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RESEARCH ARTICLE

# HETEROSIS AND COMBINING ABILITY STUDIES FOR IMPROVEMENT OF SEED COTTON YIELD AND FIBRE QUALITY TRAITS IN INTER AND INTRASPECIFIC HYBRIDS OF ALLOTETRAPLOID COTTONS

*[1]Eswari, K.B., [2]Dr. Sudheer Kumar, [3]Dr.Gopinath and [4]Dr. Rao, M.V.B.

Department of Genetics and Plant Breeding, PJTSAU, Rajendranagar, Hyderabad (500030) Telangana, India

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**ABSTRACT**

The present investigation was carried out at college farm, College of Agriculture, Rajendranagar, Hyderabad to study the combining ability and heterosis for quality and yield characters in cotton. Further an attempt was made to trace out the best parents and crosses for future breeding programmes. In this direction seven lines and four testers were crossed in LxT mating design to generate 28 hybrids and evaluated with check NHH44 to know the combining ability of parents and crosses. The estimates of the components of variance and their ratios indicated the preponderance of non additive gene action for days to 50% flowering, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight and seed cotton yield per plant, whereas non additive gene action was observed for the fiber quality traits viz., 2.5% span length, uniformity ratio, micronaire value and bundle strength. Based on gca effects the lines, CPD 420 and among the testers, HAG 1055 were identified as best general combiners for yield which were also observed to be good combiners for one or other fibre quality characters. The crosses involving the lines L604, LK 861 and MCU 17 among the testers were identified as best combiners for earliness. Based on sca effects the intra specific crosses, Galama x MCU 17 (G.*hirsutum* x G. *hirsutum*) and CPD 420 x HAG 105 (G.*hirsutum* x G. *hirsutum*) exhibited positive sca effects for bundle strength. Studies on heterosis revealed that the intraspecific cross CPD 420 x HAG 1055 were identified as promising heterotic hybrid for seed cotton yield and boll number an interspecific cross Galama x Suving were identified as early maturing along with high bundle strength and seed cotton yield.



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## INTRODUCTION

Cotton (*Gossypium species*), is the world's most utilized natural textile fibre. It is also one of the most important cash crops of India, which accounts for 60% of total foreign exchange earnings through export of lint and value added cotton products. India is one of the important cotton growing countries in world and occupies an area of 110 lakh hectares, production of 325 lakh bales and productivity of 503 kg per hectare. Improving cotton fibre quality and lint yield remains challenging for cotton breeders. Many of the current high yielding, commercial upland cotton cultivars do not posses the fibre quality desired by the textile industry. One of the ways to improve fibre quality and cotton yield is to transfer genes into high yielding *G.hirsutum* cultivar from *G.barbadense* (Mc Carty *et al.,* 2004).

***Corresponding author: Eswari***
Department of Genetics and Plant Breeding, PJTSAU, Rajendranagar, Hyderabad (500030) Telangana, India

Genetic improvement has been hampered by the association of poor fibre properties with high yields and a lack of knowledge about genes that effect fibre properties. Cotton production in the country has registered marked improvement in recent decades, yield levels of hybrids appeared to have reached stagnation. One of the important reasons attributed to this is the lack of systematic efforts to improve parents for combining ability and develop new hybrids on such new high combiner lines. To overcome the decline in productivity and quality in interspecific hybrids, it is necessary to develop and utilize potential *hirsutum* and *barbadense* lines. In the present study, it was proposed to evaluate interspecific and intraspecific hybrid combinations based on these new *G.hirsutum and* G.*barbadense* lines. To mould the genetic base of a crop, estimation of gene action, relative magnitude of genetic variance and combining ability estimates are essential. Combining ability analysis helps in selection of parents and appropriate breeding strategy to achieve the objectives quickly in a reliable manner. The main objective of this study is to identify parents with better potential to transmit desirable characters to the progeny and to identify the better specific crosses for quality, yield and yield components and find out best combination of parent for their prospects for future use in hybrid breeding programme.

## MATERIALS AND METHODS

The present investigation was carried out at college farm, college of Agriculture, Rajendranagar, Hyderabad during *Kharif* 2007-08 to 2008-09. Seven lines and four testers were crossed in L x T design to generate 28 hybrids and evaluated with check. NHH 44 to know the combing ability of parents and crosses. (includes seven *Gossypium hirsutum* lines *viz*., Narasimha, Galama, L 604, L 389, LK 861, CPD 420 and AKH 9331, four testers out of which two (2) are *G.barbadense viz*., Suvin, Pima and the rest two (2) *viz*., HAG 1055 and MCU 17) and 28 hybrids derived from 7 x 4; line x tester programme. During *Kharif*, 2007, the parents (seven lines and four testers) were sown in a crossing block at a spacing of 120 x 60 cm. Crosses were effected in a 7 x 4 line x tester design to produce 28 crosses. Hybridization was carried out following hand emasculation and pollination method. Crossing was taken up one week after flower initiation. Flower buds, likely to open the next day were chosen for emasculation and anthers of selected buds were removed gently with the help of nail and covered with red colored straw tube to prevent natural out crossing. Emasculation was carried out between 3 and 6 P.M.

The emasculated buds were pollinated on next day with pollen of male parent between 9 and 11 A.M. Four to five flower buds of female parent were pollinated by one flower of male parent. After pollination, the staminal column was covered with white colored straw tube for prevention of cross- pollination with undesirable pollen. A label with details of the cross was also tied on the pedicel for identification at harvest.

