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Combining ability studies for seed cotton yield and its attributing characters in tetraploid cotton (*G. hirsutum* L.)

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Abstract
The present investigation was carried out to study combing ability of parental lines and hybrids of American cotton (*Gossypium hirstum* L.). The estimation of combining ability of hybrids were significant for all characters except for ginning percentage. Mean squares due to lines effects were significant for sympodia per plant, seed index and fibre strength, whereas testers effects noticed non-significant for all the traits. Line x tester effects reported significant for all characters except for ginning percentage indicating that considerable GCA and SCA was present for parents and hybrids, respectively. Combining ability analysis revealed importance of both additive and non-additive components in the expression of seed cotton yield and other traits. The cross combinations GSHV 185 x RAH 1069, GSHV 172 x TCH 1824 and GSHV 172 x CPD 1501 recorded higher per se performance as well as significant SCA effect, heterobeltiosis and standard heterosis over both the standard checks for seed cotton yield per plant. The estimates of general combining ability suggested that parents GSHV 172 and RAH 1069 were good general combiner for seed cotton yield per plant.

Keywords: Combining ability; gene action; cotton; hybrids; line x tester

Introduction

Cotton (*Gossypium hirstum* L.) is the king of fibre and an important cash crop of India which exercise profound influence on economics and social affairs. Although cotton in India is grown chiefly for its fiber but it also gained additional economic importance as a major contributor of edible oil, proteins and other by-products. Cotton is the most important raw material for Indian textile industry, which makes up 70 per cent of its raw material needs. It is one of the largest contributing sectors of India's export. The world-wide trade of textiles and clothing has boosted the GDP of India to a great extent. The textile industry is claimed to be biggest revenue earner in India in term of foreign exchange and also biggest employer in the country, providing employment to over 119 million people either directly or indirectly. There are four cultivated species of cotton *viz. Gossypium arboreum*, *Gossypium herbaceum*, *Gossypium hirsutum* and *Gossypium barbadense*. Among which *Gossypium hirsutum* is the predominant species which alone contributes about 90% to the global production. India is the only country in the world where all the four cultivated species are grown on commercial scale. Cotton is one of the few crops which are accessible to the development of genotypes as varieties and at the same time amenable for commercial exploitation of heterosis. Sprague and Tatum in 1942 used the term combining ability to describe the average performance of a line in a series of cross combinations. The information on the nature and magnitude of gene action is important in understanding the genetic potential of population and decide the breeding procedure to be adopted in given population. Line x tester analysis is a precise method for obtaining such information when a large number of parents to be tested. In the present study, line x tester analysis has been used to exploit the best heterotic crosses for seed cotton yield and other traits among thirty-two upland cotton hybrids developed by crossing four female parents (lines) with eight male parents (testers) in a line x tester mating design.

Material and Methods

Forty-five specific crosses were undertaken during kharif 2016-2017 by using 12 parents of *G. hirsutum* viz., GSHV 172, GSHV 173, GSHV 185, GISV 310, BGDS 1033, CPD 1501, TCH

1716, TCH 1824, CCH 15-1, Suraj, RAH 1069 and TCH 321 with diverse origin. These hybrids along with one standard check G. COT. Hy. -14 were grown in randomized block design with 3 replications at MCRS Surat, Navsari Agricultural University. Observations were recorded on five randomly selected plants for days to 50 % flowering, plant height (cm), number of sympodia per plant, number of bolls per plant, boll weight (g), seed cotton yield per plant (g), ginning out turn (%), seed index (g) and lint index (g) and lint yield per plant (g). The useful combining ability was estimated as per standard method.

