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# INTER AND INTRASPECIFIC COTTON CROSSES 1-HETEROSIS PERFORMANCE AND GENERATIONS CORRELATION TARGETED GROWTH, EARLINESS AND YIELD VARIABLES OF $F_1$ AND $F_2$

**A. M. A. Abdalla**

Cairo University, Faculty of Agriculture, Agronomy Department, Giza, Egypt.

## ABSTRACT

*This study was initiated in 2001-2006 at Cairo University experimental farm to investigate the main performance and heterotic effects for growth, earliness and yield characteristics of inter and intraspecific cotton crosses resulted from 5X5 set of half diallel crossing design. Correlations between individual generation and midparent values as well as between $F_1$ and $F_2$ are highlighted too. Significant heterotic effects were found over mid parent and high parent for the majority of studied traits. A trend of improved earliness and yield variables were observed in the inter-intraspecific crosses, some $F_2$ crosses exhibited accumulated additive effects that reflected on the $F_2$ superiority over the best parent and were associated comprehensively with the crosses G89XP6, P6XG85, P6XTamcot and G85XTamcot. Parental average was not indicator of the earliness of $F_2$ hybrids. Significant correlations were found between $F_1$crosses and midparent values for yield variables; number of bolls per plant (0.59), Boll weight (0.66), Lint percentage (0.74), Seed cotton yield (0.47) and Lint cotton yield (0.49), and between $F_2$ crosses and mid-parent value for Boll weight (0.90), Lint percentage (0.77), Seed cotton yield (0.59) and Lint cotton yield (0.49). Significant correlation coefficients, 0.77 for Boll weight, 0.76 for Lint percentage and 0.68 for Seed cotton yield between $F_1$ and $F_2$ also existed. The study concluded that the two genotypes P6 and Tamcot can combine with cultivars from Egyptian breeding programs like G85 to provide genes for compacted flowering zone, short stature and suitable height of fruiting branch node to improve Egyptian genotypes and help establishing a practical genetic base for mechanical picking of Egyptian cottons.*

Key words: *Egyptian cottons, Hybrids, Heterosis, Correlation, Machine-harvested cotton*

## INTRODUCTION

In Egypt as well as many other countries, cotton *Gossypium spp.* is one of the most important fiber and oil crops. The recent dramatic changes in the field crops production methods especially with Egyptian cottons (*G. barbadense*) have been influenced the attitude of cotton breeders. These changes that mostly due to altering cropping patterns and high price labor have demanded adapting genotypes suitable for these new situations like tolerant to late planting, revolving technology, and mechanical harvesting. These breeding goals should be concurrent with maintaining the prized quality of Egyptian cottons as much we can, because the cotton production must be profitable for the growers and the fiber must be competitive for spinning purposes. For example, on the topic of cotton machinery level, Abdalla *et al* (2005) pointed out that if we can transfer the cotton harvesting technology and we can train a new generation of cotton farmers to be familiar with the technology, we are still in need to develop methodologies to maintain our cotton grade and quality until the scientific sectors be able to introduce a new generation of varieties fitted to mechanical harvesting. Egyptian cotton cultivars breeding purposes and developing continued to be high quality, productivity and earlier in maturity or tolerant to late planting. Improvements in mechanical management especially with harvesting (picking), however, have not been associated with cultivars developing in breeding programs. The published data under Egyptian conditions regarding machine harvested cottons are very rare. This was mainly back to the accessible cheap labor, awareness about quality decrease and the expected cost of the technology compared to manual Picking. This technology (machine harvested cottons) is brand-new for Egyptian cotton growers and needs a lot of efforts from both cotton breeder and producer to be attained.

On the other hand, implementing heterosis in cotton production, locally as well as globally, has been standing before many breeding and economical restrictions. Hybrid cotton, however, is receiving expanding interests in some countries like India (Roupakias *et al* 1998) and China (Wu *et al* 2005) following the commercial exploitation of transgenic Bt cottons and mechanizing all managemental steps from planting to harvesting. Intra / interspecific heterosis have been reported in cotton by many researchers (Turner 1953, Davis and Palomo 1980, Wells and Meredith 1986, Roupakias *et al* 1998, Stella and Demetrious1999, Wu *et al* 2005). Moreover, some of these works showed deviation of cotton $F_2$ hybrids from the 50% expected reduction of heterosis as proposed by Hayman (1958) in favor of the $F_2$ generation giving a prove for the credibility of $F_2$ for measuring the deviation from high parents heterosis with cotton. The yield performance of $F_2$ cotton hybrids then suggests the existence potential for the successful use of the F2 as commercial hybrids (Meredith 1990, Tang *et al* 1993 and Gutie´rrez *et al* 2002).

To take advantage of breeding by crossing serving in mechanized operation, one needs to control the growth habit of the Egyptian cotton plants. The genotype G85 was recommended throughout cotton mechanical harvesting preliminary experiments carried out by Agriculture engineering research institute (MOA unpublished experiments). The genotype G89 was used by Abdalla *et al* (2005) to evaluate mechanical harvesting process. Therefore, the chosen Egyptian parents (G89 and G85) for the present investigation are exploited to represent the standard Egyptian genotypes and possessed the upper-end potential and stability among locally adapted cultivars under Egyptian conditions (Abdalla 2005). The *G. hirsutum* parental strains used herein were chosen as a source for extracting useful genes for early maturity (short season), low fruiting node, heavier boll weight and small plant size, stripper harvesting (Percy and Turcotte 1988) plus boll weevil tolerance (wild *hirsutum* accession). Being short statured, high micronaire, long season, higher fruiting node, and fitted to mechanical picking, Pima S6 parent from *barbadense* taxa is also adopted. Pima S6 proved to be yield competitor (Feaster and Turcotte 1984) and early mature under Egyptian conditions (Abdalla *et al* 1999). The present study was, therefore, carried out to investigate the performance and heterotic effects of $F_1$ and $F_2$ populations resulted from a half diallel with the aim of developing a practical base to start selection program for cotton mechanical harvesting.

## MATERIAL AND METHODS

### Breeding scheme, crop monitoring and traits studied

In the summer of 2001 several cotton collections belonging to different cultigens taxa *viz.*, tetraploid of Egyptian *barbadense*, Pima *barbadense*, other *barbadense* from Caribbean islands, upland *hirsutum*, diploids from *G arboreum* and *herbaceum*, some wild types and Egyptian x Pima crosses were growing in the green house at Cairo University Agriculture Experiment Station. In the same year, seeds of a plant belonging to wild (WH) and Tamcot (Tam) of *hirsutum*, Egyptian cottons (G85 and G89), and Pima (S6) had selected and selfed breed. Seeds of these plants had yearly selfed breed for the next tow years. Concurrently, In the years of 2003-2004 an experiment conducted at Gemmiza Agric. Res. Station using cotton varieties Giza 85 and G89 to shed light on basic requirements for machine-harvested cotton under Egyptian conditions and its effect on the lint yield, quality and test the additional machinery levels necessary for serving the cotton production under these stressed conditions, Abdalla, *et al*, 2005. In the summer of 2004 three *G. barbadense* genotype viz. G89, G85, Pima S6 and two *G. hirsutum* genotypes *viz.* Tamcot SP and wild *hirsutum* were taken from a three years-selfed breed and crossed in a diallel mating design set of 5X5 (without reciprocal ) to develop ten $F_1$ crosses and subsequent ten $F_2$ generation. The genotypes were symbolized G for Giza, P6 for Pima S6, Tamcot and Wild. The experiments were conducted at Cairo University Agriculture Experiment Station. The pointed out set of genotypes was crossed using hand emasculation and pollination techniques. In 2005 season, parents were recrossed from the same seed stock to obtain more hybrid seeds and artificial selfing for $F_1$ hybrid plants made to obtain $F_2$ selfed seed. On March 29, 2006 selfed seed of parents and their filial generations were planted in RCBD with four replications. The lay out included two adjoin trials; first one contained parents and $F_1$ and the second contained parents and $F_2$. The ridges were 5m long and 0.60m apart. Sowing was done in hills spaced 0.25m apart. Soon after complete emergence, seedlings were thinned to one plant per hill. Plants of each parent and hybrid were grown in one ridge. With the exception of using recommended growth regulators for enhancing yield and uniform growing as normally done with machine-harvested cottons, standard crop management practices were followed as recommended for cotton culture including pest control. Five representative plants were tagged from each plot 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 three frequent intervals until all bolls had been harvested. Their mean values were used for statistical analysis for the following characters: 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.

