8$, and $P_5 \times P_6$) and three cross combinations in SSE ($P_3 \times P_9$, $P_5 \times P_8$, and $P_7 \times P_8$) exhibiting very high percentage of F_2HPH as well as significant SCA effect, capable of giving maximum transgressive effects. The three crosses $P_3 \times P_4$, $P_5 \times P_8$, and $P_7 \times P_8$ were classified as tolerant to stress of short season environment based on both seed and lint cotton yield. Therefore, much emphasis will be concentrated on these crosses to be used directly for selecting superior segregants of high yielding ability with stability mean performance and adapted to SSE. Other alternative, their parents, P_3 (Pima S_7), P_4 (Dandara), and P_8 (G.89) coupled with P_6 (G.90), the highest yielding parent, may be incorporated in multiple crosses system followed by pedigree selection for obtaining high yielding, stable, and adapted to short season lines.

Key words: ***Cotton, Short season environment, Combining ability, Heterosis, Yield.***

INTRODUCTION

The competition for more planting acreages between cotton and food crops has become intense and will remain so in the near foreseeable future under the situation of a large population need for food and clothing in a limited farm land in Egypt.

Short season cotton (SSC) is an ecotype of cotton that has relatively short growing period, adaptable to certain social-economical levels under specific ecological conditions. SSC has its own apparent morphological and developmental characteristics, and biochemical and cultivating properties.

Increasing lint yield and improving fibre quality are the most important purposes of cotton genetic improvement in SSC. The biggest obstacle for developing early maturing, high yielding, and improved fibre SSC genotypes is premature senescence of such genotypes. In order to attain an early maturity of SSC that fits the requirements of double or multiple cropping practiced in various cotton producing areas, an effective means for delaying premature senescence of early maturing SSC is through coordination of vegetative and reproductive growth.

Twenty years ago the Department of Agronomy, Fac. Agric., Cairo University, initiated and emphasized the need for considering the concept of double cropping of Egyptian cotton with winter crops as an objective selection aim in Egyptian cotton. Nowadays, late planting system is an agricultural practice adopted by farmers in some areas of Egyptian cotton belt. Several papers were presented and discussed in this important topic of research (Abo El-Zahab, 1994, Abo El-Zahab and Amein, 1996a,b,c and 2000a,b,c,d and Abo El-Zahab *et al* 2003 a,b&c).

Short-season environments (SSE) are challenge to plant breeders to develop better adapted, high yielding cotton cultivars. Early crop maturity is a prerequisite for cultivars grown in such environments because it enables a marketable crop to be produced in SSE (Keim *et al* 1985).

With these objectives in mind, several suggested guidelines for efficient breeding program for developing superior cultivars for full season environment (FSE) and short season environment (SSE) were investigated. Five Egyptian cotton genotypes (Abo El-Zahb and Amein, 2000a) and three Pima ones (Abo El-Zahb *et al* 2003a) previously identified as tolerant to late planting stress plus Giza 90, the highest yielding cultivar and their all possible cross combinations (36) were used in this investigation to gain information in this respect

MATERIALS AND METHODS

Three Pima (Eearlipima, Pima S-6 and Pima S-7) and six long-staple (Dandara, Giza 80, Giza 90, Giza 85, Giza 89, and Giza 83) Egyptian cotton genotypes were crossed in all possible combinations excluding reciprocals to generate a half diallel mating scheme in 2003 at Giza Agricultural Experimental Station, ARC. Inbreeding for the resultant 36 F_1's to produce F_2's was done in 2004. Designation, pedigree, main fiber characteristics of the genotypes used are presented in Table (1).

In 2005, field evaluation of 81 entries (9 parents, 36 F_1's and 36 F_2's) was made at two planting dates, 17 March, designated as full season environment (FSE) and 1 May for late planting cropping system designated as short season environment (SSE) in the agriculture Extension field, Maghagha, El-Menia Governorate.

The experimental design was a randomized complete-block design with a split-plot treatment arrangement and four replications were used. Main plots were planting dates and sub-plots were genotypes. Plot size was

Table 1. Designation, pedigree, year released, zone of cultivation and main characteristics of genotypes.

Genotypes	Pedigree	Year release	Cultivation area	Fiber characteristics			
				Length		Fineness	Strength
				UHM (mm)	UI (%)	MR (unit)	T_1 (g/tex)
A. Pima genotypes							
1.Earlipima	(Sakel × Pima) × Pima		Experimental line	30.6†	83.7	4.4	31.6
2 Pima S-6	(5934-23-2-6) × (5903-98-4-4)	1983	High elevations (above 750 m), partially in New Mexico and Texas	33.8†	84.4	4.2	31.3
3. Pima S-7	(6614-91-9-3)×(6907-513-509-501)	1991	Low (< 450 m) and intermediate (450-750 m) elevations	34.0†	84.8	4.1	31.4
B. Egyptian genotypes							
4.Dandara	Giza 3	1951	Obsolete cultivar	30.6†	85.1	4.3	34.4
5. Giza 80	Giza 66 × Giza 73	1981	Beni-Suef, El-Menia.	31.6	85.8	4.4	37.9
6. Giza 90	Giza 83 ×Dandara	2000	Sohag, Faiyum,Assiut.	30.3	85.0	4.0	35.8
7. Giza 85	Giza 67 × C.B 58	1993	Menofia.	30.5	87.8	3.9	40.8
8. Giza 89	Giza 75×S-6022 Russian	1993	Qalyubyia.	32.4	87.5	4.3	41.5
9. Giza 83	Giza 72 × Giza 67	1992	Obsolete cultivar	30.1†	84.8	4.6	37.3

B.Spinning test report on the Egyptian cotton crop of 2006, reported by Cotton Research Institute, ARC, Egypt.
1. Crops Research Division, ARS, U.S.Dept.Agr.April 1962.
2. Crop Sci. vol 24, 1984 p. 382.
3. Crop Sci. vol 32, 1992 p.1291.
†. From data presented in this study.

one row, 0.60 m. wide × 4 m long, spacing within rows was 25 cm between hills leaving one plant /hill (16 plants/row).

The different agricultural practices for cotton plants at FSE were kept at optimum levels throughout the growing season to obtain maximum productivity. However, for SSE the integrated production management (IPM) for late planting format as outlined by Abo-El-Zahab (1994) was applied. Where double rows, 60 cm apart system in beds 120 cm apart were adopted. Early thinning 19 days after planting to on plant per hill was undertaken. PIX, a growth regulator of 1 liter/fed. at early flowering period was applied.

Ten individual random guarded plants from each row (plot) were marked to provide data. At maturity, a random representative sample of 50 open bolls (5 from each plant) was picked from each plot for seed cotton yield components determination. Seed cotton from the 50-boll samples was cleaned, weighed, ginned, and the lint was weighed to determine lint percentage. The following yield contributing traits were calculated as follows: Boll weight (BW, g), Lint percentage (LP, %), Seed index (SI, g), Lint index (LI, g), Seed cotton yield/plant (SCY/P, g), Lint cotton yield/plant (LCY/P, g), and Number of bolls/plant (B/P).General combining ability (GCA) and specific combining ability (SCA) were calculated according to Griffing (1956) method 2, model 1 (fixed effects).

RESULTS AND DISCUSSION

Data presented in Table (2) indicated that genotypes (G), environments (E) and genotypes × environments (G×E) interactions were significant for cotton yields expressed as seed cotton yield (SCY) and lint cotton yield (LCY) and yield contributing variables.

The significant variation of genotypes indicated that the data are reliable for further analysis by the diallel mating procedure as suggested by Griffing (1956). Significant G×E interactions suggested that genotypes performances (parents and their cross combinations) in F_1 and F_2 generations were not the same over environments (FSE and SSE). This suggested performing the analysis of variance for the traits under FSE and SSE separately.

Significant environment indicated significant differences in average genotypes yield in favour of FSE. Average yields in F1 generation were 45.48; 16.94 g/plant in FSE compared to 22.42; 8.20 g/plant in SSE for seed cotton and lint cotton yield, respectively. Whereas, the comparable values in F_2 generation were 43.70; 16.32 g/plant in FSE relative to 22.32; 8.17 g/plant in SSE for seed cotton and lint cotton yield in the same order (data do not presented). Similar reductions detectable in yielding ability of 10 Egyptian parent diallel crosses in SSE relative to those in FSE were observed in Egyptian cotton by Abo El-Zahab and Amein (2000c) for both seed cotton and lint cotton yields. Several reports indicated reduction in cotton yields as planting dates were delayed or in other words in SSE (Bilbro and Ray, 1973; Smith and Varvil, 1982; Hopkins and Culp, 1984; Baker, 1987; Silvertooth, 2001; Selvertooth *et al* 2001 and Norton *et al* 2002 and 2003).

