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Heterosis studies for yield and fiber quality traits in intra hirsutum hybrids of cotton (*Gossypium hirsutum* L.)

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ABSTRACT

The present study was performed to evaluate the heterosis effects for seed cotton yield and fiber quality traits of 56 hybrids and their parents involving seven lines and eight testers along with a check at Acharya N.G. Ranga Agricultural University, Hyderabad. The results showed that, range of relative heterosis varied from -3.40 to 13.29 in ginning percentage, -5.28 to 14.10 in 2.5% span length, -8.72 to 8.25 in uniformity ratio, -16.39 to 14.88 in micronaire value, -5.97 to 10.02 in bundle strength and -32.57 to 113.40 in seed cotton yield per plant, where, highest number of crosses (24) with significant mid parental heterosis in desirable direction was observed for seed cotton yield per plant followed by 2.5 % span length (16) and ginning percentage (12). Desirable and significant heterosis over better parent was observed in the crosses for all the studied characters except for uniformity ratio. A good number of crosses recorded significant standard heterosis over check for all the studied parameters except for uniformity ration and micronaire value. Apart from showing considerable level of heterosis for seed cotton yield, the crosses AKH 9331 x HAG 1055 exhibited good level of heterosis for ginning percentage, Galama x L 604 and Galama x JK 344 for uniformity ratio, Galama x HAG 1055, AKH 9331 x HAG 1055 and CPD 420 x IC 356932 for 2.5% span length and CPD 420 x JK 344 and BC 68-2 x LK 861 for bundle strength. So these crosses could be exploited to improve the yield along with one or more fiber quality traits through heterosis breeding.

Key words: Cotton, Fiber quality, Heterosis, Line x Tester analysis, Seed cotton yield.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important fiber crop and plays a vital role as a cash crop in commerce of many countries such as USA, China, India, Pakistan, Uzbekistan and Australia. Cotton is produced as raw material for the textile industry and is a high value crop. The most widely planted current cotton cultivars are high yielding, day-length neutral and early maturing with easily ginned and abundant fiber. These improved characteristics resulted from human selection from perennial ancestors with shorter and sparser fiber. With the modernization of spinning industry and quality conscious consumers, there is an increased emphasis on the production of superior quality cotton. However, the interest of the farmers is that increase in yield should also not be ignored while producing quality cotton. The only way to meet this dual requirement is to develop high yielding superior fiber quality cotton varieties or hybrids through systematic breeding programmes. The pre-requisites for commercial exploitation of heterosis in cotton are identification of parents which show good heterosis on crossing and production of hybrids with low cost. Several studies have been reported on yield and yield attributing traits, but little work has been reported on the genetics and heterosis of fiber quality traits in cotton breeding. The work on heterosis has been reviewed for time to time on various quality and yield components in cotton by many workers (Karademir *et al.*, 2009, Karademir and Gencer, 2010, Karademir *et al.*, 2011, Bolek *et al.*, 2011 and Ashokkumar *et al.*, 2013) and determined that cotton genotypes differ in fiber quality traits. Thus, the aim of heterosis analysis is to find out the best combination of parents for their prospects for future use in hybrid breeding programme. Therefore, present study was carried out to measure heterosis over mid parent, better parent and standard check (NHH 44) for yield and quality components to obtain information on heterotic potential as to develop hybrids in cotton with improved fiber quality traits.

MATERIALS AND METHODS

The experimental material comprised of seven lines (CPD-420, Galama, NA 1325, L-389, IC 357063, BC-68-2 and AKH-9331), eight testers (HAG-1055, LK-861, L-604, JK-344, 4084, IC 356932, LRA-5166 and L-761) and their fifty six crosses and check NHH 44. All the 56 hybrids and their parents along with the check were evaluated in R.B.D with three replications at College Farm, College of Agriculture, Rajendranagar, Hyderabad during *kharif*, 2007. Each entry was sown in two rows of 5 m length with a spacing of 120 cm between the rows and 60 cm within the rows. Observations were recorded on five randomly selected plants

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for each genotype in each replication. The characters studied were ginning percentage, 2.5% span length, uniformity ratio, micronaire value, bundle strength and seed cotton yield per plant. The mean data of 5 plants over three replications were used for statistical analysis. Fiber quality traits were analyzed by high-volume instrument (HVI).The data were analyzed to find out the extent of heterosis through Kempthorne's method (1957) using the WINDOW STAT statistical package.

RESULTS AND DISCUSSION

To draw the valid conclusions regarding the extent of heterosis for various characters, the overall mean of parents, F_1s and standard check were computed to obtain average and standard heterosis for all the traits studied and was presented in Table 1. The degree of heterosis varied considerably for seed cotton yield and quality traits. The highest percentage of average heterosis was observed for seed cotton yield followed by 2.5 % span length, ginning percentage and bundle strength, whereas negative average heterosis was observed for micronaire value which is desirable in negative direction. Highest percentage of standard heterosis in desirable direction was obtained in 2.5 % span length followed by bundle strength, seed cotton yield per plant and ginning percentage, whereas the trait uniformity ratio recorded negative values. Range and number of crosses with significant desirable heterosis for seed cotton yield and quality traits is presented in Table 2. The magnitude of heterosis exhibited by 56 hybrids was measured as per cent increase or decrease over the mean of parents (relative or mid parental heterosis), over the better parent (heterobeltiosis) and over the standard check (standard heterosis) NHH 44 for seed cotton yield and fiber quality characters is presented in the Table 3.