## Statistical Analysis

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. Thus, Analysis of variation for growth, earliness and yield variables was done using the separate two trails populations. Analysis of variance for heterosis followed the methodology described by AL-Rawi and Kohel, 1969. The data mean were used for calculating heterosis over mid and better parent for each trail individually 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 were tested using the Fisher's least significant difference. Correlation coefficient and it relevant t-test were calculated as proposed by Steel and Torrie 1980.

## RESULTS AND DISCUSSION

### Significance of breeding materials

Analysis of variance presented in Table 1 revealed the existence of significant differences among genotypes at the two generations indicating a large amount of variation in the adopted breeding materials. Analysis of variance for individual generation showed significant difference for all

Table1. Analysis of variance (*mean squares*) of $F_1$ and $F_2$ inter/intraspecific cotton crosses in respect to growth, earliness and yield variables in cotton

| | $F_1$ experiment | | | | |
|---|---|---|---|---|---|
| *Variable*† | *Source* | Blocks | Genotypes | Heterotic variance | Error |
| | *df*‡ | 3 | 14 | 1 | 42 |
| Growth Variables | PH | 288.56 | 1281.19** | 50.06** | 133.48 |
| | NFB | 59.11 | 35.01* | 5.20** | 13.87 |
| | NFFB | 3.84 | 5.275* | 0.78 | 2.09 |
| Earliness Variables | DFF | 12.531 | 11.99* | 1.87* | 4.99 |
| | DFB | 7.917 | 35.76** | 3.165** | 8.44 |
| | BP | 3.92 | 25.21** | 2.49* | 6.66 |
| | EI | 210 | 655.55** | 38.25** | 102.02 |
| Yield Variables | NB/P | 67.54 | 154.25** | 11.52** | 30.72 |
| | BW | 0.82 | 4.06* | 0.33* | 0.88 |
| | L% | 27.94 | 54.97** | 7.72** | 20.6 |
| | SI | 5.41 | 22.13* | 2.22* | 5.92 |
| | SCY | 1754.8 | 4000.70** | 261.18** | 696.48 |
| | LCY | 412.11 | 299.87** | 53.45** | 142.52 |
| | $F_2$ experiment | | | | |
| *Variable* | *Source* | Blocks | Genotypes | Heterotic variance | Error |
| | *DF* | 3 | 14 | 1 | 42 |
| Growth Variables | PH | 366.32 | 1721.21** | 143.49** | 217.64 |
| | NFB | 21.84 | 37.32* | 3.08** | 8.2 |
| | NFFB | 1.32 | 4.54* | 0.24 | 0.64 |
| Earliness Variables | DFF | 7.53 | 14.90** | 1.34** | 3.56 |
| | DFB | 9.07 | 29.42** | 1.39* | 3.72 |
| | BP | 5.72 | 27.11 | 1.28* | 3.4 |
| | EI | 110 | 607.43** | 30.05** | 80.28 |
| Yield Variables | NB/P | 50.78 | 130.06* | 14.47** | 38.6 |
| | BW | 1.1 | 5.03** | 0.23* | 0.62 |
| | L% | 35 | 83.21* | 15.22* | 40.6 |
| | SI | 11.11 | 17.05** | 1.15* | 3 |
| | SCY | 1223.08 | 4301.32* | 165.70* | 441.88 |
| | LCY | 300.1 | 363.60** | 64.26* | 171.36 |

† 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.

characters except BP at the $F_2$ population. Heterosis mean squares at the two populations were significant except NFFB.

As the over all averages mean performance of the studied traits at the two populations looks image to each other, the $F_1$ and $F_2$ crosses performance were superior to the parents (Tables 2-4). This generally indicated reasonable heterosis but was not wide in magnitude. Growth variabies presented in Table (2) revealed a wide range in performance

**Table2. Mean performance (M) and percentage of heterotic effects relative to mid (MP) and best (BP) parent for growth variables of $F_1$ and $F_2$ cotton crosses based on diallel mating design**

