Combining Ability Estimates for Yield and Fibre Quality Traits in Line X Tester Crosses of Upland Cotton, (*Gossypium hirsutum)*

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Abstract

This study was to estimate the GCA of the parents and SCA considered for the development of high yielding and better quality cultivars. Eleven genotypes and 28 F_1 hybrids obtained by crossing 4 lines and 7 testers in line X tester mating system were sown in randomized complete block design. L X T analysis revealed significant GCA and SCA effects for all the traits except earliness. Among the parents: MCU 12 for number of bolls per plant, boll weight, seed cotton yield per plant, F 1861 for seed cotton yield and number of bolls per plant, SOCC 17 for earliness, SURABHI for number of sympodia and TCH 1641 for ginning outturn and lint index with high GCA. Parent F 776 and F1861 were good combiners for fibre quality traits. The high yielding quality hybrids were deducted with significant SCA effects for seed cotton yield and fibre characteristics.

Keywords: Cotton, Fibre quality traits, General (GCA) and specific combining ability (SCA), Line X Tester analysis, Lint index

1. Introduction

Cotton (*Gossypium hirsutum* L.) is an important fibre crop and plays a vital role as a cash crop in commerce of many countries such as USA, China, India, Pakistan, Uzbekistan, Australia and Africa. Cotton crop is mainly cultivated for fibre. Development of new variety with high yield and fibre quality is the primary objective of all cotton breeders. The first step in successful breeding program is to select appropriate parents. Line x Tester analysis provides a systematic approach for detection of appropriate parents and crosses in terms of investigated traits. This method was applied to improve self and cross-pollinated plants (Kempthorne 1957). Previous studies showed that variation in seed cotton yield and its components were controlled by genes acting additively and non-additively.

Studies of Shakeel *et al.,*(2001), Ahuja and Dhayal (2007) revealed that number of bolls, boll weight and seed cotton yield were influenced by the genes acting non-additively and in contrast studies of Khan and Idris (1995). Kumaresan *et al.* (1999) indicated that both additive and non-additive gene effects were important for controlling number of bolls and seed cotton yield. However, Lukange *et al.* (2007) revealed additive gene effects for fibre strength and microanire value and non-addidive gene action for fibre length. Non-additive gene action for fibre quality traits: fibre length, fibre strength and micronaire value have been reported by Baloch *et al.* (1997), Hassan *et al.* (1999 and 2000), Ahuja and

Dhayal (2007) and Preetha and Raveendran (2008). The purposes of this research were to estimate the GCA and SCA effects for seed cotton yield, its components and fibre quality traits among 4 genotypes taken as female, and 7 taken as male *G. hirsutum* lines and to determine appropriate parents and crosses for the investigated traits.

2. Materials and Methods

2.1 Plant materials

The materials used in the present study was developed by crossing four local cultivars, viz: MCU 5, MCU 12, SURABHI, and SVPR 2 with 7 diverse genetic accessions: F 776, F 1861, SOCC 11, SOCC 17, TCH 1641, TCH 1644 and TCH 1646 all belonging to *G. hirsutum.* When the parental lines started to flower, these were crossed in line x tester fashion. Some of the buds of parents were also selfed. Maximum numbers of crosses were made to develop sufficient F_1 seed.

2.2 Field layout

The F_1 seed of 28 hybrids and parents were planted in the field during Kharif 2005-2006 crop season at Cotton Breeding Station Coimbatore, Tamil Nadu (India). Each entry was sown in three replications following randomized complete block design. Each genotype seed was sown in a 3 plot of 4.5 meter length adopting a spacing of 75 cm between rows and 30 cm between the plants in the row, so as to have 15 plants per row.

2.3 Data analysis

Data were recorded on middle five competitive plants for all the 17 characters viz., Days to first flowering, days to 50% flowering on whole plot basis, plant height (cm), number of sympodia per plant, number of bolls per plant, boll weight (g), number of seeds per boll, ginning outturn (%), lint index (g), seed index (g), seed cotton yield per plant (g), 2.5% span length (mm), fibre strength (g/tex), micronaire value (µg/inch), uniformity ratio and fibre elongation (%). Lint samples were submitted to Central Institute for Research on Cotton Technology unit at Coimbatore, Tamil Nadu (India) for analysis of fibre quality traits: 2.5% span length (mm), Micronaire value (µg/inch), fibre strength (g/tex) and fibre elongation (%).

