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Heterosis and combining ability studies for fibre quality traits in desi cotton (*Gossypium arboreum* L.)

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Abstract
Cotton crop is mainly cultivated for its fibre and hence quality of lint is important in cotton. Thirty hybrid combinations developed by crossing 5 lines and 6 testers were tested along with their parents including 3 checks in Line X Tester design for fibre quality characters. The magnitude of heterosis was estimated in relation to mid parent, better parent and standard checks. Results revealed that the cross combination PA 828 x AKA 7 showed highest and desirable significant standard heterosis for upper half mean length, PA 828 x RAC 024 for micronaire, whereas the cross PA 760 x AKA 7 for uniformity index and PA 740 x RAC 024 for fibre strength. With regards to quality traits, AKA 9703 was found to be best general combiner for upper half mean length, fibre fineness, uniformity index and fibre strength. The cross PA 828 x AKA 7 had good specific combining ability effects (SCA) for upper half mean length, PA 760 x AKA 7 for micronaire, whereas the cross PA 740 x Phule Dhanwantary for uniformity index and PA 740 x RAC 024 for fibre strength.

Keywords: Desi cotton, fibre strength, heterobeltiosis, standard heterosis

Introduction
Cotton is the most important fibre crop grown in India. Cotton is used in textile industries while it is also called as king of fiber, white gold crop. Since India is having a large domestic textile industry, the mill consumption of cotton in the country especially, textile mills and small scale spinning unit had been continuously on the rise. Although, Indian cotton have very wide quality spectrum, the right combination of fibre length, micronaire and desirable fibre strength is however absent in many of the popular varieties and hybrids. There is an urgent need to promote those cotton that could come closer in quality to the most sought by modern textile mills.
Cotton improvement programmes primarily lay emphasis on development of hybrids, which have contributed in improving productivity of cotton. Hybridization is the most potent technique for breaking yield barriers. In heterosis breeding programme, the selection of parents or inbreds based on their morphological diversity with good combining ability is very important in producing superior hybrids. The analysis of general combining ability and specific combining ability helps in identifying potential parents or inbreds for the production of superior hybrids. The Line x Tester analysis (Kempthorne, 1957) [6] is one of the simplest and efficient methods of evaluating large number of inbreds/parents for their combining ability. Based on the information from Line x Tester analysis, production of commercially viable hybrids is possible.

Materials and methods
Five lines namely, PA 740, PA 760, PA 828,PA 848 and PAIG 77 crossed as females (lines) to six male parents of cotton *viz,* AKA 9703, AKA 7, JLA 505, RAC 024, PA 08 and Phule Dhanwantary as testers in line x tester manner. Thirty F_1's along with 11 parents and three checks were grown in randomized block design with three replications at Cotton Research Station, Mahboob Baugh Farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2017-2018. Two rows of each treatment having 6.0 m length and spacing of 60 cm between rows and 30 cm between plants was sown. All the recommended package of practices were followed to raise a good crop. Observations were recorded on 5 randomly selected plants in each plot on upper half mean length, fibre fineness, uniformity index, fibre strength and ginning outturn. After recording the observations for each character, the analysis of variance was carried out. The mean square from line x tester design and the general combining ability (GCA) and specific combining ability (SCA) variance and effects were

calculated. Analysis for heterosis was carried out as per the method suggested by Fonesca and Patterson (1968).

Results and discussion

Analysis of variance revealed significant genotype effects for all the characters studied. This indicates that genotypes studied were different for the fibre characters (Table 1). In the present study, superiority of the hybrids was observed over mid parent, better parent and standard check for all the fibre characters. The range of heterosis over mid parent, better parent and standard check in respect of each of the character studied are presented in the Table 2.