| Variable | PH | | | | | | NFB | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Generation | $F_1$ | | | $F_2$ | | | $F_1$ | | | $F_2$ | | |
| Genotype | M | MP | BP | M | MP | BP | M | MP | BP | M | MP | BP |
| G89 | 109 | | | 106.2 | | | 11.9 | | | 12.08 | | |
| P6 | 93.4 | | | 94.09 | | | 10.7 | | | 10.55 | | |
| G85 | 99.8 | | | 99.16 | | | 13.8 | | | 14 | | |
| Wild | 70.1 | | | 69.12 | | | 9.92 | | | 9.3 | | |
| Tam | 82.6 | | | 85.02 | | | 9.81 | | | 9.72 | | |
| Parents Mean | 90.9 | | | 90.72 | | | 11.2 | | | 11.13 | | |
| G89XP6 | 79.1 | -21.67 | -15.3 | 100 | -0.13 | 6.28 | 10.6 | -6.19 | -10.92 | 10.62 | -6.14 | -12.09 |
| G89XG85 | 114 | 9.61 | 14.46 | 105.2 | 2.48 | 6.1 | 14.8 | 15.2 | 24.52 | 13.77 | 5.6 | 13.99 |
| G89XWild | 89.5 | 0.23 | 27.81 | 80.58 | -7.6 | 17.16 | 13.3 | 21.9 | 11.75 | 12.01 | 12.4 | -0.58 |
| G89XTam | 92.1 | -3.63 | 11.55 | 81.88 | -14.4 | -3.69 | 13.9 | 27.9 | 16.62 | 11.54 | 5.87 | -4.47 |
| P6XG85 | 88.9 | -7.96 | -4.83 | 97.42 | 0.82 | 3.54 | 11.4 | -7.25 | -17.72 | 10.81 | -11.9 | -22.79 |
| P6XWild | 82.7 | 1.14 | 18 | 80.65 | -1.17 | 16.68 | 10.5 | 1.6 | -2.15 | 10.76 | 8.41 | 1.99 |
| P6XTam | 80.5 | -8.52 | -3.69 | 71.86 | -20.7 | -16.42 | 14.3 | 39.7 | 33.8 | 12.3 | 21.4 | 16.59 |
| G85XWild | 71.9 | -15.35 | 2.61 | 84.04 | -0.12 | 19.97 | 13.9 | 17.4 | 0.8 | 13.1 | 12.5 | -6.43 |
| G85XTam | 102 | 11.37 | 21.49 | 90.23 | -2.02 | 6.13 | 11.9 | 0.93 | -16.16 | 12.89 | 8.68 | -7.93 |
| WildXTam | 77 | 0.88 | 9.91 | 88.14 | 14.36 | 27.52 | 12.1 | 23.1 | 22.38 | 11.74 | 23.5 | 20.78 |
| Crosses Mean | 87.7 | -3.39 | 8.201 | 87.96 | -2.84 | 8.327 | 12.7 | 13.43 | 6.292 | 11.95 | 8.01 | -0.094 |
| Over all Mean | 88.8 | | | 88.93 | | | 12.2 | | | 11.66 | | |
| LSD | 13.7 | | | 16.29 | | | 4.42 | | | 3.41 | | |
| Variable | NFFB | | | | | | | | | | | |
| Generation | $F_1$ | | | | | | $F_2$ | | | | | |
| Genotype | M | | MP | | BP | | M | | MP | | BP | |
| G89 | 6.8 | | | | | | 6.1 | | | | | |
| P6 | 4.35 | | | | | | 5.1 | | | | | |
| G85 | 4.86 | | | | | | 5.23 | | | | | |
| Wild | 4.1 | | | | | | 4 | | | | | |
| Tam | 4.15 | | | | | | 4.23 | | | | | |
| Parents Mean | 4.85 | | | | | | 4.93 | | | | | |
| G89XP6 | 5.9 | | 5.83 | | 35.63 | | 5.89 | | 5.18 | | 15.5 | |
| G89XG85 | 4.87 | | -16.5 | | 0.21 | | 5 | | -11.74 | | -10.7 | |
| G89XWild | 4.52 | | -17.1 | | 10.24 | | 4.61 | | -8.71 | | 15.3 | |
| G89XTam | 4.09 | | -25.3 | | -1.45 | | 4.5 | | -12.88 | | 6.38 | |
| P6XG85 | 4.4 | | -4.45 | | 0 | | 4.34 | | -15.97 | | -14.9 | |
| P6XWild | 4.56 | | 7.93 | | 11.22 | | 4.11 | | -9.67 | | 2.75 | |
| P6XTam | 4.4 | | 3.53 | | 6.02 | | 4.54 | | -2.68 | | 7.33 | |
| G85XWild | 4.14 | | -7.59 | | 0.96 | | 4.1 | | -11.16 | | 2.5 | |
| G85XTam | 4.2 | | -6.77 | | 1.2 | | 4.4 | | -6.98 | | 4.02 | |
| WildXTam | 4 | | -3.03 | | -2.44 | | 4.15 | | 0.85 | | 3.75 | |
| Crosses Mean | 4.51 | | -6.34 | | 6.161 | | 4.56 | | -7.376 | | 3.19 | |
| Over all Mean | 4.68 | | | | | | 4.75 | | | | | |
| LSD | 1.72 | | | | | | 0.95 | | | | | |

• Plant height (PH cm), Number of fruiting branches (NFB), the node number of first fruiting Branch (NFFB)

among the parental materials as well as the crosses over the two populations. The Egyptian genotype G89 was the tallest parent (108.60 cm, 106.20 cm) while the wild *hirsutum* was the shortest one (70.05 cm, 69.12 cm) at $F_1$ and $F_2$ populations, respectively. The crosses mean performance of plant height at the two populations presented in Table (2) showed that the cross G89XG85 was the highest at the two populations while the genotype

Wild X Tamcot (76.99 cm) and P5XTamcot (71.06 cm) were the shortest at $F_1$ and $F_2$, respectively.

Parents of *barbadense* showed superiority with NFB, the genotype G85 surpassed all parents and hybrids at $F_2$ (14 branches) and was the greater parent at $F_1$. With the $F_1$ population the cross G89 X G85 recorded the greater number (14.83 branches). The two *hirsutum* genotypes showed trend of earliness with node number of first fruiting branch (NFFB) (4.1 and 4.2) and earliness index (EI) (89.1 and 76.4), respectively. Parental differences in the node of first fruiting branch NFFB were clearly evident.

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 (4.10 and 4 nodes), while the full season genotype (PS6) that had been developed for mechanical picking was relatively higher (4.35 and 5 nodes) at the two populations, respectively (Table 2). Regarding earliness variable, the genotype wild *hirsutum* showed the lowest DFF (56.40 and 57.68days) and the lowest DFB (100, 100.17days) at the $F_1$ and $F_2$ populations respectively, while the lines of *barbadense* cultivar G89 showed the longest period from planting to first flower and boll at the two populations. Parental differences in the *per se* performance regarding boll maturation period were small and sometimes bewildering especially with the introduced genotypes. The crosses mean performance presented in Table (3) indicated that the crosses (P6XWild and WildXTamcot), (WildXTamcot and G85XTamcot), (PS6XG85 and G85XTamcot), (G58Xwild and WildXTamcot) were the top significantly over other hybrids regarding DFF, DFB, BP, and EI earliness characters at $F_1$ and $F_2$ populations, respectively. From these findings, it is evident that the *barbadense* parents influenced hybrid plant stature by producing the tallest hybrid G89 XG85. The late maturing parent G89 produced later-maturing hybrids while the early-maturing strains wild *hirsutum* and Tamcot produced earlier-maturing hybrids, Pima S6-based crosses (the word *genotype-based* used in the current text means its impact as feminine parent) were intermediate. In general, Tables (2 and 3) showed that the values of the majority crosses 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 $F_2$ hybrids were more than the higher (earlier) or less than the lower parent (late), showing over dominance inheritance for the studied characters. Comparable findings attained by many investigators (White and Kohel 1964, White 1966, Marani 1968a, b and Bhatt *et al* 1981). Table 4 presented performance and heterotic effects

**Table3. Mean performance (M) and percentage of heterotic effects relative to mid (MP) and best (BP) parent for Earliness variables of $F_1$ and $F_2$ cotton crosses based on diallel mating design**