2.4 Statistical Analysis

The mean values of the characters measured in 59 genotypes in each replication were analysed for Analysis of variance, estimation of Standard Error and Critical Difference by adopting the method suggested by Panse and Sukhatme (1964). Prior to estimation of combining ability effects, the data on 16 traits was subjected to path coefficient analysis suggested by Dewey and Lu (1959) to study direct contribution of different traits and nature of their relation to seed cotton yield. The Line x Tester analysis of combining ability was performed as suggested by Kempthorne (1957).

3. Results

Significant difference among parents and hybrids revealed presence of genetic diversity among them. From the parents versus hybrids components of variance, it was observed that significant heterosis (average) was exhibited by all the characters except days to first flowering and days to fifty per cent flowering (Table 1). Path coefficient analysis at genotypic level indicated that out of sixteen traits under study, six traits viz: boll weight, number of sympodia per plant, lint index, number of seeds per boll, uniformity ratio and micronaire value depicted direct effects in desirable directions on seed cotton yield (Table 2). The genotypic correlations of these traits with seed cotton yield were also positive for all of these characters and desirable negative for days to first flowering and micronaire value. Using the technological evolution of yarn developed from solely ring-based spinning to predominately rotor and air-jet spinning, need for intensification of fibre property profiles to suit the automated spinning systems. Nevertheless, successful rotor spinning requires high fibre strength for all yarn counts, along with fibre fineness for fine count yarns. The stable more productive air-jet spinning requires a minimum, but uniform fibre length, fibre fineness, and to a less extent strong fibre. On the differing, ring spinning requires a minimum fibre length, fibre strength, and to a lesser extent fibre fineness. Thus fibre length and fibre strength being indispensable traits though showing negative direct effect on seed cotton yield were not excluded for further analysis for combining ability. Seed cotton yield exhibited positive but non-significant association with fibre length and fibre strength. Its correlation with micronaire value, uniformity ratio and elongation percentage was non-significant and negative. Mean squares of genotypes, GCA and SCA for all the characters under study were significant except days to 50 per cent flowering indicating prevalence of genetic diversity among parents and F_1 hybrids.

The combining ability analysis gives useful information regarding selection of parents based on the performance of their hybrids and further it helps for the exploitation of heterosis. Among the parents, the best general combiner was line MCU 12 and testers F 1861 and SOCC 17 recorded significant *gca* effects for bolls per plant. Apart from this MCU 12 has recorded high *gca* for seed cotton yield, number of bolls per plant and while F 1861 exhibited high *gca* effects for number of bolls per plant and seed cotton yield. Therefore the line MCU 12 and tester F 1861 were identified as good source of favourable genes in improving yield characters. Further the study revealed that high and significant *gca*

effects for seed cotton yield result from combined effect of yield component, number of bolls which is an concordance with results of Patel et al. (1992). Significant and positive gca effects were recorded for number of sympodia the line Surabhi presented in Table 3. For fibre quality characters MCU 5 and MCU12 showed high significant *gca* for 2.5 % span length and bundle strength. Similarly among the testers F776 recorded high *gca* for both fibre length and strength. In addition it also showed high *gca* for 2.5 per cent span length (F 776) as indicated in Table 3.The specific combining ability value of any cross was helpful in predicting the performance of the better parents. Out of the 28 hybrids, only three hybrids, MCU 12 x F 1861, SVPR 2 x F 776 and MCU 5 x TCH 1644 showed significantly negative *sca* effects for earliness. Beyond the 28 hybrids MCU5 x TCH 1641 for plant height and ginning outturn, MCU 12 x TCH 1641 for number of sympodia per plant, MCU 12 x SOCC 17 and MCU12 x F 1861 for number of bolls, Surabhi x F 1861 for boll weight per plant, Surabhi x SOCC 11 for number of seeds per boll, MCU 5 x TCH 1644 and MCU 12 x SOCC 11 for lint index, MUC 5x TCH 1646 for seed index were exhibited to significant high *sca* expression, presented in Table 4. The hybrid MCU 5 x SOCC11 for ginning outturn and MCU 5 x TCH 1646 for seed index had superior per se performance, with high sca effects. The hybrids can be exploited as basic material for breeding

