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Study on Heterosis and Combining ability in Interspecific Hybrids of Cotton (*G. hirsutum* x *G. barbadense*)

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ABSTRACT

Exploitation of heterosis is common practice in both self and cross pollinated crops. The development of superior and high yielding hybrids are essential due to increasing demand of natural fibre products for which superior quality parameters like fibre length, strength, elongation, micronnaire and uniformity ratio determines the spinnability in the modern mills. This study sought to harness the expression of hybrid vigour from 48 interspecific F_1 hybrids and to prescribe good combiners amongst eight hirsutum and six babadense parents in a Line x Tester fashion. Highly significant differences among genotypes, F_1 hybrids and parents were observed in all the characters and some quality parameters. Seed cotton yield per plant varied between 112.29g to 230.74g and hybrid TCH1819 X TCB37 gave the highest yield per plant of 230.74g. Highly significant positive heterobeltiosis and standard heterosis were exploited for seed cotton yield in all the hybrids, however, MCU7 X TCB209, MCU7 X DB3, TCH1777 X TCB26 and MCU9 X CCB36 were identified for best heterotic effect in seed cotton yield for both heterobeltiosis and standard heterosis. MCU9 X SUVIN and TCH1716 X CCB36 displayed the best heterosis in Micronnaire. TCH1819 and TCB37 showed best Line and Tester combiners respectively having the highest positive gca for seed cotton yield and micronnaire. TCH1819 X TCB37 and TCH1777 X TCB26 also were identified as the best sca for both yield and quality which can be exploited by selection

Key words: *Cotton, Heterosis, Combining ability, Interspecific, Hybrids.*

INTRODUCTION

Cotton is a natural fibre and industrial crop often referred to as "white Gold". Its importance to farm family and industry is immense, it plays a vital role in economic, political and social affairs of most countries of the world. The cultivated species are the Asiatic diploids (*G. arboreum* and *G. herbaceum* having 2n= 26) and allotetraploids (*G. hirsutum* and *G. barbadense* having 2n = 4x = 52). While *G. barbadense* is valued for its good fibre quality properties, the upland cotton *G. hirsutum* is treasured for its high yielding ability. The two genomes can be hybridized, however due to continuous and repeated incorporation of genes and subsequent selection from the same breeding stock, it resulted in poor agronomic qualities in the progeny, disruption of segregation, sterility and limited recombination due to erosion of genetic diversity.

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In lieu of the aforementioned, several breeding efforts to improve yield per hectare, adaptation to several environmental conditions, higher fertilizer doses tolerance and fibre quality properties have proved successful, however, heterosis breeding is yet to be fully exploited especially in interspecific hybrids. Heterosis is also referred to as hybrid vigour, according to Kaeppler[5], it has been observed and harnessed in many diverse systems. Kalhoro *et al*.[6] has reported succinct exploitation of heterosis in hexaploid wheat population. This phenomenon has also been reported in inter-specific and intra-specific hybridization in both diploid and tetraploid cotton[3]. Its manifestation is viewed to be largely dependent on the genetic diversity of parental lines[1]. Hence, more heterosis is expected from interspecific hybrids than in intra-specific hybrids. According to Madic *et al*.[8] and Singh *et al*.[12], general and specific combining ability effects on character performances are vital in designing different stages of breeding program. For instance, selection of pure lines of high general combining ability that indicate additive gene effects has proved to be important in predicting progenies and deciding on cross combination. They help plant breeders to select parents with good and desirable genes that can be transferred to the offspring. This experiment therefore was designed to estimate the mean performance, heterosis and good parental combinations in yield and quality traits of interspecific F_1 hybrids of cultivated cotton.

MATERIALS AND METHODS

The Study Location

The experiment was conducted in the research field of the Department of Cotton, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore during the summer season of 2016. Coimbatore has a mean maximum and minimum temperature during summer and winter which vary between 35 ^{0}C to 18 ^{0}C. The town has an annual rainfall of 700mm with the northeast and southwest monsoons contributing to 47% and 28% respectively to the total rainfall.

Experimental Design

This genetic study was conducted with 48 hybrids along with their 14 parents and a check hybrid DCH 32. Eight *G. hirsutum* genotypes (MCU13, SVPR4, KC3, TCH1777, MCU9, TCH1716, MCU7 and TCH1819) and six *G. barbadense* genotypes (TCB26, TCB37, TCB209, CCB36, DB3, SUVIN) with varying agronomic and morphological characters were crossed in a Line x Tester design to generate 48 hybrids during the *Kharif*, 2015. The materials were planted out in a Randomized Block Design with two replications. Two rows of each parents and hybrids were planted at a spacing of 90cm between rows and 60cm between plants in February 2016. Standard procedure was adhered to in the basic agronomic practices like irrigation, soil conditioning, fertilizer application, weed and pest control. Observations were recorded from five randomly selected plants in each entry and in each replications for the traits *viz*., seed cotton yield (g), plant height (cm), number of bolls per plant, number of sympodia branches per plant, number of monopodia branches per plant, boll weight (g), number of seeds per boll, ginning percentage, lint index, seed index, 2.5% span length (mm), fibre strength, fibre finness (micronaire), bundle strength, elongation percentage and uniformity ratio. Seed cotton obtained was pooled from the sampled plants, ginned and the lint obtained was evaluated for fibre quality characters estimation using High Volume Instrument 900 classic.