Significant environment interaction with both GCA and SCA for all variables studied, indicated that GCA effects of these parents or at least some parents and SCA effects of the cross combinations or at least some of these crosses were inconsistent across environments (FSE and SSE). In general, the interactions of yield components with environments were of lesser magnitude than for total yield

LCY is probably best understood in terms of the components that make it up. Fiber or lint yield in cotton is defined by two major components, i.e., the number of seeds produced per unit area and the weight of fiber produced on the seed. Yield = [(No. of seeds/unit area) × (Weight of fiber /Seed)] (Lewis *et al* 2000). According to Kerr (1966), the primary lint yield

Table 2. Mean squares of individual and combined (C) across environments (E) for 9-parent diallel crosses in F_1 and F_2 generation for seed cotton yield, and its contributing variables.

S.V.	df		FSE	SSE	C	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C
				F_1			F_2			F_1			F_2	
	E	C	SCY/P (g)						LCY/P (g)					
Rep. (R)	3	6	57.07	29.70	43.36	59.77	20.92	40.03	7.55	4.13	5.84	7.26	1.92	4.59
Env. (E)		1			47855**			41122 **			6877.4**			5980**
Genot.(G)	44	44	142.86**	57.18**	71.31**	193.77**	61.65**	102.41**	22.56**	6.98**	11.26**	32.49**	9.12**	18.48**
G × E		44			128.74**			153.01**			18.28**			23.03**
GCA	8	8	80.24**	13.61**	36.44**	128.43**	13.19*	51.06**	11.47**	1.49**	5.59**	21.28**	1.90*	9.80**
SCA		36	25.82*	14.45**	13.69**	30.67*	15.91**	19.95*	4.35*	1.80**	2.20**	5.20**	2.33**	3.47**
	36													
GCA × E		8			57.42**			22.64**			7.38**			13.37**
SCA × E		36			26.58**			26.63**			3.95**			4.07**
Error	132	264	14.15	7.07	5.30	4.56	6.24	6.13	2.15	0.92	0.77	2.57	0.86	0.86
GCA/SCA			3.11*	0.94	2.66*	4.19**	0.83	2.56*	2.64*	0.83	2.54*	4.09**	0.82	2.82
			B/P						BW (g)					
Rep. (R)	3	6	17.18	3.12	10.15	10.93	2.06	6.49	0.155	0.007	0.081	0.045	0.015	0.030
Env. (E)		1			5251.3**			4591**			0.128*			0.005
Genot.(G)	44	44	16.38**	8.11**	8.92**	23.30**	8.69**	13.67**	0.062**	0.107**	0.086**	0.078**	0.092**	0.115**
G × E		44			15.58**			18.32**			0.082**			0.055**
GCA	8	8	8.75**	2.45*	1.50**	14.94**	1.95*	7.44**	0.026**	0.029**	0.031**	0.032**	0.014**	0.023**
SCA		36	3.06**	1.94**	2.39**	3.80**	2.23**	2.53**	0.013*	0.026**	0.019**	0.017**	0.025**	0.030**
	36													
GCA × E		8			4.95**			10.03**			0.023**			0.023**
SCA × E		36			3.66**			3.37**			0.020**			0.012**
Error	132	264	1.62	0.97	0.65	2.10	0.80	0.73	0.006	0.008	0.003	0.005	0.009	0.008
GCA/SCA			2.79*	1.26	0.62	3.93**	0.87	2.94*	3.00*	1.10	1.50	1.88	0.56	0.75
			LP (%)						SI (g)					
Rep. (R)	3	6	5.79	2.53	4.16	4.25	2.95	3.60	1.666	0.146	0.906	1.763	0.609	1.186
Env. (E)		1			27.88**			43.56**			36.506**			34.919**
Genot.(G)	44	44	8.10**	5.07**	7.18**	9.40**	5.79**	9.01**	1.391**	1.289**	2.10**	1.491**	1.043**	1.942**
G × E		44			6.83**			6.18**			0.580*			0.593*
GCA	8	8	3.61**	1.27**	2.33**	4.93**	1.23**	4.14**	1.159**	1.031**	1.906**	1.337**	0.863**	1.963**
SCA		36	1.93**	1.27**	1.68**	1.78**	1.50**	1.83**	0.167*	0.165*	0.218**	0.158**	0.127	0.157*
	36													
GCA × E		8			2.56**			2.01**			0.284**			0.238*
SCA × E		36			1.52**			1.44**			0.114			0.128
Error	132	264	0.31	0.22	0.14	0.20	0.35	0.14	0.092	0.101	0.048	0.089	0.107	0.049
GCA/SCA			1.87	1.01	1.39	2.77*	0.82	2.26*	7.73**	6.06**	8.76**	8.38**	6.62**	12.46**
			LI (g)											
Rep. (R)	3	6	0.333	0.080	0.206	0.480	0.136	0.308						
Env. (E)		1			4.977**			3.114**						
Genot.(G)	44	44	0.655**	0.839**	0.977**	0.695**	0.769**	0.843**						
G × E		44			0.522**			0.621**						
GCA	8	8	0.337**	0.381**	0.470**	0.457**	0.261**	0.424**						
SCA	36	36	0.125*	0.172**	0.193**	0.111**	0.177**	0.163**						
GCA × E		8			0.248**			0.293**						
SCA × E		36			0.104**			0.125**						
Error	132	264	0.044	0.047	0.023	0.035	0.049	0.021						
GCA/SCA			2.62*	2.24*	2.44*	4.11**	1.44	2.62*						

components are lint weight per seed (lint index), seeds per boll, and bolls per plant (or per unit area). Worley *et al* (1976) showed that lint weight per seed and seeds per boll could be subdivided into smaller components. Whereas Kerr (1966) concluded that boll number per plant or per unit area is a primary yield component, whereas boll weight and lint percentage are secondary yield components. Plant breeders routinely select for these variables to increase lint yield.

The genetic design of the present study also allows for the partitioning of the F_1 and F_2 sources of variability to general (GCA) and specific combining ability (SCA) (Table 2). Significant GCA and SCA in separate environments and their combined analysis in both generations were obtained for both SCY and LCY, and all the yield contributing variables except SCA for seed index in F_2 generation in SSE (Table 2).

The relative magnitude of additive to non-additive effects for the combined data expressed as GCA/SCA ratios were more greater than the unity and significant for all traits except bolls number/plant and lint percentage in F_1 and boll weight in both generations. However, for separate environments significant GCA/SCA were recorded for yield and all yield contributing variables in FSE in both generations, except boll weight in F_2 and lint percentage in F_1. However, for SSE only significant GCA/SCA were recorded for lint index in F_1 and seed index in both generations. In general, magnitude of GCA mean square was several times greater than of SCA mean square.

The use of GCA/SCA ratio (Griffing, 1956), as indicator for the relative importance (RI) of additive and non-additive effects was criticized by Baker (1978) by stating that such procedure may be misleading and suggested the calculating of GCA and SCA equivalent variance from the expectations of the components of mean squares for diallel designs.

Therefore, taking the criticism of Baker (1978) in mind, the expectation of the mean squares for Model I, Method II were used for obtaining the estimates of components of variance due to GCA and SCA. According to Singh and Chaudhary (1985), the following expressions for obtaining the estimates of these components were used:

$$\delta^2_{GCA} = \sum_{i} g_i^2 / n\text{-}1 = (MS_{GCA} - MS_e') / n+2$$

$$\delta^2_{SCA} = 2 \sum_{i} \sum_{j} S_{ij}^2 / n\,(n\text{-}1) = MS_{SCA} - MS_e'$$

The relative importance (RI) of general and specific combining ability on progeny performance (i.e., the ratio between additive vs. total genetic variance components) was estimated according to Betran *et al* (2003) as the ratio: $2\ \delta^2_{GCA}\ /\ (2\ \delta^2_{GCA} + \delta^2_{SCA})$, where δ^2_{GCA}, δ^2_{SCA} are the variance components for GCA and SCA (Table 3). The closer this ratio is to unity, the greater the predictability based on general combining ability alone.

Table 3. Components of variance due to additive ($2\delta^2_{GCA}$), non additive (δ^2_{SCA}) and environment (δ^2_e) and the relative importance (RI) of additive vs total genetic variance for yield, and yield components in F_1 and F_2 generations of 9-partnt diallel cross of cotton.

