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INTERPRETING THE MAGNITUDE OF GENETIC PERFORMANCE, HETEROSIS AND ANATOMICAL DIFFERENCES AMONG EGYPTIAN AND IMPORTED COTTON GERMPLASM CROSSES

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ABSTRACT

The current study was carried out at Cairo University Experimental Farm during the summer seasons of 2004 and 2005 as a first step to broaden the Egyptian cotton genetic base and initiate a practical genetic foundation to improve some important traits like fitting to machine harvesting. The study utilized the F_1 crosses to investigate the main performance variation, heterotic effects and anatomical differences for growth, earliness and yield characteristics of inter and intraspecific cotton crosses resulted from 5X5 set of half diallel crossing design. The original parents were taken from a three years-selfed individual plants. The anatomical measurements were done on the eleventh internode of the main stem and on the corresponding leaf of the parents; Giza 89, Pima 6, Giza 85, Wild and Tamcot as well as some of their selected crosses; Giza89 X Pima6, Giza89 X Wild, Pima6 X Giza85 and Giza 85 X Tamcot at flowering stage.

Compared to their parents, the main stem diameter was larger in F_1 hybrid plants (Giza 89 X Pima 6, Pima 6 X Giza 85, Giza 89 X Wild and Giza 85 X Tamcot). All included tissues (thickness of epidermis, cortex, vascular tissues and parenchymatous area of the pith) shared to different extents in increasing the thickness of stem diameter of F_1 hybrid plants. The increment in cortex thickness was attributed to the increase in cell size and number of cell layers. The larger thickness of vascular cylinder was due to the larger amount of conducting elements; phloem and xylem tissues. The cambial activity was obviously stimulated since wider phloem and xylem tissues were produced. Moreover, xylem vessels had wider cavities which amounted to more total active conducting area to cope with vigorous growth produced by such types of F_1 cotton crosses plants. Likewise, the leaf lamina in F_1 hybrid plants was thicker than that of their original parents. Both of the palisade and spongy tissues as well as leaf midvein were increased in thickness and the midvein bundle was increased in size.

A trend of improved earliness and yield variables were observed in the inter-intraspecific crosses, since significant heterotic effects were found over mid parent and high parent for the majority of the studied traits with slight magnitude. In addition to the crosses G89XP6, P6XG85, P6Xtamcot and G85Xtamcot, the study comprehensively showed that the mean performance of G89-based crosses array appeared to progress satisfactorily among all hybrids arrays for the most traits. This result is important too, since the majority of the genetic constitution of the hybrids of these crosses can be revealed belonging to barbadense group. This may accelerates the attainment of the breeding objectives through reducing the required trait fixation steps in the breeding programmes, meanwhile reduce the expected backwardness and lint deterioration that might be happened thru exploiting some hirsutum germplasm. Thus, the study has a tendency to suggest these crosses for further breeding studies and selection in the subsequent segregating populations to improve Egyptian cotton and looking for a cotton genotype can be mechanically harvested.

Keywords: Egyptian cottons- Hybrid breeding – Heterosis – Leaf anatomy – Stem anatomy

INTRODUCTION

Cotton is by nature perennial crop. However, it is grown (for agronomical purposes) in temperate zones as an annual crop. Basically, cotton is grown for the production of fiber to serve the textile industry. Its other industrial and agricultural uses (oil and animal feed) are significant too. Egypt is producing the Extra-fine cottons, including both the long and extra long staple varieties. The extra-fine cotton is the type which are used to spin yarns of 50 or higher count. The cultivated tetraploid species (*G. hirsutum* (AD_1) *and G. barbadense* (AD_2)) have 52 chromosomes ($2n = 4x = 52$) with a relatively larger genome size of 4700 cM than many other major crops (Hendrix and Stewart, 2005)**.** Nowadays, Egyptian cotton production is suffering many troubles in cost of field production, marketing policy, and maintaining or improving fiber production and quality to meet the production and industrial worldwide challenges with other cottons. Overcoming these dilemmas (at least that connected to fiber production and quality) is perhaps requiring making rapid and precision genetic changes in cultivar development to increase yielding capacity and help cotton breeder in selection methodologies.

For example in the context of cotton machinery level needed to harvest Egyptian cottons mechanically, Abdalla *et al.* (2005) concluded that long way needs to be passed through before seeing an Egyptian cotton genotype can be economically harvested by machine. They recommended, as a beginning step, that scientific sectors should be able to introduce a new generation of varieties fitted to machine harvesting. Moreover, evaluation of breeding capacity in forms of mean performance and mode of gene introgression of the within cotton germplasm repositories is warranted to identify populations with vigor potential than those currently adopted, Gutie´rrez *et al.* (2002). The term heterosis mainly expressed to describe the potential of F_1 crosses compared to its parents. Intraspecific as well as interspecific heterosis has been reported in cotton by many researchers (Davis and Palomo, 1980 and Wells and Meredith, 1986). Employing heterosis in cotton has many breeding and economical restrictions. Hybrid cottons, however, is receiving increased attention in some countries like India (Roupakias *et al.,* 1998) and China (Wu *et al*., 2004). Despite some documented drawbacks related to interspecific hybridization, it seems that the hybrids between the two tetraploid cottons species tend to combine the high yielding ability of *G. hirsutum* and the appropriate level fiber quality of *G. barbadense* (Abdalla, 2006). Moreover, given the “upland” (Wells and Meredith, 1986) and “Pima” (Abdalla *et al.,* 1999) germplasm ability to generate highly yielding hybrids and mechanically harvested genotypes, it is possible that genetically broad-based resulted hybrid populations demonstrate significant mean performance help attaining the goals of Egyptian cotton breeder.