The white colored straw tubes were removed after completion of fertilization *i.e*., four days after pollination. Sufficient care was taken to ensure nicking of parents and all recommended practices were adopted to obtain sufficient number of crossed bolls for each cross combination. In 2009 *kharif*, two experiments were conducted. In one experiment, all the 28 $F_1$s, 11 parents along with check NHH 44 were evaluated for combining ability. The material was sown in Randomized Block Design replicated thrice. Parents and hybrids were sown in two rows with spacing of 90 x 60 cm for parents and 120 x 60 cm for hybrids. All the recommended agronomic and plant protection practices were followed to raise a good crop. Five randomly selected plants from each treatment of three replications were chosen and labeled for recording observations on days to 50% flowering, number of monopodia per plant , number of sympodia per plant, number of bolls per plant, boll weight (g), ginning percentage (%), 2.5% span length (mm), uniformity ratio, micronaire value, bundle strength (g/tex), and seed cotton yield per plant (g) and the means were taken into consideration for statistical analysis. Heterosis was measured over mid parent, better parent and standard check (NHH 44). The data recorded on the material generated as per Line × Tester model of Kempthorne (1957) were analyzed.

## RESULTS AND DISCUSSION

Analysis of variance for combining ability revealed significant differences within parents, crosses, lines (except for days to 50 % flowering and number of sympodia per plant, no of bolls per plant, boll weight, bundle strength and seed cotton yield per plant), testers (except for number of monopodia per plant, number of sympodia per plant, no of bolls per plant, boll weight, ginning percentage and seed cotton yield per plant) and line x tester (except for 2.5% span length, uniformity ratio and micronire value). However, significant differences were also observed for parents and crosses for all the traits studied, except for 2.5% span length and uniformity ratio which indicated the role of non additive gene action as well as heterosis in the studied material. The results of the Analysis of variance (mean squares) for combining ability for quality yield and yield component characters in cotton are presented in Table 1. The estimates of general and specific combining ability variances and proportionate gene action (Table 2) revealed that the variance due to SCA were higher in magnitude than the variance due to GCA for the characters days to 50% flowering, number of monopodia, number of sympodia, number of bolls, boll weight, ginning percentage and seed cotton yield per plant which indicated the predominance of non-additive gene action, the results are in concordance with the findings of Ahuja and Dhayal (2007) for days to 50% flowering, number of monopodia, number of sympodia and boll weight. whereas additive gene action was predominant for the fibre quality traits 2.5% span length, uniformity ratio, microniare value and bundle strength as the GCA variance was higher in magnitude than SCA variance and the results are in conformity with the findings of the Subramanian *et al.* (2005) for 2.5% span length, uniformity ratio and bundle strength. The non-additive gene action has played an important role in expression of seed cotton yield and its component traits which justify the heterosis breeding and its exploitation commercially.

Among the lines CPD 420 and among the testers, HAG 1055 was identified as best general combiners for yield, which were also observed to be good combiners for one or other fibre quality characters.(Table 3). For the characters days to 50% flowering, uniformity ratio and microniare value, MCU 17 (*G.hirsuitum*) was found to be good general combiner for days to 50% flowering, number of bolls, 2.5% span length, uniformity ratio, microniare value and bundle strength. Pima (*G.barbadense*) was found to be good general combiner. The results of specific combining ability (*sca*) effects of crosses for eleven characters in cotton are present in Table 4. The crosses involving the lines L604, LK861 and MCU17 among the testers were identified as best combiners for earliness. Based on sca effects, the intra specific crosses, Galama x MCU 17 (G. hirsutum x G. hirsutum) and CPD 420 x HAG 1055 (G. hirsutum x G. hirsutum) wee identified as best specific combiners for yield and its important component traits. For fibre quality traits, both inter and intra specific cross combinations i.e., CPD 420 x HAG 1055(G. hirsutum x G. hirsutum) for micronaire value, L604 x MCU 17 (G. hirsutum x G. hirsutum), L389 x HAG 1055(G. hirsutum x G. hirsutum), Galama x suvin (G. hirsutum x G. barbadense) and AKH 9331 x Pima (G. hirsutum x G. barbadense) exhibited positive sca

**Table 1. Analysis of variance (mean squares) for combining ability for quality, yield and yield component characters in cotton**

| Source of variation | Degrees of freedom | Days to 50 % flowering | No. of mono-podia/plant | No. of sympo-dia/ plant | No. of Bolls/plant | Boll weight | Ginning Percent-tage | 2.5 % span length | Uniformity ratio | Micro-naire value | Bundle strength | Seed Cotton Yield/plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replications | 2 | 6.01 | 0.38 | 25.35* | 58.78 | 1.58** | 3.77 | 10.65* | 0.57 | 0.14 | 6.86* | 277.52 |
| Treatments | 38 | 17.79** | 0.54** | 18.90** | 292.22** | 2.18** | 23.66** | 25.86** | 10.48** | 0.72** | 18.11** | 754.50** |
| Parents | 10 | 8.28** | 0.33 | 14.24* | 166.28** | 1.66** | 33.65** | 15.64** | 11.30* | 0.63** | 19.68** | 1497.82** |
| Parents vs | 1 | 22.13** | 3.09** | 91.09** | 1126.79** | 3.16** | 89.32** | 126.45 | 0.04 | 3.36** | 44.13** | 1965.64** |
| Crosses | 27 | 21.15** | 0.52** | 17.96** | 307.95** | 2.33** | 17.53** | 25.91** | 10.57** | 0.66** | 16.56** | 434.34** |
| Crosses | 6 | 17.46 | 1.19* | 16.47 | 337.71 | 2.46 | 47.01** | 19.73** | 13.47** | 0.76* | 6.73 | 441.64 |
| Lines | 3 | 56.30* | 0.05 | 22.59 | 156.11 | 2.87 | 11.85 | 174.83** | 50.00** | 2.96** | 99.39** | 714.85 |
| Testers | 18 | 16.52** | 0.37** | 17.68** | 323.34** | 2.20** | 8.66** | 3.15 | 3.02 | 0.24 | 6.03** | 385.15** |
| Lines x Testers | 76 | 2.68 | 0.19 | 5.81 | 22.11 | 0.29 | 3.00 | 3.29 | 4.48 | 0.17 | 1.87 | 97.77 |
| Error Total | 116 | 7.69 | 0.31 | 10.43 | 111.23 | 0.93 | 9.78 | 10.81 | 6.38 | 0.35 | 7.27 | 316.00 |