For upper half mean length, the cross combination PA 760 x AKA 9703 was found superior over mid parent, while the cross combination PA 828 x AKA 7 displayed maximum significant positive heterosis over better parent. The cross combination PA 828 x AKA 7 exhibited highest significant positive heterosis over standard checks PKVDH 1, PKV Suvarna and NACH 12 for upper half mean length. Out of 30 crosses, nine crosses were found superior over mid parent, two crosses over better parent, two over standard check PKVDH 1, twenty crosses were found superior over standard check PKV Suvarna, while twenty one crosses were found superior over standard check NACH 12 for upper half mean length. Similar results were obtained by Khan *et al.* (2015) [7], Patel *et al.* (2011) [12], Tuteja *et al.* (2011) [17], Ashokkumar *et al.* (2013) and Singh *et al.* (2013) [16]. Heterosis in negative direction is desirable for micronaire value. The cross combination PAIG 77 x AKA 9703 was found superior as it showed the highest significant negative heterosis over mid parent and better parent for fibre fineness. Two and nine crosses each recorded significant negative heterosis over mid parent and better parent, whereas fifteen and thirty crosses each over standard checks PKVDH 1 and NACH 12. Heterosis in negative direction for this trait was reported by Tuteja *et al.* (2011) [17].

For fibre strength, the cross combination PAIG 77 X AKA 9703 was found superior over mid parent and better parent with highly significant positive heterosis for fibre strength. Whereas, the cross combination PA 740 x RAC 024 showed highly significant heterosis over standard check NACH 12. Out of 30 crosses, ninteen crosses showed significant positive heterosis over check NACH 12, for fiber strength. Similar results were reported by Tuteja *et al.* (2011) [17] and Ranganatha *et al.* (2013) [14]. For the uniformity index, positive heterosis is desirable. Out of thirty, the crosses *viz.*, PA 760 x AKA 9703, PA 760 x AKA7 and PA 740 x AKA 9703 exhibited significant positive heterosis over mid-parent for uniformity index. Only two cross combination PA 760 x AKA and PA 760 x AKA 9703 exhibited significant positive heterosis over better parent. Heterosis for this trait was reported by the earlier workers Patil *et al.* (2012) [13] and Ranganatha *et al.* (2013) [14].

For ginning outturn, positive heterosis is desirable. Heterosis for this trait was observed to the extent of 69.01 per cent in the cross combination PAIG 77 x RAC 024 over mid parent. Out of thirty crosses, six crosses showed significant positive heterosis over mid-parent and only two crosses displayed significant positive heterosis over better parent for ginning outturn. The cross combination PA 760 x RAC 024 exhibited maximum positive significant heterosis over the standard check PKV Suvarna. Heterosis for this trait was reported by the earlier worker, Tuteja *et al.* (2011) [17], Balu *et al.* (2012) [3] and Khan *et al.* (2015) [7].

The combining ability analysis indicated presence of considerable genetic variability among the crosses for all the traits under study (Table 3). None of the female and male line exhibited significant differences for all the characters studied. The crosses and Male x female interaction exhibited significant differences for all the characters except fibre fineness. General combining ability effects of lines and testers were presented in Table 4 and 5. Specific combining ability effects were presented in Table 6.

The present finding indicate that among female parents, parent AKA 7 and was found good general combiner for upper half mean length. Among male parents, AKA 9703 showed desirable positive general combining ability effect (GCA) for uniformity index. Similar results were reported by Anandan (2010) [1], Nadigundi *et al.* (2011) [11], Mendez-Natera *et al.* (2012) [10] and Kumar *et al.* (2014) [9] for these characters.

The study of specific combining ability effect (SCA) of fibre quality traits revealed that the cross PA 740 x Phule Dhanwantary exhibited positive significant specific combining ability effect (SCA) for uniformity index. The cross PA 740 x RAC 024 showed highest significant positive specific combining ability effect (SCA) for fibre strength. Similarly, the cross PA 760 x AKA 7 exhibited negative significant specific combining ability effect (SCA) for micronaire value in desirable direction. The results are in agreement with findings of Anandan (2010) [1], Basal *et al.* (2011) [4]. Similarly, male parent AKA 9703 had significant general combining ability effect (GCA) for ginning outturn. The results are in agreement with the reports of Giri *et al.* (2006) [5] Sarvanan *et al.* (2010) [15] and Kumar *et al.* (2013) [8].