On the other hand, understanding such heterotic effect of the traits of interest can be related to the botany of external (morphology) and internal structure (histology) of the plant. A variety of genetical (Schnell and

Cockerham, 1992) physiological (Wells *et al.,* 1988) and biochemical (Meredith and Brown, 1998) theories expressed to explain the basis of heterosis. The key cotton traits, however, are complex traits which means that heterosis associated with these traits controlled by numerous genetic factors interacting together to express the heterotic effects. Such interaction would translate comprehensively into the final form of plant morphology like shape, stature and performance. Thus, the modification of the morphological features associated with heterosis phenomenon can be interpreted through assessing the growth and yield performance and also examination of the internal structure of the main stem and the leaves. The present study, therefore, investigated the heterotic performance and its impact on anatomical structure of cotton F_1 crosses resulted from a straight diallel design to help identify hybrid progenies that comprise superior potential for studied traits and also developing a practical base to start selection program in the subsequent segregating generations for cotton improvement.

MATERIALS AND METHODS

Breeding scheme and crop monitoring:

Field experimentation was conducted at Cairo University Experiment Farm during the two growing seasons 2004 and 2005. The mating scheme includes five local and introduced genotypes. These genotypes were Giza 89, Giza 85 and Pima S6 from *barbadense* taxa as well as two *G. hirsutum* genotypes/lines *viz.*, Tamcot SP and Wild. The genotypes were symbolized G for Giza, P6 for Pima S6, Tamcot and Wild. The original parents were taken from a three years-selfed individual plants. In 2004 season, half diallel crosses were made among the five genotypes. At flowering, the parental lines were crossed in diallel fashion. Flowers were hand emasculated in the evening and all necessary precautions were taken to avoid alien pollen contamination. For this purpose, after emasculation the flowers were covered with polythene bags. As the stigma became receptive next day of emasculation, the anthers from the male parent were collected in clean Petri dishes. Pollens from anthers were dusted on stigma of emasculated female parents which were labeled and covered again with the respective polythene bag until boll formation. At maturity, crossed bolls were picked and seed cotton was ginned. In 2005 an experiment were conducted to evaluate the obtained F_1 crosses along with their parents in a replicated trial with four replications using RCBD. The rows were 5m long and 0.60m apart. Sowing was done by hand in hill spaced 0.25m apart. Soon after complete emergence, seedlings were thinned to one plant per hill. Plants of each parents and hybrids were grown in one row. Standard crop management practices were followed through the growing season as usual done with ordinary cotton culture including pest control.

Data Collection:

After seedling became well established, five representative plants were selected from each plot of each category and marked for identification.

These plants were monitored and tagged to provide the following data: Growth and earliness variables were plant height (PH/cm), number of fruiting branches (NFB), node number of first fruiting branch (NFFB), date of first flower (DFF/day)–number of days from planting to appearance of first flower, date of first open boll (DFB/day)–number of days from planting to opening of the first boll and boll maturation period (BP/day)–the time from anthesis of the flower until the resulting boll was sufficiently open to see the lint.

Additional five guarded plants from each plot were hand harvested at frequent intervals until all bolls had been harvested. Their mean values were used for statistical analysis for the following characters. Yield and its major components were number of harvested bolls per plant (NB/p), Boll Weight (BW) gm- average weight in grams of fifty-sound, opened, random, bolls. Lint Percentage (L %)-the amount of lint in seed cotton sample, expressed as percentage. Seed Index (SI) gm-Estimated as 100 seed weight in gm, seed cotton yield (SCY/p) gm-mean weight of sampled plants and earliness index(EI)–ratio of weight of seed cotton harvested at the first picking to total weight of seed cotton harvested, expressed as a percentage. The anatomical measurements were done on the eleventh internode of the main stem and on the corresponding leaf of the parents as well as some of their F_1 hybrids; Giza89 X Pima6, Giza89 X Wild, Pima6 X Giza85 and Giza 85XTamcot at flowering stage based on their potential and Egyptian parent included. Specimens were killed and fixed for at least 48 hr. in F.A.A. (10 ml. Formalin, 5 ml glacial acetic acid and 85 ml. Ethyl alcohol 70%). The selected materials were washed in 50% ethyl alcohol, dehydrated in a normal butyl alcohol series, embedded in paraffin wax of 56^0C melting point, sectioned to a thickness of 20 microns, double stained with crystal violet-erythrosine, cleared in xylene and mounted in Canada balsam (Nassar and El-Sahhar, 1998). Sections were examined to detect histological manifestations of the chosen F_1 hybrids.

Statistical Analysis

For justifying the significance among breeding materials data were subjected to regular analysis of variance using RCBD with four replications. The statistical analyses were based on plot means from the data collected on individual plants. The model of variability used can be wrote as $Y= \mu +T+B+ \varepsilon$. Hence the term $\varepsilon=TB$ interaction. Thus, Analysis of variation for growth, earliness and yield variables has done using the F_1 population derived from hybridization between aforementioned inbred lines (Steel and Torrie, 1980). The data mean were used for calculating heterosis over mid and better parent according to the following criteria: Heterosis (MP) =[(F_1- mid parent value)÷ (mid parent value)]X100. Heterosis (BP) = [(F_1-better parent value) ÷(better parent value)] X 100. Mean performance of the contributed entries are tested using the Fisher’s least significant difference.

RESULTS AND DISCUSSION

Analysis of variance for breeding materials

Significant and highly significant differences among genotypes were existed for all characters except BP as it shown in ANOVA Table (1). The results indicated that parental genotypes as well as the crosses possess a reasonable degree of variability for growth, earliness and yield variables. This pointed out to the possibility to carry on the next step of analysis *i.e.*, interpreting the mean performance and heterosis index for the assigned traits.