Specific combining ability effects of these crosses were related with general combining ability effects of their parents as they involved at least one parent with high or average GCA effects for particular traits. Similar results have been reported by Punitha et al.(1991), Khan and Idris (1995), Baloch et al.(1997), Hassan et al. (1999), Kalwar and Babar (1999), Kumaresan et al. (1999), Hassan et al. (2000), Shakeel et al. (2001) and Ahuja and Dhayal (2007). Mean values for characters of parents and F_1 hybrids are given in Table 6. The means of F_1 crosses were higher than those of parents in all the characters. In majority of cross combinations having significant SCA effects showed better mean performance (average performance over three replication of a cross for a trait) as reflected by positive association between them indicating that the cross combinations may be selected either on the basis of SCA or mean performance or in combination. Several workers found that hybrids superior with fibre quality traits were not good in seed cotton yield and vice-versa [Tuteja et al. (1995); Hassan et al. (1999); Jagtap (1994); Neelam Dheva et al. (2002)]. In the present study, of the best three cross combinations: MCU 12 x F 1861, MCU 12 x SOCC 17 and MCU 12 x SOCC 11 exhibited high heterotic effect and *per se* performances for seed cotton yield per plant. Four hybrids recorded significant and positive *sca* effects for fibre elongation percentage, the hybrids being SVPR 2 x TCH 1641, Surabhi x TCH 1644, MCU 12 x SOCC 17 and MCU 5 x F 1861. Among these, SVPR 2 x TCH 1641 and MCU 12 x SOCC 17 had superior *per se* performance, significant standard heterosis with high *sca* effects for fibre elongation. For ginning outturn MCU 5 x TCH 1641 had superior *per se* performance, significant standard heterosis with high *sca* effects. These hybrids can be exploited as basic material for breeding purposes.

4. Discussion

The 11 parents and 28 hybrids used in this study varied significantly for each yield component and fibre quality parameter evaluated (Table 1, 3). These data indicated that the highest values of yield components and fibre quality parameters do not follow same pattern in every line i.e. the parent or the cross with high yield or its component traits did not necessarily had high fibre quality parameters. GCA variances were lower than SCA variances for all the characters as indicated by their lower ratios indicating predominance of non-additive gene action (dominant or epistasis) in the inheritance for all of these traits (Sprague and Tatum 1942). Studies of Shakeel et al. (2001) and Ahuja and Dhayal (2007) revealed that number of bolls, boll weight and seed cotton yield were influenced by the genes acting non-additively and in contrast studies of Khan and Idris (1995), and Kumaresan et al. (1999) indicated that both additive and nonadditive gene effects were important for controlling number of bolls and seed cotton yield. However, Lukange et al. (2007) revealed additive gene effects for fibre strength and microanire value and non-addidive gene action for fibre length. Non-additive gene action for fibre quality traits: fibre length, fibre strength and micronaire value have been reported by Baloch et al. (1997), Hassan et al. (1999 and 2000), Ahuja and Dhayal (2007) and Preetha and Raveendran (2008). Predominance of non additive gene action for days to fifty per cent flowering, plant height, number of bolls per plant and boll weight was observed by Neelam Deva et al. (2002), number of sympodia per plant reported by Valarmathi and Jehangir, (1998), number of seed per boll, ginning outturn [Sandhu et al. (1993)], lint index, seed cotton yield [Patel et al. (1992); Ahuja and Dhayal (2007)]. These results suggested that heterosis breeding was suitable for all the characters including fibre properties. The non-additive gene actions are also important for varietal adaptability.

Amudha et al. (1997); Mandloi et al. (1998) and Modi et al. (1999) also observed superior per se performance with high SCA effects for ginning outturn. The results indicate the predominance of non- additive genetic variation in the inheritance of these characters, which was in accordance with results, was obtained by Krishna Rao (1998). The hybrid combinations, which were, have good *sca* and *per se* performance for seed cotton yield, indicated the possibility for simultaneous improvement of seed cotton yield and yield-attributed traits by exploring these hybrids.