Variance components	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C
		F_1			F_2			F_1			F_2	
			SCY/P (g)						LCY/P (g)			
$2\delta^2_{GCA}$ (δ^2a)	12.0164	1.1873	5.6527	22.5218	1.2636	8.1691	1.6945	0.1036	0.8764	3.4018	0.1891	1.6255
	(31.76)	(7.62)	(29.22)	(42.34)	(7.36)	(29.10)	(28.03)	(5.44)	(28.49)	(39.55)	(7.51)	(31.90)
δ^2_{SCA} (δ^2na)	11.6700	7.3300	8.3800	26.1100	9.6700	13.7700	2.2000	0.8800	1.4300	2.6300	1.4700	2.6100
	(30.84)	(47.03)	(43.32)	(49.09)	(56.31)	(49.06)	(36.40)	(46.23)	(46.48)	(30.57)	(58.35)	(51.22)
δ^2_e	14.1500	7.0700	5.3100	4.5600	6.2400	6.1300	2.1500	0.9200	0.7700	2.5700	0.8600	0.8600
	(37.40)	(45.36)	(27.45)	(8.57)	(36.33)	(21.84)	(35.57)	(48.33)	(25.03)	(29.88)	(34.14)	(16.88)
Total	37.8364	15.5873	19.3427	53.1918	17.1736	28.0691	6.0445	1.9036	3.0764	8.6018	2.5191	5.0955
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
RI	0.51	0.14	0.40	0.46	0.12	0.37	0.44	0.11	0.38	0.56	0.11	0.38
$\bar{x}$	45.48	22.42	33.95	43.70	22.32	33.01	16.94	8.20	12.57	16.32	8.17	12.24
P.C.V	13.52	17.61	12.95	16.69	18.57	16.05	14.51	16.83	13.95	17.97	19.43	18.44
AG.C.V	7.62	4.86	7.00	10.86	5.04	8.66	7.68	3.93	7.45	11.30	5.32	10.42
			B/P						BW (g)			
$2\delta^2_{GCA}$ (δ^2a)	1.2964	0.2691	0.1545	2.3345	0.2091	1.2200	0.0036	0.0038	0.0051	0.0049	0.0009	0.0027
	(29.76)	(12.18)	(6.07)	(38.06)	(8.57)	(32.53)	(21.86)	(12.80)	(21.13)	(22.41)	(3.51)	(8.33)
δ^2_{SCA} (δ^2na)	1.4400	0.9700	1.7400	1.7000	1.4300	1.8000	0.0070	0.0180	0.0160	0.0120	0.0160	0.0220
	(33.06)	(43.91)	(68.38)	(27.71)	(58.63)	(48.00)	(42.08)	60.37)	(66.42)	(54.77)	(61.75)	(67.22)
δ^2_e	1.6200	0.9700	0.6500	2.1000	0.8000	0.7300	0.0060	0.0080	0.0030	0.0050	0.0090	0.0080
	(37.19)	(43.91)	(25.54)	(34.23)	(32.80)	(19.47)	(36.07)	(26.83)	(12.45)	(22.82)	(34.74)	(24.44)
Total	4.3564	2.2091	2.5445	6.1345	2.4391	3.7500	0.0166	0.0298	0.0241	0.0219	0.0259	0.0327
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
RI	0.47	0.22	0.08	0.58	0.13	0.40	0.34	0.18	0.24	0.29	0.05	0.11
$\bar{x}$	15.29	7.65	11.47	14.68	7.54	11.11	2.98	2.94	2.96	2.98	2.97	2.98
P.C.V	13.65	19.43	13.91	16.87	20.71	17.43	4.33	5.87	5.24	4.97	5.42	6.07
AG.C.V	7.45	6.78	3.43	10.41	6.06	9.94	2.02	2.10	2.41	2.35	1.02	1.75
			LP (%)						SI (g)			
$2\delta^2_{GCA}$ (δ^2a)	0.6000	0.1909	0.3982	0.8600	0.1600	0.7273	0.1940	0.1691	0.3378	0.2269	0.1375	0.3480
	(23.72)	(13.07)	(19.16)	(32.58)	(9.64)	(28.44)	(53.74)	(50.61)	(60.78)	(58.95)	(51.98)	(68.91)
δ^2_{SCA} (δ^2na)	1.6200	1.0500	1.5400	1.5800	1.1500	1.6900	0.0750	0.0640	0.1700	0.0690	0.0200	0.1080
	(64.03)	(71.87)	(74.10)	(59.85)	(69.28)	(66.09)	(20.78)	(19.16)	(30.59)	(17.93)	(7.56)	(21.39)
δ^2_e	0.3100	0.2200	0.1400	0.2000	0.3500	0.1400	0.0920	0.1010	0.0480	0.0890	0.1070	0.0490
	(12.25)	(15.06)	(6.74)	(7.58)	(21.08)	(5.47)	(25.48)	(30.23)	(8.64)	(23.12)	(40.46)	(9.70)
Total	2.5300	1.4609	2.0782	2.6400	1.6600	2.5573	0.3610	0.3341	0.5558	0.3849	0.2645	0.5050
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
RI	0.27	0.15	0.21	0.35	0.12	0.30	0.72	0.73	0.67	0.77	0.87	0.76
$\bar{x}$	37.23	36.61	36.92	37.28	36.57	36.92	9.97	10.60	10.29	9.92	10.54	10.23
P.C.V	4.27	3.30	3.90	4.36	3.52	4.33	6.03	5.45	7.25	6.25	4.88	6.95
AG.C.V	2.08	1.19	1.71	2.49	1.09	2.31	4.42	3.88	5.65	4.80	3.52	5.77
			LI (g)									
$2\delta^2_{GCA}$ (δ^2a)	0.0533	0.0607	0.0813	0.0767	0.0385	0.0733						
	(29.88)	(26.09)	(29.63)	(40.87)	(17.88)	(31.01)						
δ^2_{SCA} (δ^2na)	0.0810	0.1250	0.1700	0.0760	0.1280	0.1420						
	(45.44)	(53.71)	(61.98)	(40.48)	(59.38)	(60.10)						
δ^2_e	0.0440	0.0470	0.0230	0.0350	0.0490	0.0210						
	(24.68)	(20.20)	(8.39)	(18.64)	(22.73)	(8.89)						
Total	0.1783	0.2327	0.2743	0.1877	0.2155	0.2363						
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)						
RI	0.40	0.33	0.32	0.50	0.23	0.34						
$\bar{x}$	5.91	6.13	6.02	5.90	6.08	5.99						
P.C.V	7.14	7.87	8.70	7.34	7.64	8.11						
AG.C.V	3.91	4.02	4.74	4.69	3.23	4.52						

$$RI = 2\,\delta^2_{GCA} / (2\,\delta^2_{GCA} + \delta^2_{SCA}),\ P.C.V = \frac{(\text{Total variance})^{½}}{\bar{x}} \cdot 100, \text{ and } AG.C.V = \frac{(2\delta^2_{GCA})^{½}}{\bar{x}} \cdot 100.$$

When the analysis is based on a model with fixed effects, one would use equivalent components of mean squares.

It's evident from data presented in Table 3 that all the traits studied clearly were influenced by environmental variation, especially for cotton yields, which reflected in lower values for RI for cotton yields especially under SSE. This is expected on the basis that these traits are quantitative inherited ones and normally distributed and very affected by the environmental conditions.

The additive genetic variance ($2\delta^2_{GCA}$) expressed as percent of total genetic variance (RI) constitute somewhat small portion of total genetic variance for most traits studied except seed and lint indices which exhibited somewhat higher values. Moreover, environments had profound effect on the expression of these genetic variances, where obvious reductions in those estimates were obtained in SSE relative to those reported for FSE. To obtain reliable estimates for comparable magnitude of these variances in the two environments (FSE and SSE), phenotypic (P.C.V.) and additive genetic coefficient of variability (AG.C.V.) were calculated. The collective data presented in Table (3) clearly indicated that there is great discrepancy between P.C.V. and AG.C.V, indicating the pronounced effect of non-additive and environmental effects for the studied traits. In the same time lower estimates were obtained in SSE compared to FSE, indicating that the stresses of SSE induced detectable reduction in additive genetic variability of the studied traits. Also, estimates of RI, the relative importance of additive to total genetic variance, were low especially in SSE, indicating the important role of non-additive genetic variance in controlling cotton yields and related traits in the stress environment of SSE. These results probably indicate that epsistasis and/or dominance effects for F_2 performance in SSE in cotton could be important to a certain extent. This was also supported by F_2-HPH for yields and its related traits in some crosses in F_2 generation.

So it is recommended that in the segregating generation, breeder should be very careful for selection and pedigree method should be adopted for improving these traits from the population, which are under study.