* Significant at 5 % level, ** Significant at 1 % level

**Table 2. Estimates of general and specific combining ability variances and proportionate gene action for eleven characters in cotton**

| Character | $\sigma^2$ gca | $\sigma^2$ sca | $\sigma^2$ gca / $\sigma^2$ sca |
|---|---|---|---|
| Days to 50 % flowering | 2.07 | 4.61 | 0.45 |
| Number of monopodia per plant | 0.03 | 0.06 | 0.44 |
| Number of sympodia per plant | 0.83 | 3.96 | 0.21 |
| Number of bolls per plant | 13.62 | 100.41 | 0.14 |
| Boll weight | 0.14 | 0.64 | 0.23 |
| Ginning percentage | 1.60 | 1.89 | 0.85 |
| 2.5 % span length | 5.70 | -0.04 | -127.79 |
| Uniformity ratio | 1.65 | -0.49 | -3.39 |
| Micronaire value | 0.10 | 0.02 | 4.80 |
| Bundle strength | 3.10 | 1.39 | 2.23 |
| Seed cotton yield per plant | 29.12 | 95.79 | 0.30 |

**Table 3. General combining ability (*gca*) effects of parents for eleven characters in cotton**

| Parents | Days to 50% flowering | No. of monopodia/ plant | No. of sympodia/ plant | No. of bolls /plant | Boll weight | Ginning percentage | 2.5% span length | Unifor-mity ratio | Micro-naire value | Bundle strength | Seed cotton yield/plant |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lines | | | | | | | | | | | |
| NA 1325 | -0.32 | 0.23 | 0.38 | -2.00 | -0.74*** | 2.03*** | -0.77 | -0.04 | -0.07 | -0.32 | 5.88* |
| Galama | 1.43** | 0.44** | -0.92 | -5.54** | -0.09 | -0.94 | 2.08*** | -0.78 | -0.28* | 0.59 | -2.45 |
| L 604 | -1.57** | 0.17 | -1.51** | 1.28 | -0.06 | -0.71 | -0.06 | 0.26 | -0.12 | 0.38* | 1.65 |
| L 389 | 1.09* | -0.38** | -0.02 | -0.39 | -0.76** | -0.22 | 0.54 | -0.91 | 0.06 | -1.32** | -5.75* |
| LK861 | -1.57** | -0.39** | -0.34 | 7.70** | 0.14 | -3..16*** | -0.84 | -0.43 | -0.17 | -0.27 | 1.46 |
| CPD420 | 0.43 | 0.15 | 0.21 | 5.50** | 0.20 | 0.17 | 0.85 | -0.33 | 0.08 | -0.56 | 8.03** |
| AKH 9331 | 0.51 | 0.09 | 2.19** | -6.55** | -0.17 | 2.82*** | -1.80** | 2.22** | 0.50** | -0.13 | -8.82** |
| SE($g_i$) | 0.47 | 0.18 | 0.70 | 1.36 | 0.16 | 0.50 | 0.52 | 0.61 | 0.12 | 0.39 | 2.85 |
| Testers | | | | | | | | | | | |
| Suvin | -0.44 | 0.07 | 0.77 | 1.07 | -0.13 | -0.63 | 2.72** | -1.85*** | 0.37** | 2.06** | -2.98 |
| Pima | -1.16** | -0.05 | 0.62 | 3.33** | -0.26* | -0.67 | 2.09** | -0.67 | -0.28** | 1.68** | -6.07** |
| HAG1055 | 2.42** | -0.02 | -1.50** | -2.66* | 0.55** | 0.70 | -3.31** | 1.50** | 0.34** | -2.13** | 7.30** |
| MCU17 | -0.82* | 0.00 | 0.11 | -1.73 | -0.16 | 0.60 | -1.50** | 1.02* | 0.30** | -1.61** | 1.75 |
| SE($g_j$) | 0.36 | 0.10 | 0.53 | 1.03 | 0.12 | 0.38 | 0.40 | 0.46 | 0.09 | 0.30 | 2.16 |