Among the derived hybrids, five hybrids recorded significant and positive *sca* effects for uniformity ratio. The hybrid between Surabhi x TCH 1644 exhibited high *sca* for uniformity ratio. Six hybrids recorded significant and positive *sca*

effects for bundle strength, with MCU 5 x SOCC 17 recording the highest value followed by Surabhi x F 776, MCU 5 x F 1861, MCU 12 x TCH 1644, MCU 12 x TCH 1641 and Surabhi x TCH 1646. Among these, the hybrid MCU 5 x SOCC 17 exhibited (good x poor general combiner) *sca* for bundle strength and MCU 12 x TCH 1644 (moderate x good general combiner) for micronaire were the other crosses with high *per se* performance and high *sca* effects for the characters mentioned (Table.5). The four cross combinations recorded significant and positive *sca* effects for fibre elongation percentage being SVPR 2 x TCH 1641, Surabhi x TCH 1644, MCU 12 x SOCC 17 and MCU 5 x F 1861. The results indicated the predominance of non- additive genetic variation in the inheritance of these characters. The presence of parallelism between *per se* and heterosis in present study suggest the possibility of direct exploitation of these hybrids for commercial exploitation. The study indicated the possibility of developing hybrids with high seed cotton yield and quality traits through heterosis breeding.

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Table 1. Analysis of variance showing mean squares for seed cotton yield, its components and fibre quality traits in *G. hirsutum*

Source of variation	df	Days to 50% flowering	Number of Sympodia /plant	Number of bolls	Boll weight (g)	Lint index (g)	Seed index (g)	Seed cotton yield/plant (g)	2.5% span length (mm)	Micronaire Value (ug/inch)	Fibre strength (g/tex)	Fibre elongation (%)
Replication	2	1.57	1.71	1.18	0.93	1.38	1.28	2.41	117.64	41.97	13.20	18.49
Parents	10	1.41	3.91**	2.95**	2.38*	5.28**	2.41*	12.22**	108.48**	5.42**	22.74**	25.06**
Hybrids	27	0.75	1.73*	4.92**	1.72*	2.38**	2.61**	23.53**	77.15**	4.19**	23.27**	11.73**
Par vs Hyb	1	7.43**	6.61*	20.39**	17.71**	2.36	2.88	523.99**	322.09**	16.70**	105.71**	4.35*
Error	76	3.98	2.90	3.57	0.07	0.30	1.13	8.9	0.18	0.08	0.19	0.14
Replication	2	1.42	2.26	1.67	0.66	1.79	1.26	3.35	78.11	43.17	8.41	10.28
Lines	3	0.36	4.29**	6.17**	1.40	0.56	2.24	12.47**	6.59**	0.71	8.74**	6.76**
Tester	6	0.77	0.55	0.91	1.88	1.73	1.40	3.23**	2.80*	0.81	1.14	1.02
line x tester	18	1.88*	2.08*	4.35**	2.01*	2.25*	1.92*	10.15**	32.45**	5.02**	12.90**	6.38**
Error	54	4.96	3.39	2.59	0.08	0.28	1.39	9.4	0.21	0.07	0.18	0.15

*, ** Significant at 0.05 and 0.01 % levels respectively

Table 2. Direct and indirect effects of various characters on seed cotton yield at genotypic (G) level

Traits	Days to First flowering	Days to 50% flowering	Plant height (cm)	Number of sympodia per plant	Number of bolls per plant	Boll weight per plant (g)	Number of seeds per boll	Ginning outturn	Lint Index (g)	Seed index (g)	2.5% span length (mm)	Micronaire value (µg inch)	Fibre strength (g tex)	Correlation with seed cotton yield
Days to first flowering	**0.1384**	0.4093	-0.1222	-0.1662	-0.0117	-0.1702	-0.1266	-0.1711	-0.0407	0.0263	-0.0052	0.0164	-0.0906	-0.1032
Days to 50% flowering	0.5010	**0.1694**	0.1317	0.1580	0.0491	0.0336	0.2705	0.1109	-0.0875	-0.0739	0.0705	-0.1697	0.1345	0.6521**
Plant height (cm)	0.0105	-0.0092	**-0.0119**	-0.0057	0.0024	-0.007	-0.0045	-0.0034	-0.0022	-0.0051	-0.004	0.0056	-0.0024	0.1635
No.of sympodia /plant	-0.4949	0.4573	0.1987	**0.4121**	0.1374	0.1399	0.0869	0.1377	0.0505	0.1178	0.2161	-0.1201	0.2423	0.4805**
No. of bolls per plant	-0.0542	0.1561	-0.1311	0.2141	**0.6421**	0.1923	0.0026	0.2073	0.2427	0.1164	0.0982	0.0445	0.1663	-0.0243
Boll weight (g)	-0.0570	0.0064	0.0177	0.0175	0.0137	**0.0301**	0.0179	.0214	0.0244	0.0166	0.0160	-0.0052	0.0133	0.3566**
No. of seeds per boll	-0.3473	0.6061	0.1433	0.034	0.0016	0.2265	**0.3799**	0.0999	0.0073	-0.0454	0.0803	-0.1676	0.0963	0.5779***
Ginning outturn	0.1127	-0.0597	-0.0239	-0.0305	-0.0294	-0.0643	-0.0240	**-0.0912**	-0.0470	0.0099	0.0023	0.0148	-0.0179	0.3339*
Lint index (g)	-0.1161	-0.2041	0.0747	0.0484	0.1495	0.3210	0.0082	0.2037	**0.3951**	0.3200	0.1183	0.0432	0.1015	0.5553***
Seed index (g)	0.0020	-0.0046	0.0027	0.003	0.0019	0.0058	-0.0013	-0.0011	0.0086	**0.0106**	0.0074	-0.0007	0.0047	0.4465***
2.5% Span length (mm)	-0.0066	0.0725	0.0592	0.0916	0.0267	0.0931	0.0279	-0.004	0.0523	0.1229	**0.1747**	-0.0714	0.1023	0.2955
Micronaire value (µg inch)	-0.0338	0.0682	0.0782	0.0982	0.0328	0.09525	0.0045	**0.038**	0.0645	0.0789	0.0532	**0.2116**	-0.0807	-0.0625
Fibre strength (g tex)	-0.0259	0.0027	-0.0240	-0.0011	0.0323	-0.0007	0.0047	-0.0454	0.0603	-0.1676	0.0099	0.0524	**-0.0850**	0.4158***