| Genotype | DFF | | | | | | DFB | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | | | $F_2$ | | | $F_1$ | | | $F_2$ | | |
| | M | MP | BP | M | MP | BP | M | MP | BP | M | MP | BP |
| G89 | 83.00 | | | 83.29 | | | 126.54 | | | 128.46 | | |
| P6 | 76.00 | | | 76.31 | | | 120.60 | | | 119.27 | | |
| G85 | 76.70 | | | 79.23 | | | 121.00 | | | 125.91 | | |
| Wild | 56.40 | | | 57.68 | | | 100.00 | | | 100.17 | | |
| Tam | 61.20 | | | 65.61 | | | 103.00 | | | 108.55 | | |
| Parents Mean | 70.66 | | | 72.42 | | | 114.23 | | | 116.47 | | |
| G89XP6 | 75.10 | -5.57 | -1.22 | 72.19 | -9.54 | -5.40 | 120.90 | -2.16 | 0.25 | 118.04 | -4.70 | -1.00 |
| G89XG85 | 84.50 | 5.86 | 5.53 | 76.77 | -5.53 | -3.10 | 127.00 | 2.61 | 4.96 | 124.04 | -2.47 | -1.50 |
| G89XWild | 69.10 | -0.90 | 22.50 | 70.94 | 0.65 | 22.99 | 115.00 | 1.53 | 15.00 | 115.95 | 1.43 | 16.00 |
| G89XTam | 65.90 | -8.61 | 25.70 | 70.23 | -5.67 | 7.04 | 112.58 | -1.91 | 9.30 | 114.10 | -3.72 | 5.10 |
| P6XG85 | 78.40 | 2.62 | 3.09 | 72.69 | -6.53 | -8.25 | 120.00 | -0.66 | -0.50 | 117.11 | -4.47 | -1.80 |
| P6XWild | 62.10 | -6.19 | 10.10 | 67.84 | 1.26 | 17.61 | 110.43 | 0.12 | 90.50 | 112.30 | 2.35 | 12.00 |
| P6XTam | 67.20 | -2.01 | 9.89 | 71.82 | 1.21 | 9.47 | 111.57 | -0.21 | 8.32 | 115.96 | 1.80 | 6.80 |
| G85XWild | 65.20 | -2.03 | 15.60 | 62.43 | -8.80 | 8.24 | 112.00 | 1.36 | 12.00 | 107.21 | -5.16 | 7.00 |
| G85XTam | 70.50 | 2.34 | 15.40 | 65.22 | -9.94 | -0.59 | 116.36 | 3.89 | 12.97 | 108.00 | -7.87 | -0.50 |
| WildXTam | 65.00 | 10.56 | 15.20 | 63.52 | 3.04 | 10.12 | 110.20 | 8.57 | 10.20 | 106.48 | 2.03 | 6.30 |
| Crosses Mean | 70.30 | -0.39 | 12.18 | 69.37 | -3.99 | 5.81 | 115.60 | 1.31 | 16.30 | 113.92 | -2.08 | 4.84 |
| Over all Mean | 70.48 | | | 70.89 | | | 114.90 | | | 115.19 | | |
| LSD | 2.65 | | | 2.25 | | | 3.45 | | | 2.30 | | |
| Genotype | BP | | | | | | EI | | | | | |
| | $F_1$ | | | $F_2$ | | | $F_1$ | | | $F_2$ | | |
| | M | MP | BP | M | MP | BP | M | MP | BP | M | MP | BP |
| G89 | 43.50 | | | 45.17 | | | 39.53 | | | 41.89 | | |
| P6 | 44.60 | | | 42.96 | | | 59.76 | | | 61.00 | | |
| G85 | 44.30 | | | 46.68 | | | 54.10 | | | 49.72 | | |
| Wild | 43.60 | | | 42.49 | | | 80.60 | | | 82.35 | | |
| Tam | 41.90 | | | 42.94 | | | 75.67 | | | 76.38 | | |
| Parents Mean | 43.58 | | | 44.05 | | | 61.93 | | | 62.27 | | |
| G89XP6 | 45.80 | 3.99 | 5.26 | 45.85 | 4.05 | 6.73 | 69.00 | 39.00 | 15.50 | 65.16 | 26.66 | 6.80 |
| G89XG85 | 42.50 | -3.30 | -2.46 | 47.27 | 2.93 | 4.65 | 61.16 | 30.60 | 13.10 | 60.24 | 31.51 | 21.00 |
| G89XWild | 45.90 | 5.42 | 5.49 | 45.01 | 2.69 | 5.93 | 62.81 | 4.57 | -22.00 | 73.09 | 17.66 | -11.00 |
| G89XTam | 46.70 | 9.40 | 11.60 | 43.87 | -0.42 | 2.17 | 76.00 | 31.90 | 0.44 | 77.01 | 30.23 | 0.80 |
| P6XG85 | 41.70 | -6.30 | -5.98 | 44.42 | -0.89 | 3.40 | 65.57 | 15.20 | 9.72 | 64.17 | 15.91 | 5.20 |
| P6XWild | 48.30 | 9.59 | 10.90 | 44.46 | 4.06 | 4.64 | 68.40 | -2.54 | -15.00 | 70.48 | -1.67 | -14.00 |
| P6XTam | 44.40 | 2.65 | 6.02 | 44.14 | 2.77 | 2.79 | 69.70 | 2.93 | -7.90 | 69.65 | 1.40 | -8.80 |
| G85XWild | 46.80 | 6.48 | 7.34 | 44.78 | 0.44 | 5.39 | 89.20 | 32.40 | 10.70 | 79.91 | 21.01 | -0.90 |
| G85XTam | 45.80 | 6.37 | 9.47 | 42.78 | -4.54 | -0.37 | 77.30 | 19.13 | 2.15 | 77.30 | 22.60 | 1.20 |
| WildXTam | 45.20 | 5.84 | 8.05 | 42.96 | 0.57 | 1.11 | 83.20 | 6.48 | 3.23 | 83.23 | 4.87 | 1.10 |
| Crosses Mean | 45.31 | 4.01 | 5.57 | 44.55 | 1.80 | 3.64 | 72.23 | 17.97 | 0.99 | 72.02 | 17.02 | 0.14 |
| Over all Mean | 44.44 | | | 44.30 | | | 67.08 | | | 67.15 | | |
| LSD | 3.07 | | | 2.20 | | | 12.00 | | | 10.65 | | |

● **Date of first flower (DFF day), Date of first open boll (DFB day), boll period (BP day), earliness index (EI).**

associated with the two studied populations of yield and its major components. Genotypes exhibited significant effects, since the mean performance of potential materials and their respective crosses showed a wide range of yield and its components. At the $F_1$ population the crosses G89XP6 (24.30 bolls), G85XTamcot (3.59gm), G89XG85 (40.99%), G85XTamcot (12.18gm), G85XTamcot (62.46gm) and Wild X Tamcot (25.7gm) were the best in respect to NB/p, BW/gm, L%, SI/gm and SCY/p (gm), LCY/p (gm), respectively. At the $F_2$ population the crosses G85XTamcot (21.64 boll), Wild X Tamcot (4.78gm), G89XP6 (40%), Wild

**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 $F_1$ and $F_2$ cotton crosses based on half diallel mating design in cotton**