**Table 4. Specific combining ability (*sca*) effects of crosses for eleven characters in cotton**

| Crosses | Days to 50% flowering | No. of monopodia/ plant | No. of sympodia/ plant | No. of bolls / plant | Boll weight | Ginning percentage | 2.5% span length | Uniformity ratio | Micro-naire value | Bundle strength | Seed cotton yield/ plant |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NA 1325 x Suvin | 0.06 | -0.23 | 0.63 | -12.37** | 0.33 | -0.49 | 0.48 | -0.13 | 0.20 | 0.89 | 11.30 |
| NA 1325 x Pima | 1.66 | -0.14 | 0.58 | 16.64** | 0.52 | -2.06* | -0.18 | 0.42 | 0.19 | -0.20 | -6.12 |
| NA 1325 x HAG 1055 | -1.92 | -0.04 | 2.90* | -13.24** | -1.09** | 0.91 | 0.57 | 0.26 | -0.54* | 0.75 | -7.79 |
| NA 1325 x MCU 17 | 0.32 | 0.41 | 1.69 | 8.96** | 0.24 | 1.65 | -0.87 | -0.54 | 0.18 | -1.44 | 2.70 |
| Galama x Suvin | -2.14* | -0.20 | -0.07 | -6.24* | 0.24 | -0.53 | 0.53 | -0.73 | -0.18 | 1.71* | -19.90** |
| Galama x Pima | -1.76 | -0.28 | 0.35 | -6.43* | -0.86** | -0.15 | -1.01 | 0.33 | -0.04 | -0.84 | 2.39 |
| Galama x HAG 1055 | 6.33** | 0.42 | -0.00 | 8.23** | 0.02 | 0.49 | -1.03 | 0.20 | 0.09 | -0.10 | -7.59 |
| Galama x MCU 17 | -2.43* | 0.06 | -0.28 | 4.43 | 0.60 | 0.19 | 1.51 | 0.24 | 0.13 | -0.78 | 25.10** |
| L 604 x Suvin | 0.52 | 0.53* | 3.98** | 3.81 | 0.35 | 0.02 | 0.27 | -0.13 | 0.38 | -1.98* | 5.27 |
| L 604 x Pima | -0.76 | -0.22 | 0.13 | 6.02* | 1.08** | 0.98 | 0.10 | -1.16 | -0.22 | -0.10 | 6.15 |
| L 604 x HAG 1055 | -2.67** | -0.18 | -1.75 | -5.19 | 0.09 | -1.07 | -0.58 | 1.62 | -0.02 | -0.85 | -3.49 |
| L 604 x MCU 17 | 2.91** | -0.14 | -2.36 | -4.65 | -1.52** | 0.06 | 1.22 | -0.37 | -0.14 | 2.93** | -7.93 |
| L 389 x Suvin | 1.52 | -0.12 | 1.10 | 8.41** | -0.73* | -0.73 | -0.69 | 0.24 | -0.08 | -0.74 | -6.20 |
| L 389 x Pima | -0.10 | -0.33 | -1.62 | 0.49 | -0.31 | -1.04 | 0.25 | 0.53 | -0.00 | -1.70* | 4.09 |
| L 389 x HAG 1055 | -0.33 | -0.16 | 2.43 | -1.45 | 0.13 | 1.38 | 0.22 | -0.70 | 0.00 | 1.71* | -0.15 |
| L 389 x MCU 17 | -1.09 | -0.05 | -1.91 | -7.45** | 0.91** | 0.39 | 0.23 | -0.07 | 0.09 | 0.73 | 2.27 |
| LK 861 x Suvin | 1.19 | -0.02 | --2.25 | -0.27 | -0.07 | 1.19 | -0.90 | 0.96 | -0.18 | -0.03 | 5.98 |
| LK 861 X Pima | 1.24 | 0.21 | 2.57 | 4.47 | 0.26 | 2.29* | -0.59 | 0.41 | 0.33 | 0.12 | 3.20 |
| LK 861 X HAG 1055 | 2.67** | -0.15 | -1.79 | -5.67* | -0.81* | -4.31** | 1.09 | -0.19 | -0.16 | 0.23 | -0.37 |
| LK 861 X MCU 17 | 0.24 | -0.08 | 1.47 | 1.46 | 0.47 | 0.83 | 0.41 | -0.18 | 0.01 | -0.32 | -8.82 |
| CPD 420 X Suvin | -1.48 | -0.29 | -1.67 | 8.60** | 0.94** | -0.64 | 0.62 | 0.52 | -0.21 | 1.01 | 0.82 |
| CPD 420 X Pima | -0.09 | -0.10 | -0.85 | -5.99** | -0.35 | -0.24 | 0.13 | 0.74 | -0.08 | 1.03 | -5.10 |

**Table 4 Contd...**

| Crosses | Days to 50% flowering | No. of Mono-podia/ plant | No. of sympodia/ plant | No. of bolls /plant | Boll weight | Ginning Percent-age | 2.5% span length | Uni-formity ratio | Micro-Naire value | Bundle strength | Seed cotton yield/ plant |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CPD 420 x HAG 1055 | 0.00 | -0.13 | 4.26** | 10.93** | 1.60** | 1.61 | 0.60 | -0.85 | 0.59* | -1.10 | 19.40** |
| CPD 420 x MCU 17 | 1.57 | 0.51* | -1.72 | 13.54** | -0.31 | -0.74 | -1.35 | -0.41 | -0.30 | -0.95 | -15.12** |
| AKH 9331 x Suvin | 0.44 | 0.28 | -1.72 | -1.95 | 0.68* | 1.17 | -0.31 | -0.73 | 0.06 | -0.87 | 2.73 |
| AKH 9331 x Pima | -0.18 | 0.20 | -1.17 | -15.21** | -0.34 | 0.20 | 1.31 | -1.31 | -0.18 | 1.68* | -4.51 |
| AKH 9331 x HAG 1055 | 1.25 | 0.24 | -0.25 | 6.38* | 0.05 | 1.01 | 0.14 | -0.30 | 0.08 | -0.65 | -0.02 |
| AKH 9331 x MCU 17 | -1.51 | 0.72** | 3.14* | 10.78** | -0.39 | -2.38* | -1.14 | 2.34 | 0.03 | -0.16 | 1.80 |
| SE (sij) | 0.95 | 0.25 | 1.39 | 2.71 | 0.31 | 1.00 | 1.05 | 1.22 | 0.24 | 0.79 | 5.71 |