Statistical Analysis

The mean data obtained from F_1 hybrids, parents and check were subjected to statistical analysis. Analysis of variance (ANOVA), heterosis of hybrids, combining ability of parents and hybrids were done using the AGRISTAT statistical analyses software. The Line x Tester design was adapted because the results obtained are believed to have high level of precision.

Heterosis Analysis

Estimation of heterosis over mid parent (Relative) better parent (Heteobeltiosis) and the standard hybrid value (Standard heterosis) were worked out in percent deviation of the mean as follows;

Relative heterosis = (F_1 – MP/MP) x 100;
Heterobeltiosis = (F_1 – BP/BP) x 100;
Standard Heterosis = (F_1 – SP/SP) x 100

Where;

F_1 = Mean of the F_1 Hybrid
MP = Mean of mid parent
BP = Mean of Better parent
SP = Mean of standard hybrid (DCH32)

The significance was subjected to test according to the formulae suggested by Turner[13].

Combining Ability Analysis

The general and specific combining ability effects of the parents and hybrids respectively were assessed by line × tester analysis according to the method outlined by Kempthorne[7].

RESULTS AND DISCUSSION

Evaluation of 48 F_1 hybrids from the possible cross combinations of 8 Lines and 6 Testers in cultivated cotton was carried out by analysis of variance (ANOVA), heterobeltiosis, standard heterosis, general combining ability (*gca*), specific combining ability (*sca*) using different yield and quality characteristics. ANOVA results are presented in Table 1, Mean and *per se* performances are shown in Tables 2 and 3 respectively, heterosis is in Table 4, while *gca* and *sca* are shown in Tables 5 and 6 respectively.

ANOVA

For various characters, ANOVA indicated highly significant differences among genotypes, F_1 hybrids and parents. To indicate the expression of parental variability in their hybrids, the mean square was further partitioned into lines, testers and their interaction, their variance showed significant for majority of the characters.

Mean performance, coefficient of variation and range of eighteen characters studied (Table 2), number of bolls per plant showed the maximum variability of 18.65% followed by 17.4% of seed cotton yield per plant. The least variability of 3.08% was recorded by days to first bursting.

According to *per se* performance Table, the range of seed cotton yield per plant varied between 112.29g to 230.74g. Cross combination TCH1819 x TCB37 gave the highest yield per plant of 230.74g followed by TCH1777 x TCB37 with 185.53g. The F_1 hybrid MCU13 x CCB36 was ranked least in terms of cotton yield per plant, SVPR4 X CCB36 recorded least value of 14.55 for number of seeds per boll, KC3 x CCB36 gave the least seed Index of 5.85 and KC3 x TCB209 had the least Lint Index of 2.35. The cross combinations KC3 x TCB209 (25.02%), SVPR4 x SUVIN (2.22g), TCH1819 x SUVIN (1.5), TCH1819 x SUVIN (13.4), TCH1716 x TCB209 (32.4) and KC3 x TCB209 (78.75) as indicated showed the least performance in Ginning outturn, Boll weight, number of monopodia branches, number of sympodia branches, number of bolls per plant and plant height respectively. Also, the cross combination SVPR4 x DB3 recorded the highest plant height of 155.5cm followed by MCU9 x CCB36 (153.1cm) and SVPR4 x TCB209 (152.5). The hybrids SVPR4 x TCB209 (4.32), MCU13 x CCB36 (27.2), SVPR4 x SUVIN (41.26), MCU7 x DB3 (5.11) and MCU7 x TCB209 (11.09) recorded the highest value for boll weight, number of sympodia, ginning outturn, lint index and seed index respectively. Amongst the cotton quality parameters 2.5% span length, uniformity ratio, bundle strength, elongation ratio and fibre fineness the hybrids; TCH1716 x CCB36 (39), MCU13 x CCB36 (60.1), TCH1777 x TCB209 (29.6), TCH1819 x TCB209 (8.6), TCH1819 x TCB37 (4.7) recorded the highest values respectively among the other cross combinations.

As stated above, the mean sum of squares for the F_1 hybrids was further partitioned into Lines, Testers and their

interactions. The variance due to interaction showed significant in all the parameters except plant height, 2.5% span length, elongation percentage and fibre fineness. The parents as indicated in Table 4, possess good general combining ability suitable for selection in breeding program. Determination for the seed cotton yield on the performance of the parents over the F_1 hybrids, the male parents TCB37 and DB3 were found to be the best general combiners. Their general combining ability value was highly significant not only in seed cotton yield but also in ginning outturn. The potential female parents identified as good general combiners for seed cotton yield are MCU9, TCH1819, and TCH1777. They also showed great potential in plant height, number of bolls/plant and ginning outturn. Hence, these identified testers and lines can be very helpful for improvement of different yield and quality parameters. Hussain *et al*. (2010), reporting on upland cotton stated that Genetic analysis revealed highly significant effects due to general as well as specific combining ability ($P \leq 0.01$) for all the fiber quality characters. However, in F_1 interspecific hybrids, the general and specific combining ability did not show highly significant for all the fibre quality parameters except for elongation percentage, also MCU13 and TCH1819 showed high significant for general combining ability amongst the upland parents for quality parameters. All the hybrids demonstrated positive and high significant values in specific combining ability for seed cotton yield except TCH1819 x TCB209.