Table (1): Analysis of variance (*Mean squares*) of F_1 inter/intraspecific cotton crosses in respect to growth, Earliness and yield variables in cotton

Variable☻	Source☺	Blocks	Genotypes	Error
	df	3	14	42.00
Growth Variables	**PH**	392.93	1951.56**	225.24
	NFB	44.06	48.53**	12.36
	NFFB	3.46	6.59**	1.53
Earliness Variables	**DFF**	8.45	16.40**	5.88
	DFB	7.15	46.99**	10.15
	BP	4.06	20.75	3.32
	EI	134.72	757.79**	79.90
Yield Variables	**NB/P**	60.93	184.80**	40.61
	BW	0.98	5.91**	0.53
	L%	37.76	71.85*	28.55
	SI	7.52	23.51**	4.88
	SCY	1206.04	4649.13**	746.8
	LCY	527.39	404.72**	155.8

☻ Plant height (PH cm), Number of fruiting branches (NFB), the node number of first fruiting Branch (NFFB),Date of first flower (DFF day), Date of first open boll (DFB day), boll period (BP day), earliness index (EI), number of harvested bolls per plant (NB/p), seed cotton yield per plant (SCY/p) and lint cotton yield per plant (LCY/p). ☺degrees of freedom (df). *, ** **Significant at 0.05 and 0.01 levels of probability, respectively**

I-Meam performance and heterosis index:

1-Growth and earliness variables:

Mean performance for growth variables presented in Table (2) revealed a broad range among entries. The Egyptian genotypes G89 (104.70 cm) and P6 X G85 (106.12) were the tallest parent and cross, respectively. While the wild *hirsutum* (69.46 cm) and the cross P6Xtamcot (74.16cm) were the shortest parent and cross, respectively. Parents of *barbadense* showed superiority with NFB, the genotype G89 surpassed all parents and the cross G89 X P6 recorded the greatest number (15.77 branches). Parental differences in the node of first fruiting branch NFFB were clearly evident. Regarding NFFB, data presented in Table (2) showed that the genotypes that had been adopted primarily in the study for short season (American aspect) and adaptation to machine, stripper, harvest (Tamcot) had the lowest NFFB (3.70, wild and 4.05, Tamcot), while the full season genotype (PS6) that had been developed for mechanical picking was relatively higher (4.57 nodes). Plant height heterosis given in Table (2) showed positive and significant heterosis associated with the cross WildXTamcot compared with either midparent or high parent values. The number of sympodial branches (NFB) showed positive highly significant heterosis index with seven crosses over mid parents and five crosses over higher parent. The node of first fruiting branch (NFFB) showed three positive significant midparent heterosis indexes compared with only one (G85Xtamcot) with high-parent heterosis (Table2).

Table (2): Mean performance (M) and percentage of heterotic effects relative to mid (MP) and best (BP) parent for growth variables of F_1 crosses based on diallel mating design

Genotype	PH			NFB			NFFB		
	M	MP	BP	M	MP	BP	M	MP	BP
G89	104.7			12.64			5.94		
P6	93.50			12.31			4.57		
G85	95.30			14.00			4.46		
Wild	69.46			8.80			3.70		
Tam	78.61			9.81			4.05		
G89XP6	102.32	3.25	-2.27	15.77	26.41**	24.76**	5.50	4.66**	-7.41**
G89XG85	105.21	5.21	0.49	14.25	6.98*	12.74**	4.44	-14.62**	-25.25**
G89Xwild	88.24	1.33	-15.72	13.14	22.57**	3.96	4.75	-1.45	-20.03**
G89Xtam	90.75	-0.99	-13.32	14.77	31.58**	16.85**	4.09	-18.12**	-31.14**
P6XG85	106.12	12.42	13.50	11.42	-13.19**	-18.43**	4.00	-11.41**	-12.47**
P6Xwild	84.70	3.95	-9.41	12.85	21.74**	4.39*	4.16	0.60	-8.97**
P6Xtam	74.16	-13.82	-20.68*	14.88	34.54**	20.88**	4.54	5.34**	-0.66
G85Xwild	90.56	9.93	-4.97	12.87	12.89**	-8.07**	3.76	-7.84**	-15.70**
G85Xtam	88.89	2.23	-6.73	10.86	-8.78**	-22.43**	4.77	12.10**	6.95**
WildXTam	93.32	26.05**	18.71*	11.65	25.20**	17.44**	3.60	-7.10**	-11.11**
LSD	17.87			4.19			1.47		

☻ Plant height (PH cm), Number of fruiting branches (NFB), the node number of first fruiting Branch (NFFB).
***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

The lack of heterosis associated with plant height looks to be a positive phenomenon, since one of our breeding objective was to establish a cotton plant genotype little smaller than the currently adopted genotypes, *i.e.* compacted with flowering zone to be fitted to machine harvest. Moreover, the (NFFB) showed negative and highly significant heterosis with both heterotic levels in most crosses. This may indicate that the lower fruiting node was inherited as a dominant character and should take into consideration when breeding for machine harvested genotype.

The earliness variables presented in Table (3) revealed that the genotype wild *hirsutum* showed the lowest DFF, (55.33 days) and the lowest DFB (101.25days) while the lines of barbadense cultivar G89 showed the longest period from planting to first flower and boll at the two populations. The crosses mean performance indicated that the hybrids G89XG85, G89XG85, G89XP6, and G58Xwild were the top significantly over other hybrids regarding DFF, DFB, BP, and EI earliness characters. Heterotic effects associated with earliness variables were presented in Table (3).