* Significant at 5 % level, ** Significant at 1 % level

**Table 5. Estimation of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for days to 50% flowering, no. of monopodia per plant and no. of sympodia per plant**

| Crosses | Days to 50% flowering | | | No. of monopodia per plant | | | No. of sympodia per plant | | |
|---|---|---|---|---|---|---|---|---|---|
| | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) |
| NA 1325 x Suvin | -4.50* | -5.92* | -8.62** | 26.88 | 11.32 | 25.53 | 31.47** | 26.44* | -11.05 |
| NA 1325 x Pima | -1.22 | -1.22 | -6.90** | 30.34 | 9.43 | 23.40 | 26.25* | 18.05 | -11.86 |
| NA 1325 x HAG 1055 | -2.11 | -2.99 | -6.90** | 30.26 | 16.98 | 31.91 | -16.78 | -29.15** | -34.50** |
| NA 1325 x MCU 17 | -0.63 | -3.05 | -8.62** | 63.44** | 43.40* | 61.70** | 45.77** | 39.42** | -9.43 |
| Galama x Suvin | -7.06** | -7.60** | -9.20** | 65.00** | 65.00* | 40.43 | 12.78 | 10.70 | -19.14* |
| Galama x Pima | -6.27** | -8.19** | -9.77** | 57.89* | 50.00 | 27.66 | 10.95 | 9.75 | -18.06* |
| Galama x HAG 1055 | 13.61** | 12.28** | 10.34** | 110.26** | 105.00** | 74.47** | -13.03 | -22.16* | -28.03** |
| Galama x MCU 17 | -4.59* | -8.77** | -10.34** | 80.00** | 80.00** | 53.19* | 16.90 | 5.90 | -22.64** |
| L 604 x Suvin | -3.68 | -7.10** | -9.77** | 53.34** | 26.98 | 70.21** | 26.62** | 19.32 | -5.12 |

…………continue

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L 604 x Pima | -5.92** | -7.93** | -13.22** | 9.09 | -14.29 | 14.89 | 2.10 | -1.02 | -21.29** |
| L 604 x HAG 1055 | -3.70 | -6.59** | -10.34** | 10.89 | -11.11 | 19.15 | -27.27** | -32.36** | -37.47** |
| L 604 x MCU 17 | 4.15 | 3..82 | -6.32** | 12.62 | -7.94 | 23.40 | -4.08 | -16.27 | -33.42** |
| L 389 x Suvin | 0.60 | -0.59 | -3.45 | -15.38 | -31.25 | -6.38 | 16.65 | 7.82 | -10.78 |
| L 389 x Pima | -2.13 | -2.42 | -7.47** | 8.00 | -15.62 | 14.89 | -1.37 | -6.19 | -22.37** |
| L 389 x HAG 1055 | 3.01 | 2.40 | -1.72 | -21.57 | -37.50* | -14.89 | -2.46 | -7.15 | -14.56 |
| L 389 x MCU 17 | 0.93 | -3.64 | -8.62** | -15.38 | -31.25 | -6.38 | 4.74 | -10.10 | -25.61** |
| LK 861 x Suvin | -4.79* | -5.92* | -8.62** | 20.00 | 20.00 | 2.13 | 4.56 | 3.37 | -25.61** |
| LK 861 x Pima | 4.56* | -4.85 | -9.77** | 31.58 | 25.00 | 6.38 | 27.21** | 24.91* | -6.74 |
| LK 861 x HAG 1055 | -6.02** | -6.59** | -10.34** | 2.56 | 0.00 | -14.89 | -18.36* | -27.41** | -32.88** |
| LK 861 x MCU 17 | -3.43 | -6.06* | -10.92** | 7.50 | 7.50 | -8.51 | 32.24** | 20.60 | -13.21 |

**Table 5 Contd...**

| Crosses | Days to 50% flowering | | | No. of monopodia per plant | | | No. of sympodia per plant | | |
|---|---|---|---|---|---|---|---|---|---|
| | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) |
| CPD 420 x Suvin | -7.31** | -7.65** | -9.77* | 2.22 | -8.00 | -2.13 | 11.20 | 10.15 | 21.02* |
| CPD 420 x Pima | -4.79* | -6.47** | -8.62** | 11.63 | -4.00 | 2.13 | 11.60 | 9.39 | -18.33* |
| CPD 420 x HAG 1055 | 0.89 | 0.00 | -2.30 | 9.09 | -4.00 | 2.13 | 14.29 | 1.46 | -6.20 |
| CPD 420 x MCU 17 | 1.23 | -2.94 | -5.17* | 51.11* | 36.00 | 44.68 | 16.05 | 6.02 | -23.99** |
| AKH 9331 x Suvin | -0.91 | -3.55 | -6.32** | 68.67** | 62.79* | 48.98* | 22.43* | 21.51 | -13.21 |
| AKH 9331 x Pima | -1.85 | -3.05 | -8.62** | 62.03* | 48.84 | 36.17 | 21.03* | 18.41 | -11.59 |
| AKH 9331 x HAG 1055 | 6.42** | 4.19 | 0.00 | 62.96** | 53.49* | 40.43 | 1.97 | -9.62 | -16.44* |
| AKH 9331 x MCU 17 | -1.27 | -2.50 | -10.34** | -8.43 | -11.63 | -19.15 | 58.67** | 45.28** | 3.77 |