Heterosis

Several reports abound on the expression of heterosis in intra specific crosses. Baloch *et al.*[2] reported over 100% relative heterosis and over 80% heterobeltiosis for bolls per plant and seed cotton yield. Shakeel *et al*.[11], Rajamani *et al*.[10] and Pathak and Parkash Kumar[9] also reported several levels of heterosis and standard heterosis for several intraspecific (intra *hirsutum*) F_1 hybrids. For the interspecific hybrids, highly significant positive heterobeltiosis and standard heterosis was exploited for seed cotton yield in all the crosses. This confirms the high significant value of Specific combining ability for all the crosses in the seed cotton yield. The maximum heterobeltiosis and standard heterosis for seed cotton yield were exploited in the crosses MCU7 x DB3 and TCH1777 x TCB26 respectively. Number of bolls/plant and number of monopodia branches/plant showed desirable standard heterosis by all the F_1 hybrids and they were all significant. Similar result was reported by Rajamani *et al.*[10] in intraspecific *hirsutum* hybrid. Standard heterosis as high as 132.93% by MCU7 x TCB209 and 163.64% by SVPR4 x SUVIN were recorded for Number of bolls/plant and Number of monopodia branches/plant respectively. Fibre fineness showed no desirable heterosis effects in the entire cross combinations, however, all the F_1 hybrids had highly significant positive *sca* effect for seed cotton yield.

The results however showed great potential and opportunity to develop useful interspecific hybrids with desirable cross combinations for cotton yield and yield components. Hybrids identified as the best cross combinations for high *per se* and *sca* include TCH1819 X TCB37, TCH1777 X TCB37, TCH1777 x TCB26, TCH1819 x DB3, TCH1819 x CCB36, MCU7 x DB3, MCU 7 x TCB26, MCU7 x TCB209 MCU9 x SUVIN MCU9 x DB3, MCU9 x CCB26 and MCU9 x TCB26. Among them, TCH 1777 x TCB 26 demonstrated great potential in heterosis and also for *sca*. All these hybrids can be further evaluated for their stability and can be released for commercial cultivation. These hybrids definitely increase the extra-long cotton production in India. The parents MCU9, TCH1819, TCH1777 and TCB 37 are identified for good *per se* performance and general combining ability.

Table 1: Mean Squares for different yield and quality parameters

Sources of variation	d.f	Plant height	Number of bolls/plant	Number of sympodia/plant	Number of monopodia/ plant	Boll weight	Ginning outturn	Lint index	Seed index	2.5% Span length	Elongation %	Micronaire	Number of seeds /boll	Seed cotton yield/plant
Replication	1	591.26	0.57	43.15**	0.0007	0.04	22.85	0.28	1.09	4.3	1.28	0.00	32.01	0.00
GENO	61	746.75	289.43**	17.02**	0.46**	0.48**	25.76**	0.72**	3.17**	22.45	1.20	0.81**	17.94**	1978.32**
Crosses	47	657.03	150.99**	14.03**	0.19**	0.48**	24.33**	0.67**	2.96**	6	1.17	0.37**	18.28**	1143.33**
Lines	7	1786.99**	186.5**	29.21**	0.3**	0.29	31.1**	0.85**	5.95**	11.99	3.95**	0.55*	13.83	1416.30**
Testers	5	918.86**	172.85**	13.07**	0.1	0.95**	30.94**	1.06**	4.12**	6.48	1.31	0.33	44.38**	823.60**
LXT	35	393.64	140.76**	11.14**	0.18**	0.45**	22.04**	0.58**	2.19**	4.74	0.59	0.34	15.44*	1134.41**
Parents	13	319.63*	31.13**	16.27**	0.3**	0.44**	32.91**	0.73**	1.93**	30.27	1.38*	1.10	14.44*	784.49**
Cross vs Parent	1	10516.31**	10153.9905**	166.89**	15.13**	0.79	0.14	2.88**	29.54**	693.86**	0.42	17.71**	47.33*	56742.55**
Error	61	185.19	2.85	3.19	0.04	0.22	6.1	0.14	0.56	37.21	0.66	0.19	7.43	0.52

Table 2: Mean performance, Coefficient of Variation and Range for various characters of Interspecific F_1 Hybrids

Traits	Mean	SE (D)	Range	CV
Days to flowering	50.25	0.27	47 - 53.5	3.70
Days to 50% flowering	56.94	0.25	54 - 61.6	3.08
Days to first bursting	92.59	0.61	87.5 - 105	4.60
Plant height	125.04	2.62	78.75 - 155.5	14.50
Number of bolls/plant	46.60	1.25	32.4 - 58.7	18.65
Number of sympodia/plant	19.68	0.38	13.4 - 27.2	13.46
Number of monopodia/plant	2.36	0.04	1.5 - 3	13.05
Boll weight	3.06	0.07	2.22 - 4.32	16.03
Ginning outturn	29.90	0.50	25.02 - 41.26	11.67
Lint index	3.53	0.08	2.35 - 5.11	16.41
Seed index	8.45	0.18	5.85 - 11.09	14.40
2.5% Span length	36.02	0.25	29.9 - 39	4.81
Uniformity ratio	46.82	0.42	42.2 - 60.1	6.22
Bundle strength	25.53	0.26	22 - 29.6	7.06
Elongation %	5.95	0.11	4.3 - 8.6	12.85
Micronaire	3.31	0.06	2.2 - 4.7	13.00
Number of seeds/boll	20.76	0.44	14.55 - 28.1	14.57
Seed cotton yield/plant	137.42	3.45	112.29 - 230.74	17.40