| | NB/P ($F_1$) | | | NB/P ($F_2$) | | | BW/g ($F_1$) | | | BW/g ($F_2$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Genotype | M | MP | BP | M | MP | BP | M | MP | BP | M | MP | BP |
| G89 | 16.4 | | | 17.45 | | | 2.23 | | | 2.2 | | |
| P6 | 19.1 | | | 19.71 | | | 2.06 | | | 2.45 | | |
| G85 | 19.1 | | | 19.45 | | | 2.87 | | | 2.77 | | |
| Wild | 14.6 | | | 14.04 | | | 3.51 | | | 3.76 | | |
| Tam | 11 | | | 13 | | | 4.88 | | | 4.54 | | |
| Parents Mean | 16.1 | | | 16.73 | | | 3.11 | | | 3.14 | | |
| G89XP6 | 24.3 | 36.9 | 27.36 | 18.73 | 0.81 | -5 | 2.46 | 14.7 | 10.31 | 2.34 | 0.65 | -4.49 |
| G89XG85 | 20.3 | 14.32 | 23.75 | 21.47 | 16.37 | 10.4 | 3.11 | 22.1 | 8.54 | 2.91 | 17.1 | 5.05 |
| G89XWild | 23 | 48.21 | 40.13 | 19.13 | 21.5 | 9.63 | 3.02 | 5.23 | -14 | 3.54 | 18.8 | -5.85 |
| G89XTam | 12.2 | -10.9 | -25.6 | 21.5 | 41.22 | 23.2 | 3.41 | -4 | -30.1 | 3.51 | 4.15 | -22.7 |
| P6XG85 | 23 | 20.39 | 20.23 | 16.34 | -16.6 | -16 | 2.3 | -6.6 | -19.7 | 2.48 | -5 | -10.5 |
| P6XWild | 13.6 | -19.1 | -28.5 | 16.4 | -2.81 | -17 | 3.5 | 25.7 | 13.68 | 3.24 | 4.35 | -13.8 |
| P6XTam | 18.1 | 19.97 | -5.4 | 20.45 | 25.04 | 3.75 | 3.35 | -3.5 | -31.4 | 3.57 | 2.15 | -21.4 |
| G85XWild | 20.5 | 21.45 | 7.16 | 20.29 | 21.17 | 4.32 | 3.59 | 12.6 | 2.28 | 3.64 | 11.5 | 3.7 |
| G85XTam | 20.6 | 36.5 | 7.53 | 21.64 | 33.37 | 11.3 | 3.13 | -19 | -35.9 | 3.31 | -9.4 | -27.1 |
| WildXTam | 16.3 | 26.76 | 11.07 | 15.21 | 12.5 | 8.33 | 3.5 | -17 | -28.3 | 4.78 | 15.2 | 5.29 |
| Crosses Mean | 19.2 | 19.45 | 7.77 | 19.12 | 15.26 | 3.31 | 3.137 | 3.05 | -12.5 | 3.33 | 5.94 | -9.17 |
| over all mean | 17.6 | | | 17.93 | | | 3.12 | | | 3.23 | | |
| LSD | 6.58 | | | 7.4 | | | 1.11 | | | 0.94 | | |
| Genotype | L% ($F_1$) | | | L% ($F_2$) | | | SI($F_1$) | | | SI ($F_2$) | | |
| | M | MP | BP | M | MP | BP | M | MP | BP | M | MP | BP |
| G89 | 39.2 | | | 39.64 | | | 9.68 | | | 9.92 | | |
| P6 | 38.7 | | | 39.38 | | | 10.14 | | | 10.06 | | |
| G85 | 37.7 | | | 37.4 | | | 9.7 | | | 9.9 | | |
| Wild | 34.8 | | | 35.61 | | | 12.38 | | | 12.16 | | |
| Tam | 35.2 | | | 33.66 | | | 11.71 | | | 12 | | |
| Parents Mean | 37.1 | | | 37.14 | | | 10.72 | | | 10.81 | | |
| G89XP6 | 39.8 | 2.16 | 1.51 | 40.1 | 1.49 | 1.16 | 11.18 | 12.8 | 10.27 | 10.68 | 6.91 | 6.16 |
| G89XG85 | 41 | 6.61 | 4.62 | 39.04 | 1.35 | -1.5 | 11.11 | 14.7 | 14.54 | 10.66 | 7.57 | 7.46 |
| G89XWild | 38 | 2.85 | -2.94 | 37.33 | -0.78 | -5.8 | 11.58 | 4.98 | -6.47 | 10.47 | -5.2 | -13.9 |
| G89XTam | 38 | 2.21 | -2.94 | 37.12 | 1.28 | -6.4 | 10.16 | -5 | -13.2 | 11.4 | 4.01 | -5 |
| P6XG85 | 39.8 | 4.12 | 2.83 | 40.67 | 5.94 | 3.28 | 10.32 | 4.03 | 1.78 | 10.04 | 0.6 | -0.99 |
| P6XWild | 36.2 | -1.32 | -6.3 | 36.08 | -3.77 | -8.4 | 11.45 | 1.69 | -7.51 | 11.15 | 0.36 | -8.31 |
| P6XTam | 37.2 | 0.53 | -3.94 | 35.18 | -3.67 | -11 | 11.42 | 4.53 | -2.47 | 11.68 | 5.89 | -2.67 |
| G85XWild | 37.2 | 2.64 | -1.36 | 35.57 | -2.56 | -4.9 | 10.36 | -6.2 | -16.3 | 11.03 | 0 | -9.29 |
| G85XTam | 33.4 | -8.55 | -11.6 | 36.11 | 1.63 | -3.5 | 12.18 | 13.8 | 4.01 | 11.14 | 1.74 | -7.17 |
| WildXTam | 36.5 | 4.39 | 3.7 | 36.35 | 4.95 | 2.08 | 11.2 | -7 | -9.53 | 11.73 | -2.9 | -3.54 |
| Crosses Mean | 37.7 | 1.56 | -1.64 | 37.36 | 0.586 | -3.5 | 11.1 | 3.83 | -2.5 | 10.1 | 1.9 | -3.72 |
| Over all Mean | 37.4 | | | 37.25 | | | 10.91 | | | 10.9 | | |
| LSD | 5.4 | | | 7.59 | | | 2.9 | | | 2.89 | | |

● Number of harvested bolls per plant (NB/p), seed cotton yield per plant (SCY/p) and lint cotton yield per plant (LCY/p).

Table 4. Cont.

| Genotype | SCY/p ($F_1$) | | | SCY/p ($F_2$) | | | LCY/p ($F_1$) | | | LCY/p ($F_2$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | MP | BP | M | MP | BP | M | MP | BP | M | MP | BP |
| G89 | 40.8 | | | 39.56 | | | 15.98 | | | 15.68 | | |
| P6 | 43.2 | | | 42.11 | | | 16.72 | | | 16.58 | | |
| G85 | 48.1 | | | 46.96 | | | 18.14 | | | 17.56 | | |
| Wild | 60.9 | | | 58.9 | | | 21.17 | | | 20.97 | | |
| Tam | 58.7 | | | 67.25 | | | 20.67 | | | 21.64 | | |
| Parents Mean | 50.3 | | | 50.96 | | | 18.54 | | | 18.49 | | |
| G89XP6 | 45.6 | 8.56 | 5.48 | 55.13 | 35.08 | 30.9 | 18.14 | 10.9 | 8.47 | 20.23 | 25.4 | 21.97 |
| G89XG85 | 61.2 | 37.7 | 27.23 | 47.69 | 10.24 | 1.55 | 25.08 | 47 | 38.28 | 18.62 | 12 | 6.01 |
| G89XWild | 57.9 | 13.9 | -4.9 | 60.72 | 23.34 | 3.09 | 22.02 | 18.5 | 4.01 | 22.67 | 23.7 | 8.07 |
| G89XTam | 49.6 | -0.21 | -15.4 | 56.63 | 6.04 | -16 | 18.87 | 2.97 | -8.72 | 21.02 | 12.7 | -2.86 |
| P6XG85 | 65.3 | 43.07 | 35.84 | 59.78 | 34.23 | 27.3 | 19.63 | 12.6 | 8.22 | 20.92 | 22.5 | 19.11 |
| P6XWild | 59.2 | 13.8 | -2.69 | 55.12 | 9.14 | -6.4 | 21.47 | 13.3 | 1.42 | 18.26 | -2.8 | -12.9 |
| P6XTam | 75.9 | 48.98 | 29.39 | 72.84 | 33.21 | 8.31 | 26.01 | 39.1 | 25.81 | 25 | 30.8 | 15.53 |
| G85XWild | 62.3 | 14.38 | 2.37 | 56.9 | 7.5 | -3.4 | 23.18 | 18 | 9.52 | 20.24 | 5.04 | -3.5 |
| G85XTam | 71.5 | 33.88 | 21.82 | 77.65 | 35.98 | 15.5 | 20.83 | 7.37 | 0.8 | 23.06 | 17.7 | 6.58 |
| WildXTam | 66 | 10.39 | 8.38 | 62.21 | -1.37 | -7.5 | 25.76 | 23.2 | 21.71 | 22.61 | 6.13 | 4.5 |
| Crosses Mean | 61.5 | 22.45 | 10.75 | 60.47 | 19.33 | 5.35 | 22.1 | 19.3 | 10.95 | 21.26 | 15.3 | 6.25 |
| over all mean | 55.9 | | | 55.71 | | | 20.32 | | | 19.88 | | |
| LSD | 31.4 | | | 25.03 | | | 14.22 | | | 15.68 | | |

• Number of harvested bolls per plant (NB/p), seed cotton yield per plant (SCY/p) and lint cotton yield per plant (LCY/p).