Cotton yields of all 45 genotypes (9 parental genotypes + 36 cross combinations) in SSE was significantly lower than its counterpart in FSE (data do not presented). Late planting stress in SSE, on the average reduced seed cotton yield expressed as percentages by 51.59 in F_1 and 48.92 in F_2; lint yield by 51.77 in F_1 and 49.94 in F_2; bolls number by 49.97 in F_1 and 48.64 in F_2; lint percentage by 1.67 in F_1 and 1.90 in F_2, and boll weight by 1.34 in F_1. However, more or less similar means for boll weight were obtained in F_2. Favourable effect for SSE with percentage superiority of 6.32, 6.25 and 3.72, 3.05 in F_1 and F_2 populations, respectively for seed and lint indices in the same order, were obtained. The largest reductions in lint yield due to the stress of SSE were observed for the higher yielding parental genotypes G.85 (63.98%) and G.90 (60.81%), whereas the lowest reductions were detected in the lower yielding genotypes G.89 (24.43%) and Pima S_6 (26.20%). This was reflected in higher sensitively stress indices, SSI for G.85 (1.24) and G.90 (1.18) and lower SSI for G.89 (0.47) and Pima S_6 (0.51). In this connection, Niles (1969, 1974) in USA observed that "short-season" strains flowered earlier, had more rapid flowering rates, and exhibited earlier boll maturity when compared with standard cultivars. Even though "short-season" strains possessed fewer fruiting sites and produced less lint yield per plant (Niles, 1974 and Quisenberry, 1977).

GCA effects:

Significant GCA and SCA effects provide information to help determine the efficacy of breeding for improvements in given traits and they can be used to identify lines to serve as parents in a breeding program for trait improvement (Kearsey and Pooni, 1996). The GCA effects reflect performance of parental lines in combination with all other lines, so the parents with the highest GCA effects should have the greatest impact on trait improvement.

For most parents GCA effects for seed cotton and lint yields (Table 4) were inconsistent and changed across environments (FSE and SSE). Summing over individual environments (FSE and SSE), generations (F_1 and F_2) and combined across environments, six cases for estimating GCA effects for parents and SCA effects for the cross combinations are available. These cases are FSE F_1, FSE F_2, SSE F_1, SSE F_2, C F_1 (FSE+SSE), and C F_2 (FSE+SSE).

None of the parents exhibited significant GCA effects for cotton yields per plant in all cases. However, P_1 (1 case for SCY in F_1), P_2 (1 case for LCY in F_1), P_5 (5 cases, 2 for SCY in F_2 and 3 for LCY in F_1), P_6 (5 cases, 3 for SCY in F_1 and F_2, and 2 for LCY in F_1 and F_2) and P_7 (3 cases, 2 for SCY in F_1 and 1 for LCY in F_1) revealed significant GCA effects in at least one or more of the six cases sampled (Table 4). These results are in line with those reported by Lee *et al* (1967) from their study of interaction of combining ability effects with environments in diallel crossed of upland cotton. They found some parental lines tended to be good combiners for LCY at one location and poor at others and had an overall effect of 0 for combining ability.

Parental rating according to their stress susceptibility index (SSI) indicated that out of these parents exhibiting significant GCA effects only P_2, Pima S_6 (SSI F_1=0.37, F_2=0.39) was classified as tolerant to the stress of SSE (Table 6a).

Table 4. GCA effects for parental genotypes for seed cotton yield, and its contributing variables in two environments (FSE and SSE) and combined (C) across environments in F_1 and F generations.

Genotype	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C
		F_1			F_2			F_1			F_2	
			SCY/P (g)						LCY/P (g)			
1Earlipima	3.10**	-1.41	0.42	0.79	-1.08	-0.15	0.78	-0.57*	0.11	-0.01	-0.45	-0.23
2 Pima S-6	0.79	0.18	0.48	-1.39	0.81	-0.29	0.69	0.08	0.38*	-0.14	0.29	0.07
3 Pima S-7	-0.37	-0.51	-0.44	0.08	0.66	0.37	-0.09	-0.13	-0.11	0.21	0.29	0.25
4 Dandara	0.01	1.35	0.67	1.58	0.21	0.89	0.06	0.39	0.22	0.40	0.02	0.21
5 G. 80	2.29*	1.90	0.20	2.90*	1.26	2.08**	0.54	0.63*	0.04	1.56**	0.52*	1.04
6 G. 90	2.57*	-1.18	0.70	4.54**	1.54*	1.5**	0.97*	0.39	0.29	1.65**	0.58*	0.54
7 G. 85	2.15*	0.59	1.37**	-1.79	-0.83	-1.31*	0.67	0.15	0.41*	0.79	0.38	0.58
8 G. 89	-5.60*	-0.43	-3.02	-7.46*	1.38	-3.04*	-2.35**	[illegible]	-1.24	3.07*	0.47	1.30
9 G. 83	-0.33	-0.50	-0.41	0.76	-0.87	-0.06	-0.19	-0.03	-0.11	0.20	0.19	0.01
			B/P						BW (g)			
1Earlipima	0.76*	0.53	0.32*	-0.15	-0.46	0.65**	0.05*	0.01	0.03*	0.07**	0.03	0.05**
2 Pima S-6	-0.01	-0.13	0.07	-0.48	0.21	-0.50*	0.06*	0.07	0.06**	0.01	0.02	0.003
3 Pima S-7	0.22	0.18	0.04	0.59	0.19	0.04	-0.08**	-0.01	-0.04*	-0.11*	0.01	-0.05*
4 Dandara	0.19	0.78**	0.01	0.38	0.25	0.61**	-0.03*	-0.09	-0.06*	0.02	0.06	0.02
5 G. 80	0.61	0.74**	0.15	0.83*	0.58*	0.04	-0.03*	-0.02	-0.03*	0.03	0.04	0.01
6 G. 90	0.61	-0.40	0.05	1.35**	0.61*	0.69**	0.04*	0.01	0.02	0.03	0.05	0.04**
7 G. 85	0.73*	0.06	0.07	-0.50	-0.26	-0.71*	0.001	0.04	0.02	-0.01	-0.02	-0.02
8 G. 89	-2.09*	0.03	-0.63*	2.65	0.42	0.82*	0.04*	-0.05	-0.01	0.03	0.01	0.02
9 G. 83	0.20	-0.36	-0..08	0.60	0.33	0.08	0.05*	0.07	0.01	-0.05*	0.01	-0.03
			LP (%)						SI (g)			
1Earlipima	-0.82*	-0.29*	-0.55*	-0.63*	-0.30	-0.47*	0.49*	0.47**	0.48**	0.50**	0.50**	0.50**
2 Pima S-6	0.84**	0.07	0.45**	0.98**	0.06	0.52**	-0.06	-0.22*	-0.14*	-0.15	-0.22*	-0.18*
3 Pima S-7	0.16	0.25	0.20**	0.39**	0.19	0.29**	-0.42*	-0.47*	-0.44*	-0.61*	-0.35*	-0.48*
4 Dandara	0.17	-0.36*	-0.10	-0.36*	-0.38*	-0.37*	0.17	0.22*	0.20**	0.22*	0.18	0.20**
5 G. 80	0.78**	0.33*	0.22**	1.08**	0.21	0.64**	-0.28*	-0.21*	-0.24*	-0.06	-0.28*	-0.17*
6 G. 90	0.07	0.17	0.12*	-0.14	0.02	-0.06	0.37**	0.33**	0.35**	0.40**	0.27**	0.33**
7 G. 85	-0.33*	-0.25	-0.29*	-0.35*	-0.29	-0.32*	-0.28*	-0.06	-0.17*	-0.22*	-0.04	-0.13*
8 G. 89	-0.67*	0.09	-0.29*	-0.77*	-0.18	-0.47*	0.23	0.20*	0.01	0.14	-0.14	-0.03
9 G. 83	0.20	0.66**	0.23**	0.20	0.68**	0.27**	-0.23	0.14	-0.04	-0.22*	0.09	-0.06
			LI (g)									
1Earlipima	0.08	0.19**	0.13**	0.14*	0.21**	0.17**						
2 Pima S-6	0.18**	0.10	0.04	0.16**	0.10	0.03						
3 Pima S-7	-0.21*	-0.22*	-0.21*	-0.29*	-0.16*	-0.23*						
4 Dandara	0.14*	0.03	0.09*	-0.01	0.00	-0.04						
5 G. 80	0.02	0.21*	0.09*	0.28**	0.11	0.09**						
6 G. 90	0.23**	0.24**	0.23**	0.21**	0.16*	0.18**						
7 G. 85	-0.25*	-0.09	-0.17*	-0.19*	-0.09	-0.14*						
8 G. 89	0.04	-0.10	-0.07	-0.09	-0.13	-0.11*						
9 G. 83	0.16	0.26**	0.05	0.20*	0.23**	0.01						

It worth to mention that when the parental genotypes exhibiting significant GCA effects were rated according to their stability mean performance based on SCY, YS_i stability statistic revealed that P_1 (Earlipima) and P_5 (G.80) were rated as stable on the basis of SCY and LCY, respectively. Whereas, P_6 (G.90) and P_7 (G.85) were classified as stable genotype on basis of both SCY and LCY.

Table 5. Positive significant estimates of SCA effects for cotton yield, and its components in two environments (FSE and SSE) and combined (C) across environments in F_1 and F_2 generations.