Table 3: *Per se* performance of 48 Interspecific F_1 Hybrids for seed cotton yield and some Quality Parameters

Crosses	Plant height	Number of bolls/plant	Number of sympodia/ plant	Number of monopodia/ plant	Boll weight	Ginning outturn	Lint index	Seedindex	2.5% Span length	Uniformity ratio	Bundle strength	Elongation %	Micronaire	Number of sees/boll	Seed cotton yield/plant
MCU13 X TCB26	136	58.7	21.6	2.6	2.9	31.4	4.75	8.63	36.9	47.5	27.1	6.3	3.4	18.55	116.96
MCU13 X TCB37	102	38.4	17.6	2.6	2.59	29.15	2.99	7.25	33.85	42.4	26.3	6.3	3.3	20.65	134.68
MCU13 X TCB209	134.5	51.7	23.8	2.6	3.2	30.74	3.49	7.83	29.9	51.3	26.9	6.9	3.6	23.6	133.97
MCU13 X CCB36	140.9	57.6	27.2	2.1	3.11	32.63	4.48	9.24	35.9	60.1	24	6.9	3.8	17.5	121.04
MCU13 X DB3	135.5	32.6	19.4	2.3	3.3	29.85	3.44	8.11	34.7	44.9	24.1	6.7	3.2	22.35	112.28
MCU13 X SUVIN	117	55.4	18.9	2.4	2.67	37.99	2.95	6.15	36.1	47.3	25.6	7.3	3.1	23.65	114.26
SVPR4 X TCB26	147.5	51.3	21.8	2.4	3.42	35.27	3.59	8.16	36.9	42.3	26.7	6.1	3	21.7	119.46
SVPR4 X TCB37	140	57.4	23.4	2.3	3.36	26.4	3.56	9.87	36.2	45.7	24.6	5.9	3.4	21	134.39
SVPR4 X TCB209	152.5	58	21.8	2.3	4.32	29.12	3.34	9.2	36.7	47.1	27.3	5.8	3.5	28.1	124.42
SVPR4 X CCB36	131.5	46.9	17.6	2.8	2.33	28.73	3.33	8.26	35.2	47.9	27	5.8	3	14.55	117.86
SVPR4 X DB3	155.5	36.7	21.6	2	3.83	33.9	3.3	7.65	36.4	42.7	23.4	6.2	3.1	26.25	155.59
SVPR4 X SUVIN	119.17	44.8	20.3	2.9	2.22	41.26	4.03	7.15	36.7	46.4	26.2	5.3	3.2	16.6	151.21
KC3 X TCB26	135	58.2	21.3	2.2	3.23	29.88	3.89	9.18	36.8	44.8	24.8	5.7	3.5	20.55	115.45
KC3 X TCB37	97	41.9	16.9	2.3	2.3	30.46	2.96	6.76	34.1	42.2	24	5.5	3.7	16.35	113.31
KC3 X TCB209	78.75	33.5	15	3	3.31	25.02	2.35	7.05	38.9	44.4	24.3	5.5	2.7	22.9	132.82
KC3 X CCB36	91.5	35.1	15.3	1.8	2.22	30.26	2.51	5.85	36.6	47.3	26.4	5.3	2.7	18.85	132.71
KC3 X DB3	118	34.1	18.5	2.8	2.82	28.37	2.94	6.66	34.8	49.1	23.9	6.4	2.9	21.85	133.24
KC3 X SUVIN	121	40.7	18.7	2.3	3.6	29.63	3.36	8.05	33.3	44.4	22.9	5.4	3.3	24.85	133.36
TCH1777 X TCB26	125.7	46.3	19.8	2.4	4	27.98	4.04	10.54	36.5	50.1	26.9	6.2	3.7	23.05	180.71
TCH1777 X TCB37	137	58.2	22.3	2.5	2.75	26.76	3.19	8.72	36.1	47.9	23.8	6.2	2.9	17.85	185.53
TCH1777 X TCB209	133	51.1	20.8	3	2.86	25.33	3.2	9.39	35.9	47.4	29.6	6	3.2	20.4	117.62
TCH1777 X CCB36	143.5	44.6	20.1	2.5	2.77	27.21	3.86	10.24	37.4	46.5	25.6	5.2	4	16.6	127.47
TCH1777 X DB3	139	51.7	20.8	2.2	3.32	32.71	4.2	9.72	37.6	46.6	23.3	5.5	3.5	24.2	116.64
TCH1777 X SUVIN	146	52	22	2.3	2.77	27.51	3.54	9.33	37.2	50.1	22.4	5.4	4.2	17.45	115.62
MCU9 X	138	57.1	23.7	2.7	2.89	29.78	3.88	9.04	35.9	49.8	25.2	5.2	3.7	21.1	157.58