* Significant at 5 % level, ** Significant at 1 % level

**Table 6. Estimation of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for no. of bolls per plant, boll weight and ginning percentage**

| Crosses | No. of bolls per plant | | | Boll weight | | | Ginning percentage | | |
|---|---|---|---|---|---|---|---|---|---|
| | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) |
| NA 1325 x Suvin | -2.62 | -17.44 | -14.06 | 39.45** | 26.49** | 35.21** | 3.68 | -1.61 | -4.06 |
| NA 1325 x Pima | 71.07** | 62.74** | 69.40** | 30.79** | 27.73** | 36.53** | -1.26 | -6.31 | -8.64* |
| NA 1325 x HAG 1055 | -35.56** | -40.86** | -26.33* | 13.08 | 12.62 | 21.37* | 8.06* | 6.40 | 3.75 |
| NA 1325 x MCU 17 | 44.13** | 30.09** | 35.41** | 15.40* | 7.54 | 33.08** | 19.37** | 8.26 | 5.57 |
| Galama x Suvin | 10.13 | -3.51 | -7.12 | -22.67** | 12.02 | 17.98* | 0.93 | -0.22 | -12.65** |
| Galama x Pima | 3.46 | 2.22 | -1.60 | -8.44 | -9.93 | -5.14 | 2.06 | 0.90 | -11.66** |
| Galama x HAG 1055 | 10.07 | -2.43 | 21.53* | 18.85** | 17.50* | 26.63** | 4.49 | -0.45 | -5.92 |
| Galama x MCU 17 | 26.48** | 18.30 | 13.88 | 8.42 | 0.35 | 24.19** | 12.68** | 8.60 | -7.08 |
| L 604 x Suvin | 28.63** | -2.88 | 37.90** | 19.12** | 4.45 | 20.61* | 0.23 | -1.79 | -10.41* |
| L 604 x Pima | 27.00** | 5.51 | 49.82** | 21.36** | 14.22 | 31.89** | 3.18 | 1.11 | -7.77 |
| L 604 x HAG 1055 | -22.03** | -26.82** | 3.91 | 15.18* | 11.34 | 28.57** | -2.80 | -4.49 | -9.14* |
| L 604 x MCU 17 | -4.49 | -24.06** | 7.83 | 28.92** | -31.29** | -14.97 | 9.28* | 2.19 | -6.79 |
| L 389 x Suvin | 51.11** | 20.97* | 45.73** | -2.83 | -5.69 | -12.78 | 11.12* | 1.47 | -11.17* |
| L 389 x Pima | 21.83* | 8.42 | 30.60** | -4.58 | -8.98 | -7.27 | 9.89* | 0.35 | -12.15** |
| L 389 x HAG 1055 | -10.68 | -12.14 | 9.43 | 15.89* | 7.67 | 16.04 | 18.27** | 4.40 | -1.34 |
| L 389 x MCU 17 | -6.10 | -20.38* | -4.09 | 8.55 | -5.16 | 17.36* | 25.95** | 20.38** | -4.45 |
| LK 861 x Suvin | 58.98** | 32.35** | 44.13** | 14.39* | -1.71 | 19.05* | 7.01 | -1.85 | -14.08** |
| LK 861 x Pima | 60.53** | 49.51** | 62.81** | 7.95 | -0.62 | 20.36* | 10.81* | 1.63 | -11.02** |
| LK 861 x HAG 1055 | 2.59 | -3.86 | 19.75 | 0.85 | -4.71 | 15.41 | -11.67** | -21.71** | 26.01** |
| LK 861 x MCU 17 | 46.63** | 29.74** | 41.28** | 3.07 | 1.97 | 26.19** | 16.01** | 11.38* | -11.60** |

**Table 6. Contd…**

| Crosses | No. of bolls per plant | | | Boll weight | | | Ginning percentage | | |
|---|---|---|---|---|---|---|---|---|---|
| | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) |
| CPD 420 x Suvin | 92.39** | 68.83** | 61.92** | -6.61 | -22.03** | 1.32 | -2.49 | -7.47 | -9.78* |
| CPD 420 x Pima | 35.90** | 34.51** | 29.00** | -5.14 | -15.38* | 9.96 | -1.36 | -6.40 | -8.74* |
| CPD 420 x HAG 1055 | 43.50** | 27.00** | 58.19** | 36.22** | 24.59** | 61.90** | 4.63 | 3.20 | 0.45 |
| CPD 420 x MCU 17 | 6.14 | -0.56 | -4.63 | -11.19 | -13.31* | 12.66 | 5.67 | -4.16 | -6.56 |
| AKH 9331 x Suvin | 24.27* | 11.52 | -1.60 | 16.67* | -1.63 | 24.75** | 10.02** | 3.34 | 2.97 |
| AKH 9331 x Pima | -21.92* | -23.11* | -27.76** | -9.81 | -18.68** | 3.13 | 6.96 | 0.47 | 0.10 |
| AKH 9331 x HAG 1055 | 5.61 | -8.57 | 13.88 | 7.21 | -0.84 | 25.75** | 9.52* | 6.70 | 6.31 |
| AKH 9331 x MCU 17 | 46.49** | 40.62** | 28.11** | -16.98** | -17.98** | 4.01 | 7.64 | -3.30 | -3.65 |