Hybrid	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C	FSE	SSE	C
		F_1			F_2			F_1			F_2			F_1			F_2			F_1			F_2	
		SCY/P (g)						LCY/P (g)						B/P						BW (g)				
$P_1 \times P_4$				*						*					**									
$P_1 \times P_5$																						*		**
$P_1 \times P_6$															**			**						
$P_1 \times P_9$	**		*		*		**		*			*	*											
$P_2 \times P_4$							*														*	*		**
$P_2 \times P_5$				**		**	*			**		**							**		*	**		**
$P_2 \times P_6$																				**	**		*	**
$P_2 \times P_8$																				*	*			
$P_2 \times P_9$																		*						*
$P_3 \times P_4$					*	*					**	**												
$P_3 \times P_9$			*			**			*	*		**	*											
$P_4 \times P_5$		**						*						**										
$P_4 \times P_7$		*						*												**	**			
$P_4 \times P_8$				*					*	*			*									*		
$P_4 \times P_9$															*			**						
$P_5 \times P_6$				*						**		*				*							**	**
$P_5 \times P_7$																								**
$P_5 \times P_8$					**	**					**	**			**		**							
$P_5 \times P_9$		**						**						**										
$P_6 \times P_7$			*						*						*									
$P_6 \times P_8$																		**		*				
$P_6 \times P_9$																		*				*		*
$P_7 \times P_8$					**	**					**	*					**							*
$P_7 \times P_9$																			**					
$P_8 \times P_9$															*									*
		LP (%)						SI (g)						LI (g)										
$P_1 \times P_2$			*		**	**											**	**						
$P_1 \times P_4$	**																							
$P_1 \times P_5$		*				**			**			*		*	**		*	**						
$P_1 \times P_7$		**												*										
$P_1 \times P_9$	*		**	**									**		**									
$P_2 \times P_3$		*												**	**		*	*						
$P_2 \times P_4$	**	**	**			**		**	**					*	**		*	**						
$P_2 \times P_6$					**							**					**	*						
$P_2 \times P_8$				*					**					**	*									
$P_2 \times P_9$	**		**	**																				
$P_3 \times P_4$	**	**	**	**	**	**								*	**									
$P_3 \times P_6$					**				**			*			**		**	**						
$P_3 \times P_9$			*	**		**										*								
$P_4 \times P_6$				**		**																		
$P_4 \times P_8$				**																				
$P_4 \times P_9$	**	**	**	**		**			**			**	**	**	**	**	**	**						
$P_5 \times P_6$						*										*		**						
$P_5 \times P_7$				*											**	*	*	**						
$P_5 \times P_8$							**					**	**	**	**	**	**	**						
$P_5 \times P_9$			**																					
$P_6 \times P_7$		*	**	*																				
$P_6 \times P_8$									**					*	*									
$P_7 \times P_8$												**												
$P_7 \times P_9$											*	**												

Table 6a. Summary of the important genetical estimates (Mean; g_i; S_{ij} ; F_1HPH; F_2HPH, and ID) for seed cotton and lint yields per plant for eleven crosses exhibiting F_2HPH in FSE and SSE.

Hybrid	Statistical estimates	SCY/P (g/p)								LCY/P (g/p)							
		FSE				SSE				FSE				SSE			
		P_1	P_2	F_1	F_2	P_1	P_2	F_1	F_2	P_1	P_2	F_1	F_2	P_1	P_2	F_1	F_2
$P_3\times P_4$	$\bar{x}$	44.90	46.36	39.57	47.8	24.58	26.6	21.9	28.22	16.8	15.57	15.76	18.64	8.81	9.34	8.48	11.1
Pima S_7×Dandara	g_i (F_1)	-0.37	-0.01			-0.51	1.35			-0.09	0.06			-0.13	0.39		
	g_i (F_2)	0.08	1.58			0.66	0.21			0.21	0.4			0.29	0.02		
	S_{ij}			-5.54	2.45			-1.3	5.02*			-1.15	1.72			0.02	2.61**
	F_1 HPH (%)			-14.6				-17.5				-6.47				-9.21	
	F_2 HPH (%)				3.11				6.09				10.6				18.84
	ID				-20.8				-28.74				-18.2				-30.9
	SSI					0.89	0.84	0.88	0.84					0.92	0.78	0.90	0.81
	YSi					Yes	Yes	No	Yes					Yes	No	No	Yes
$P_3\times P_9$	$\bar{x}$	44.90	41.75	50.19	50.17	24.58	17.43	22.2	25.38	16.8	13.93		20.11	8.81	6.61	8.44	9.62
(Pima S_7×G.83)	gi (F_1)	-0.37	-0.33			-0.51	-0.5			-0.09	-0.19			-0.13	-0.03		
	gi (F_2)	0.08	0.76			0.66	-0.87			0.21	0.2			0.29	-0.19		
	S_{ij}			5.40	5.64			0.83	3.27			2.38	3.37*			0.40	1.35
	F_1HPH (%)			11.78				-9.44				13.00				-4.2	
	F_2HPH (%)				11.74				3.25				19.35				9.19
	ID				0.04				-14.02				-5.62				-13.98
	SSI					0.89	0.46	1.10	1.01					0.92	1.02	1.08	1.04
	YSi					Yes	No	Yes	Yes					Yes	No	Yes	Yes
$P_1\times P_9$	$\bar{x}$					22.45	17.43	18.5	25.05	17.1	13.93	21.07	17.42	7.88	6.61	6.82	9.09
Eearlipima×G.83	gi (F_1)					-1.41	-0.5			0.78	-0.19			-0.57*	-0.03		
	gi (F_2)					-1.08	-0.87			-0.01	0.2			-0.45	-0.19		
	Sij							-2.0	4.67*			3.53**	0.91			-0.78	1.56
	F_1HPH (%)							-17.5				23.22				-13.45	
	F_2HPH (%)								11.58				1.87				15.36
	ID								-35.41				17.32				-33.28
	SSI					1.05	1.15	1.32	0.95					1.05	1.02	1.31	0.96
	YSi					Yes	No	Yes	Yes					No	No	Yes	Yes
$P_5\times P_9$	$\bar{x}$	45.09	41.75	36.41	52.95					17.61	13.93	13.88	19.94	7.71	6.61	12.56	8.06
(G.80×G.83)	g_i (F_1)	-2.29*	-0.33							-0.54	-0.19			0.63*	-0.03		
	g_i (F_2)	2.90	0.76							1.56*	0.20			0.52*	-0.19		
	S_{ij}			-6.43	5.6							-2.32	1.86			3.76**	-0.44
	F_1 HPH (%)			-19.2								-21.18				62.91	
	F_2 HPH (%)				17.4								13.2				4.54
	ID				-45.4								-43.6				35.83
	SSI					1.03	0.46	0.17	1.23					1.09	1.02	0.18	1.19
	YSi					No	No	No	Yes					Yes	No	Yes	Yes
$P_1\times P_4$	$\bar{x}$	48.06	46.36	52.77	53.91					17.1	15.57	20.17	19.92				
(Eearlipima× Dandara)	gi (F_1)	3.10**	-0.01							0.78	0.06						
	gi (F_2)	0.79	1.58							-0.01	0.4						
	S_{ij}			4.2	7.85*							2.39	3.22				
	F_1HPH (%)			9.8								17.95					
	F2HPH (%)				12.17								16.49				
	ID				-2.16								1.24				
	SSI					1.05	0.84	1.29	1.32					1.05	0.78	1.34	1.32
	YSi					Yes	Yes	Yes	Yes					No	No	Yes	Yes
$P_1\times P_5$	$\bar{x}$					22.45	21.63	20.9	24.23					7.88	7.71	7.74	9.12
Eearlipima×G.80	gi (F_1)					-1.41	1.90							-0.57*	0.63*		
	gi (F_2)					-1.08	1.26							-0.45	0.52*		
	S_{ij}							-1.95	1.73							-0.52	0.88
	F1HPH (%)							-6.68								-1.78	
	F2HPH (%)								7.93								15.74
	ID								-15.66								-17.83
	SSI					1.05	1.03	1.08	0.97					1.05	1.09	1.05	0.96
	YSi					Yes	No	No	Yes					No	Yes	No	Yes
$P_2\times P_4$	$\bar{x}$									14.6	15.57	20.93	16.7				
PimaS$_6$×Dandara	gi (F_1)									0.69	0.06						
	gi (F_2)									-0.14	0.40						
	S_{ij}											3.25*	0.15				
	F_1HPH (%)											34.43					
	F_2HPH (%)												7.39				
	ID												20.11				
	SSI													0.51	0.78	1.27	1.01
	YSi													No	No	Yes	Yes
$P_2\times P_5$	$\bar{x}$	37.39	45.09	50.91	55.87					14.6	17.61	19.71	21.7				
(Pima S$_6$×G.80)	gi (F_1)	0.79	-2.29*							0.69	-0.54						
	gi (F_2)	-1.39	2.90*							-0.14	.56**						
	S_{ij}			6.94*	10.66*							2.63	3.96**				
	F_1HPH (%)			12.91								11.93					
	F_2HPH (%)				23.91								23.2				
	ID				-9.74								-10.1				
	SSI					0.37	1.03	1.21	1.12					0.51	1.09	1.24	1.13
	YSi					No	No	Yes	Yes					No	No	Yes	Yes
$P_3\times P_5$	$\bar{x}$													8.81	7.71	8.66	9.11
(Pima S$_7$×G.80)	gi (F_1)													-0.13	0.63*		
	gi (F_2)													0.29	0.52*		
	S_{ij}															-0.03	0.13
	F_1HPH (%)															-1.70	
	F_2HPH (%)																3.41
	ID																-5.2
	SSI													0.92	1.09	0.79	0.86
	YSi													Yes	Yes	No	Yes

Table 6a. Cont.