X Tamcot (11.73gm), G85XTamcot (63.87gm) and Wild X Tamcot (22.61gm) were the best in respect to NB/p, BW/gm, L%, SI/gm and SCY/p (gm), LCY/p (gm), respectively. From these results we can infer, first, 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.

This suggests that we have to take care in the subsequent selection steps when this germplasm imparted in the Egyptian cotton breeding programs; in the sake of maintain our high quality cottons. Second, the significance of *hirsutum* regarding seed cotton yield was due to the ascendancy in boll weight and seed index. The seed cotton yield of *barbadense*, however, mainly was due to the significance of number of harvested bolls/plant and lint percentage.

## Heterosis among hybrids

The magnitude and significance of heterotic effects for the adopted growth character i.e. PH, NFB and NFFB are calculated and presented in (Table 2). Plant height PH heterosis index showed negative (shorter) and significant effects over mid-parents associated with the crosses G89XP6 and Pima G85XWild at $F_1$ and P6XTamcot and G89XTamcot at $F_2$. Better parent heterosis indicated that the crosses G89XP6 and P6XTamcot were significantly shorter at the two populations. An upland parent was involved in the majority of short hybrids; the heterosis performance of the short stature associated with the intraspecific crosses contains P6, however, looks remarkable. The number of sympodial branches NFB showed highly significant heterosis index with six crosses over mid parents and five crosses over higher parent at the $F_1$ population (Table 2). A significant heterotic effect over higher parent was recorded in three cases; G89XG85 and P6XTamcot WildXTamcot at the $F_2$ population. The node of first fruiting branch NFFB showed six significant midparent heterosis indexes compared with only one (P6XTamcot) with high parent heterosis at the $F_1$ population. At the $F_2$ population, seven crosses showed significant heterotic effects compared to only two cases (G89XP6 and P6XG85) over the shorter parent. This may indicate that the lower fruiting node was inherited as a dominant character. It is important to notice that these two crosses belonging totally to *barbadense* category. Node number of first fruiting branch is one morphological character that can be used as a good indicator for earliness of maturity (Godoy and Palomo 1999) and also indicate small plant size. NFFB as earliness parameter can be easily and precisely identified, and it is independent of complications arising from shedding of fruit forms. Correlations coefficients were significantly positive between crosses mean performance and midparents heterosis at $F_1$ and $F_2$ for PH and NFB and NFFB at $F_1$ only (Table 5). Significant positive correlation coefficients, 0.49 for PH, 0.77 for NFB and highly significant 0.92 for NFFB, respectively, between $F_1$ and $F_2$ also existed. These results along with midparent values correlations implied that the growth performance of hybrids could be primarily predicted according to the average performance of their parents. This is very important for selecting parents in cotton breeding programs interested in these characters.

Heterotic effects associated with earliness variables are presented in Table (3). The results of DFF presented in Table (3) indicated that the heterosis magnitude over mid parents was significantly negative in six out of the ten studied crosses; the significance had a sizeable tendency towards earliness at the $F_1$. It was negative in three cases, however, when compared with earlier parent. The crosses G89X PS6 G89X G85, and PS6XG85 showed highly significant negative heterosis over mid and high parent at the $F_2$ population. DFB results presented in Table (3) showed that the number of significantly negative heterosis index over mid-parents revealed in 5 cases including mean and reduced to only two significant cases G89X G85, and PS6XG85 when compared to high parent at the $F_2$ population. These findings confirmed that the parent PS6 is in particular desired when breeding for reducing number of days to first flower, first boll, and boll period. The superiority of hybrids over the midparents was indicating the partial dominance mode of inheritance. 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 presented in Table (3) showed

**Table5. Correlation coefficients and significance values between; $F_1$ and $F_2$ crosses mean performance- $F_1$ crosses mean performance and midparents values (MPV)- $F_2$ crosses mean performance and midparents values (MPV)- $F_1$ crosses mean performance and both two types of heterotic effects- $F_2$ crosses mean performance and both two types of heterotic effects.**

| Correlation coefficients between $F_1$ and $F_2$ mean performance for Growth and earliness variables | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable● | PH | NFB | NFFB | DFF | DFB | BP | EI | | | | | |
| Correlation | 0.49* | 0.77* | 0.92** | 3.07 | 3.35 | -0.94 | 4.41 | | | | | |
| Significance | 1.57 | 3.42 | 6.60 | 0.74 | 0.76 | -0.32 | 0.84 | | | | | |
| Correlation coefficients between $F_1$ and $F_2$ crosses mean performance for Yield and components | | | | | | | | | | | | |
| Variable | NB/P | BW/g | L% | SI | SCY/P | LCY/P | | | | | | |
| Correlation | 0.04 | 0.77* | 0.76* | 0.18 | 0.68* | 0.29 | | | | | | |
| Significance | 0.12 | 3.43 | 3.27 | 0.52 | 2.65 | 0.87 | | | | | | |
| Correlation coefficient between; crosses Mean performance and Mid parents values (MPV) - cross mean performance and midparents heterosis (MP) and better parent (BP) at $F_1$ and $F_2$ generations. | | | | | | | | | | | | |
| Variable | PH | | | | | | NFB | | | | | |
| Generation | $F_1$ | | | $F_2$ | | | $F_1$ | | | $F_2$ | | |
| Heterosis | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP |
| Correlation | 0.62* | 0.70* | 0.46 | 0.62* | 0.61* | 0.18 | 0.21 | 0.78* | 0.73* | 0.44* | 0.38 | 0.40 |
| Significance | 2.24 | 2.77 | 1.45 | 2.23 | 2.17 | 0.52 | 0.61 | 3.52 | 2.98 | 1.38 | 1.17 | 1.25 |
| Variable | NFFB | | | | | | | | | | | |
| Generation | $F_1$ | | | | | | $F_2$ | | | | | |
| Heterosis | MPV | MP | BP | MPV | MP | BP | | | | | | |
| Correlation | 0.49* | 0.84** | 0.74* | 0.78* | 0.41 | 0.31 | | | | | | |
| Significance | 1.59 | 4.46 | 3.14 | 3.51 | 1.26 | 0.93 | | | | | | |
| Variable | DFF | | | | | | DFB | | | | | |
| Generation | $F_1$ | | | $F_2$ | | | $F_1$ | | | $F_2$ | | |
| Heterosis | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP |
| significance | 0.83** | 1.05 | -2.07 | 0.80 | -0.63 | -0.78 | 0.87** | -0.59 | -1.36 | 0.78* | -0.57 | -0.86 |
| correlation | 4.16 | 0.35 | -0.59 | 3.75 | -0.22 | -0.26 | 5.03 | -0.20 | -0.43 | 3.56 | -0.20 | -0.29 |
| Variable | BP | | | | | | EI | | | | | |
| Generation | $F_1$ | | | $F_2$ | | | $F_1$ | | | $F_2$ | | |
| Heterosis | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP |
| significance | -0.26 | 5.61 | 5.99 | 0.28 | 0.28 | 0.19 | 0.61* | 0.31 | 0.73 | 0.76* | -1.01 | -1.31 |
| correlation | -0.75 | 0.89 | 0.90 | 0.83 | 0.83 | 0.07 | 2.21 | 0.11 | 0.25 | 3.29 | -0.34 | -0.42 |
| Variable | NB/P | | | | | | BW/g | | | | | |
| Generation | $F_1$ | | | $F_2$ | | | $F_1$ | | | $F_2$ | | |
| Heterosis | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP |
| correlation | 0.59* | 0.78* | 0.89** | 0.06 | 0.60* | 0.66* | 0.66* | 0.03 | -0.10 | 0.90** | 0.55* | 0.1[illegible] |
| significance | 2.07 | 3.52 | 5.56 | 0.16 | 2.13 | 2.48 | 2.50 | 0.08 | -0.29 | 5.68 | 1.87 | 0.45 |