TCB26															
MCU9 X TCB37	124.5	43.65	18.52	2.05	2.9	27.34	2.79	7.4	35.4	45.4	24	5.3	3.1	21.15	129.61
MCU9 X TCB209	130.4	40.5	19.8	2.6	3.25	26.15	3.32	9.39	36.3	44.5	22	5.5	3.8	20.15	126.49
MCU9 X CCB36	153.1	50.9	22.9	2.3	2.68	27.57	2.91	7.62	37.4	46.9	26.5	5.3	3.2	18.1	175.6
MCU9 X DB3	139	52.1	20	2.5	2.79	34.56	3.97	9.01	36.5	45.4	22.6	5.8	3.5	17.3	154.66
MCU9 X SUVIN	117.5	35.7	19.2	2.6	3.82	26.76	3.53	9.33	38.3	43.5	29.1	4.3	2.9	25.95	145.34
TCH1716 X TCB26	98	36.1	16.8	2.1	2.96	29.07	3.66	8.9	37.9	46	27.2	4.8	3.1	19.2	133.27
TCH1716 X TCB37	130.5	48.5	21.25	2.3	2.84	27.86	3.75	9.78	36.8	46.7	25.9	6.3	3.4	18	125.59
TCH1716 X TCB209	102.5	32.4	16.9	2	2.5	29.28	3.22	7.75	35.9	46.1	24.4	5.3	3.2	18.4	121.59
TCH1716 X CCB36	115.5	33.5	16.2	2.4	2.94	29.65	3.91	8.99	39	46.4	26.1	4.9	2.9	15.25	146.78
TCH1716 X DB3	125	53	19.7	2.6	3.59	26.06	3.51	9.95	37.4	47.2	25.7	6.2	3.1	20.45	134.56
TCH1716 X SUVIN	96	39.55	15.05	2.35	2.42	31.82	3.49	7.35	38.6	45.4	26.2	5.4	3.1	20.8	129.64
MCU7 X TCB26	117	50.6	18.3	2.2	2.67	29.41	3.33	7.88	35.9	46.5	25.6	6.1	3.4	19.35	135.42
MCU7 X TCB37	119.5	51.2	19.7	2	3.08	27.75	3.03	7.73	34.8	46.6	26.5	5.7	3	24.05	125.74
MCU7 X TCB209	136.5	57.3	22	2.4	3.59	27.27	4.14	11.09	36.3	47	25.7	6.4	3.6	19.75	172.79
MCU7 X CCB36	115	41.9	18.3	2.4	2.32	29.54	2.81	6.72	34.5	49.3	24.9	6.1	2.8	19.25	123.9
MCU7 X DB3	142	56.4	21.2	2.3	3.08	39.2	5.11	9.6	36.1	49.9	26.6	5.9	3.3	24.4	175.78
MCU7 X SUVIN	104	37	16.1	2.9	3.32	26.51	2.42	6.65	34.7	45.7	26.4	6.5	2.2	20.45	113.06
TCH1819 X TCB26	128.3	55.1	20.7	2.1	3.39	29.63	4.21	10.09	34.8	44.7	22	6.3	3.6	20.2	130.55
TCH1819 X TCB37	130.5	52.4	19.9	2.1	3.81	31.23	4.04	8.8	35.5	45.7	28.5	6.9	4.7	25.5	230.74
TCH1819 X TCB209	122.6	38.5	18.8	2	3.28	33.21	4.35	8.76	30.9	47.2	24.7	8.6	4	20.85	126.74
TCH1819 X CCB36	108.5	50.1	19	2.2	3.03	32.6	3.79	7.86	35.7	47.7	27.1	5.8	3.3	21.85	158.67
TCH1819 X DB3	141.5	53.4	20.8	2.1	3.64	29.15	3.79	9.24	36.1	50.7	27.6	7.8	3.1	23.45	162.09
TCH1819 X SUVIN	89	33	13.4	1.5	2.71	26.26	3.34	7.6	37.7	46.5	27.9	5.6	3	21.95	119.4
DCH -32	116	35.2	18.25	2	2.42	28.95	3.06	7.8	36.05	45.85	26.33	6.25	3.83	19.3	116.16

Table 4: Relative, Heterobeltiosis and Standard Heterosis of Promising Interspecific F_1 Hybrids for different Traits