Table 1: ANOVA for fibre quality characters

Source of variation	d.f.	Ginning out turn (%)	Upper half mean length (mm)	Fibre fineness (micronaire) (µg/inch)	Fibre strength (g/tex)	Uniformity ratio (%)
		Mean sum of squares				
Replications	1	1.550	2.635	0.045	3.180	2.556
Treatments	43	35.45**	5.545**	0.162**	4.701**	4.138**
Error	43	1.481	1.457	0.039	1.252	1.859

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

Table 2: Per cent heterosis over mid parent (M.P.), better parent (BP), standard hybrid PKVDH 1, PKV Suvarna and NACH 12

Sr. No.	Hybrids	Fibre fineness/ Micronaire (µg/inch)						Fibre strength					
		Mean	M.P. Heterosis (%)	B.P. Heterosis (%)	% standard heterosis over			Mean	M.P. Heterosis (%)	B.P. Heterosis (%)	% standard heterosis over		
					PKVDH 1	PKV Suvarna	NACH 12				PKVDH 1	PKV Suvarna	NACH 12
1	PA 740 x AKA 9703	5.40	0.00	-8.47*	-4.42	6.93	-14.29**	27.05	17.16**	14.01**	-0.55	0.00	9.29
2	PA 740 x JLA 505	5.60	6.67	0.00	-0.88	10.89*	-11.11**	25.15	0.15	-5.09	-7.54	-7.02	1.62

3	PA 740 x RAC 024	5.05	-1.94	-6.48	-10.62**	0.00	-19.84**	29.35	19.86**	16.24**	7.90	8.50	18.59**
4	PA 740 x AKA 7	5.45	2.83	-4.39	-3.54	7.92	-13.49**	27.45	10.41*	5.58	0.92	1.48	10.91*
5	PA 740 x PA 08	5.20	2.97	0.00	-7.96*	2.97	-17.46**	24.90	-1.92	-7.95	-8.46	-7.95	0.61
6	PA 740 x Phule Dhanwantary	5.15	0.49	-3.74	-8.85*	1.98	-18.25**	25.05	-2.39	-9.24*	-7.90	-7.39	1.21
7	PA 760 x AKA 9703	5.25	0.48	-11.02**	-7.08	3.96	-16.67**	27.45	18.06**	14.14**	0.92	1.48	10.91*
8	PA 760 x JLA 505	5.30	4.43	-5.36	-6.19	4.95	-15.87**	27.15	7.42	2.45	-0.18	0.37	9.70*
9	PA 760 x RAC 024	5.35	7.54*	-0.93	-5.31	5.94	-15.08**	26.00	5.48	2.97	-4.41	-3.88	5.05
10	PA 760 x AKA 7	5.00	-2.44	-12.28**	-11.50**	-0.99	-20.63**	28.35	13.29**	9.04	4.23	4.81	14.55**
11	PA 760 x PA 08	5.15	5.64	-0.96	-8.85*	1.98	-18.25**	28.05	9.78*	3.70	3.13	3.70	13.33**