Residual effect = (G) -0.1518

** Significant at 0.01% level

Table 3. Analysis of Variance and Genetic contribution of lines, Testers and Line x Tester to seed cotton yield, its components and fibre quality traits in *G. hirsutum*

Sources of Variation	Days to 50% flowering	No. Of Sympodia /plant	No. Of Bolls /plant	Boll Weight (g)	Lint Index (g/100 Seeds)	Seed Index (g/100 Seeds)	Seed Cotton Yield (g/plant)	2.5% span length (mm)	Micronaire Value (µg/inch)	Fibre strength (g/tex)	Fibre elongation (%)
σ^2 GCA	-	0.03	0.14	-	-	0.01	8.86	0.16	-	0.04	0.01
σ^2 SCA	0.05	0.09	2.90	0.14	0.11	0.21	54.20	2.28	0.09	0.72	0.28
σ^2GCA/ σ^2SCA	-	0.03	0.04	-	-	0.04	0.17	0.07	-	0.05	0.03
Lines	4.63	42.70	44.10	12.57	5.61	20.33	55.37	36.21	8.52	51.32	45.66
Testers	19.64	8.92	13.02	33.60	34.64	25.43	23.17	30.85	19.55	13.48	13.87
Lines x Testers	75.68	48.39	42.88	53.68	59.76	54.24	21.47	32.94	71.92	35.20	40.47

Table 4. General combining ability effects for seed cotton yield, its components and fibre quality traits of 11 parents in *G. hirsutum*

Character / Parents	Days to 50% flowering	Number of sympodia /plant	Number of bolls/plant	Boll weight (g)	Lint index (g)	Seed index (g)	Seed cotton yield/plant (g)	2.5% span length (mm)	Micronaire Value (µg/inch)	Fibre strength (g/tex)	Fibre elongation (%)
Females											
MCU 5	0.35	0.20	-1.26 **	-0.03	0.26*	0.63 *	-1.51	1.13**	0.14*	0.86**	-0.29**
MCU 12	-0.08	0.78*	2.57 **	0.16*	-0.05	-0.01	17.15 **	0.53**	0.16*	0.50**	-0.11
Surabhi	-0.23	0.80 *	0.02	-0.16*	-0.24*	-0.14	-8.12 **	0.54**	-0.03	0.04	-0.43**
SVPR 2	-0.04	-1.39 **	-1.33 **	0.03	0.03	-0.68*	-7.53 **	-2.20	-0.02	-1.40**	0.83**
SE±	0.4861	0.4018	0.3516	0.0628	0.1165	0.2575	1.1336	0.1020	0.0593	0.0933	0.0870
Males											
F 776	-0.10	1.66**	-0.54	0.07	0.16	0.16	-3.28 *	2.07**	-0.26**	0.51**	0.24**
F 1861	0.24	-0.17	1.40 **	0.04	0.35*	0.32	11.60 **	-0.52**	0.19*	0.24**	0.06
SOCC 11	0.65	-0.11	-0.29	-0.04	0.11	-0.24	0.68	-0.72**	-0.14*	0.59**	-0.24**
SOCC 17	-1.30*	0.41	1.22 *	-0.04	0.30*	-0.09	7.89 **	-0.51**	-0.06	-0.44**	0.26**
TCH 1641	-0.51	-0.56	-0.84*	-0.16*	-0.35 *	-0.45	-7.06 **	-0.23	-0.01	-0.36**	0.23**
TCH 1644	1.49*	-0.00	-0.18	-0.06	-0.47 **	-0.65*	-4.29 **	-0.58**	-0.04	-0.60**	0.06
TCH 1646	-0.26	-0.23	-0.88*	0.75*	-0.05	0.86*	-5.53 *	1.49**	0.17*	0.06	-0.57**
SE±	0.64	0.53	0.46	0.08	0.1541	0.3407	1.4996	0.1349	0.0785	0.1235	0.1151
Correlation with mean performance	2.95	0.48	0.33	0.45	0.51	0.81	0.41	0.70	-0.40	-0.38	-0.38

