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Heterosis studies for qualitative and quantitative characters in cotton (*Gossypium arboreum* L.)

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ABSTRACT : Twenty four hybrid combinations developed by crossing 6 lines and 4 testers were tested along with their parents including 2 checks in line x tester design. The magnitude of heterosis was estimated in relation to mid parent, better parent and standard parent. Results revealed that the cross combination PA 740 x RAC 024 showed highest and desirable significant standard heterosis for seed cotton yield / plant, PA 741 x JLA 505 for sympodia / plant, whereas the cross PA 710 x RAC 024 for seeds / boll, PA 760 x CINA 363 for boll weight and plant height. With regards to quality traits significant standard heterosis was exhibited by the cross combination PA 760 x RAC 024 for 2.5 per cent for span length, PA 740 x JLA 505 for fibre fineness, PAIG 326 x RAC 024 for ginning outturn, PA 741 x AKA 7 for fibre strength and JLA 505 for uniformity ratio.

Key words : Fibre quality, *Gossypium arboreum*, line x tester analysis, seed cotton yield, standard heterosis

Cotton is *"King of Fibre"*, a crop of prosperity and importance is closely linked with human civilization ' itself '. India continued to maintain largest area under cotton and is the second largest producer of cotton next to china with 34 per cent of world area and 21 per cent of world production. As the population is increasing at an alarming rate, by 2020 AD Indian population is projected to be demanding about 230-240 lac bales of cotton. In addition to global competition in the production and consumption of cotton fibre combined with technological evolution of yarn and manufacturing machineries warrant renewal of efforts for fibre quality. Hence, the textile industry demands long staple cotton for better quality clothes. For developing potential hybrids in cotton,it is necessary to exploit the hybrid vigour available in cotton. Hybridization is the most potent technique for breaking yield barriers and evolving genotypes with higher yield potential. Selection of appropriate parents for hybridization is the single most important factor determining both the extent and magnitude of success of any plant breeding programme. Therefore, the present investigation aims at establishing the extent of relative heterosis, heterobeltiosis and standard heterosis for yield and fibre quality characters.

The experimental material comprised 6 lines (PA 710, PA 741, PA 734, PA 760, PA 740 and PAIG 326) as females and 4 testers (AKA 7, JLA 505, RAC 024 and CINA 363) as males were tested along with their parents including 2 checks (PKVDH 1 and Swadeshi 651) in 'Line x Tester' fashion (Kempthorne, 1957) during *kharif* 2013. The parents and their twenty four hybrids were grown in randomized block design with three replications at Cotton Research Farm, Mahboob Baugh farm, Vasantrao Naik Marathwada Krishi Vidyapeeth , Parbhani. Each genotype was sown in two rows of 15 hills at 60 x 30 cm spacing. Data on five randomly selected plants in each genotype were collected for days to 50 per cent flowering, days to maturity, plant height (cm), sympodia / plant, seeds / boll, boll weight(cm), seed index (g), lint index, harvest index (%) and seed cotton yield / plant.

The relative or average heterosis, heterobeltiosis and standard heterosis were calculated as per cent deviation of mean of the F_1 hybrid from the mid parent, better parent and standard parental value, respectively between two parents involved in the hybrids.

The heterosis / cent was worked out for all the characters included in the study and presented in the Table 1.

Seed cotton yield / plant : As far as the seed cotton yield / plant is concerned, the cross PA 740 x RAC 024 showed highest positive significant standard heterosis followed by PA 741 x JL 505, PA 710 x AKA 7, PA 710 x CINA 363 and PA 760 x CINA 363. The highest positive significant heterobeltiosis was exhibited by the hybrid PA 740 x RAC 024 followed by PA 741 x JL 505, PA 734 x RAC 024 and PAIG 326 x AKA 7. With regards to mid parental heterosis the cross PA 740 x RAC 024 showed highest positive significant average heterosis followed by PA 741 x JL 505, PA 731 x RAC 024, PA 734 x AKA 7 and PA 710 x AKA 7. This is in agreement with earlier findings of Tuteja *et al.,* [2011], Patil *et al.,* [2012] and Kumar *et al.,* [2013]. Out of 24 hybrids 12 recorded highest significant mid parental heterosis, 8 recorded highest significant heterobeltiosis and 7 recorded highest significant standard heterosis for seed cotton yield.

Days to 50 per cent flowering : Out of 24 hybrids 9 hybrids recorded negative significant relative heterosis, 12 hybrids recorded negative significant heterobeltiosis while 5 hybrids showed negative significant standard heterosis for days to 50 per cent flowering. The negative significant standard heterosis was displayed by PA 710 x AKA 7 followed by PA 740 x RAC 024. This is in accordance with Deosarkar *et al.,* [2009], Patel *et al.,* [2010].