12	PA 760 x Phule Dhanwantary	5.35	8.08*	0.00	-5.31	5.94	-15.08**	27.95	8.23*	1.27	2.76	3.33	12.93**
13	PA 848 x AKA 9703	5.45	-0.46	-7.63*	-3.54	7.92	-13.49**	28.35	16.79**	8.62	4.23	4.81	14.55**
14	PA 848 x JLA 505	5.05	-5.16	-9.82*	-10.62**	0.00	-19.84**	26.55	0.95	0.19	-2.39	-1.85	7.27
15	PA 848 x RAC 024	5.20	-0.48	3.70	-7.96*	2.97	-17.46**	26.30	2.43	0.77	-3.31	-2.77	6.26
16	PA 848 x AKA 7	5.45	1.40	-4.39	-3.54	7.92	-13.49**	27.90	7.10	6.90	2.57	3.14	12.73*
17	PA 848 x PA 08	5.40	5.37	3.85	-4.42	6.93	-14.29**	25.75	-3.10	-4.81	-5.33	-4.81	4.04
18	PA 848 x Phule Dhanwantary	5.20	0.00	-2.80	-7.96*	2.97	-17.46**	26.50	-1.30	-3.99	-2.57	-2.03	7.07
19	PA 828 x AKA 9703	5.10	-7.27*	-13.56**	-9.73*	0.99	-19.05**	27.50	14.11**	6.80	1.10	1.66	11.11*
20	PA 828 x JLA 505	5.15	-3.74	-8.04*	-8.85*	1.98	-18.25**	26.15	0.10	-1.32	-3.86	-3.33	5.66
21	PA 828 x RAC 024	5.00	-4.76	-7.41	-11.50**	-0.99	-20.63**	28.15	10.39*	9.32*	3.49	4.07	13.74**
22	PA 828 x AKA 7	5.25	-2.78	-7.89*	-7.08	3.96	-16.67**	28.10	8.60*	8.08	3.31	3.88	13.54**
23	PA 828 x PA 08	5.35	3.88	2.88	-5.31	5.94	-15.08**	27.70	4.92	2.40	1.84	2.40	11.92*
24	PA 828 x Phule Dhanwantary	5.25	0.48	-1.87	-7.08	3.96	-16.67**	27.45	2.91	-0.54	0.92	1.48	10.91*
25	PAIG 77 x AKA 9703	5.05	-8.60*	-14.41**	-10.62**	0.00	-19.84**	29.35	24.63**	19.07**	7.90	8.50	18.59**
26	PAIG 77 x JLA 505	5.30	-1.40	-5.36	-6.19	4.95	-15.87**	27.95	9.29*	5.47	2.76	3.33	12.93**
27	PAIG 77 x RAC 024	5.20	-1.42	-3.70	-7.96*	2.97	-17.46**	27.22	9.10*	7.80	0.07	0.63	9.98*
28	PAIG 77 x AKA 7	5.45	0.46	-4.39	-3.54	7.92	-13.49**	24.15	-4.64	-7.12	-11.21*	-10.72*	-2.42
29	PAIG 77 x PA 08	5.00	-3.38	-3.85	-11.50**	-0.99	-20.63**	27.82	7.62	2.85	2.28	2.85	12.40*
30	PAIG 77 x Phule Dhanwantary	5.10	-2.86	-4.67	-9.73*	0.99	-19.05**	28.15	7.75	1.99	3.49	4.07	13.74**
	S.E.±	5.275	0.174	0.201	0.201	0.201	0.201	26.66	0.996	1.151	1.151	1.151	1.151