*Significant at 5 % level, ** Significant at 1 % level

**Table 7. Estimation of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for ginning percentage, 2.5% span length and uniformity ratio**

| Crosses | 2.5% span length | | | Uniformity ratio | | | Micronaire value | | |
|---|---|---|---|---|---|---|---|---|---|
| | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) |
| NA 1325 x Suvin | 22.78** | 20.56** | 6.60 | -0.57 | -2.81 | -0.40 | -18.06* | -27.10** | -13.04 |
| NA 1325 x Pima | 10.37* | 5.29 | 2.53 | 1.37 | -2.70 | 3.54 | -19.06** | -25.33** | -10.93 |
| NA 1325 x HAG 1055 | -5.52 | -10.03* | -12.04 | 7.37* | 4.47 | 8.08* | -22.87** | -28.51** | -14.71 |
| NA 1325 x MCU 17 | -0.80 | -2.33 | 10.89 | 1.42 | -4.01 | 5.20 | -6.26 | -12.63 | 4.23 |
| Galama x Suvin | 23.66 | 13.52 | 15.72** | -3.74 | -5.76 | -3.43 | -19.46* | -23.13* | -28.55** |
| Galama x Pima | 9.25* | 6.80** | 8.87 | -0.63 | -4.48 | 1.60 | -16.81* | -24.12** | -22.38* |
| Galama x HAG 1055 | 7.09 | 9.87* | 8.13 | 5.33 | 2.64 | 6.19 | 4.30 | 4.58 | 2.82 |
| Galama x MCU 17 | 9.25* | 3.52 | 5.52 | 1.35 | -3.94 | 5.28 | 3.71 | -5.64 | -2.73 |
| L 604 x Suvin | 23.92** | 21.05* | 8.18 | -4.34 | -6.43 | 0.28 | -7.99 | -12.62 | -9.69 |
| L 604 x Pima | 13.15** | 8.50 | 5.65 | -5.67 | -6.01* | 0.73 | -25.11** | -25.49** | -23.00* |
| L 604 x HAG 1055 | -10.82** | -14.65** | -16.56** | 6.22 | 4.38 | 11.87** | -3.91 | -4.60 | -1.41 |
| L 604 x MCU 17 | 8.40 | 7.29 | -2.11 | -1.96 | -3.04 | 6.26 | -8.49 | -8.61 | -5.55 |
| L 389 x Suvin | 14.88** | 5.85 | 7.03 | -3.38 | -3.92 | -1.54 | -11.50 | -12.00 | -17.27 |
| L 389 x Pima | 8.82* | 6.81 | 7.99 | -2.01 | -4.34 | 1.80 | -11.13 | -14.73 | -12.78 |
| L 389 x HAG 1055 | -8.53* | -10.04* | -9.05 | 1.48 | 0.44 | 3.92 | 5.98 | 1.90 | 3.79 |
| L 389 x MCU 17 | 0.49 | -4.42 | -3.36 | -1.11 | -4.84 | 4.29 | 6.66 | 1.97 | 5.11 |
| LK 861 x Suvin | 16.72** | 13.83** | 2.06 | -4.40 | -7.35* | 1.19 | -25.16** | -29.54** | -25.81** |
| LK 861 x Pima | 8.04 | 3.76 | 1.04 | -4.81 | -6.03 | 2.63 | 13.33 | -14.56 | -10.04 |
| LK 861 x HAG 1055 | -4.62 | -8.58 | -10.61* | -0.14 | -2.77 | 6.19 | -9.74 | -11.21 | -6.52 |
| LK 861 x MCU 17 | 2.71 | 1.82 | -7.10 | -5.99 | -6.15 | 2.86 | -6.98 | -7.98 | -3.08 |

**Table 7. Contd…**

| Crosses | 2.5% span length | | | Uniformity ratio | | | Micronaire value | | |
|---|---|---|---|---|---|---|---|---|---|
| | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) |
| CPD 420 x Suvin | 29.10** | 26.73** | 12.12* | -1.60 | -2.00 | 0.43 | -16.74* | -19.36* | -20.00* |
| CPD 420 x Pima | 16.84** | 11.50 | 8.58 | -0.40 | -2.63 | 3.61 | -14.74 | -16.02 | -14.10 |
| CPD 420 x HAG 1055 | 0.01 | -4.75 | -6.87 | 2.29 | 1.39 | 4.90 | 19.19* | 17.65* | 19.82* |
| CPD 420 x MCU 17 | 3.14 | 1.58 | -7.32 | -0.74 | -4.34 | 4.84 | -5.84 | -7.61 | -4.76 |
| AKH 9331 x Suvin | 23.37** | 18.41** | 0.91 | -2.60 | -5.86 | 3.39 | -11.37 | -23.68** | -1.76 |
| AKH 9331 x Pima | 18.32** | 6.77 | 3.96 | -3.12 | -4.62 | 4.75 | -18.31** | -26.69** | -5.64 |
| AKH 9331 x HAG 1055 | -5.31 | -14.71** | -16.61** | 4.97 | 1.93 | 11.94** | 2.03 | -8.62 | 17.62 |
| AKH 9331 x MCU 17 | 0.27 | -6.80 | -14.97** | 6.52* | 6.41 | 16.87** | -0.57 | -10.47 | 15.24 |