Results and Discussion

For Days to 50 per cent flowering negative value is desirable for this character. A perusal of GCA estimates of days to 50 per cent flowering for parents ranged between -2.21 (CCH 15-1) and 1.59 per cent (TCH 321). Among the parents, two lines *viz.* GSHV 173 (-1.28) and GSHV 185 (-1.50) one testers CCH 15-1 exhibited significant and negative GCA effects (Table 1. 3). A perusal of SCA effects estimates of days to 50 per cent flowering for hybrids ranged between -9.950 (GSHV 173 x CCH 15-1) and 5.149 (GSHV 185 x CCH 15-1). Out of thirty-two hybrids, eleven hybrids showed negative value and out of them five hybrids showed significant and negative SCA effects, GSHV 173 x CCH 15-1 (-9.950), GSHV 185 x Suraj (-4.816), GSHV 185 x RAH 1069 (-4.663), GSHV 185 x TCH 1824 (-4.832) and GSHV 173 x BGDS 1033 (-4.129) (Table 1. 2). A perusal of GCA estimates of plant height for parents ranged between -4.99 (Suraj) to 6.71 (TCH 321). Among these, one of the female parent exhibited significantly positive GCA effect GSHV 173 (4.18) Similarly, in case of male parents, two of parents exhibited significantly positive GCA effect TCH 1824 (5.77) and TCH 321 (6.71) but, one male parent (Suraj) (-4.99) exhibited significantly negative effect which may be used as source of dwarf plants for breeding programmes (Table 1.3). Also, the spectrum of differences in SCA effects ranged from -24.66 (GISV 310 x CPD 1501) to 24.09 (GSHV 173 x CPD 1501). Out of 32 crosses, four crosses *viz*., GSHV 173 x CPD 1501 (24.09), GSHV 185 x BGDS 1033 (20.06), GSHV 185 x TCH 321 (10.24) and GISV 310 x Suraj (18.60) registered significant and positive SCA effects and thus seemed to possess desirable gene combinations for this trait (Table 1.2). On the contrary, five hybrids showed significantly negative SCA effect, which proved to be poor specific cross combination for this trait. For sympodia per plant magnitude of GCA effects among parents varied from -2.94 (TCH 321) to 3.79 (GSHV 173). One-line GSHV 173 (3.79) and two testers CPD 1501 (1.11) and TCH 1824 (1.72) revealed significant positive GCA effect. Magnitude of SCA effects among hybrids varied from -5.85 (GISV 310 x CPD 1501) to 8.23 (GISV 310 X BGDS 1033) (Table 1.3). Out of thirty-two hybrids, seven hybrids showed significant positive SCA effects, best among these are GISV 310 X BGDS 1033 (8.23), GSHV 172 x TCH 321 (5.98), GSHV 173 x CPD 1501 (5.61) and GSHV 173 x RAH 1069 (4.27) (Table 1.2). The result of GCA effects of number of bolls per plant ranged between -3.12 (CPD 1501) to 3.41 (GSHV 172). Among the females, GSHV 172 (3.41) and male, RAH 1069 (3.08) and BGDS 1033 (1.89) showed significant and positive GCA effects, thus seemed to be good general combiners for number of bolls per plant (Table 1.3). Magnitude of SCA effect ranged between -6.56 (GSHV 173 x BGDS 1033) to 9.24 (GSHV 172 x BGDS 1033). Among 32 crosses, eight crosses exhibited significant and positive SCA effects *viz.*, GSHV 172 x BGDS 1033 (9.24), GSHV 173 x RAH 1069 (3.26), GSHV 173 x TCH 321 (2.32), GSHV 185 x TCH 1716 (4.38), GSHV 185 x RAH 1069 (4.02) and GISV 310 x CCH 15-1 (2.98), thus seemed to be good specific cross combinations for number of bolls per plant (Table 1.2). While, six crosses registered as poor specific cross combinations by virtue of exhibiting significant and negative SCA effects for this trait. Highest negative SCA effect were observed for GSHV 173 x BGDS 1033 (-6.56). An examination of GCA estimates for boll weight the value fluctuated from -0.17 (TCH 321) to 0.18 (CPD 1501). A perusal of GCA estimates of boll weight for parents revealed that one female GSHV 185 (0.15) and two male CPD 1501 (0.18), RAH 1069 (0.16) and TCH 1824 (0.11) depicted significantly positive GCA effects indicating its superiority as good general combiners (Table 1.3). The range of SCA effect for boll weight lies between -0.70 (GSHV 172 x BGDS 1033) to 0.62 (GSHV 173 x TCH 1824). Out of 32 crosses, 17 exhibited positive SCA effects, among these eight cross combination depicted significantly positive SCA effect for boll weight which proved to be good specific cross combination, best among them are GSHV 173 x TCH 1824 (0.62), GSHV 172 x TCH 1716 (0.48), GSHV 173 x CCH 15-1 (0.46) and GSHV 173 x BGDS 1033 (0.47). In contrast, ten crosses showed significant and negative SCA effects and therefore, proved to be poor specific cross combinations for this trait (Table 1.2). The result of GCA effects for seed cotton yield per plant ranged between -7.61 (TCH 321) to 19.26 (RAH 1069). The GCA effect indicated that among the parents, one female GSHV 172 (6.14) and one male parent RAH 1069 (19.26) recorded significant GCA effects in desired direction. Thus, these two genotypes seemed to be good general combiners for seed cotton yield per plant. Significant and negative GCA effects among females were exhibited by GSHV 185 (-3.80) and GISV 310 (-3.08), and two tester CCH 15-1 (-4.68) and TCH 321 (-7.61) hereby suggesting their poor general combining ability for this trait (Table 1.3). The spectrum of variation in SCA effects for seed cotton yield per plant was from -19.46 (GSHV 172 x CCH 15-1) to 16.62 (GSHV 172 x BGDS 1033). Among 32 crosses, six crosses *viz.*, GSHV 172 x BGDS 1033 (16.62), GSHV 172 x CPD 1501 (14.45), GSHV 172 x TCH 1824 (11.82), GSHV 173 x CCH 15-1 (15.84), GSHV 185 x TCH 1716 and GISV 310 x TCH 1716 (12.52) recorded significant and positive SCA effects, thus proved to be good specific cross combinations for seed cotton yield per plant (Table 1.2). In contrast, five crosses showed significant and negative SCA effects and proved to be poor specific cross combinations for this trait. The values of GCA effects for lint yield per plant fluctuated between -1.84 (TCH 1716) to 6.70 (RAH 1069). Significant and positive GCA effects were recorded by one female parents *viz*., GSHV 172 (2.43) judged to be good general combiners for lint yield per plant. Whereas, one female parents depicted significantly negative GCA effects GSHV 185 (-1.83), thereby indicating their poor general combining ability for this trait. Out of eight, one male parents RAH 1069 (6.70) depicted significantly positive GCA effect, thus revealing their good combining nature (Table 1.3). The scale of variation in specific combining ability effect meant for lint yield per plant was from -7.05 (GISV 310 x RAH 1069) to 6.22 (GISV 310 x TCH 1716). Among 32, seven hybrids depicted significant and positive SCA effects, best among them are GISV 310 x TCH 1716 (6.22), GSHV 185 x RAH 1069 (5.01), GSHV 172 x CPD 1501 (5.08), GSHV 172 x TCH 1824 (4.97) and GSHV 173 x CCH 15-1 (4.42) depicted significant and positive SCA effects, thus proved to be good specific cross combinations (Table 1.2). In contrast, ten crosses showed significant and negative SCA effects which proved to be poor specific cross combinations for this trait. The estimates of general combining ability effects for ginning percentage revealed that none of parents (4 lines and 8 testers) were found to be significant. For ginning percentage, magnitude of variation for SCA effects was varied from -1.98 (GISV 310 x TCH 1824) to 5.40 (GSHV 173 x TCH 321) (Table 1.2). Out of total 32 hybrids, only one cross GSHV 173 x TCH 321 (5.40) exhibited significantly positive SCA effects for ginning percentage, thus proved to be good specific cross combinations. The higher seed index is desirable trait in cotton. Out of 12 parents, female GSHV 173 (0.40) were identified as good general combiners by virtue of exhibiting significantly positive GCA effect for this trait (Table 1.3). For seed index, magnitude of variation for SCA effects was varied from -1.33 (GISV 310 x TCH 321) to 1.45 (GSHV 172 x TCH 1824). Out of total 32, only three crosses *viz.