Days to 50 per cent boll bursting : Out of 24 hybrids 9 hybrids recorded negative significant relative heterosis, 15 hybrids recorded negative significant heterobeltiosis while 7 hybrids showed negative significant standard heterosis for days to 50 per cent boll bursting. The negative significant standard heterosis was displayed by PA 740 x RAC 024 and PA 710 x AKA 7.

Sympodia/plant : As regards of this character out of 24 hybrids 13 recorded highest significant mid parental heterosis, 7 recorded highest significant heterobeltiosis and 9 recorded highest significant standard heterosis. The highest significant standard heterosis was exhibited by PA 734 x RAC 024, PA 740 x JL 505 and PA 760 x CINA 363.This is in agreement with earlier findings of Tuteja *et al.,* [2011], and Balu *et al.,* [2012].

Bolls/plant : Out of 24 hybrids 17

Table. 1. Estimate of heterosis in percentage over mid parent (M.P.), better parent (B.P.), standard check (S.C.) in selected 10 crosses for different characters.

Genotypes	Days to 50 per cent flowering				Days to maturity				Sympodia/plant			
	MP	BP	SC		MP	BP	SC		MP	BP	SC	
			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651
PA 710 x AKA 7	-2.48	-4.37	-6.64**	-5.29**	-7.12	-2.48	-3.96*	-3.67*	16.23	10.88	7.29	10.42
PA 710 x CINA 363	0.72	0.00	-0.95	0.48	-0.61	-1.52	-1.22	-0.92	27.87**	25.30*	26.32*	30.00*
PA 741 x JLA 505	-0.24	-0.48	-1.90	-0.48	0.00	-0.61	-0.61	-0.31	56.65**	45.08**	45.06**	59.58**
PA 734 x AKA 7	0.24	-2.84	-2.84	-1.44	-1.23	-3.03*	-2.44	-2.14	27.84**	15.67	25.51*	29.17*
PA 734 x RAC24	-2.13	-2.36	-1.90	-0.48	-1.21	-1.51	-030	0.00	25.70	25.00*	35.63*	39.58*
PA 760 x CINA 363	-1.92	-2.39	-3.32*	-1.92	-2.30	-3.04*	-2.74	-2.45	33.62**	25.30*	26.32*	30.00*
PA 740 x JLA 505	-1.66	-2.82	-1.90	-0.48	-2.74*	-3.03*	-2.44	-2.14	35.46**	19.81	28.06*	31.79*
PA 740 x RAC 024	-4.94**	-5.16**	-4.27**	-2.88	-5.14**	-5.42**	-4.27**	-3.98**	23.82*	9.34	17.31	20.73
PAIG 326 x AKA 7	0.49	-2.83	-2.37	-0.96	0.31	-1.81	-0.61	-0.31	33.46**	27.32*	23.20	27.79*
PAIG 326 XJLA 505	-2.86*	-3.77*	-3.32*	-1.92	-2.42*	-3.01*	-1.83	-1.53	17.50	11.93	19.64	23.13
SE+	0.891	1.031	1.031	1.31	1.313	1.516	1.526	1.516	1.654	1.910	1.910	1.910

Continued

Genotypes	Bolls/plant				Seeds/boll				Boll weight (g)			
	MP	BP	SC		MP	BP	SC		MP	BP	SC	
			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651
PA 710 x AKA 7	49.79**	4979**	37.69**	35.61**	18.32**	15.85*	15.85*	14.77*	15.03**	8.51	15.03	14.71**
PA 710 x CINA 363	46.86**	42.52**	39.23**	37.12**	22.66**	18.83**	21.45**	20.31**	-6.85	-8.25	0.27	0.00
PA 741 x JLA 505	84.47**	75.81**	87.31**	84.47**	10.90	9.03	1.89	0.94	-0.89	-2.02	6.01	5.72
PA 734 x AKA 7	33.60**	27.97**	28.46**	26.52**	8.81	4.73	4.73	3.75	4.81	-5.25	7.10	6.81
PA 734 x RAC24	45.93**	37.55**	38.08**	35.98**	16.13*	14.66*	8.83	7.81	2.87	0.00	17.76**	17.44**
PA 760 x CINA 363	34.97**	29.92**	26.92**	25.00**	8.02	1.85	4.10	3.13	11.38*	8.90	18.31**	17.98**
PA 740 x JLA 505	25.24**	15.52	23.08*	21.21*	10.27	8.87	-1.69	-2.61	19.16**	14.82**	7.65	7.36
PA 740 x RAC 024	40.65**	39.74**	25.77*	23.86*	9.33	5.35	0.00	-0.94	3.96	1.81	6.28	5.99
PAIG 326 x AKA 7	28.80**	23.37*	23.85*	21.97*	16.58**	11.99	11.99	10.94	8.69	4.75	10.93	10.63
PAIG 326 XJLA 505	16.73	13.36	20.77*	18.94	12.17	11.06	2.30	1.34	13.25**	-3.26	2.19	1.91
SE+	1.501	1.733	1.733	1.733	1.223	1.412	1.412	1.412	0.111	0.129	0.129	0.129