Table (3): Mean performance (M) and percentage of heterotic effects relative to mid (MP) and best (BP) parent for Earliness variables of F_1 cotton crosses based on diallel mating design

Genotype	DFF			DFB		
	M	MP	BP	M	MP	BP
G89	80.65			129.46		
P6	73.87			122.36		
G85	75.63			124.48		
Wild	55.33			101.25		
Tam	61.48			105.85		
G89XP6	71.42	-7.56**	-3.32*	122.26	-2.90	-0.08
G89XG85	78.23	0.12	3.44*	128.61	1.29	3.31
G89Xwild	67.90	-0.12	22.73**	117.13	1.54	15.69**
G89Xtam	66.01	-7.11**	7.37**	114.76	-2.46	8.42**
P6XG85	73.25	-2.00	-0.83	121.31	-1.71	-0.86
P6Xwild	63.02	-2.44	13.90**	112.61	0.72	11.22**
P6Xtam	67.42	-0.37	9.67**	114.49	0.33	8.16**
G85Xwild	61.90	-5.46**	11.88**	112.43	-0.38	11.05**
G85Xtam	65.84	-3.95*	7.10**	116.02	0.74	9.61**
WildXTam	62.32	6.71**	12.64**	110.85	7.05**	9.48**
LSD	2.89			3.79		
Genotype	BP			EI		
	M	MP	BP	M	MP	BP
G89	48.81			37.94		
P6	48.49			56.15		
G85	48.86			52.25		
Wild	45.92			75.17		
Tam	44.37			72.35		
G89XP6	50.84	4.50**	4.84**	63.09	34.11**	12.36*
G89XG85	50.38	3.17*	3.22*	55.60	23.30**	6.41
G89Xwild	49.23	3.94*	7.21**	62.90	11.22*	-16.32*
G89Xtam	48.75	4.64**	9.88**	72.14	30.82**	-0.29
P6XG85	48.06	-1.27	-0.90	61.77	13.97**	18.22*
P6Xwild	49.59	5.05**	7.99**	65.08	-0.88	-13.42*
P6Xtam	47.06	1.36	6.07**	64.79	0.84	-10.45
G85Xwild	50.53	6.64**	10.05**	77.39	21.47**	2.95
G85Xtam	50.17	7.64**	13.09**	72.88	16.98**	-3.69
WildXTam	48.52	7.49**	9.36**	77.38	4.91	6.95
LSD	2.17			10.64		

☻ **Date of first flower (DFF day), Date of first open boll (DFB day), boll period (BP day), earliness index (EI). *, ** Significant at 0.05 and 0.01 levels of probability, respectively**

The results of DFF indicated that the heterosis magnitude over mid parent was significantly negative in five out of the ten studied crosses; the significance had a sizeable tendency towards earliness. It was negative in two cases, however, when compared with earlier parent. DFB results presented in Table (3) showed that the number of significantly negative heterosis index over mid-parent revealed in 4 cases, none of reached the 5% level of significance. The slight reduction in the heterotic effects with days to open boll than first flower and the increase in heterotic effects with boll period may be back to the vigorous shape of hybrid plants than their relevant parents that in turn delay boll maturation period. Heterosis over mid and better parents with EI showed significance over midparents in six cases out of ten crosses.

The best heterotic crosses were associated with crosses G89XPS6, G89XG85 and G89Xtamcot. The cross P6XG85, however were the best high-parents heterosis. It is worth to mention that in the beginning of breeding program, it may be helpful to evaluate earliness based on the morphological and honological growth characters like first flower, first boll and first sympodial node. In the advanced generation, however, it is better to use the yield dependent-earliness estimators like EI, MMD and PRI. From the growth and earliness performance results presented in Tables (2 and 3), it is evident that the *barbadense* parents influenced hybrid plant stature by producing the tallest hybrid and the late maturing parent G89 produced later-maturing hybrids while the early-maturing Wild *hirsutum* and Tamcot produced earlier-maturing hybrids. The mean performance in most cases regarding earliness and growth were intermediate between their respective parents and tended towards either (earlier) higher or lower (late) parent, indicating that the studied characters in these crosses inherited as partial dominant traits. Meanwhile, the performance of some of the other F_1 hybrids were more than the higher (earlier) or less than the lower parent (late) such as P6Xtamcot, P6XG85 with PH and NFFB respectively, showing over dominance inheritance for the studied characters. Such awareness for these traits inheritance would consider when breeding for mechanically harvested cotton genotype. Similar findings achieved by variable values of mean performance and heterosis had recorded for earliness and growth character in cotton by may researchers White and Kohel (1964), White (1966), Marani (1868b), Bhatt and Rao (1981), Bhardwaj and Weaver (1984) and Wells and Meredith (1986).

2-Yield and its major components:

Table (4) showed the mean performance of yield and its major components in inter and intraspecific cotton crosses. The crosses G89XP6 (24.14 bolls), WildXTamcot (4.79gm), P6XG85 (40.15%), G85Xtamcot (12.89gm), G85Xtamcot (83.46gm) and P6X Tamcot (31.58gm) were the best in respect to NB/p, BW/gm, L%, SI/gm and SCY/p (gm) and LCY/p (gm), respectively. It is obvious that the parental genotype from *hirsutum* taxon placed its genetic print in the cotton yield and components; there were common *hirsutum* parents in each distinct cross for the majority of the traits studied. Second, the significance of *hirsutum* taxa germplasm regarding seed cotton yield was due to the superiority in boll weight and seed index. The seed cotton yield of *barbadense* germplasm taxa, however, mainly was due to the significance of number of harvested bolls/plant and lint percentage. The mid-parent and high-parent heterosis percentages for cotton yield and its major components are presented in Table (4).

Table (4): The mean performance (M) and percentage of heterotic effects relative to mid (MP) and best parent (BP) for yield and Major components of F_1 cotton crosses.