* GSHV 172 x TCH 1824 (1.45), GSHV 172 x TCH 321 (1.30) and GSHV 173 x BGDS 1033 (1.11) depicted significantly positive SCA effects for seed index (Table 1.2). In the contrary, two hybrid GSHV 172 x BGDS 1033 (-1.10) and GISV 310 x TCH 321 (-1.33) showed significant and negative SCA effects and thus proved to be poor specific cross combination for this trait. A perusal of the results for lint index revealed that, none of parents showed significantly positive GCA effects (Table 1. 3). A perusal of data for lint index revealed that the magnitude of SCA effects ranged between -1.38 (GISV 310 x TCH 321) to 1.63 (GSHV 173 x TCH 321) (Table 1. 2). Among 32 crosses, only one cross GSHV 173 x TCH 321 (1.63) showed significantly positive SCA effects and thus these cross combinations seemed to be best desired specific cross combinations for lint index. On the other hand, GISV 310 x TCH 321 (-1.38) showed negative SCA effect of the cross was observed as the poor specific cross combinations by virtue of exhibiting significant and negative SCA effects for this trait. Variances estimates due to general combining ability (σ^2GCA) were observed to be significant for number of sympodia per plant, number of bolls per plant, seed cotton yield per plant, lint yield per plant, seed index and fibre strength. The estimates of variance due to specific combining ability (σ^2SCA) were observed significant for all the characters except ginning percentage. (Table 1. 1) Variances due to GCA and SCA were found significant for number of sympodia per plant, number of bolls per plant, seed cotton yield per plant, lint yield per plant, seed index and fibre strength. both additive as well as non-additive types of gene actions were involved in the inheritance of these traits. Importance of additive and non-additive genetic components in the expression of different characters in cotton has been also reported by Giri *et al.* (2006) [1], Nirania *et al.* (2005) [4], Reddy and Nandarajan (2006) [12], Patel *et al.* (2007) [8], Preetha and Raveendaran (2008) [11], Nirania *et al.* (2010) [5], Singh (2010) [13], Sohu *et al.* (2010) [14], Kumar *et al.* (2013) [2], Pandit *et al.* (2014) [6]. Thus, non-additive gene action influenced all the charactres which emphasized the use of heterosis breeding approach to exploit the available vigour. Importance of additive and non-additive genetic components in the expression of different characters in cotton has been also reported by Giri *et al.* (2006) [1], Nirania *et al.* (2005) [4], Reddy and Nandarajan (2006) [12], Patel *et al.* (2007) [8], Preetha and Raveendaran (2008) [11], Nirania *et al.* (2010) [5], Singh (2010) [13], Sohu *et al.* (2010) [14], Kumar *et al.* (2013) [2], Pandit *et al.* (2014) [6]. Thus, non-additive gene action influenced all the charactres which emphasized the use of heterosis breeding approach to exploit the available vigour. The ratio of σ^2GCA/ σ^2SCA revealed that all the characters manifested less than unity which indicated preponderance of non-additive genetic variance for inheritance of these traits. Saini *et al*. (2005), Preetha and Raveendran (2008) [11], Nirania *et al*. (2010) [5], Patel *et al*. (2010) [7], Patil *et al*. (2011) [10], Patel *et al.* (2012) [9] and Lodam *et al.* (2014) [3] also found preponderance of non-additive genetic variance for inheritance of several traits of cotton.