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Genotypes	Plant height (cm)				Days to maturity				Lint index			
	MP	BP	SC		MP	BP	SC		MP	BP	SC	
			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651
PA 710 x AKA 7	11.71*	8.27	0.54	5.55	-2.48*	-2.48*	-3.13**	-2.70*	7.47	4.91	7.22	4.19
PA 710 x CINA 363	13.79**	9.16	10.35*	15.84*	-1.11	-2.41*	-0.45	0.00	-3.21	-3.95	-6.51	-9.15
PA 741 x JLA 505	22.23**	15.45**	21.13**	30.30**	-1.33	-1.55	-0.22	0.22	16.41**	13.44**	-0.71	-3.51
PA 734 x AKA 7	17.40**	7.66	12.47**	18.07**	-2.12	-3.09**	-1.79	-1.35	14.05**	-1.23	0.94	-1.91
PA 734 x RAC 024	13.44**	12.41**	17.43**	23.27**	-1.44	-1.55	-0.22	0.22	10.19	1.32	-9.65	-12.20
PA 760 x CINA 363	35.45**	31.14**	32.57**	39.17**	-2.44*	-3.73**	-1.79	-1.35	8.47	0.08	-4.08	-6.78
PA 740 x JLA 505	10.23*	7.60	8.01	13.38*	-2.33*	-2.65*	-1.34	-0.90	-1.46	-2.95	-12.39*	-14.86**
PA 740 x RAC 024	22.71**	21.40**	24.51**	30.70**	-3.55**	-3.76**	2.68*	-2.25*	-8.48	-9.04	-17.88	-20.20**
PAIG 326 x AKA 7	7.31	1.22	-0.49	4.46	-2.11*	-3.30**	-1.57	-1.12	-28.52**	-30.08**	-28.55**	-30.56**
PAIG 326 XJLA 505	25.39**	23.66**	21.57**	27.62**	-1.98*	-2.20*	-0.45	0.00	-27.01**	-30.82**	-32.39**	-34.30**
SE+	5.631	6.502	6.502	6.502	1.365	1.576	1.576	1.576	0.187	0.216	0.216	0.216

Genotypes	Seed index				Harvest index				Ginning outturn (%)			
	MP	BP	SC		MP	BP	SC		MP	BP	SC	
			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651
PA 710 x AKA 7	5.90	2.92	7.09	9.56	16.60*	13.11	14.17	-4.45	-11.64**	-16.08**	-11.24**	-13.55**
PA 710 x CINA 363	6.45	5.71	11.54*	14.11*	9.30	6.26	0.84	-15.61*	-0.07	-0.82	-5.64*	-8.10**
PA 741 x JLA 505	2.92	2.25	5.12	7.55	6.86	5.03	6.32	-11.02	2.88	-2.66	-5.67*	-8.12**
PA 734 x AKA 7	16.10**	14.11**	12.05*	14.63**	13.19	5.14	6.13	-11.18	1.91	-5.22*	0.25	-2.36
PA 734 x RAC 024	8.35	5.14	5.97	8.41	15.60**	21.54*	12.50	-5.85	1.91	-5.22*	0.25	-2.36
PA 760 x CINA 363	3.74	0.75	6.31	8.76	13.43	8.35	6.67	-10.73	0.12	-1.45	-7.65**	-10.06**
PA 740 x JLA 505	9.36*	9.18	11.15*	13.71*	9.09	6.41	4.03	-12.94	-1.00	-3.44	-6.43**	-8.86**
PA 740 x RAC 024	20.07**	19.47**	21.62**	24.42**	26.57**	26.30**	17.41*	-1.74	-2.71	-4.41	-8.75**	-11.12**
PAIG 326 x AKA 7	-3.75	-4.51	-4.73	-2.53	23.06**	17.79*	18.89*	-0.50	-14.37**	-20.41**	-15.82**	-18.01**
PAIG 326 XJLA 505	6.21	5.33	6.87	9.33	6.49	3.50	1.19	-15.32*	-5.53*	-8.48**	-11.31**	-13.62**
SE+	0.268	0.310	0.310	0.310	2.856	3.297	3.297	3.297	0.770	0.889	0.889	0.889