Sr. No.	Hybrids	Uniformity ratio (%)						Ginning outturn (%)					
		Mean	M.P. Heterosis (%)	B.P. Heterosis (%)	% standard heterosis over			Mean	M.P. Heterosis (%)	B.P. Heterosis (%)	% standard heterosis over		
					PKVDH1	PKV Suvarna	NACH 12				PKVDH 1	PKV Suvarna	NACH 12
1	PA 740 x AKA 9703	4.00	4.02*	2.44	2.44	2.44	2.44	36.39	-0.70	-5.35	-6.46	-2.36	-18.11**
2	PA 740 x JLA 505	81.50	0.31	-0.61	-0.61	-0.61	-0.61	37.31	1.93	-2.74	-4.11	0.09	-16.05**
3	PA 740 x RAC 024	82.50	0.92	0.61	0.61	0.61	0.61	36.08	9.39**	3.53	-7.27*	-3.21	-18.81**
4	PA 740 x AKA 7	82.00	0.92	0.00	0.00	0.00	0.00	35.95	6.33	3.17	-7.60*	-3.54	-19.10**
5	PA 740 x PA 08	79.50	-3.05*	-3.05	-3.05	-3.05	-3.05	34.06	-7.80*	-12.76**	-12.45**	-8.61*	-23.35**
6	PA 740 x Phule Dhanwantary	83.50	1.83	1.83	1.83	1.83	1.83	34.25	-5.74	-9.46**	-11.97**	-8.10	-22.92**
7	PA 760 x AKA 9703	84.00	5.00**	4.35*	2.44	2.44	2.44	37.55	-1.52	-2.33	-3.48	0.75	-15.49**
8	PA 760 x JLA 505	83.00	3.11*	3.11	1.22	1.22	1.22	36.54	-4.06	-4.73	-6.08	-1.96	-17.77**
9	PA 760 x RAC 024	83.00	2.47	1.84	1.22	1.22	1.22	40.23	16.75**	6.40	3.42	7.96*	-9.45**
10	PA 760 x AKA 7	84.50	4.97**	4.97**	3.05	3.05	3.05	33.76	-4.33	-10.71**	-13.21**	-9.40**	-24.01**
11	PA 760 x PA 08	83.50	2.77	1.83	1.83	1.83	1.83	36.06	-6.16*	-7.63*	-7.31*	-3.25	-18.85**
12	PA 760 x Phule Dhanwantary	78.00	-4.00*	-4.88**	-4.88**	-4.88**	-4.88**	34.92	-7.67*	-7.69*	-10.24**	-6.31	-21.41**
13	PA 848 x AKA 9703	83.50	3.09*	1.21	1.21	1.83	1.83	39.97	3.85	3.75	2.72	7.23*	-10.06**
14	PA 848 x JLA 505	82.00	0.61	-0.61	-0.61	0.00	0.00	37.05	-3.62	-3.83	-4.78	-0.60	-16.63**
15	PA 848 x RAC 024	83.00	1.22	0.61	0.61	1.22	1.22	34.91	0.29	-9.36**	-10.26**	-6.32	-21.42**
16	PA 848 x AKA 7	83.50	2.45	1.21	1.83	1.83	1.83	35.17	-1.35	-8.71*	-9.61**	-5.65	-20.86**
17	PA 848 x PA 08	81.50	-0.91	-1.21	-0.61	-0.61	-0.61	35.74	-7.84**	-8.45*	-8.14*	-4.11	-19.57**
18	PA 848 x Phule Dhanwantary	82.00	-0.30	-0.61	0.00	0.00	0.00	36.52	-4.32	-5.18	-6.12	-2.00	-17.80**
19	PA 828 x AKA 9703	83.50	3.73*	2.45	1.83	1.83	1.83	37.88	3.12	-1.47	-2.63	1.64	-14.75**
20	PA 828 x JLA 505	82.50	1.85	1.23	0.61	0.61	0.61	36.01	-1.83	-6.10	-7.43*	-3.37	-18.95**
21	PA 828 x RAC 024	83.00	1.84	1.84	1.22	1.22	1.22	34.64	4.78	-1.07	-10.95**	-7.04*	-22.03**
22	PA 828 x AKA 7	83.00	2.47	1.84	1.22	1.22	1.22	35.44	4.55	1.20	-8.91**	-4.91	-20.24**
23	PA 828 x PA 08	83.50	2.14	1.83	1.83	1.83	1.83	35.81	-3.31	-8.29*	-7.97*	-3.93	-19.42**
24	PA 828 x Phule Dhanwantary	82.00	0.31	0.00	0.00	0.00	0.00	36.15	-0.77	-4.45	-7.09*	-3.02	-18.66**
25	PAIG 77 x AKA 9703	83.00	3.11*	1.84	1.22	1.22	1.22	36.85	43.74**	-4.14	-5.27	-1.11	-17.06**
26	PAIG 77 x JLA 505	78.00	-3.70*	-4.29*	-4.88**	-4.88**	-4.88**	34.74	35.73**	-9.43**	-10.71**	-6.79*	-21.82**