*, ** Significant at 0.05 and 0.01 % levels respectively

Table 5. Specific combining ability effects for seed cotton yield, its components and fibre quality traits of 28 F₁s in *G. hirsutum*

Character / Hybrids	Days to 50% flowering	Number of sympodia /plant	Number of bolls /plant	Boll Weight (g)	Lint Index (g)	Seed index (g)	Seed cotton yield/plant (g)	2.5% span length (mm)	Micronaire value (ug/inch)	Fibre strength (g/tex)	Fibre elongation (%)
NCU 5 X F 776	-2.36*	-2.35*	1.35	-0.07	-0.34	-0.35	-2.46	-1.02**	0.19	-0.56*	-0.17
NCU 5 X F 1861	0.57	0.59	-1.49	0.41*	-0.18	-0.41	-0.92	-1.23**	0.31*	0.91**	0.57*
NCU 5 X SOCC 11	1.15	0.96	1.93*	-0.02	-0.62*	-0.67	-1.49	-0.14	0.14	-0.05	0.14
NCU 5 X SOCC 17	-0.68	-0.39	-1.98	-0.02	0.03	-0.18	-3.09	1.05	-0.14	1.79**	-0.53*
NCU 5 X TCH 1641	0.32	-0.29	-0.19	0.04	0.18	-0.46*	-0.66	-0.22	-0.16	-0.99**	0.13
NCU 5 X TCH 1644	0.65	0.12	0.72	-0.03	0.89**	1.46*	4.74	0.73**	0.06	-0.69*	-0.03
NCU 5 X TCH 1646	-0.26	0.35	-0.45	-0.01	-0.10	1.47*	3.88*	0.85**	-0.31*	-0.41	0.09
NCU 12 X F 776	1.00	-0.39	-3.05**	0.07	-0.18	-1.30*	-8.06**	0.67*	-0.32*	0.00	0.24
NCU 12 X F 1861	-1.00	-2.19*	3.05*	-0.42*	-0.01	1.41	9.69**	0.06	-0.63*	-0.22	0.08
NCU 12 X SOCC 11	-0.08	-0.52	1.76	0.41*	0.88*	0.91	12.25**	0.65*	0.07	0.32	-0.54*
NCU 12 X SOCC 17	1.08	0.87*	3.12**	0.40*	0.36	0.33	9.47**	-1.86**	0.39*	-1.35**	0.98**
NCU 12 X TCH 1641	-0.58	2.43*	-2.85*	0.04	-0.71*	0.02	-15.32**	0.27	-0.33	0.68	-0.36
NCU 12 X TCH 1644	0.42	0.64	-1.01	-0.00	-0.64*	0.28	-4.95	2.02**	0.09	0.81*	-0.52*
NCU 12 X TCH 1646	-0.83	0.07	-1.01	-0.03	0.11	-0.94	-3.03	-1.79**	0.69**	-0.25	0.11
SURABHI X F 776	1.48	0.72	0.63	0.05	0.00	0.09	7.04*	0.06	0.00	1.46**	0.03
SURABHI X F 1861	0.48	0.72	-1.64	0.44*	0.21	0.19	-6.74*	1.15	0.55*	-0.96*	-0.49*
SURABHI X SOCC 11	-2.37*	-2.34*	-0.66	-0.43*	-0.22	0.20	-6.41*	0.61*	-0.15	-0.69**	0.18
SURABHI X SOCC 17	-0.44	-0.92	-0.66	0.09	-0.03	-0.02	0.64	0.34	-0.32*	0.34	0.01
SURABHI X TCH 1641	-2.31*	0.28	1.83	-0.11	0.62*	1.35*	10.52**	1.96**	0.35	-0.13	-0.87*
SURABHI X TCH 1644	-0.44	0.52	-0.30	-0.06	-0.20	-0.80	-1.75	-3.09**	-0.12	0.51*	1.01*
SURABHI X TCH 1646	2.31*	0.01	0.80	0.42*	-0.27	-0.81	-6.60*	-1.03*	-0.33*	-0.90*	-0.13
SVPR 2 X F 776	-0.71	2.12*	1.98*	-0.05	0.61*	1.36*	3.48	0.30	0.16	0.27	-0.10
SVPR 2 X F 1861	-0.05	0.78	0.08	-0.05	-0.02	-0.18	-3.03	0.02	-0.16	0.15	0.04
SVPR 2 X SOCC 11	0.20	0.89	-2.34*	0.06	-0.19	-0.44	-6.64*	-1.12**	-0.06	0.25	0.22
SVPR 2 X SOCC 17	0.04	0.44	-1.28	-0.00	-0.35	-0.14	-7.46*	0.47	0.07	-0.46*	-0.46*
SVPR 2 X TCH 1641	2.37*	-2.43*	1.21	0.03	0.02	-0.72	5.46	-2.00**	0.14	-0.03	1.10**
SVPR 2 X TCH 1644	-0.63	-2.28*	0.59	0.09	-0.25	-0.57	1.96	0.35	-0.03	0.01	-0.46*
SVPR 2 X TCH 1646	-0.21	-0.43	0.65	-0.08	0.26	0.78	4.80	1.97**	-0.04	0.25	-0.33
SE±	1.15	1.06	0.93	0.16	0.30	0.68	2.99	0.26	0.15	0.24	0.23