Continued

Genotypes	2.5 per cent Span length (mm)				Fibre fineness /Micronaire(µg/inch)				Uniformity ratio (%)			
	MP	BP	SC		MP	BP	SC		MP	BP	SC	
			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651
PA 710 x AKA 7	8.98*	1.91	10.79*	36.92**	-0.88	-5.08	-6.67	-20.00**	-2.97	-5.77*	-3.92	-9.26**
PA 710 x CINA 363	-2.75	-7.63	0.41	24.10**	-8.62*	-14.52**	-11.67*	-24.29**	-1.01	-2.00	-3.92	-9.26**
PA 741 x JLA 505	-0.38	-4.04	8.30	33.85**	6.09	1.67	1.67	-12.86**	7.22**	6.12*	1.96	-3.70
PA 734 x AKA 7	1.82	-5.62	4.56	29.23**	1.69	1.69	0.00	-14.29**	-3.85	-3.85	-1.96	-7.41**
PA 734 x RAC 024	10.64*	7.12	18.67**	46.67**	3.51	0.00	-1.67	-15.71**	-3.92	-5.77*	-3.92	-9.26**
PA 760 x CINA 363	6.53	-1.09	12.86*	39.49**	-4.42	-12.90**	-10.00*	-22.86**	4.08	2.00	0.00	-5.56*
PA 740 x JLA 505	5.54	1.85	14.52**	41.54**	-29.41**	-30.00**	-0.30.00	-40.00	-1.03	-2.04	-5.88*	-11.11**
PA 740 x RAC 024	4.41	0.37	12.86*	39.49**	-10.53*	-13.56**	-15.00**	-27.14**	-2.04	-4.00	-5.88*	-11.11**
PAIG 326 x AKA 7	3.66	-7.56	11.62*	37.95**	-9.57*	-11.86*	-13.33**	-25.71**	-5.88*	-7.69**	-5.88*	-11.11**
PAIG 326 XJLA 505	-12.71**	-18.56**	-1.66	21.54**	-6.90	-10.00*	-10.00*	-22.86**	5.05*	4.00	1.96	-3.70
SE+	1.028	1.187	1.187	1.187	0.242	0.280	0.280	0.280	1.172	1.354	1.354	1.354

Genotypes	Fibre strength (g/tex)				Seed cotton yield/plant (g)			
	MP	BP	SC		MP	BP	SC	
			PKVDH 1	Swadeshi 651			PKVDH 1	Swadeshi 651
PA 710 x AKA 7	6.41	2.14	-2.55	7.30	40.75**	26.37*	47.51**	54.66**
PA 710 x CINA 363	0.00	-4.81	-9.18*	0.00	25.41*	15.85	35.23**	41.79**
PA 741 x JLA 505	11.05*	10.73*	0.00	10.11*	72.04**	67.93**	50.00**	57.28**
PA 734 x AKA 7	0.27	-5.70	-7.14	2.25	55.76**	32.18**	22.78	28.73*
PA 734 x RAC 024	2.44	-2.07	-3.57	6.18	62.15**	45.93**	18.15	23.88
PA 760 x CINA 363	16.38**	11.35*	5.10	15.73**	24.37*	16.72	31.67*	38.06*
PA 740 x JLA 505	9.60*	9.60	-1.02	8.99	37.54**	28.09*	14.41	19.96
PA 740 x RAC 024	6.52	6.21	-4.08	5.62	90.77**	86.15**	50.71**	58.02**
PAIG 326 x AKA 7	-3.64	-7.03	-12.24**	-3.37	40.59**	37.36**	27.58*	33.77*
PAIG 326 XJLA 505	6.08	3.78	-2.04	7.87	32.80*	32.27*	18.15	23.88
SE+	0.732	0.846	0.846	0.846	4.033	4.657	4.657	4.657

recorded highest significant mid parental heterosis, 14 recorded highest significant heterobeltiosis and 14 recorded highest significant standard heterosis for bolls / plant. The highest significant standard heterosis was exhibited by PA 741 x JL 505, PA 710 x CINA 363 and PA 734 x RAC 024.