Table 1.1: Mean sum of squares due to general & specific combining ability for different characters in tetraploid cotton (*G. hirsutum* L.)

Source of variation	D.F.	Days to 50% Flowering	Plant height (cm)	Sympodia per plant	Bolls per plant	Boll Weight (g)
Replications	2	1.93	157.34	13.00 **	24.63 **	0.04
Hybrids	31	40.93 **	409.33 **	61.07 **	54.29 **	0.46 **
Lines effect	3	62.37	218.27	190.48 *	134.92	0.27
Testers effect	7	22.14	236.32	26.98	46.71	0.29
Line x tester effect	21	44.13 **	494.30 **	53.94 **	45.31 **	0.55 **
Error	62	8.22	66.43	3.96	4.62	0.03
σ^2f		2.24	6.38	7.79 *	5.46	0.01
σ^2m		1.13	14.28	1.96	3.57	0.02
σ^2gca		1.86	9.01	5.84 *	4.83 *	0.01
σ^2sca		11.84 **	143.12 **	16.81 **	13.81 **	0.17 **
σ^2gca/σ^2sca		0.15	0.06	0.35	0.35	0.07

*, ** Significant at 5 % and 1 % levels, respectively

Table 1.1: contd...

Source of variation	D.F.	Seed cotton yield/plant (g)	Lint yield/plant (g)	Ginning percentage	Seed index (g)	Lint index (g)
Replications	2	323.43 **	47.54 **	33.63 *	1.48	2.74 *
Hybrids	31	588.34 **	70.35 **	11.14	2.34 **	1.18 *
Lines effect	3	498.33	81.38	3.47	6.75 *	0.45
Testers effect	7	826.32	92.04	15.64	1.57	0.87
Line x tester effect	21	521.87 **	61.54 **	10.73	1.97 **	1.38 *
Error	62	50.26	6.29	8.19	0.80	0.68
σ^2f		18.44	3.16	-0.38	0.24 *	-0.0038
σ^2m		64.21	7.21	0.24	0.06	0.03
σ^2gca		33.70 *	4.51 *	-0.17	0.18 *	0.01
σ^2sca		155.38 **	18.70 **	-0.66	0.38 **	0.28 **
σ^2gca / σ^2sca		0.21	0.48	0.26	0.48	0.02

*, ** Significant at 5 % and 1 % levels, respectively

Table 1.2: Specific combining ability (SCA) effects of hybrids for various characters in tetraploid cotton (*G. hirsutum* L.)

S. No.	Crosses	Days to 50% flowering	Plant height (cm)	Sympodia per plant	Bolls per plant	Boll Weight (g)
1	GSHV 172 x BGDS 1033	0.33	-16.15 **	-5.33 **	9.24 **	-0.70 **
2	GSHV 172 x CPD 1501	-1.80	-2.03	1.15	-0.28	0.09
3	GSHV 172 x TCH 1716	-1.45	-3.39	-2.03	-4.12 **	0.48 **
4	GSHV 172 x TCH 1824	1.71	5.45	2.02	2.29 *	-0.24 *
5	GSHV 172 x CCH 15-1	1.68	7.09	0.78	-4.58 **	0.20 *
6	GSHV 172 x Suraj	0.71	-7.44	-0.94	1.31	-0.10
7	GSHV 172 x RAH 1069	0.22	9.74 *	-1.65	-1.88	0.08
8	GSHV 172 x TCH 321	-1.41	6.70	5.98 **	-1.99	0.17
9	GSHV 173 x BGDS 1033	-4.12 *	-2.71	-5.46 **	-6.56 **	0.47 **
10	GSHV 173 x CPD 1501	2.14	24.09 **	5.61 **	-1.95	0.20 *
11	GSHV 173 x TCH 1716	0.66	-0.95	0.13	-1.41	-0.56 **
12	GSHV 173 x TCH 1824	2.99	0.67	-1.06	0.38	0.62 **
13	GSHV 173 x CCH 15-1	-9.95 **	3.08	-2.21 *	1.71	0.46 **
14	GSHV 173 x Suraj	4.05 *	-10.82 *	3.69 **	2.25	-0.32 **
15	GSHV 173 x RAH 1069	3.54 *	-5.28	4.27 **	3.26 **	-0.40 **
16	GSHV 173 x TCH 321	0.69	-8.09	-4.98 **	2.32 *	-0.47 **
17	GSHV 185 x BGDS 1033	3.70 *	20.06 **	2.55 *	-3.16 **	0.15
18	GSHV 185 x CPD 1501	1.24	2.60	-0.92	-0.67	0.06
19	GSHV 185 x TCH 1716	2.15	-0.12	-1.34	4.38 **	-0.27 **
20	GSHV 185 x TCH 1824	-4.83 **	-5.38	-0.70	-1.15	-0.34 **
21	GSHV 185 x CCH 15-1	5.149 **	-11.44 *	0.01	-0.10	-0.05
22	GSHV 185 x Suraj	-4.81 **	-0.35	-2.77 *	-2.58 *	0.12
23	GSHV 185 x RAH 1069	-4.66 **	-15.61 **	-0.73	4.02 **	-0.04
24	GSHV 185 x TCH 321	2.07	10.24 *	3.89 **	-0.74	0.37 **
25	GISV 310 x BGDS 1033	0.10	-1.20	8.23 **	0.48	0.07
26	GISV 310 x CPD 1501	-1.58	-24.66 **	-5.85 **	2.89 *	-0.35 **
27	GISV 310 x TCH 1716	-1.37	4.46	3.23 **	1.15	0.35 **
28	GISV 310 x TCH 1824	0.13	-0.73	-0.26	-1.53	-0.04
29	GISV 310 x CCH 15-1	3.12	1.27	1.42	2.98 *	-0.61 **
30	GISV 310 x Suraj	0.04	18.60 **	0.02	-0.97	0.30 **
31	GISV 310 x RAH 1069	0.90	11.14 *	-1.90	-5.41 **	0.35 **
32	GISV 310 x TCH 321	-1.34	-8.89	-4.90 **	0.40	-0.08
	S.E. (Sij) ±	1.69	4.65	1.08	1.14	0.10
	S.E. (Sij - Skl)	2.40	6.58	1.52	1.61	0.14
	S. E. (Sij - Sik)	1.89	5.20	1.20	1.27	0.11