	Plant height			Number of bolls/plant			Number of sympodia/plant			Boll weight			Ginning outturn			Lint index		
	di	Dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
MCU13 X TCB209	5.7	0.75	0.75	126.75**	110.16**	110.16**	16.67*	-2.06	-2.06	9.61	-6.99	-6.99	2.4	-3.44	-3.44	-3.66	-17.42	-17.42
SVPR4 X TCB37	36.25**	21.21	4.87	107.97**	96.58**	133.33**	36.84**	29.28**	-3.7	17.93	11.28	-2.33	-13.53	-24.65**	-17.07*	23.54*	8.38	-15.76
SVPR4 X DB3	45.67**	34.63**	16.48	35.67**	30.6**	49.19**	26.69**	19.34	-11.11	27.24*	27.03	11.5	22.99**	16.49	6.49	9.56	-6.92	-21.92*
SVPR4 X SUVIN	10.85	3.17	-10.74	74.32**	72.31**	82.11**	6.01	0.5	-16.46*	-14.45	-26.37	-35.37*	52.07**	46.1**	29.61**	38.49**	20.48	-4.5
KC3 X SUVIN	21.91	21.61	-9.36	50.74**	42.31**	65.45**	3.03	-7.43	-23.05**	36.95*	16.91	4.66	0.95	-2.74	-6.93	7.96	0.3	-20.5*
TCH1777 X TCB26	36.93**	30.94*	-5.84	64.77**	41.16**	88.21**	33.33**	19.28	-18.52*	42.55**	41.67*	16.3	11.18	6.94	-12.09	49.86**	36.78**	-4.38
TCH1777 X CCB36	42.79**	36.67**	7.49	95.61**	90.6**	81.3**	22.56**	21.08	-17.28*	8.95	-0.54	-19.36	-5.22	-12.93	-14.53	33.85**	31.02*	-8.41
MCU9 X TCB26	44.05**	32.69*	3.37	112.66**	74.09**	132.11**	52.41**	31.67**	-2.47	7.14	2.48	-15.87	12.4	3.31	-6.44	49.86**	41.27**	-7.94
MCU9 X CCB36	46.51**	45.81**	14.68	136.19**	129.28**	106.91**	33.92**	27.22**	-5.76	9.74	3.88	-22.13	-8.22	-11.78	-13.4	4.39	3.01	-31.04**
MCU9 X DB3	37.62**	33.65*	4.12	112.65**	85.41**	111.79**	17.65	11.11	-17.7*	0	-7.15	-18.78	19.33*	18.78*	8.58	26.23*	12.15	-5.92
MCU9 X SUVIN	15.48	12.98	-11.99	54.21**	40.55**	45.12**	0.52	-4.95	-20.99**	61.05**	48.54**	11.35	-6.22	-7.18	-15.94*	15.67	5.38	-16.47
TCH1716 X TCB26	2.03	-6.22	-26.59*	42.41**	10.06	46.75**	11.63	-1.18	-30.86**	-5.51	-14.08	-13.83	3.43	-9.28	-8.67	22.31*	3.1	-13.27
TCH1716 X CCB36	10.26	10	-13.48	67.08**	50.9**	36.18**	-2.41	-4.71	-33.33**	2.35	-14.66	-14.41	-6.32	-7.49	-6.86	22.82*	10.28	-7.23
TCH1716 X DB3	23.46*	19.62	-6.37	130.43**	88.61**	115.45**	19.39*	15.88	-18.93*	11.16	4.06	4.37	-14.75*	-18.67*	-18.12*	-0.99	-1.13	-16.82
MCU7 X TCB26	28.5*	23.81	-12.36	81.69**	54.27**	105.69**	25.77*	14.38	-24.69**	-1.39	-5.32	-22.27	16.29	11.34	-7.6	30.53*	24.67	-20.97*
MCU7 X TCB209	26.68*	12.81	2.25	161.05**	150.22**	132.93**	35.38**	33.33**	-9.47	43.89**	38.34*	4.51	-0.14	-3.3	-14.32	45.52**	37.31**	-1.9
MCU7 X DB3	47.53**	44.9**	6.37	121.18**	100.71**	129.27**	32.5**	32.5**	-12.76	10	2.5	-10.33	41.21**	34.71**	23.13**	64.44**	44.35**	21.09*
TCH1819 X CCB36	8.99	3.33	-18.73	106.17**	89.77**	103.66**	32.4**	17.28	-21.81**	-0.66	-20.26	-11.79	-8.11	-17.88**	2.39	4.48	-14.45	-10.19
TCH1819 X DB3	47.32**	44.39**	5.99	95.96**	90.04**	117.07**	45.96**	30**	-14.4	7.13	-4.08	6.11	-15.25*	-26.56**	-8.43	-5.02	-14.56	-10.31
SE+	9.6227			1.1930			1.2631			0.3283			1.7457			0.2639		
CD@5%	26.945			3.3406			3.5367			0.9193			4.8883			0.7388		
CD@1%	35.7906			4.4373			4.6978			1.2210			6.4930			0.9814		

Table 4: contd.