Hybrid	Statistical estimates	SCY/P (g/p)								LCY/P (g/p)							
		FSE				SSE				FSE				SSE			
		P_1	P_2	F_1	F_2	P_1	P_2	F_1	F_2	P_1	P_2	F_1	F_2	P_1	P_2	F_1	F_2
P4×P5 (Dandara×G.80)	$\bar{x}$	46.36	45.09	39.25	47.0					15.5	17.61	14.88	17.98				
	gi (F_1)	-0.01	-2.29*							0.06	-0.54						
	gi (F_2)	1.58	2.90*							0.40	1.56*						
	S_{ij}			-3.93	-1.1							-1.57	0.30				
	F_1 HPH (%)			-15.3								-15.5					
	F_2 HPH (%)				1.5								2.1				
	ID				-19.9								-20.8				
	SSI					0.84	1.03	0.33	1.16					0.78	1.09	0.44	1.20
	YSi					Yes	No	Yes	Yes					No	Yes	Yes	Yes
$P_4\times P_8$ (Dandara×G.89)	$\bar{x}$									15.5	10.56	17.09	17.16				
	gi (F_1)									0.06	-2.35*						
	gi (F_2)									0.40	-3.07						
	S_{ij}											2.45	3.51*				
	F_1 HPH (%)											9.76					
	F_1 HPH (%)												10.21				
	ID												-0.41				
	SSI													0.78	0.47	0.99	1.32
	YSi													No	No	Yes	No
$P_5\times P_6$ (G.80× G.90)	$\bar{x}$	45.09	58.49	40.45	60.2					17.6	21.61	15.61	23.43				
	gi (F_1)	-2.29*	2.57*							-0.5	0.97						
	gi (F_2)	2.90*	4.54**							1.56*	1.65*						
	S_{ij}			-5.30	9.12*							-1.57	3.89**				
	F_1HPH (%)			-30.8								-27.76					
	F_2HPH (%)				3.01								8.42				
	ID				-49								-50.1				
	SSI					1.03	1.17	0.82	1.41					1.09	1.18	0.90	1.40
$P_5\times P_7$ (G.80×G.85)	$\bar{x}$					21.63	19.3	26.1	23.13					7.71	7.28	9.27	8.33
	gi (F_1)					1.9	0.59							0.63*	0.15		
	gi (F_2)					1.26	-0.83							0.52*	-0.38		
	S_{ij}							1.25	0.38							0.29	0.02
	F_1HPH (%)							20.9								20.23	
	F_2HPH (%)								6.93								8.04
	ID								11.58								10.14
	SSI					1.03	1.26	0.86	0.81					1.09	1.24	0.92	0.90
	YSi					No	Yes	Yes	No					Yes	Yes	Yes	No
$P_5\times P_8$ (G.80×G.89)	$\bar{x}$					21.63	21.9	22.2	36.67					7.71	7.98	8.22	13.71
	gi (F_1)					1.90	-0.4							0.63*	-0.13		
	gi (F_2)					1.26	1.3							0.52*	0.47		
	S_{ij}							-1.6	11.71**							-0.47	4.54**
	F_1 HPH (%)							1.23								3.01	
	F_2 HPH (%)								67.06								71.8
	ID								-65.03								-66.79
	SSI					1.03	0.46	0.91	-0.05					1.09	0.47	0.88	-0.02
	YSi					No	No	No	Yes					Yes	No	No	Yes
$P_6\times P_8$ (G.90×G.89)	$\bar{x}$					23.64	21.9	17.7	24.97					8.47	7.98	6.66	8.88
	gi (F_1)					-1.18	-0.43							-0.39	-0.13		
	gi (F_2)					-1.54*	1.38							-0.58*	0.47		
	S_{ij}							-3.11	2.81							-1.01	0.81
	F_1HPH (%)							-25.1								-21.37	
	F_2HPH (%)								5.54								4.84
	ID								-41.07								-33.33
	SSI					1.17	0.46	1.07	0.39					1.18	0.47	1.01	0.36
	YSi					Yes	No	No	No					Yes	No	Yes	No
$P_7\times P_8$ (G.85×G.89)	$\bar{x}$					19.35	21.9	26.5	31.15					7.28	7.98	9.68	11.31
	gi (F1)					0.59	-0.43							0.15	-0.13		
	gi (F2)					-0.83	1.38							-0.38	0.47		
	S_{ij}							3.95	8.28**							1.47	3.05**
	F_1HPH (%)							21.0								21.3	
	F_2HPH (%)								41.91								41.73
	ID								-17.24								-16.84
	SSI					1.26	0.46	0.77	0.22					1.24	0.47	0.78	0.17
	SYi					Yes	No	Yes	No					Yes	No	Yes	No
$P_7\times P_9$ (G.85×G.83)	$\bar{x}$					19.35	17.4	22.2	22.12					7.28	6.61	7.93	7.98
	gi (F_1)					0.59	-0.5							0.15	-0.03		
	gi (F_2)					-0.83	-0.8							-0.38	-0.19		
	S_{ij}							-0.2	1.50							-0.38	0.39
	F_1HPH (%)							15.1								8.93	
	F_2HPH (%)								14.32								9.62
	ID								0.76								-0.63
	SSI					1.26	1.15	1.13	1.02					1.24	1.02	1.15	1.03
	YSi					Yes	No	Yes	Yes					Yes	No	No	Yes
$P_8\times P_9$ (G.89×G.83)	$\bar{x}$									10.5	13.93	14.45	14.27				
	gi (F_1)									-2.35*	-0.19						
	gi (F_2)									-3.07	0.2						
	S_{ij}											0.05	0.82				
	F_1HPH (%)											3.73					
	F_2HPH (%)												2.44				
	ID												1.25				
	SSI													0.47	1.02	0.81	0.94
	YSi													No	No	No	No

SCA effects

P_6 (G.90) and P_7 (G.85) were the highest yielding potential genotypes in FSE; P_2 (Pima S6) was among the highest yielding potential in SSE for lint yield. These collected results indicate that the five parents (P_1, P_2, P_5, P_6 and P_7) out of the nine genotypes tested for GCA effects were classified as good combiners for cotton yields and some of theme were rated as stress tolerant to SSE and/or are classified as stable in their mean performance for yielding ability based on SCY and/or LCY. Of particular interest are combinations of lines with good to superior trait mean performance and beneficial GCA effects that also have beneficial SCA effects. Such combinations tend to be rare, as observed for this population. More common are cases in which SCA effects are beneficial but mean performance and GCA are not. Given the definition of SCA effects as deviations from expectations based on GCA effects, this is not surprising. SCA effects identify the best hybrid combinations, but they also identify complementary alleles for trait performance (Kearsey and Pooni, 1996). Novel combinations of beneficial alleles at multiple loci could lead to new potential for inbred improvement (Ragsdale, 2003).

In maize and possibly other hybrid crops, heterosis seems to be largely attributable to dominance or apparent overdominance (Stuber *et al* 1992). However, in rice, which is inbred, there is evidence to suggest that the nature of heterosis does not depend on overdominance (Xiao *et al* 1995; Yu *et al* 1997). This suggests that hybrid performance could be captured in elite inbreds. Xiao *et al* (1995) demonstrated this empirically; advanced inbreds (F_8 generation) were found that exceeded F_1 hybrid performance for 12 traits including yield. Singh *et al* (1983) demonstrated that a large part of heterosis in cotton is of a type which could be captured in elite inbreds (e.g., additive by additive epistasis). Therefore, hybrid performance as indicated by SCA effects might be a useful parameter in parent selection for trait improvement in cotton.