Seeds/bolls : In case of seeds / bolls 14 hybrids recorded highest significant mid parental heterosis, 10 hybrids recorded highest significant heterobeltiosis while 6 hybrids recorded highest significant standard heterosis for seeds/bolls. The highest significant standard heterosis was exhibited by PA 710 x CINA 363 and PA 710 x AKA 7. Heterosis for this trait was reported by Kumar *et al.,* (2013).

Boll weight (g) : Out of 24 hybrids 9 recorded highest significant mid parental heterosis, 2 recorded highest significant heterobeltiosis and 9 recorded highest significant standard heterosis for boll weight. The highest significant standard heterosis was recorded by PA 734 x RAC 024 and PA 760 x CINA 363. The results are in agreement with earlier findings of Kumar *et al.,* (2013), and Rangnathan *et al.,* (2013).

Plant height (cm) : Relative heterosis, heterobeltiosis and standard heterosis for plant height was recorded by 21, 14 and 18 hybrids. The highest significant standard heterosis was recorded by PA 760 x CINA 363, PA 740 x RAC 024 and PAIG 326 x JLA 505 . The findings are in agreement with earlier findings of Patel *et al.,* (2011) and Kumar *et al.,* (2013).

Days to maturity : Out of 24 hybrids 15 hybrids recorded negative significant relative heterosis, 17 hybrids recorded negative significant heterobeltiosis while 5 hybrids showed negative significant standard heterosis for days to maturity. The negative significant standard heterosis for days to maturity was displayed by PA 710 x AKA 7 followed by PA 740 x RAC 024. This is in accordance with Deosarkar *et al.,* (2009), Patel *et al.,* (2010).

Lint index : For lint index, positive heterosis is desirable. Out of 24 hybrids 11 hybrids recorded significant relative heterosis, 8 hybrids recorded significant heterobeltiosis while 10 hybrids showed significant standard heterosis for lint index. The highest standard heterosis was exhibited by PA 710 x AKA 7. The results are in agreement with the results of Tuteja *et al.,* (2011), and Balu *et al.,* (2012).

Seed index : Manifestation of this character mostly bears positive correlation with lint index and negative correlation with ginning percentage. The hybrid PAIG 326 x JLA 505 recorded highest negative standard heterosis for seed index. Most of the crosses showed negative heterosis for this trait.

Harvest index : Positive heterosis for harvest index is desirable. The hybrids PAIG 326 x AKA 7 and PA 740 x RAC 024 showed maximum positive heterosis over standard parent. While 14 and 8 crosses showed significant heterosis over mid and better parent.

2.5 per cent Span length (mm) : In

recent years, more emphasis was laid on quality parameters apart from seed cotton yield. The cross PA 740 x CINA 363 was found superior over mid parent while PA 760 x RAC 024 showed significant heterosis over better as well as standard parent. Similar results were obtained by Patil *et al.,* (2010) and Tuteja *et al.,* (2011).

Fibre fineness (µg/inch) : Out of 24 crosses 6 crosses recorded significant heterosis over mid parent, 11 crosses over better parent and almost all the crosses recorded highest significant heterosis over standard parent Swadeshi 651. Heterosis in negative direction for this character was reported by Tuteja *et al.,* (2011).

Uniformity ratio : For this trait heterosis in positive direction is desirable. Heterosis for this character was to the extent of 7.22 and 6.12 per cent in hybrid PA 741 x JLA 505 over mid and better parent respectively. The results were reported by earlier workers Patil *et al.,* (2010) and Kumar *et al.,* (2013).

Short fibre index : The cross PA 740 x AKA 7 showed negative significant heterosis over standard parent. Out of 24 crosses,17 crosses exhibited highest negative average heterosis while 21 exhibited highest negative heterosis over better parent and 21 exhibited highest negative heterosis over standard parent PKVDH 1. Heterosis in negative magnitude for this character was reported by Patil *et al.,* (2012).

In the present study high x high, high x average and high x poor, average x average and average x poor cross combinations had exhibited considerable amount of heterosis over mid parent, better parent and standard checks. As far as the seed cotton yield / plant is concerned, the crosses PA 740 x RAC 024, PA 741 x JL 505, PA 710 x AKA 7, PA 710 x CINA 363 and PA 760 x CINA 363 showed highest positive significant standard heterosis. The parents PA 740, RAC 024, PA 741, JL 505, PA 710, AKA 7, PA 710, PA 760 and CINA 363 were involved in most of the promising hybrids exhibiting high heterotic vigour for most of the characters. Involvement of these parents in crossing programme may be fruitful for developing desirable hybrids having better quality characters with high yield potential.

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