	Seed index			Uniformity ratio			Bundle strength			Micronaire			Number of seeds/bool			Seed cotton yield/plant		
	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	Dii	diii
MCU13 X TCB209	-4.8	-18.01	-18.01*	8.11	7.55	8.69	0.94	-1.82	-1.82	-17.24	-26.53**	-26.53**	19.49	11.32	11.32	48.68**	31.72**	31.72**
SVPR4 X TCB37	41.94**	38.94**	3.3	-0.98	-8.78	-3.18	-0.4	-5.75	-10.22	-11.69	-24.44*	-30.61**	0.72	-5.41	-0.94	37.22**	6.23**	32.12**
SVPR4 X DB3	-2.48	-10.99	-19.84*	-9.25	-14.77	-9.53	-2.7	-5.65	-14.6	-25.3**	-31.11**	-36.7**3	29.47*	18.24	23.82	46.38**	22.99**	52.96**
SVPR4 X SUVIN	-6.23	-12.27	-25.13**	-7.29	-7.39	-1.69	4.38	-2.6	-4.38	-14.67	-28.89**	-34.69**	-18.83	-25.23*	-21.7	68.22**	19.53**	48.66**
KC3 X SUVIN	9.45	-1.23	-15.71*	-11.55	-11.9	-5.93	-4.58	-14.87	-16.42	-17.5	-34**	-32.65**	22.11	12.95	17.22	76.82**	36.67**	31.11**
TCH1777 X TCB26	42.14**	31.26**	10.37	-3.93	-9.07	6.14	17.47	14.96	-1.82	-15.91	-24.49**	-24.49**	32.85*	29.86	8.73	116**	96.63**	77.67**
TCH1777 X CCB36	43.92**	27.52**	7.23	-6.81	-8.1	-1.48	14.29	14.29	-6.57	-21.57**	-24.53**	-18.37*	9.57	-2.06	-21.7	67.55**	38.69**	25.32**
MCU9 X TCB26	33.43**	32.94**	-5.34	-4.78	-9.62	5.51	5.66	3.7	-8.03	0	-5.13	-24.49**	15.93	13.14	-0.47	82.76**	62.42**	54.92**
MCU9 X CCB36	17.61	12.81	-20.26*	-6.29	-7.31	-0.64	13.49	9.05	-3.28	-27.27**	-39.62**	-34.69**	13.13	-2.95	-14.62	123.32**	81**	72.64**
MCU9 X DB3	17.39*	4.77	-5.65	-2.89	-8.28	-3.81	-7.94	-8.87	-17.52	-4.11	-7.89	-28.57**	-6.49	-7.24	-18.4	68.95**	59.42**	52.05**
MCU9 X SUVIN	25.23**	14.48	-2.3	-12.56	-13	-7.84	13.67	8.18	6.2	-10.77	-17.14	-40.82**	38.96**	38.77**	22.41	93.42**	49.81**	42.89**
TCH1716 X TCB26	24.15**	18.03	-6.75	-12.13	-16.52	-2.54	16.99	16.24	-0.73	-20.51*	-20.51	-36.73**	7.41	6.67	-9.43	42.59**	19.51**	31.03**
TCH1716 X CCB36	30.74**	19.09	-5.92	-7.39	-8.3	-1.69	14.73	12.99	-4.74	-36.96**	-45.28**	-40.82**	-2.71	-15.28	-28.07*	70.91**	31.62**	44.31**
TCH1716 X DB3	23.26**	15.7	4.19	0.85	-4.84	0	7.31	3.63	-6.2	-19.48	-20.51	-36.73**	12.52	11.44	-3.54	36.2**	20.66**	32.29**
MCU7 X TCB26	22.72*	15.96	-17.43*	-10.66	-15.61	-1.48	14.8	9.4	-6.57	-16.05	-19.05	-30.61**	0.78	-6.3	-8.73	74.3**	69.35**	33.13**
MCU7 X TCB209	71.2**	60.65**	16.07*	-2.79	-4.08	-0.42	9.13	-0.77	-6.2	-10	-14.29	-26.53**	1.41	-4.36	-6.84	118.09**	116.1**	69.88**
MCU7 X DB3	30.99**	11.57	0.47	7.31	1.84	5.72	15.65	7.26	-2.92	-17.5	-21.43*	-32.65**	25.13*	18.16	15.09	111.75**	104.24**	72.81**
TCH1819 X CCB36	19.92*	13.84	-17.75*	-5.82	-5.92	1.06	30.29	20.98	-1.09	-36.54**	-37.74**	-32.65**	16.07	-10.08	3.07	128.61**	101.95**	55.99**
TCH1819 X DB3	19.16*	7.38	-3.3	7.07	0	7.42	25.45	11.29	0.73	-30.34**	-39.22**	-36.73**	9.96	-3.5	10.61	96.91**	88.33**	59.36**
SE+	0.5294			7.2084			3.415			0.3099			1.9277			0.5098		
CD@5%	1.4825			20.1844			9.563			0.867			5.3978			1.4276		
CD@1%	1.9692			26.8106			12.703			1.1527			7.1697			1.8962		

** significant at 1% , * significant at 1%

Table 5: General Combining Ability of 14 Parents

Parents	Plant height	Number of bolls/plant	Number of sympodia/plant	Number monopodia/plant	Ginning outturn	Lint index	Seed index	Elongation %	Micronaire	Number of seeds/boll	Seed cotton yield/plant
Lines											
MCU13	2.61	2.47**	1.73**	0.07	2.06**	0.15	-0.58**	0.78**	0.09	0.29	-15.22**
SVPR4	15.99**	2.58**	1.4*	0.09	2.55**	-0.01	-0.07	-0.1	-0.11	0.61	-3.6**
KC3	-18.16**	-6.02**	-2.07**	0.04	-0.96	-0.53**	-1.19**	-0.32	-0.18	0.14	-10.6**
TCH1777	12.33**	4.05**	1.28*	0.12	-1.98**	0.14	1.21**	-0.2	0.27	-0.83	3.18**
MCU9	8.71*	0.06	1.01	0.1	-1.21	-0.13	0.18	-0.72**	0.06	-0.13	10.79**
TCH1716	-13.79**	-6.09**	-2.03**	-0.07	-0.94	0.06	0.34	-0.47	-0.18	-2.07*	-5.51**
MCU7	-2.71	2.47**	-0.42	0.01	0.05	-0.06	-0.17	0.16	-0.26	0.45	3.69**
TCH1819	-4.97	0.48	-0.92	-0.36**	0.44	0.39**	0.28	0.88**	0.31	1.54	17.28**
SE	**16.32**	**1.96**	**2.04**	**0.24**	**2.51**	**0.43**	**0.78**	**0.91**	**0.50**	**3.2**	**0.52**
Testers											
TCB26	3.15	5.08**	0.82	-0.02	0.4	0.39**	0.6**	-0.12	0.11	-0.29	-1.25**
TCB37	-2.41	2.36**	0.27	-0.09	-1.53**	-0.24*	-0.16	0.06	0.13	-0.19	10.03**
TCB209	-1.2	-1.23**	0.18	0.13*	-1.63**	-0.11	0.36*	0.3	0.14	1.01	-5.37**
CCB36	-0.1	-1.52**	-0.11	-0.05	-0.13	-0.08	-0.35	-0.29	-0.1	-3.01**	0.58**
DB3	11.9**	-0.35	0.57	-0.01	1.83**	0.25*	0.29	0.36	-0.1	1.77*	5.68**
SUVIN	-11.33**	-4.33**	-1.73**	0.05	1.07	-0.2*	-0.75**	-0.3	-0.19	0.71	-9.68**
SE	**14.13**	**1.7**	**1.77**	**0.21**	**2.18**	**0.37**	**0.68**	**0.79**	**0.44**	**2.77**	**0.45**