*, ** Significant at 0.05 and 0.01 % levels respectively

Table 6. Mean performance of seed cotton yield and fibre quality traits of 11 parents and 28 F₁s in *G. hirsutum*

Characters / Parents/hybrids	Days to 50% flower	Number of sympodia /plant	Number of bolls per plant	Boll weight /boll	Lint Index (g)	Seed index (g)	Seed cotton Yield (gm/plant)	2.5% Span length (mm)	Micronaire Value (µg/inch)	Fibre strength (g/tex)	Fibre elongation (%)
Lines											
MCU 5	67.83	24.97	24.07	4.19	5.74	10.09	86.93	28.3	4.3	20.1	6.9
MCU 12	68.00	24.13	25.17	4.14	6.12	10.44	95.33	29.6	4.1	22.2	6.8
SUPRABHI	71.33	24.17	26.47	3.96	5.36	9.20	88.13	32.9	3.4	22.9	6.9
SVPR.2	68.33	20.07	23.83	4.12	5.47	8.87	91.03	28.9	4.3	19.8	8.5
Testers											
F 776	68.33	19.80	20.10	4.02	5.78	11.11	78.70	27.5	3.7	21.8	8.1
F 1861	69.67	21.88	25.03	4.00	4.78	8.05	87.80	28.4	3.4	21.1	7.4
SiOCC 11	71.00	23.53	24.20	3.66	3.93	8.46	77.33	23.0	4.3	20.7	9.6
SiOCC 17	68.67	19.90	24.80	3.92	4.76	8.55	80.03	24.5	4.6	20.0	8.6
TCH 1641	71.00	28.97	22.10	3.90	4.62	9.62	79.47	29.1	4.2	18.9	5.8
TCH 1644	70.33	24.13	21.57	3.36	4.20	8.48	59.40	28.3	4.0	19.7	7.6
TCH 1646	69.33	22.07	22.27	3.85	4.31	8.84	93.57	29.1	4.0	20.1	6.6
Hybrids											
MCU 5 x F 776	69.00	24.57	24.90	4.11	5.17	10.02	99.71	32.0	3.6	22.4	7.1
MCU 5 x F 1861	71.67	25.67	24.00	4.27	5.46	10.12	116.13	29.2	4.1	23.6	7.5
MCU 5 x SiOCC 11	72.67	26.10	25.03	4.05	4.98	9.31	104.63	30.1	3.7	23.0	7.0
MCU 5 x SiOCC 17	69.67	25.27	24.13	4.06	5.67	9.94	110.25	30.5	3.6	23.8	6.8
MCU 5 x TCH 1641	70.67	24.40	23.07	4.06	5.18	9.30	97.73	30.5	3.5	21.1	7.4
MCU 5 x TCH 1644	72.00	25.37	24.63	4.03	5.76	10.76	105.90	31.1	3.7	21.1	7.1
MCU 5 x TCH 1646	70.33	25.37	22.87	4.24	5.19	12.04	103.80	33.3	3.5	22.1	6.6