	NB/P			BW/g			L%		
Genotype	M	HP	BP	M	MP	BP	M	MP	BP
G89	19.32			2.51			39.57		
P6	21.22			2.40			38.72		
G85	23.15			3.29			38.06		
Wild	16.20			4.36			34.96		
Tam	13.15			4.80			36.16		
G89XP6	24.14	19.09**	13.76**	2.88	17.31**	14.74	41.04	4.84	3.71
G89XG85	22.19	4.50	-4.15	3.53	21.72**	7.29	40.12	3.36	1.39
G89Xwild	24.35	37.11**	26.04**	3.86	12.37**	-11.47	39.32	5.51	-0.63
G89Xtam	19.60	20.73**	1.45	4.06	11.08**	-15.42	39.11	3.29	-1.16
P6XG85	23.57	6.24	1.81	2.87	0.88*	-12.77	40.15	4.58	3.69
P6Xwild	17.55	-6.20	-17.30**	4.03	19.23**	-7.57	36.12	-1.95	-6.71*
P6Xtam	22.10	28.60**	4.15	4.55	26.39**	-5.21	37.94	1.34	-2.01
G85Xwild	22.59	14.82**	-2.42	4.24	10.85**	-2.75	38.11	4.38	0.13
G85Xtam	23.02	26.83**	-0.56	3.68	-9.02**	4.38	35.14	-5.31	-7.67*
WildXTam	18.88	28.65**	16.54**	4.79	4.59**	-0.21	36.77	3.40	1.69
LSD	7.59			0.87			6.36		
	SI				SCY/p		LCY/p		
	M	HP	BP	M	MP	BP	M	MP	BP
G89	9.92			44.20			17.49		
P6	10.25			45.23			17.51		
G85	10.02			51.03			19.42		
Wild	12.92			65.87			23.03		
Tam	11.56			69.55			25.15		
G89XP6	10.51	4.21*	2.54	47.43	6.07	4.86	19.47	11.22	11.15
G89XG85	11.63	16.65**	16.07**	62.32	30.88	22.12	25.00	35.47**	28.73**
G89Xwild	12.23	7.09**	-5.34*	69.16	25.67	5.00	27.19	34.23**	18.09*
G89Xtam	11.98	11.55**	3.63	60.74	6.80	-3.63	23.76	11.43**	-5.54
P6XG85	10.91	7.65**	6.44**	60.59	25.89	18.73	24.33	31.73**	25.25**
P6Xwild	12.52	8.07**	-3.10*	64.07	15.34	-2.73	23.14	14.17	0.50
P6Xtam	11.45	5.00*	-0.95	83.24	45.05*	32.08	31.58	48.06**	25.59**
G85Xwild	12.14	5.84*	-6.04**	65.53	12.12	-0.51	24.97	17.66*	8.45
G85Xtam	12.89	19.46**	11.51**	83.47	38.44*	32.43	29.33	31.61**	16.63**
WildXTam	12.55	2.53	-2.86*	70.91	4.74	7.66	26.08	8.25	3.69
LSD	2.63			32.54			14.86		

☻ **Number of harvested bolls per plant (NB/p), boll weight (gm/boll), lint percentage (L %), seed index (SI), seed cotton yield per plant (SCY/p) and lint cotton yield per plant (LCY/p). *, ** Significant at 0.05 and 0.01 levels of probability, respectively.**

As the magnitude of heterosis index for number of harvested bolls/plant over Mid-parent heterosis ranged significantly from 37.11% (G89Xwild) to –6.20 (PS6Xwild), it ranged from 26.04% to –17.30 with the same genotypes when compared with the higher parent. Regarding boll weight, results showed positive significant midparent heterosis in 7 cases while the significant positive heterosis over better parent associated with only 3 cases. Results of lint percentage showed that none of the crosses reached the positive threshold of 5% level of significant at the two heterosis levels. With respect to seed cotton yield SCY/p, the crosses P6Xtamcot and G85Xtamcot exhibited the highest positive significant heterotic effects over the midparents and better parent heterosis. The lack of heterosis associated with SCY may due to the lack of significant heterosis associated with L% and highly significant heterosis with the SI. This is because LCY (the lint after excluding the seed) was significant and highly significant in most cases at the two levels of heterosis.

Moreover, to relate the positive heterosis obtained for yield on one hand and its major contributing attributes (number of harvested bolls, seed index, boll weight and lint percentage) on the other hand, the following observations are gained. The outcomes at the level of midparent heterosis revealed that out of the ten studied crosses, 10 cases of positive heterosis for seed cotton yield (two significant), 9 for

Number of harvested bolls (7 significant), 9 for boll weight (8 significant), 7 for lint percentage (no significance). These results certainly indicated that the number of harvested bolls and boll weight reflected more effect on yield more than the other components of yield and can be adopted as selection criteria for yield improvement. Similar conclusions had reached by other researchers (Turner 1953, Davis and Palomo 1980, Stella and Demetrious 1999). In the over all basis the study likely to recommend crosses G89Xwild, P6XG85, P6Xtamcot and G85 X Tamcot for further breeding programmes aimed at the improvement of Egyptian cotton.

II-Anatomical investigation:

The study objectives extended to investigate the differences in the internal structure of the main stem and the leaves of the used five parents and some of their F_1 crosses. These crosses had selected based on their growth and yield performance. Microscopical counts and measurements of certain histological characters in transverse sections through the eleventh internode on the main stem and its corresponding leaf at flowering stage, almost 80 days old, are given in Table (5). Likewise, microphotographs illustrating these selected crosses as well as their parents are shown in Figures (1 and 2).