** significant at 1% , * significant at 1%

Table 6: Specific Combining Ability of Promising Interspecific F_1 Hybrids

Hybrids	Plant height	Number of bolls/plant	Number of sympodia/plant	Number of Monopodia/plant	Ginning outturn	Lint Index	Seed index	Uniformity ratio	Elongation %	Bundle strength	Micronaire	Number of seeds/boll	Seed cotton yield/plant
MCU13 X TCB209	8.05	3.86**	2.2	0.04	0.41	-0.09	-0.4	2.32	-0.13	1.15	0.06	1.54	17.14**
MCU13 X SUVIN	0.68	10.66**	-0.79	-0.08	4.97**	-0.53	-0.97	-0.96	0.87	-0.37	-0.11	1.89	1.74**
SVPR4 X DB3	2.57	-12.13**	-0.05	-0.44**	-0.37	-0.48	-1.02*	-2.9	-0.01	-1.59	0	3.11	16.08**
SVPR4 X SUVIN	-10.53	-0.05	0.94	0.4*	7.75**	0.71*	-0.49	1.7	-0.25	0.03	0.19	-5.47*	27.07**
KC3 X TCB209	-26.93*	-5.86**	-2.8*	0.47**	-2.28	-0.55	-0.57	-1.03	-0.43	-0.16	-0.57	1	11.37**
KC3 X CCB36	-15.27	-3.96**	-2.21	-0.55**	1.46	-0.41	-1.06*	-0.26	-0.04	1.6	-0.34	0.97	5.31**
KC3 X DB3	-0.77	-6.13**	0.32	0.41*	-2.4	-0.31	-0.89	3.49	0.41	0.4	-0.14	-0.82	0.74*
KC3 X SUVIN	25.46*	4.45**	2.81*	-0.15	-0.37	0.56	1.54**	-0.31	0.07	-1.79	0.35	3.25	16.23**
TCH1777 X TCB26	-14.81	-9.42**	-1.98	-0.06	-0.34	-0.02	0.28	2.35	0.57	1.48	0	3.42	41.36**
TCH1777 X TCB37	2.05	5.19**	1.07	0.11	0.37	-0.24	-0.77	1.29	0.39	-1.39	-0.81*	-1.89	34.91**
MCU9 X TCB26	1.1	5.37**	2.19	0.26	0.69	0.1	-0.2	4.24	0.08	0.14	0.22	0.77	10.61**
MCU9 X CCB36	19.45	5.77**	2.32	-0.11	-1	-0.41	-0.66	-1.21	0.36	1.18	-0.07	0.49	26.81**
MCU9 X DB3	-6.65	5.79**	-1.26	0.05	4.05*	0.32	0.08	-0.76	0.21	-1.42	0.23	-5.1*	0.76*
MCU9 X SUVIN	-4.92	-6.63**	0.24	0.1	-3	0.33	1.45**	-1.76	-0.63	3.89	-0.28	4.62*	6.81**
TCH1716 X TCB26	-16.4	-9.48**	-1.67	-0.17	-0.29	-0.32	-0.48	0.05	-0.57	1.13	-0.15	0.81	2.61**
TCH1716 X CCB36	4.35	-5.48**	-1.34	0.16	0.82	0.4	0.55	-2.1	-0.29	-0.24	-0.14	-0.42	14.29**
TCH1716 X SUVIN	-3.92	3.37*	-0.87	0.01	1.79	0.1	-0.69	-0.25	0.22	-0.02	0.15	1.41	7.42**
MCU7 X TCB209	15.36	9.46**	2.55	-0.09	-1.04	0.77**	2.45**	-0.56	-0.01	-0.33	0.41	-2.47	37.04**
MCU7 X DB3	7.77	7.68**	1.37	-0.06	7.43**	1.39**	1.02*	2.15	-0.57	1.53	0.35	1.42	28.98**
TCH1819 X TCB37	12.85	2.96*	0.87	0.19	2.42	0.37	0.24	0.11	0.01	2.28	0.96**	3.39	66.01**
TCH1819 X TCB209	3.73	-7.36**	-0.15	-0.13	4.5**	0.54	-0.32	0.06	1.47*	-1.68	0.24	-2.46	-22.6**
TCH1819 X CCB36	-11.46	4.54**	0.34	0.25	2.38	-0.05	-0.52	-1.58	-0.74	0.38	-0.22	2.56	3.39**
TCH1819 X DB3	9.54	6.67**	1.47	0.11	-3.02	-0.38	0.22	3.37	0.61	2.18	-0.42	-0.63	1.71**
SE (D)	**39.97**	**4.8**	**4.99**	**0.59**	**6.16**	**1.05**	**1.92**	**29.38**	**2.22**	**13.79**	**1.23**	**7.85**	**1.27**

** significant at 1% , * significant at 1%

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