● 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) and number of harvested bolls per plant (NB/p),

* ** Significant at 0.05 and 0.01 levels of probability

Table5. Cont.

| Variable | L% | | | | | | SI | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Generation | $F_1$ | | | $F_2$ | | | $F_1$ | | | $F_2$ | | |
| Heterosis | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP |
| correlation | 0.74* | 0.03 | 0.82* | 0.77* | 0.44* | 0.72* | 0.21 | 0.45* | 0.36 | 0.75* | 0.09 | -0.16 |
| significance | 3.08 | 0.08 | 4.03 | 3.42 | 1.38 | 2.93 | 0.60 | 1.44 | 1.09 | 3.22 | 0.26 | -0.46 |
| Variable | SCY | | | | | | LCY | | | | | |
| Generation | $F_1$ | | | $F_2$ | | | $F_1$ | | | $F_2$ | | |
| Heterosis | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP | MPV | MP | BP |
| correlation | 0.47* | 0.76* | 0.67* | 0.59* | 0.52* | 0.21 | 0.49* | 0.83* | 0.78* | 0.49* | 0.54* | 0.42 |
| significance | 1.51 | 3.27 | 2.54 | 2.04 | 1.70 | 0.62 | 1.60 | 4.21 | 3.52 | 1.57 | 1.83 | 1.31 |

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

significance over midparents in eight cases out of ten at $F_1$ population. The best heterotic crosses were associated with crosses G89XPS6, G89XG85 and G89XTamcot. These three crosses were highly significant over earlier parent two. At the $F_2$ population the crosses G89XG85, and P6X85 were significantly the best over better parent heterosis. Significant correlations of earliness variables were found between $F_1$ and midparents values for DFF, DFB, and Earliness index at the two populations (Table 5). Although negative, neither generation correlations nor heterotic effects correlations with the crosses mean performance of earliness variables exhibited significant correlations. This may suggest that the performance of early hybrids could not be primarily predicted according to the average performance of their parents. Variable values of heterosis were recorded for earliness and growth character in cotton by may researchers (White and Kohel 1964, White 1966, Marani 1868b, Bhardwaj and Weaver 1984 and Wells and Meredith Jr. 1986).

The mid-parent and high-parent heterosis percentages for cotton yield and its major components are presented in Table (4). As the magnitude of heterosis index for number of harvested bolls/plant over mid-parent heterosis ranged significantly from 48.21% (G89XWild) to -19.07 (PS6XWild), it ranged from 40.13% (G89XWild) to -5.40 (PS6XTamcot) when compared with the higher parent at $F_1$. some changes was seen with the $F_2$ population where the deviation of $F_2$ from the midparents ranged from 41.22% with the cross G89XTamcot to -2.81 with the cross P6XWild, while it ranges from 23.21% to -15.99 with the crosses G89XTamcot and P6XG85 at the $F_2$ population, respectively. Six crosses out of the positive 8 exhibited significant positive values for MP deviation; four hybrids from these six were exhibited significant high parent deviation. These five hybrids exceed the threshold of their respected parents mean performance. This implicating the expression of dominance and over dominance alleles linked in repulsion phase. Regarding boll weight, results presented in Table (4) showed positive significant midparent heterosis in six cases while the significant positive heterosis over better parent associated with only four cases at the $F_1$ population. Three crosses *viz.* G89XG85, G85Xwild and WildXTamcot transgress significantly the threshold of the superior parent at $F_2$ population. Results of lint percentage revealed by Table (4) showed that only two hybrids P89XG86 and G85XTamcot were the significant midparent heterotic crosses in both two generation and at the two levels of heterosis. Significant superiority associated with seed index over higher parent at $F_2$ was recorded by crosses G89XP6 and G89XG85. Negative but not significant heterosis exhibited by the cross P6XG85 at the same generation. With respect to seed cotton yield SCY/p, the crosses G89XG85, P6X85, P6XTamcot and G85XTamcot exhibited significant heterotic effects over the mid-parents heterosis at the $F_1$ population. The significant heterotic effects were reduced to two crosses P6XG85 and P6XTamcot when compared with the better parent (Table 4). Slight differences associated with the $F_2$ population. the mid-parents deviation was significantly recorded with the crosses G89XG85, P6XG85, P6XTamcot and G85XTamcot but the crosses G89XP6 and P6XG85 only exceed significantly the thresholds of the better parent. Significant correlations were found, respectively, between $F_1$ and midparent Values for NP/P (0.59), BW (0.66), L% (0.74), SCY/P (0.47) and LCY/p (0.49), and between $F_2$ and mid-parent value for BW (0.90), L% (0.77), SCY/p (0.59) and LCY/p (0.0.49) (Table 5). Significant correlation coefficients, 0.877 for BW and 0.68 for SCY/p between $F_1$ and $F_2$ also existed. These results revealed that the performance of hybrids could be primarily predicted according to the average performance of their parents which is very helpful for selecting parents in cotton hybrid breeding. 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 were gained. The $F_2$ outcomes at the level of midparent performance revealed that out of the ten studied crosses; 9 cases were positive for seed yield (three significant), 8 for number of harvested bolls (six significant) , 9 for boll weight (eight significant), 6 for lint percentage (two significant), and finally 7 for seed index (five significant). These 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).On the other hand, considering the accumulated additive effects with the $F_2$ populations that reflected on the $F_2$ superiority over the best parents associated comprehensively with the crosses G89XP6, P6XG85, P6XTamcot and G85XTamcot, as well there $F_2$ better performance for growth and earliness over better parents. The study has a tendency to suggest these crosses for further studies aimed at the improvement of Egyptian cotton to be fitted to mechanical harvesting.

## DISCUSSION

The current study is a part of ongoing project research developed to identify the capacity of introducing improved cotton especially suited for mechanical harvesting. Further improvement of Egyptian cottons will depend mainly on the presence of genetic variation in the local germplasm or, if necessary, the introduction of new sources of genetic variability. Cotton is recognized as fiber crop, it has expected 20-40% cross pollination, a fairly large DNA content; around 1.25 *GB* for diploids and 2.5*GB* for tetraploids genotypes (Hendrix and Stewart, 2005), and proven high level of similarity among and within the two cultivated tetraploid taxa (Abdalla *et al* 2001). For these reasons the study preferred to focus on a relatively small number of wide tetraploid parents that selected properly to serve the study breeding objectives.