*, ** Significant at 5 % and 1 % levels, respectively

Table 1.2: Contd…

S. No.	Crosses	Seed Cotton Yield/plant (g)	Lint Yield/ plant (g)	Ginning percentage	Seed index (g)	Lint index (g)
1	GSHV 172 x BGDS 1033	16.62 **	4.27 **	-1.68	-1.100 *	-0.65
2	GSHV 172 x CPD 1501	14.45 **	5.08 **	0.02	0.18	-0.08
3	GSHV 172 x TCH 1716	-15.50 **	-4.84 **	0.91	-0.54	-0.22
4	GSHV 172 x TCH 1824	11.82 **	4.97 **	0.68	1.45 **	0.83
5	GSHV 172 x CCH 15-1	-19.46 **	-6.45 **	0.32	-0.95	-0.32
6	GSHV 172 x Suraj	-0.35	-1.18	0.26	-0.33	-0.20
7	GSHV 172 x RAH 1069	-1.09	1.28	1.20	-0.03	0.29
8	GSHV 172 x TCH 321	-6.50	-3.15 *	-1.72	1.30 *	0.35
9	GSHV 173 x BGDS 1033	-9.73 *	-3.32 *	-1.90	1.11 *	0.33
10	GSHV 173 x CPD 1501	-19.14 **	-6.81 **	-0.48	-1.17 *	-0.80
11	GSHV 173 x TCH 1716	-11.27 *	-2.87 *	-0.07	-0.03	-0.03
12	GSHV 173 x TCH 1824	9.74 *	2.94 *	-0.31	-0.43	-0.37
13	GSHV 173 x CCH 15-1	15.84 **	4.42 **	-1.28	0.40	-0.30
14	GSHV 173 x Suraj	5.72	2.46	-0.41	-0.21	-0.26
15	GSHV 173 x RAH 1069	10.82 *	0.75	-0.95	0.35	-0.20
16	GSHV 173 x TCH 321	-1.98	2.42	5.40 *	-0.01	1.63 **
17	GSHV 185 x BGDS 1033	-7.43	-2.53	1.32	0.23	0.23
18	GSHV 185 x CPD 1501	6.25	2.22	-0.29	0.48	0.40
19	GSHV 185 x TCH 1716	11.12 *	1.49	-1.94	0.26	-0.42
20	GSHV 185 x TCH 1824	-14.11 **	-3.62 **	1.61	-0.81	0.10
21	GSHV 185 x CCH 15-1	-1.31	-0.15	0.10	-0.15	-0.04
22	GSHV 185 x Suraj	-8.14	-2.90 *	-0.17	-0.06	0.10
23	GSHV 185 x RAH 1069	8.76 *	5.01 **	1.27	0.01	0.24
24	GSHV 185 x TCH 321	4.84	0.48	-1.90	0.04	-0.60
25	GISV 310 x BGDS 1033	0.54	1.57	2.26	-0.25	0.10
26	GISV 310 x CPD 1501	-1.56	-0.49	0.75	0.53	0.47
27	GISV 310 x TCH 1716	15.65 **	6.22 **	1.10	0.31	0.67
28	GISV 310 x TCH 1824	-7.46	-4.29 **	-1.98	-0.22	-0.56
29	GISV 310 x CCH 15-1	4.93	2.18	0.87	0.70	0.67
30	GISV 310 x Suraj	2.77	1.62	0.31	0.60	0.37
31	GISV 310 x RAH 1069	-18.50 **	-7.05 **	-1.53	-0.34	-0.33