F_2 high parent heterosis (F_2HPH) plus various genetic estimates related to heterotic effect for each cross were recorded in Table 6a. For the FSE, out of 36 F_2 cross combinations; eight crosses revealed F_2HPH for SCY, ranging from 1.53 to 23.91 %. However, for LCY eleven crosses exhibited F_2HPH, ranging from 1.24 to 23.23 %. Seven crosses out of the eight ones exhibiting F_2HPH for SCY were also among the eleven ones exhibiting F_2 HPH in LCY. For SCY the eight crosses exhibiting F_2HPH were $P_1 \times P_4$ (Eearlipima×Dandara, 12.17%), $P_2 \times P_5$ (Pima S6×G.80, 23.91%), $P_3 \times P_4$ (Pima S_7×Dandara, 3.11%), $P_3 \times P_9$ (Pima S7×G.83, 11.74%), $P_4 \times P_5$ (Dandara×G.80, 1.53%), $P_5 \times P_6$ (G.80×G.90, 3.01%), $P5 \times P_9$ (G.80×G.83, 17.43%), and $P_2 \times P_8$ (Pima S_6×G.89, 1.32%). Whereas, for LCY the crosses exhibiting F_2 HPH are first forementioned seven ones ($P_1 \times P_4$-16.49%, $P_2 \times P_5$-23.23%, $P_3 \times P_4$-10.62%, $P_3 \times P_9$-19.35%, $P_4 \times P_5$-

2.10%, $P_5 \times P_6$-8.42%, and $P_5 \times P_9$ –13.23%) plus other four crosses, viz: $P_1 \times P_9$ (Eearlipima×G.83, 1.87%), $P_2 \times P_4$ (Pima S_6×Dandara, 7.39%), $P_4 \times P_8$ (Dandara×G.89, 10.21%), and $P_8 \times P_9$ (G.89×G.83, 2.44%) accounting for eleven crosses (Table 6a).

Meanwhile for SSE out of 36 crosses, nine crosses revealed F_2HPH for SCY ranging from 3.25 to 67.06 %, whereas for LCY eleven cross combinations showing F_2HPH were recorded, i.e. the nine ones recorded for SCY plus another two ones with heterotic values ranging from 3.41 to 71.80 %. These crosses are listed in Table 6a. For SCY the nine crosses exhibiting F_2HPH are $P_1 \times P_5$ (Eearlipima×G.80, 7.93%), $P_1 \times P_9$ (Eearlipima×G.83, 11.58%), $P_3 \times P_4$ (Pima S_7×Dandara, 6.09%), $P_3 \times P_9$ (Pima S_7×G.83, 3.25%), $P_5 \times P_7$ (G.80×G.85, 6.93%), $P_5 \times P_8$ (G.80×G.89, 67.06%), $P_6 \times P_8$ (G.90×G.89, 5.54%), $P_7 \times P_8$ (G.85×G.89, 41.91%), and $P_7 \times P_9$ (G.85×G.83, 14.32%). Meanwhile for LCY, the crosses exhibiting F_2HPH are nine forementioned ones ($P_1 \times P_5$ – 15.74%, $P_1 \times P_9$ – 15.36%, $P_3 \times P_4$ –18.84%, $P_3 \times P_9$ –9.19%, $P_5 \times P_7$ – 8.04%, $P_5 \times P_8$ – 71.80%, $P_6 \times P_8$ – 4.84%, $P_7 \times P_8$ – 41.73%, and $P_7 \times P_9$ –9.62%) plus two crosses, viz: $P_3 \times P_5$ (Pima S_7×G.80), and $P_5 \times P_9$ (G.80×G.83) accounting for eleven crosses (Table 6a). In this respect Reid (1995) reported that F_2 superiority over their best parents was only detected under stress conditions. Baure and Green (1996) also reported F_2's greater superiority over their best parents in lower yielding sites. Miller and Lee (1964) reported that casual inspection of earlier data collected in North Carolina had suggested that greater heterotic responses may occur under unfavourable environments than when the material is grown under conditions approaching a more optimum environment for high yield.

It worth to mention that for SCY the two crosses viz: $P_3 \times P_4$ (Pima S_7×Dandara, FSE=3.11%; SSE=6.09%), and $P_3 \times P_9$ (Pima S_7×G.83, FSE=11.74%; SSE=3.25%) were among those exhibiting F_2HPH in both FSE and SSE. Meanwhile for LCY four crosses, the forementioned two crosses for SCY, and another two crosses showing F_2HPH, viz: $P_1 \times P_9$ (Eearlipima×G.83, FSE=1.87%; SSE=15.36%) and $P_5 \times P_9$ (G.80×G.83, FSE=13.23%; SSE=4.54%) were recorded in both environments (FSE and SSE). This mean that these four crosses exhibiting F_2HPH in both environments (FSE and SSE) for LCY can be used as elite breeding material for improving the potential yielding ability of genotypes for both environments in one breeding program. However, the inconsistent mean performance of F_2HPH of all recorded crosses in both environments indicated that the evaluation of F_2 heterosis should be based on the performance of the F_2 hybrids in the environments of interest. Similar conclusion was reached by Tang *et al* (1993).

From the numerous statistical and genetical data collected for crosses exhibiting F_2HPH on the basis of SCY and LCY in both environments (FSE and SSE) and listed in Tables (6a and 6b), several guide lines for breeding cotton tolerant genotypes to the stress of late planting can be discussed and highlighted.

1. The relative contributing yield component traits to LCY may be rated as follows: lint index, boll weight, bolls number, lint percent and seed index. Therefore, all yield components traits must be considered in cotton breeding. Tang *et al* (1993) found that the heterosis for yield of F_2 cotton was due to increased boll number and boll weight.
2. Five crosses in FSE ($P_1 \times P_4$, $P_2 \times P_5$, $P_3 \times P_9$, $P_4 \times P_8$, and $P_5 \times P_6$) and three cross combinations in SSE ($P_3 \times P_9$, $P_5 \times P_8$, and $P_7 \times P_8$) exhibiting very high percentage of F_2HPH as well as significant SCA effect (Table 5), capable of giving maximum transgressive effects. The SCA estimates represent dominance and epistasis. The forementioned cross combinations were identified as good specific combiners. These crosses could be utilized to isolate high yielding segregants in later generations.
3. In their discussion for the F_2HPH in cotton, Tang *et al* (1993) stated that the F_2 population resulting from a cross of two inbred lines that differ by any number of unlinked loci expected to lose 50% of the F_1 dominance effects, whereas the additive effects should be constant from one generation to the next (Hyman, 1958). Theoretically, the presence of significant GCA and SCA in the F_1 generation is a consequence of fluctuations in additive and dominance relationships, respectively, among the parents. In the present study F_2HPH were observed for LCY, SCY and a combination of components of yield related traits. The deviation of F_2 performance from F_1 performance (inbreeding depression, ID) was quite very small and in most cases with minus values, indicating that the F_2 mean performance was higher than their respectives F_1's. These results probably indicate that epistasis and/or dominance effects for F_2 heterosis in cotton could be important to a certain extent, but additive and dominance effects are probably important than epistatic effects.
4. The F_2 hybrids are expected to express only 50% of the heterosis (F_1-mid parent) expressed in the F_1 hybrid, and even less when heterosis is defined in terms of the highest-yielding parent. Significant deviation of the F_2 from expected could be due to non-additive gene action other than dominance, or plant competition within the F_2 population. The F_2 hybrids, besides having only 50% of the F_1 heterozygosity, consist of a very heterogeneous population. This heterogeneity might result in a

Table 6b. F_2 HPH for yield components for crosses exhibiting such heterosis for yield in FSE and SSE.

Hybrid	Statistical estimate	NB		BW		LP		SI		LI	
		FSE	SSE	FSE	SSE	FSE	SSE	FSE	SSE	FSE	SSE
$P_3 \times P_4$	F_2HPH (%)	7.62			3.72	3.94	9.77			1.28	10.32
	ID	-16.42			-3.72	2.11	-1.68			10.06	-1.87
$P_3 \times P_9$	F_2HPH (%)	20.74	4.82			6.82				8.52	
	ID	-3.15	-25.00			-5.61				-2.99	
$P_1 \times P_9$	F_2HPH (%)		9.77	4.03	0.68	5.03			0.36	1.97	
	ID		-42.10	-3.68	4.55	0.19			2.60	2.36	
$P_5 \times P_9$	F_2HPH (%)	16.62	3.02	0.70			0.95	7.08		1.69	
	ID	-53.24	30.35	5.28			-1.67	-11.76		-9.64	
$P_1 \times P_4$	F_2HPH (%)	6.06		5.37		3.82				0.33	
	ID	3.11		-5.37		3.35				3.78	
$P_1 \times P_5$	F_2HPH (%)	1.93		5.54		5.55				8.94	
	ID	-12.16		-3.04		-1.87				0.15	
$P_2 \times P_4$	F_2HPH (%)			8.59							
	ID			-5.33							
$P_2 \times P_5$	F_2HPH (%)	6.38		14.09				2.03		0.95	
	ID	-7.27		-2.15				-1.93		-2.40	
$P_3 \times P_5$	F_2HPH (%)	10.48				3.63				3.69	
	ID	-23.09				0.24				-1.03	
$P_4 \times P_5$	F_2HPH (%)			5.92						6.75	
	ID			2.88						-11.05	
$P_4 \times P_8$	F_2HPH (%)			6.64		1.36				9.51	
	ID			-13.0		1.14				1.64	
$P_5 \times P_6$	F_2HPH (%)	0.76		2.02						1.43	
	ID	-45.22		-2.36						-2.90	
$P_5 \times P_7$	F_2HPH (%)			1.65							
	ID			-3.36							
$P_5 \times P_8$	F_2HPH (%)	67.59				2.81		5.55		10.42	
	ID	-62.26				-1.05		-1.53		-3.25	
$P_6 \times P_8$	F_2HPH (%)	2.01				-2.23					
	ID	-51.31				5.50					
$P_7 \times P_8$	F_2HPH (%)	36.91		0.99							
	ID	-11.48		-5.15							
$P_7 \times P_9$	F_2HPH (%)	14.26		0.33				3.41			
	ID	3.32		-2.70				-5.25			
$P_8 \times P_9$	F_2HPH (%)			0.33				5.96			
	ID			-2.37				2.64			