It has been noticed from published reports that the greater heterosis is associated with greater genetic diversity. Interspecific hybrids had been found to be heterotic for plant height and vegetative growth (Marani 1967) and generally slow maturation rate. Countering these negative aspects of interspecific hybrids were reports of seedling vigor and yield heterosis (Marani 1967). The current study, however, revealed that the heterotic effects in many traits did not reflect the parental divergence (G89 X G85 or G85 X PS6).

The hybrids derived from a *hirsutum* parent had a lower fruiting node and shorter plant height; however their heterosis magnitude was not sizeable as expected. This may due to the *hirsutum* genotypes bred to sow with the beginning of May or later, so it may be uncomfortable to plant in late March and early April as done in our study. This may caused some discrepancy with the *per se* performance of parents to be reflected in the hybrid performance regarding earliness traits especially with the three phenology- based earliness measurements. The G89 hybrids were dominated by the *barbadense* as observed in heterosis in plant height and lint percentage. These hybrids generally yielded less than the intraspecific ones but their relatively good productivity together with their good fiber quality characters that do not coexist generally in upland varieties, indicated that one could develop interspecific hybrids with acceptable performance with no excessive vegetative growth and consequently early maturing conditions. The observed good performance in some of the intra/interspecific $F_2$ hybrids indicated that hybrid cotton may have a potential use under Egyptian conditions. The potential use of interspecific cotton hybrids to serve the mechanical management based on their NFFB, NFB, and EI could be further investigated. Similar approaches were reached by other researchers (Turner 1953, Davis and Palomo 1980, Stella and Demetrious 1999). Based on the heterotic effects of earliness characters, either yield related or phenology related, the study concluded that the average of earliness index EI recorded with the $F_2$ populations over midparents heterosis was maximum (14.90) followed by NFFB (-6.39) DFF (-3.20)and DFB(-1.4). These findings going in parallel with those suggested by many writers that considering earliness index as a best indicator for earliness. Moreover, the current results showed 6 negative, 5 negative and 8 positive cases of mid-parents out of ten studied crosses associated with days to first flower, days to first boll and earliness index to have superior $F_2$ population, respectively. The lower are the node to the first fruiting branch and shorter the plant, the earlier onset of squaring flowering and boll opening (expressed as number of days from planting). These findings indicate that days to first flower/boll followed by earliness index are good indicator for measure cotton earliness and can be recommended as earliness selection criteria. Besides, hybrids G85XPS6, P6XG85, P6XTamcot and G85XTamcot cross combinations were earlier with respect to EI, required less number of days to first flower, and recorded significant heterotic effects with the yield variables. The study was, therefore, recommended these crossed populations to start a program aimed at improving Egyptian cottons for mechanical harvesting.

One final point, it is well-known that heterosis in $F_1$ may be extended to good performance of $F_2$ in cotton (Simpson 1948, Weaver 1984, Meredith 1990). However, the logic questions could be raised: is it sound to exploit heterosis commercially in cotton based on the study results? Cotton has a relatively low inbreeding depression as proved by Marani 1968b, Al-Rawi and Kohel 1969, Abdalla 2006. The current study indicated that out of the ten studied crosses at least three crosses recorded useful heterotic effects for the majority of the traits and vigor performance was extended to $F_2$ populations. If this is indeed the case, then the reasonable answer for the previous question is that specific $F_2$ crosses were capable of producing significant yield increases over original parents. Many researches (Weaver 1984, Tang *et al* 1993, Stella and Demetrious 1999 and Abdalla 2007) reached similar conclusion. Such results guided Tang *et al* 1993 to suggest the utilization of the less expensive $F_2$ hybrid seed as a commercial production. Crosses with the best combined performance $F_2$ like G85XPS6, P6XG85, P6XTamcot and G85XTamcot could be investigated and utilized as $F_2$ hybrids and/or as promising populations within which to select improved inbred for further improvement for cotton mechanical harvesting.

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# الهجن بين وداخل أنواع القطن
# 1- قوة الهجين والارتباط بين الأجيال لصفات النمو والتبكير والمحصول ومكوناته في الأجيال الأول والثاني لهجن القطن


**عبدالله محمد علي عبدالله**

جامعة القاهرة- كلية الزراعة- قسم المحاصيل



أجريت الدراسة بمزرعة كلية الزراعة – جامعة القاهرة في الفترة من 2001 وحتي 2006 بهدف تأثيث قاعة وراثية يمكن منها تربية الأقطان المصرية المواءمة للجني الميكانيكي. بحثت الدراسة تباين المتوسطات وتأثيرات قوة الهجين لصفات النمو والتبكير والمحصول ومكوناته في الهجن الصنفية والنوعية الناتجة من تهجين الداي أليل المستقيم لمجموعة من خمسة سلالات قطنية نقية. إستهدفت الدراسة أيضا الارتباطات بين متوسطات الجيلين الأول والثاني وكذلك ارتباط تلك المتوسطات بمتوسط الأبوين والأب الأعلى. وجدت الدراسة تأثيرات معنوية لتفوق الهجين منسوبا إلي متوسط الأبوين وكذلك منسوبا للأب الأعلى في بعض الهجن لمعظم الصفات وأن كان حجم هذا التفوق غير كبير الحجم. بصفة عامة تشير النتائج إلي حدوث تحسين في صفات النمو والتبكير

والمحصول حيث تراكمت جينات الإضافة في بعض هجن الجيل الثاني محدثة قوة هجين فوق اعلي الأبوين في الهجن G89XP6, P6XG85, P6XTamcot, G85XTamcot وذلك لأغلب الصفات المدروسة. متوسطات الآباء لم تكن مؤشر جيد لصفات التبكير علي حدوث التبكير في هجن الجيل الثاني. أظهرت صفات المحصول ارتباطا معنويا موجبا بين متوسط هجن الجيل الأول وقيمة متوسط الأبوين حيث كانت 0.47, 0.74, 0.66, 0.59 0.49 وذلك لصفات عدد اللوز بالنبات ووزن اللوزة ونسبة التيلة ووزن القطن الزهر والشعر علي التوالي، في حين كانت قيم معامل الإرتباط في هجن الجيل الثاني 0.90 ,0.77, 0.59 ،0.49 لصفات وزن اللوزة ونسبة التيلة ووزن القطن الزهر والشعر علي التوالي. أيضا كان هناك ارتباط معنويا موجبا 0.77، 0.76 , 0.68 لصفات وزن اللوزة ونسبة التيلة ووزن القطن الزهر علي الترتيب بين متوسطات هجن الجيلين الأول والثاني. يمكن استخلاص أن الأبوين P6 و Tamcot يمكن دمجهما في برنامج تربية يحوي الأقطان المصرية مثل جيزة 85 للوصول لطراز نباتي مناسب للجني الآلي بحيث يكون مضغوط في منطقة التزهير وقصير نسبيا وذو ارتفاع مناسب لعقدة أول فرع ثمري. وتميل الدراسة إلي التوصية باستخدام الهجن السابقة في الخطوات التالية لبرنامج تحسين القطن المصري للمواءمة للجني ميكانيكيا.

*مجلد المؤتمر الخامس لتربية النبات – الجيزة ٢٧ مايو ٢٠٠٧*

*المجلة المصرية لتربية النبات ١١(٢): ٧٩٣-٨١١ (عدد خاص)*