* Significant at 5 % level, ** Significant at 1 % level

**Table 8. Estimation of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for bundle strength and seed cotton yield per plant**

| Crosses | Bundle strength | | | Seed cotton yield per plant | | |
|---|---|---|---|---|---|---|
| | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) |
| NA 1325 x Suvin | 15.03** | 1.58 | 22.69** | 11.51 | -11.02 | 5.04 |
| NA 1325 x Pima | 5.87 | -8.53* | 16.25** | -7.56 | 25.67** | -12.26 |
| NA 1325 x HAG 1055 | 8.17 | 4.58 | 3.66 | -14.93** | -17.28** | -2.35 |
| NA 1325 x MCU 17 | -1.94 | -7.32 | -3.66 | -12.95* | -13.77* | 1.79 |
| Galama x Suvin | 16.80** | 7.88 | 30.31** | 25.70** | -41.62** | -28.15** |
| Galama x Pima | 2.36 | -7.60 | 17.42** | -9.72 | -28.53** | -12.03 |
| Galama x HAG 1055 | 3.20 | 1.57 | 3.95 | -22.57** | -26.21** | -9.18 |
| Galama x MCU 17 | 0.07 | -0.70 | 3.22 | -4.90 | -7.70 | 13.60* |
| L 604 x Suvin | 0.38 | -4.48 | 15.37** | 5.69 | -14.00* | -3.58 |
| L 604 x Pima | 3.29 | -4.03 | 21.96** | 2.84 | -15.65* | -5.43 |
| L 604 x HAG 1055 | -2.11 | -6.58 | 1.90 | -12.62* | -12.85* | -2.29 |
| L 604 x MCU 17 | 13.40** | 10.74* | 20.79** | -12.64** | -22.90** | -10.69 |
| L 389 x Suvin | -4.29 | -8.00 | 11.13* | 6.47 | -0.05 | -19.42** |
| L 389 x Pima | -11.72** | 17.17** | 5.27 | 13.37 | 6.91 | -13.37 |
| L 389 x HAG 1055 | -1.67 | -7.10 | 3.51 | -2.06 | -15.45* | -5.71 |
| L 389 x MCU 17 | -5.78 | -8.94* | 1.46 | -6.88 | -20.87** | -8.34 |
| LK 861 x Suvin | 7.05 | -1.58 | 18.89** | 10.82 | -7.28 | -3.13 |
| LK 861 x Pima | 3.21 | -7.26 | 17.86** | 4.32 | -12.00 | -8.06 |
| LK 861 x HAG 1055 | 1.39 | 0.29 | 1.61 | -7.25 | -10.19 | 0.17 |
| LK 861 x MCU 17 | -1.14 | -2.39 | 1.46 | -19.74** | -23.67** | -11.58 |

**Table 8. Contd…**

| Crosses | Bundle strength | | | Seed cotton yield per plant | | |
|---|---|---|---|---|---|---|
| | MP | BP | SH(NHH44) | MP | BP | SH(NHH44) |
| CPD 420 x Suvin | 15.81** | 5.21 | 27.09** | 10.92 | -7.89 | -1.96 |
| CPD 420 x Pima | 11.15** | -1.27 | 25.48** | 1.54 | -14.98* | -9.51 |
| CPD 420 x HAG 1055 | 0.52 | 0.30 | -0.59 | 12.20* | 9.63 | 22.27** |
| CPD 420 x MCU 17 | 1.01 | -1.55 | 2.34 | -20.24** | -23.48** | 11.36 |
| AKH 9331 x Suvin | 9.78* | -4.12 | 15.81** | 4.23 | -8.78 | -14.49* |
| AKH 9331 x Pima | 15.36** | -1.38 | 25.33** | -7.17 | -18.03* | -23.17** |
| AKH 9331 x HAG 1055 | 3.94 | -0.74 | -1.61 | -10.52 | -17.66** | -8.17 |
| AKH 9331 x MCU 17 | 5.88 | -1.13 | 2.78 | 15.35** | -23.43** | -11.30 |

* Significant at 5 % level, ** Significant at 1 % level

effects for bundle strength. Significant heterosis in desired direction was observed in many crosses for various traits under study. The estimates of heterosis were presented in Tables 5, 6, 7 & 8. The interspecific crosses Galama x Suvin exhibited significant heterosis for yield and bundle strength was also found to be early.

The intra specific cross CPD 420 X HAG 1055 recorded high heterotic values for yield and its important component characters. Negative heterosis values obtained in interspecific crosses for micronaire value and in interspecific crosses for seed cotton yield per plant. The interspecific crosses NA 1325 x Suvin, Galama x Suvin, NA1325x Pima, AKH 9331 x Pima, L 604 x Pima AND Galama x Pima exhibited high negative heterosis for micronaire value. The intra specific crosses NA 1325 x HAG 1055, NA 1325 x MCU 17, Galama x HAG 1055, L 604 x HAG 1055, LK 861 x MCU 17, CPD 420 x MCU 17, and AKH 9331 x MCU 17 exhibited significant heterosis for yield along with one or more fibre quality traits. Significant positive heterosis over mid parent was reported by Ganapathy *et al.* (2005), Soomro *et al.* (2006) and Natera *et al.* (2007). While positive heterosis over better parent was reported by Tuteja *et al.* (2004). Whereas standard heterosis for seed cotton yield was reported by many workers *viz.,* Maisuria *et al.* (2006), Soomro *et al.* (2006) and Natera *et al.* (2007).

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