greater range of adaptation or stability for variable environments for F_2's, relative to their homogeneous parents or F_1 hybrids. Conversely, this heterogeneity might result in reduced fiber quality, such as increased short-fiber (<12.7 mm) content and reduced yarn tenacity (Meredith, 1990).

5. For SCY the F_2HPH crosses P_1 (good combiner, g.c) × P_4 (poor combiner, p.c.), P_2 (p.c) × P_5 (p.c.), and P_5 (p.c) × P_6 (p.c.) in FSE and the F_2HPH crosses P_1 (p.c) × P_9 (p.c.), P_3 (p.c) × P_4 (p.c.) , P_5 (p.c) × P_8 (p.c.) and P_7 (p.c) × P_8 (p.c.) in SSE had the highest mean performance significant SCA effects for SCY (Table 6a). However, for LCY the F_2 HPH crosses P_1 (p.c) × P_4 (p.c.), P_3 (p.c) × P_9 (p.c.), P_2 (p.c) × P_5 (g.c.), P_4 (p.c) × P_8 (p.c.), and P_5 (g.c) × P_6 (g.c.) in FSE and the F_2 HPH crosses P_3 (p.c) × P_4 (p.c.), P_5 (g.c) × P_8 (p.c.), and P_7 (p.c) × P_8 (p.c.) in SSE had the highest mean performance significant SCA effects for LCY. Therefore, it is expected that these crosses, which gave high performance of heterosis as well as significant SCA effects, are capable of giving maximum transgressive effects. This could be utilized to isolate high yielding segregants in later generations. Moreover, all these crosses were identified to be superior in their yielding ability and were also stable in their mean performance, according to Kang (1995)'s yield stability statistic (YS_i), except the cross P_7 × P_8 in both SCY and LCY, and P_4 × P_8 in LCY only. This indicate the stability of mean performance of these crosses over environments (FSE and SSE). The parental genotypes of these crosses were rated as stable mean performance over environments except P_8 and P_9.

Out of the forementioned crosses, the three crosses P_3× P_4, P_5 × P_8, and P_7 × P_8 were classified as tolerant to stress of short season environment based on both SCY and LCY (low stress susceptibility index, SSI <1) according to Fisher and Maurer (1978). Out of the five parental genotypes viz: P_3, P_4 and P_8 were rated as tolerant to the stress of short season environment based on both SCY and LCY.

Therefore, much emphasis will be concentrated on these crosses to be used directly for selecting superior segregant of high yielding ability with stability mean performance and adapted to SSE. Other alternative, their parents, P_3 (Pima S_7), P_4 (Dandara), and P_8 (G.89) coupled with P_6 (G.90), the highest yielding parent (as a source of high yielding genes to enrich the gene pool), may be incorporated in multiple crosses system followed by pidegree selection for obtaining high yielding, stable, and adapted to short season lines.

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الاحتمالات المستقبلية لتربية أصناف قطن قصيرة العمر . نظرة ثانية.

القدرة على الائتلاف لمحصول القطن الزهر ومكوناتة

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تهدف هذه الدراسة إلى الحصول على بعض الخطوط الرئيسية عند لاختيار الآباء التى تدخل فى برامج التهجين بهدف إنتاج أصناف متفوقة تصلح للزراعة فى الميعاد العادى (موسم طويل النمو) وكذلك للزراعة فى الميعاد المتأخر (موسم قصير النمو) وذلك بهدف زراعة اصناف من القطن تتحمل التأخير فى ميعاد الزراعة بعد المحاصيل الشتويه.

وتم الحصول على المواد الوراثيه المستخدمه فى هذا البحث من خلال (التهجين الدائرى) لجميع الهجن الممكنه (ما عدا الهجن العكسيه) بين تسعة تراكيب وراثية تبع النوع الباربادنس (1- بيما مبكر، 2- بيما س6 ، 3- بيما س7، 4- دندرة، 5- جيزة 80، 6- جيزة 90، 7- جيزة 85، 8- جيزة 89، 9- جيزة 83) وذلك فى عام 2003 . وفى عام 2004 تم اجراء التربية الذاتيه لنباتات هجن الجيل الأول (36 هجين) لانتاج بذرة الجيل الثانى. وفى عام 2005 تم اجراء التقييم لـ 81 تركيبة وراثية (9 أباء ، 36 هجين فى الجيل الأول ، 36 هجين فى الجيل الثانى) وذلك فى ميعادين للزراعة هما 17 مارس (موسم نمو طويل او نظام الزراعة العادى) و أول مايو (موسم نمو قصير او نظام الزراعة المتأخر) وذلك فى وحدة الأرشاد الزراعى بمدينة مغاغة بمحافظة المنيا. وقد تم استخدام نظام توزيع القطع المنشقة فى تصميم القطاعات كاملة العشوائية ذات اربع مكررات بحيث

وزعت ميعادى الزراعة بالقطع الرئيسية بينما التراكيب الوراثية بالقطاعات الفرعية . وعند النضج اخذت من كل قطعة تجريبية عينة ممثلة من 50 لوزة (بواقع 5 لوزات لكل نبات من عشرة نباتات عشوائية) . ولقد استخدمت هذه العينات فى تقدير صفات مكونات المحصول وهى: متوسط وزن اللوزه ، تصافى لحليج ، معامل البذرة ، معامل التيلة، كما تم تقدير محصول القطن الزهر للنبات ومحصول القطن الشعر للنبات وعدد اللوز للنبات.

وتم اجراء التحليلات الإحصائيه على اساس متوسطات القطع التجريبية ، ومن البيانات المتحصل عليها للنباتات المختلفة (مبكر و متأخر) وتم تقدير القدرة العامة والخاصة على الائتلاف.

ومن وجهة نظر المربى التى تهدف الى انتخاب تراكيب وراثية من القطن قصير العمر تصلح للزراعة عقب المحاصيل الشتويه (زراعة محصولين بدلا من محصول واحد فى العام) فان الاستنتاجات المتحصل عليها من التحليلات الاحصائية الوراثية المتعددة التى اجريت على مجموعة الهجن الدائرية السالفة الذكر تشير الى ما يلى: يجب ان يوجه المربى عنايه خاصة الى الـ 5 هجن التالية فى البيئة قصيرة الموسم SSE (بيما مبكر×دندره ،بيما س6×جيزة80 ،بيما س7×جيزة83، دندرة×جيزة89، جيزة80×جيزة90) و الـ 3 هجن التالية فى البيئة طويلة الموسم FSE (بيما س7×جيزة83 ،جيزة80×جيزة89 ،جيزة85×جيزة89) تتميز بقوة الهجين العالية فى الجيل الثانى بالاضافة الى القدره الخاصة على الائتلاف. وان الـ 3 هجن التالية (بيما س7×دندرة ، جيزة80×جيزة89 ، جيزة85×جيزة89) اتصفت بان لها قدره عالية على تحمل الظروف البيئية القاسية نتيجة تأخر ميعاد الزراعة بناء على محصول القطن الزهر والشعر. مما يوحى باعطاء اولوية لهذه الهجن لاستخدامها المباشر لانتخاب تراكيب وراثية ذات قدره محصوليه عالية وكذلك ثبات سلوك الأداء وملائمة لموسم النمو القصير. بالاضافة ان الأباء بيما س7 و دندرة و جيزة 89 بالإضافة الى جيزة 90 (مصدر جينات المحصول العالى لإثراء حوض الجينات) يمكن ان تدخل فى نظام تهجينات متعددة يليها الانتخاب المنسب من اجل الحصول على سلالات عالية المحصول و ثابتة الأداء ومناسبة لموسم النمو القصير.