32	GISV 310 x TCH 321	3.64	0.25	-1.78	-1.33 *	-1.38 **
	S.E. (Sij) ±	4.31	1.35	2.06	0.52	0.43
	S.E. (Sij - Skl)	6.10	1.90	2.91	0.73	0.60
	S. E. (Sij - Sik)	4.82	1.50	2.30	0.58	0.48

*, ** Significant at 5% and 1% levels, respectively

Table 1.3: General combining ability (GCA) effects of parents for various characters in tetraploid cotton (*G. hirsutum* L.)

Parents	Days to 50% flowering	Plant height (cm)	Sympodia per plant	Bolls per plant	Boll Weight (g)
Lines					
GSHV-172	1.42 *	-1.98	-2.85 **	3.41 **	-0.05
GSHV-173	-1.28 *	4.18 *	3.79 **	-0.34	-0.05
GSHV-185	-1.50 *	-2.39	-1.11 **	-1.97 **	0.15 **
GISV-310	1.36 *	0.19	0.17	-1.08 **	-0.04
S. E. (gi)	0.60	1.64	0.38	0.40	0.03
S. E. (gi-gj)	0.84	2.32	0.53	0.56	0.05
Testers					
BGDS-1033	-0.58	0.23	-0.34	1.89 **	-0.15 **
CPD-1501	1.25	-3.72	1.11 *	-3.12 **	0.18 **
TCH-1716	1.61	1.46	0.88	-0.77	-0.14**
TCH-1824	-0.49	5.77 *	1.72 **	-0.08	0.11 *
CCH-15-1	-2.21 *	-4.04	0.41	-1.61 **	0.09
Suraj	-0.50	-4.99 *	-1.27 *	1.02	-0.09
RAH-1069	-0.66	-1.43	0.42	3.08 **	0.16 **
TCH-321	1.59	6.71 **	-2.94 **	-0.40	-0.17 **
S. E. (gi)	0.84	2.32	0.53	0.56	0.05
S. E. (gi-gj)	1.19	3.28	0.76	0.80	0.07

*, ** Significant at 5% and 1% levels, respectively

Table 1.3: contd…

Parents	Seed cotton yield/plant (g)	Lint yield/ plant (g)	Ginning percentage	Seed index (g)	Lint index (g)
Lines					
GSHV-172	6.14 **	2.43 **	0.41	0.08	0.08
GSHV-173	0.74	0.29	-0.35	0.40 *	0.14
GSHV-185	-3.80 *	-1.83 **	-0.29	0.28	-0.05
GISV-310	-3.08 *	-0.89	0.23	-0.77 **	-0.16
S. E. (gi)	1.52	0.47	0.72	0.18	0.15
S. E. (gi-gj)	2.15	0.67	1.03	0.25	0.21
Testers					
BGDS-1033	-4.26	-1.02	1.76	-0.52 *	0.17
CPD-1501	-3.09	-0.66	-0.31	-0.30	-0.03
TCH-1716	-0.24	-1.84 **	-1.30	-0.08	-0.35
TCH-1824	1.52	0.10	-1.05	0.48	-0.22
CCH-15-1	-4.68 *	-0.63	0.66	0.32	0.37
Suraj	-0.90	-1.24	-0.73	0.23	0.05
RAH-1069	19.26 **	6.70 **	-0.41	0.20	-0.27
TCH-321	-7.61 ***	-1.40 *	1.39	-0.33	0.28
S. E. (gi)	2.15	0.67	1.03	0.25	0.21
S. E. (gi-gj)	3.04	0.95	1.45	0.36	0.30

*, ** Significant at 5% and 1% levels, respectively

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