27	PAIG 77 x RAC 024	82.50	1.23	1.23	0.61	0.61	0.61	37.14	69.01**	19.37**	-4.55	-0.36	-16.43**
28	PAIG 77 x AKA 7	81.00	0.00	-0.61	-1.22	-1.22	-1.22	36.68	60.86**	11.93**	-5.71	-1.57	-17.44**
29	PAIG 77 x PA 08	83.00	1.53	1.22	1.22	1.22	1.22	35.82	38.10**	-8.25*	-7.93*	-3.89	-19.39**
30	PAIG 77 x Phule Dhanwantary	82.00	0.31	0.00	0.00	0.00	0.00	32.80	29.48**	-13.30**	-15.69**	-11.99**	-26.18**
	S.E.±	82.07	1.201	1.387	1.387	1.387	1.387	35.90	1.067	1.232	1.232	1.232	1.232

Sr. No.	Hybrids	Upper half mean length (mm)					
		Mean	M.P. Heterosis (%)	B.P. Heterosis (%)	% standard heterosis over		
					PKVDH1	PKV Suvarna	NACH 12
1	PA 740 x AKA 9703	29.06	12.98**	3.77	5.65	13.94**	16.22
2	PA 740 x JLA 505	25.35	-5.67	-9.46*	-7.82	-0.59	1.40
3	PA 740 x RAC 024	29.75	4.85	3.48	8.18	16.67**	19.00**
4	PA 740 x AKA 7	27.30	2.06	-2.50	-0.73	7.06	9.20
5	PA 740 x PA 08	25.00	-7.92*	-10.71*	-9.09*	-1.96	0.00
6	PA 740 x Phule Dhanwantary	29.75	6.82	6.25	8.18	16.67**	19.00**
7	PA 760 x AKA 9703	29.50	17.45**	10.07*	7.27	15.69**	18.00**
8	PA 760 x JLA 505	26.70	1.62	-0.37	-2.91	4.71	6.80
9	PA 760 x RAC 024	27.30	-1.71	-5.04	-0.73	7.06	9.20
10	PA 760 x AKA 7	29.25	11.85**	9.14	6.36	14.71**	17.00**
11	PA 760 x PA 08	27.95	5.27	4.29	1.64	9.61	11.80*
12	PA 760 x Phule Dhanwantary	29.10	6.81	5.07	5.84	14.14**	16.42**
13	PA 848 x AKA 9703	29.45	16.32**	8.27	7.09	15.49**	17.80**
14	PA 848 x JLA 505	28.80	8.78*	5.88	4.73	12.94*	15.20**
15	PA 848 x RAC 024	30.35	8.49*	5.57	10.36*	19.02**	21.40**
16	PA 848 x AKA 7	28.15	6.83	3.49	2.36	10.39*	12.60*
17	PA 848 x PA 08	24.95	-6.73	-8.27	-9.27*	-2.16	-0.20
18	PA 848 x Phule Dhanwantary	27.20	-0.91	-1.81	-1.09	6.67	8.80
19	PA 828 x AKA 9703	29.25	15.19**	6.95	6.36	14.71**	17.00**
20	PA 828 x JLA 505	28.55	7.53	4.39	3.82	11.96*	14.20**
21	PA 828 x RAC 024	28.15	0.36	-2.09	2.36	10.39*	12.60*
22	PA 828 x AKA 7	30.95	17.12**	13.16**	12.55**	21.37**	23.80**
23	PA 828 x PA 08	28.00	4.38	2.38	1.82	9.80*	12.00*
24	PA 828 x Phule Dhanwantary	28.35	3.00	2.35	3.09	11.18*	13.40**
25	PAIG 77 x AKA 9703	26.90	4.60	-3.93	-2.18	5.49	7.60
26	PAIG 77 x JLA 505	29.22	8.73*	4.36	6.25	14.59**	16.88**
27	PAIG 77 x RAC 024	29.00	2.20	0.87	5.45	13.73**	16.00**
28	PAIG 77 x AKA 7	27.95	4.49	-0.18	1.64	9.61	11.80*
29	PAIG 77 x PA 08	28.60	5.34	2.14	4.00	12.16*	14.40**
30	PAIG 77 x Phule Dhanwantary	29.90	7.36	6.79	8.73	17.25**	19.60**
	S.E.±	27.78	1.041	1.202	1.202	1.202	1.202

Table 3: Analysis of variance for combining ability analysis

Source	d.f.	Upper half mean length (mm)	Fibre fineness/ Micronaire (µg/inch)	Fibre strength (g/tex)	Uniformity ratio (%)	Ginning outturn (%)
Replications	1	12.93**	0.266*	10.15*	0.416	0.181
Crosses	29	4.443**	0.051	3.277*	4.885*	5.131**
Females	4	2.388	0.041	2.484	3.275	2.271
Males	5	6.866	0.031	2.226	7.216	10.35
M X F	20	4.248**	0.059	3.699*	4.625*	4.398*
Error	29	1.551	0.041	1.498	2.209	1.844

* and ** indicated significance at 5 and 1 per cent respectively

Table 4: Estimates of general combining ability (GCA) for lines

Parents	Upper half mean length (mm)	Fibre fineness/ Micronaire (µg/inch)	Fibre strength (g/tex)	Uniformity ratio (%)	Ginning outturn (%)
PA 740	-0.623	0.068	-0.673	-0.217	-0.409
PA760	-0.024	-0.007	0.327	0.283	0.431
PA 848	-0.174	0.052	-0.273	0.200	0.479
PA 828	0.551	-0.057	0.344	0.533	-0.092
PAIG 77	0.271	-0.057	0.275	-0.800	-0.408
S.E. (Gi)	0.347	0.058	0.332	0.400	0.355
S.E. (Gi-Gj)	0.490	0.082	0.469	0.566	0.503
CD @5%	0.709	0.119	0.679	0.819	0.727
CD @1%	0.956	0.160	0.915	1.104	0.980