Table 6 Continued

Characters Parents/hybrids	Days to 50% flower	Number of sympodia /plant	Number of bolls per plant	Boll weight /boll	Lint Index (g)	Seed index (g)	Seed cotton Yield (gm/plant)	2.5% Span length (mm)	Micronaire Value (ug/inch)	Fibre strength (g/tex)	Fibre elongation (%)
MCU 12 x F 776	71.33	25.70	24.33	4.35	5.11	8.73	112.77	33.1	3.4	22.6	7.7
MCU 12 x F 1861	69.67	23.17	32.37	4.03	5.42	10.29	145.41	29.9	3.5	22.1	7.4
MCU 12 x SOCC 11	71.00	24.80	29.40	4.36	6.11	10.25	137.03	30.3	3.9	23.0	6.5
MCU 12 x SOCC 17	71.00	26.70	32.27	4.10	5.78	9.82	141.47	27.0	4.4	20.3	8.5
MCU 12 x TCH 1641	69.33	26.30	24.23	4.15	4.06	9.15	101.73	30.4	3.6	22.4	7.1
MCU 12 x TCH 1644	71.33	26.07	26.73	4.14	4.21	9.31	114.87	31.8	4.0	22.3	6.8
MCU 12 x TCH 1646	69.33	25.27	26.13	4.31	5.18	9.49	115.50	30.1	4.8	21.9	6.8
Surabhi x F 776	71.67	27.23	25.47	4.21	5.20	9.69	102.60	32.5	3.5	23.6	7.1
Surabhi x F 1861	71.00	26.40	25.13	4.27	5.54	9.94	104.70	31.0	4.5	20.9	6.5
Surabhi x SOCC 11	69.67	24.40	24.43	3.82	4.92	9.40	94.40	30.2	3.5	21.8	6.9
Surabhi x SOCC 17	69.33	25.33	25.93	4.15	5.30	9.34	107.37	29.2	3.5	20.5	7.2
Surabhi x TCH 1641	68.67	25.57	26.37	3.89	5.20	10.14	102.30	32.1	4.1	21.6	6.3
Surabhi x TCH 1644	70.33	26.67	24.90	3.97	4.37	8.09	92.79	26.7	3.6	20.9	8.0
Surabhi x TCH 1646	71.33	25.63	25.40	4.34	4.72	9.49	87.70	30.8	3.6	22.1	6.5
SVPR 2 x F 776	69.67	25.33	24.57	4.20	5.89	10.52	99.63	30.0	3.6	19.8	8.3
SVPR 2 x F 1861	70.67	24.27	25.50	4.17	5.50	9.24	108.00	27.1	3.8	20.7	8.3
SVPR 2 x SOCC 11	71.33	24.43	21.40	4.20	5.13	8.42	94.47	25.8	3.6	20.9	8.2
SVPR 2 x SOCC 17	70.00	24.53	23.97	4.14	5.16	8.87	100.29	26.6	3.9	20.0	8.0
SVPR 2 x TCH 1641	71.33	21.67	24.40	4.12	4.89	7.93	97.83	25.4	3.9	19.8	9.5
SVPR 2 x TCH 1644	70.33	22.37	24.43	4.21	4.50	7.97	97.10	27.4	3.7	19.6	7.8
SVPR 2 x TCH 1646	70.00	23.00	23.90	4.23	5.43	10.74	98.70	31.1	3.9	20.5	7.3
General mean of parents	69.39	22.32	23.60	3.92	5.10	9.25	83.43	28.2	4.0	20.7	7.5
General mean of crosses	70.51	25.04	25.35	4.15	5.18	9.58	105.96	29.8	3.7	21.6	7.4
S.E=	1.15	0.98	1.09	0.15	0.31	0.61	2.88	0.24	0.16	0.25	0.21