1-Stem anatomy:

The transverse sections of the parental genotypes and their crosses main stem revealed that the latter had some differences in the internal structure of the main stem (Table 5 and Figure1). The main stem whole diameter was increased by 20.11 and 45.51% for the cross (G89 X P6) compared to the prenatal lines G89 and P6; respectively. The main stem diameter was larger in the hybrid (P6 X G85) by 62.21 and 52.22% over the parents P6 and G85; respectively. The hybrid (G89 X Wild) showed an increase in stem diameter being 9.84 and 81.32% relative to the original cultivars G89 and Wild; respectively. The main stem diameter for the cross (G85 X Tamcot) was increased by 29.51 and 39.46% over its parents G85 and Tamcot; respectively. However, the increase in stem diameter was accomplished by all tissues shared in the stem internal structure. Data revealed that the thickness of the epidermis was increased by 25.19 and 40.74% for cross (P6 X G85) and by 17.44 and 19.51% for cross (G85 X Tamcot) compared with the parents P6, G85 and G 85, Tamcot; respectively. The epidermis thickness was increased in the F_1 hybrid (G89 X P6) by

13.05% more than the parent G89 and was nearly similar to that of the parent P6. At the same time, the thickness of the epidermis of the cross (G89 X Wild) was nearly similar to that of the original cultivars strains G89 and Wild. The cortex was wider by 18.02 and 47.99% for cross (G89 X P6) and by 47.16 and 17.98 % for cross (P6 X G85) over their parents G89, P6 and G85; respectively. However, the thickness of the cortex for cross (G89 X Wild) was increased by 30.97% over the parental line Wild and decreased by 18.74 % below the parental line G89. Also, the thickness of the cortex for cross (G85 X Tamcot) was decreased by 6.22% below the parent G85 and was similar to that of the parent Tamcot. Willingly, the number of cortical layers was increased by (17.65 and 81.82%) for hybrid (G89 X P6) and by (68.18 and 20.92%) for cross (P6 X G85) over their parental lines G89, P6 and G85; respectively. The number of cortical layers showed an increase being 41.05% more than the parent Wild and was decreased by 21.18% below the parent G89. Also, the number of cortical layer for hybrid (G85 X Tamcot) was increased by 14.07% and was nearly similar to that of the parent Tamcot. The vascular cylinder thickness in the studied F_1 cotton plants increased by 111.43 and 128.26% for cross (G89 X P6), 151.19 and 119.34% for cross (P6 X G85), 121.29 and 89.69% for cross (G89 X Wild) and by 70.90 and 79.75% for cross (G85 X Tamcot) over their parents G89, P6, G85, G89, Wild, and Tamcot; respectively. Percentage of increase of phloem tissue was 97.92 and 168.51% for cross (G89 X P6), 93.56 and 21.00% for cross (P6 X G85), 40.59 and 29.11% for (G89 X Wild) and 44.24 and 68.83% for (G85 X Tamcot) more than that of their prenatal lines (G89 and P6), (P6 and G85), (G89 and Wild) and (G85 and Tamcot); respectively. The increase in xylem tissue amounted to 122.97 and 126.31% for F_1 hybrid (G89 X P6), 175.34 and 164.75% for (P6 X G85), 156.08 and 112.83% for (G89 X Wild) and 88.39 and 90.16% for (G85 X Tamcot) over their original lines (G 89 and P6), (P6 and G85), (G89 and Wild) and (G85 and Tamcot); respectively. Likewise, average vessel diameter increased by 44.10 and 40.81% for F_1 cross (G89 X P6), 73.66 and 98.41% for (P6 X G85), 45.25 and 52.93% for F_1 hybrid (G89 X Wild) and by 78.54 and 69.00% for (G85 X Tamcot) more than that of their parents (G89 and P6), (P6 and G85), (G89 and Wild) and (G85 and Tamcot); respectively. The results showed that the diameter of pith was increased by 71.64 and 65.61% for F_1 cross (P6 X G85) and by 31.52 and 38.83% for F_1 hybrid (G85 X Tamcot) compared to the parents (P6 and G85) and (G85 and Tamcot); respectively. However, the diameter of pith was increased by 30.45% for F_1 hybrid (G89 X P6) more than the original genotype P6 and slightly decreased by 4.33% below the other parent G89. Similarly, the cross (G89 X Wild) showed an increase of the diameter of pith by 89.03% more than of the parent Wild and reduced by 14.93% less than of the original parent G89. Whereas, the F1 hybrid plants (G85 X Tamcot) showed an enlarged pith diameter by 31.52 and 38.83% as compared with the parents G85 and Tamcot; respectively. The reported results are in harmony with those produced by Atef (1989) in flax, El-Kobisy (1996) in tomato as well as Emad El-Din (2004) in cotton plant.

Table (5): Average of certain anatomical counts and measurements in micron (µ) of transverse sections in the eleventh internode of the main stem and its corresponding leaf at the age of 80 days old for F_1 cotton crosses and their parents (Means of three sections from three specimens).