* and** indicates significance at 5 and 1 per cent respectively

Table 5: Estimates of general combining ability (GCA) of testers

Parents	Upper half mean length (mm)	Fibre fineness/ Micronaire (µg/inch)	Fibre strength (g/tex)	Uniformity ratio (%)	Ginning outturn (%)
AKA 9703	0.507	0.010	0.775*	1.217**	1.647**
JLA 505	-0.600	0.040	-0.575	-0.983*	0.248
RAC 024	0.586	-0.080	0.239	0.417	0.520
AKA 7	0.396	0.080	0.025	0.417	-0.680
PA 08	-1.424**	-0.020	-0.321	-0.183	-0.584
Phule Dhanwantary	0.537	-0.030	-0.145	-0.883	-1.153**
S.E. (Gi)	0.380	0.063	0.364	0.438	0.389
S.E. (Gi-Gj)	0.537	0.090	0.514	0.620	0.551
CD @5%	0.777	0.130	0.744	0.897	0.797
CD @1%	1.048	0.175	1.003	1.209	1.074

* and** indicates significance at 5 and 1 per cent respectively

Table 6: Estimates of specific combining ability (SCA) for crosses

Hybrids	Upper half mean length (mm)	Fibre fineness/ Micronaire (µg/inch)	Fibre strength (g/tex)	Uniformity ratio (%)	Ginning outturn (%)
PA 740 x AKA 9703	0.848	0.082	-0.217	0.617	-0.929
PA 740 x JLA 505	-1.751*	0.252	-0.767	0.317	1.385
PA 740 x RAC 024	1.464	-0.178	2.619**	-0.083	-0.117
PA 740 x AKA 7	-0.797	0.062	0.933	-0.583	0.958
PA 740 x PA 08	-1.277	-0.088	-1.271	-2.483*	-1.028
PA 740 x Phule Dhanwantary	1.513	-0.128	-1.297	2.217*	-0.269
PA 760 x AKA 9703	0.693	0.007	-0.817	0.117	-0.609
PA 760 x JLA 505	-1.001	0.027	0.233	1.317	-0.220
PA 760 x RAC 024	-1.587	0.197	-1.731*	-0.083	3.203**
PA 760 x AKA 7	0.554	-0.313*	0.833	1.417	-2.067*
PA 760 x PA 08	1.074	-0.063	0.879	1.017	0.132
PA 760 x Phule Dhanwantary	0.267	0.147	0.603	-3.783**	-0.439
PA 848 x AKA 9703	0.793	0.148	0.683	-0.300	1.759
PA 848 x JLA 505	1.250	-0.282	0.233	0.400	0.238
PA 848 x RAC 024	1.614	-0.012	-0.831	0.000	-2.165*
PA 848 x AKA 7	-0.396	0.078	0.983	0.500	-0.714
PA 848 x PA 08	-1.776*	0.128	-0.821	-0.900	-0.236
PA 848 x Phule Dhanwantary	-1.487	-0.062	-0.247	0.300	1.119
PA 828 x AKA 9703	-0.132	-0.093	-0.784	-0.633	0.244
PA 828 x JLA 505	0.275	-0.073	-0.784	0.567	-0.222
PA 828 x RAC 024	-1.311	-0.103	0.402	-0.333	-1.864*
PA 828 x AKA 7	1.679	-0.013	0.566	-0.333	0.131
PA 828 x PA 08	0.549	0.187	0.512	0.767	0.400
PA 828 x Phule Dhanwantary	-1.062	0.097	0.086	-0.033	1.309
PAIG 77 x AKA 9703	-2.202*	-0.143	1.135	0.200	-0.465
PAIG 77 x JLA 505	1.225	0.077	1.085	-2.600*	-1.181
PAIG 77 x RAC 024	-0.181	0.097	-0.459	0.500	0.942
PAIG 77 x AKA 7	-1.041	0.187	-3.315**	-1.000	1.692
PAIG 77 x PA 08	1.429	-0.163	0.701	1.600	0.731
PAIG 77 x Phule Dhanwantary	0.768	-0.053	0.855	1.300	-1.720
S.E.±	0.850	0.142	0.813	0.981	0.871

*,** - Significant at 5 per cent and 1 per cent level, respectively

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