Characters	Parents					F1 – selected hybrids			
	Giza 89	Pima 6	Giza85	Wild	Tamcot	Giza 89 X Pima	Pima X Giza 85	Giza 89 X Wild	Giza 85 X Tamcot
	Stem anatomy								
Stem diameter	7886.25	6510.00	6937.50	4777.50	6442.50	9472.50	10560.00	8662.50	8985.00
Epidermis thickness	19.93	22.63	20.13	19.79	19.78	22.53	28.33	19.26	23.64
Cortex thickness	526.67	420.00	523.89	326.75	492.14	621.56	618.06	427.95	491.28
Number of cortical layer	17.00	11.00	15.30	9.50	13.50	20.00	18.5	13.4	15.4
Vascular cylinder thickness	668.10	618.82	708.69	779.41	673.78	1412.54	1554.39	1478.45	1211.13
Phloem tissue thickness	160.71	118.64	189.50	175.00	161.90	318.08	229.29	225.95	273.33
Xylem tissue thickness	477.39	470.36	489.17	574.41	481.88	1064.46	1295.10	1222.50	907.80
Vessel diameter	59.14	60.52	52.97	56.17	55.96	85.22	105.10	85.90	94.57
Pith diameter	5625.00	4125.00	4275.00	2531.25	4050.00	5381.25	7080.00	4785.00	5622.50
	Leaf anatomy								
Leaf lamina thickness	289.97	234.61	232.18	296.10	209.22	303.26	325.64	334.14	315.97
Palisade thickness	112.27	91.54	94.55	114.52	77.78	129.17	120.19	135.44	123.21
Spongy tissue thickness	121.25	95.77	92.73	122.58	85.56	134.09	129.55	141.11	131.84
Midvein thickness	1440.00	1425.00	1515.00	1350.00	1380.00	1830.00	1762.50	1680.00	1890.00
Vessel diameter	27.02	23.02	23.84	23.63	22.50	42.80	42.39	29.05	34.70
Dimension of midvein vascular bundle:									
Length	365.72	382.21	395.25	372.91	355.55	501.67	507.50	475.00	505.00
Width	955.00	1125.00	1050.00	885.00	1037.50	1806.25	1687.50	1187.50	1420.00

2- Leaf anatomy

The blades anatomy of the hybrid plants exhibited several differences in their internal structure as compared with their parents. The differences in histological structure of different F_1 cotton hybrids are given in Table (5) and Figure (2). The leaf lamina was thicker by 4.58, 29.26% for the cross (G89 X P6), 38.80, 40.25% for the cross (P6 X G85), 15.23, 12.85% for the cross (G89 X Wild) and by 36.09, 51.02% for the cross (G85 X Tamcot) more than the original parental lines (G89 and P6), (P6 and G85), (G89 and Wild) and (G85, Tamcot); respectively. The results indicated that the palisade tissue increased by 15.05 and 41.11% for cross (P6 X G89), 31.30 and 27.12% for the cross (P6 X G85), 20.64 and 18.27% for cross (G89 X Wild) and by 30.31 and 58.41% for the hybrid (G85 X Tamcot) over their respected parents (P6 and G89), (P6 and G85), (G89 and Wild) and (G85 and Tamcot); respectively. Furthermore, the spongy tissue thickness showed an increase by 10.59 and 40.01% for cross (G89 X P6), 35.27 and 39.71% for the hybrid plants (P6 X G85), 16.38 and 15.12% for (G89 X Wild), and by 42.18 and 54.09% for F1 cross plants (G85 X Tamcot) more than the original lines (G89 and P6), (P6 and G85), (G89 and Wild cotton) and (G85 and Tamcot); respectively. The leaf midvein was increased in thickness by 27.08 and 28.42% for F1 cross (G89 X P6), 23.68 and 16.34% for F1 hybrid (P6 X G85), 16.67 and 24.44% for F1 cross plants (G89 X Wild) and by 24.75 and 36.96% for F1 hybrid (G85 X Tamcot) more than the parental lines (G89 and P6), (P6 and G85), (G89 and Wild) and (G85 and Tamcot); respectively. The midvein bundle was greatly enhanced in all F1 hybrid plants. Dimensions of the midvein bundle of F1 cross (G89 X P6) increased by 37.17 and 31.26% in length and by 89.14 and 60.56% in width more than the original lines, G89 and P6; respectively. Similarly, F1 hybrid cotton plants (P6 X G85) showed an increase in the dimensions of the midvein bundle by 32.78 and 28.40% in length and by 50.00 and 60.71% in width over the original parental lines, P6 and G85; respectively. Also, the dimensions of the midvein bundle of (G89 X Wild) were increased by 29.88 and 27.38% in length and by 24.35 and 34.18% in width more than those of the respected parents, G89 and Wild; respectively. In the same trend, the F_1 cross (G85 X Tamcot) exhibited an increase in the dimensions of the midvein bundle by 27.77 and 42.03% in length and by 35.24 and 36.87% in width over the original parents G85 and Tamcot; respectively. Likewise, average vessel diameter increased by 58.40 and 85.93% for F_1 hybrid (G89 X P6), 84.14 and 77.81% for cross plants (P6 X G85), 7.51 and 22.94% for F_1 cross (G89 X Wild) and by 45.55 and 54.22% for F1 hybrid (G85 X Tamcot) more than the respected parents (G89 and P6), (P6 and G85), (G89 and Wild cotton) and (G85 and Tamcot); respectively. Similar patterns of F_1 cotton crosses plants were reported earlier by Emad El-Din (2004).

DISCUSSION

Continuous improvement of Egyptian cotton (which has been a source for high fiber quality) is, for yield and other breeding goals, depending mainly upon the presence of genetic variation in the local germplasm or, if necessary, the introduction of new sources of genetic variability from the closer taxa. As a staring point, the study evaluated the first generation heterotic performance and related such vigorness to plant internal structure. The stem botanical analysis revealed that the increment in the thickness of vascular cylinder in F_1 cotton crosses plants G89 X P6, PS6 X G85, G85Xtamcot, G89 X wild was attributed mainly to the increase in amount of conducting elements; phloem and xylem tissues. The cambial activity was obviously stimulated since wider phloem and xylem tissues were produced. Moreover, xylem vessels had wider cavities which amounted to more total active conducting area to cope with vigorous growth produced by such types of F_1 cotton crosses plants. It was clear from leaf botanical analysis that the thicker lamina produced by F_1 crosses plants was mainly due to increase in thickness of both the palisade and the spongy tissues over their original parents.

The study also showed that the heterotic effects in many traits did not reflect the parental divergence (G89 X G85 or G85 X PS6). Thus, the study concluded that the genetic diversity of the studied population was related to heterosis, but lack of heterosis magnitude registered herein cannot be used to infer a lack of genetic divergence, same conclusion had reached by Perez et al. 1995. In this connection, a high level of similarity (Abdalla et al 2001) and low genetic distance (GD) (Gutierrez et al 2002) were confirmed among and between the tetraploid cotton taxa. Gutierrez et al (2002) studied the effect of GD on the hybrid cotton with some American, Australian, and wild cotton strains, they showed that these cultivars had a low GD and suggested that genetic distance based upon his set of molecular markers was not a good indicator of what to expect from crosses heterosis. The current study declared, however, considerable variation in heterotic effects among the used genotypes even if they are closer like G89 and G85 or Pima and also between the other two *hirsutum* strains. Thus, in spite of the relatively small population used herein there was value added information gained from making the crosses and predicting heterosis that added important information to those gained from the parental mean performance alone.

The study comprehensively showed that the mean performance of G89-based crosses array appeared to progress satisfactorily among all hybrids arrays for the most traits. This result is important too, since the majority of the genetic constitution of the hybrids of these crosses can be revealed belonging to barbadense group. This may accelerates the attainment of the breeding objectives through reducing the required trait fixation steps in the breeding programmes, meanwhile reduce the expected backwardness and lint deterioration that might be happened thru exploiting some *hirsutum* germplasm. Further advanced selection practices towards a machine harvested genotype in the next segregating generations (F_3 and higher) with that array and improved crosses like P6XG85, P6Xtamcot and G85Xtamcot should take into account the plant branching types and flowering periods too.

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استطلاع حجم الكفاءة الوراثية وقوة الهجين والفروق التشريحية لهجن الأقطان المصرية مع الأقطان المستوردة

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أجريت الدراسة بمزرعة كلية الزراعة - جامعة القاهرة في صيف ٢٠٠٤- ٢٠٠٥ كخطوة أولي تهدف إلي توسيع القاعدة الوراثية للقطن المصري وتكوين أساس وراثي عملي لتحسين بعض صفات الأقطان مثل الموائمة للجني الآلي. بحثت الدراسة تباين المتوسطات وتأثيرات قوة الهجين لصفات النمو والتبكير والمحصول ومكوناته في هجن الجيل الأول الصنفية والنوعية الناتجة من تهجين الداي أليل المستقيم لمجموعة من خمسة سلالات قطنية نقية. إستهدفت الدراسة أيضا التركيب التشريحي للسلامية الحادية عشر للساق الرئيسية والورقة المقابلة لها في الخمسة سلالات الأبوية وهي Giza 89، Pima 6، Giza 85، Wild *hirsutum* SP و Tamcot وكذلك بعض هجن الجيل الأول والتي تميزت بتحسينها ووجود الأب المصري في تركيبتها الوراثية وهي Giza 89 X Pima 6 ، Giza 89 X Wild ، Pima6 X Giza85 و Giza 85 X Tamcot وذلك في عمر التزهير.

وقد أوضحت القياسات التشريحية زيادة قطر الساق الرئيسية في الهجن المختارة مقارنة بآبائها. وقد ساهمت جميع الأنسجة المشتركة (البشرة- القشرة- الأسطوانة الوعائية- النخاع البارنشيمي) بدرجات مختلفة في زيادة قطر الساق في هذه الهجن. وتعزي الزيادة في سمك القشرة إلي زيادة في حجم وعدد صفوف الخلايا. بينما تعزي زيادة سمك الأسطوانة الوعائية إلي زيادة العناصر الوعائية(نسيجي الخشب واللحاء). النشاط الكامبيومى الواضح أدي إلي زيادة منطقة اللحاء والخشب واتساع أوعية الخشب وزيادة المساحة الناقلة للتمشي مع نمو قوي لنباتات هذه الهجن. كما أوضحت الدراسة التشريحية أن هناك زيادة في سمك نصل الورقة للهجن مقارنة بالآباء وان الزيادة في سمك النصل ترجع إلي الزيادة الحادثة في سمك كل من النسيج العمادي والإسفنجي هذا بالإضافة إلي زيادة في سمك العرق الوسطي وزيادة في حجم الحزم الوعائية.

أشارت دراسة قوة الهجين والكفاءة الوراثية للصفات المدروسة إلي حدوث تحسين في صفات النمو والتبكير والمحصول حيث وجدت الدراسة تأثيرات معنوية لتفوق الهجين منسوبا إلي متوسط الأبوين وكذلك منسوبا للأب الأعلى في معظم الصفات وان كان حجم هذا التفوق ليس كبير نسبيا. وبالإضافة إلي تحسين الهجن P6XG85 ، P6XTamcot و G85XTamcot لخدمة أغراض الدراسة فقد وجدت الدراسة أن كفاءة هجن متجه الصنف G89 كان أفضل المتجهات لأغلب الصفات. وهذه النتيجة في حد ذاتها هامة جدا حيث سيكون أغلب دم الهجن المتكونة من الباربادينس. وهذا بدوره يقلل عدد خطوات التربية اللازمة لبلوغ الصنف المرغوب كما يقلل من احتمالات الارتداد وتدهور صفات التيلة عن دخول دم الهيرسوتم للهجن المتكونة. وبالتالي تميل الدراسة إلي اقتراح التوصية بهذه الهجن للدراسات الموسعة التالية التي تهدف لتحسين صفات نمو ومحصول طرز القطن المصرية والأنتخاب في الأجيال الانعزالية التالية نحو طرز قطنية ملائمة للجني الميكانيكي.