For the trait ginning percentage, out of 56 crosses twelve crosses recorded significant and positive mid parental heterosis and the values ranged from -6.30 (NA 1325 x L 761) to 13.29 per cent (AKH 9331 x LRA 5166). Three crosses recorded positive and significant heterobeltiosis and the values varied between -11.73 (IC 357063 x 4084) and 10.69 per cent (AKH 9331 x LRA 5166). For standard heterosis eight crosses recorded positive significant values and the values ranged from -14.01 (IC 357063 x IC 356932) to 15.07 per cent (AKH 9331 x 4084). Two crosses, AKH 9331 x LRA 5166 and AKH 9331 x HAG 1055 recorded considerable high heterosis over mid parent, better parent and standard check. Similar reports were given by Ganapathy *et al.* (2005) and Maisuria *et al.* (2006) for mid parental heterosis, Solang *et al.* (2002) and Maisuria *et al.* (2006) for heterobeltiosis and Singh *et al.* (2003) for the heterosis over commercial check.

16 crosses registered significant and positive heterosis over the mid parent for the character 2.5 % span length and the values were in the range of -5.28 (BC 68-2 x 4084) to 14.01 per cent (AKH 9331 x IC 356932). The magnitude of heterobeltiosis ranged from -11.17 (Galama x 4084) to 7.32 per cent (CPD 420 x LK 861). Only two crosses recorded significant and positive heterobeltiosis. For standard heterosis, the range varied from -4.25 (BC 68-2 x 4084) to 25.82 per cent (CPD 420 x LK 861) and (Galama x L 761). Forty seven hybrids were exhibited significantly positive heterosis over NHH 44. The hybrid CPD 420 x LK 861 reported to exhibiting heterosis consistently over mid

TABLE 1: Mean performance of parents, F_1s and check and heterosis for seed cotton yield and fiber quality traits.

Character	Mean performance			Heterosis	
	Parents	F_1s	Check	Average	Standard
Ginning percentage	33.15	34.05	33.98	2.71	0.21
2.5 % span length	27.44	28.39	25.00	3.46	13.56
Uniformity ratio	48.31	47.85	50.20	-0.95	-4.68
Micronaire value	4.07	3.99	3.79	-1.97	5.28
Bundle strength	22.19	22.73	20.60	2.43	10.34
Seed cotton yield/plant	128.54	144.77	140.00	12.62	3.41

TABLE 2: Range and No. of crosses with significant and desirable heterosis for seed cotton yield and fiber quality traits.

Character	No of crosses showing heterosis			Range		
	H1	H2	H3	H1	H2	H3
Ginning percentage	12	3	8	-3.4 to 13.29	-11.73 to 6.77	-14.01 to 15.07
2.5 % span length	16	2	47	-5.28 to 14.1	-11.17 to 6.32	-4.25 to 25.82
Uniformity ratio	6	0	0	-8.72 to 8.25	-12.93 to 4.62	-1181 to 4.98
Micronaire value	7	15	0	-16.39 to 14.88	-21.84 to 11.71	-10.03 to 20.84
Bundle strength	11	5	38	-5.97 to 10.02	-11.39 to 9.12	2.43 to 19.56
Seed cotton yield/plant	24	14	19	-32.57 to 113.4	-40.70 to 94.23	-45.55 to 56.12

H1: Heterosis over mid parent, H2: Heterosis over better parent, H3: Heterosis over check

TABLE 3: Estimation of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for various fiber quality characters

Crosses	Ginning percentage			2.5% span length			Uniformity ratio			Micronaire value			Bundle strength			Seed cotton yield per plant		
	MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
CPD 420 X HAG 1055	3.98	2.44	2.74	3.27	-0.8	16.31**	-2.57	-4.82	-5.64*	-4.77	-9.17	3.69	-1.14	-2.55	5	83.80**	80.58**	40.39**
CPD 420 X LK 861	-3.35	-3.72	-2.71	9.51**	7.32**	25.82**	-7.78**	-8.64**	-9.42**	-7.38	-13.48*	-1.32	2.61	-0.72	11.17**	33.55**	9.32	33.40**
CPD 420 X L 604	0.11	-3.12	-2.85	4.63	0.01	17.23**	0.78	0.07	-0.8	-6.89	-11.02*	1.58	7.68*	4.99	15.68**	41.00**	25.30**	25.32**
CPD 420 X JK 344	-1.11	-4.11	2.38	6.87**	-1.39	15.59**	-5.07*	-5.22*	-6.04*	-11.30*	-15.95**	-3.96	9.12**	9.12*	14.22**	36.43**	22.40*	19.81*
CPD 420 X 4084	-0.74	-5.44	4.74	-3.13	-9.62**	5.95	5.25*	4.62	3.73	-4.64	-5.11	9.5	2.67	1.08	5.83	-19.22*	-31.60**	-23.32**
CPD 420 X IC 356932	0.29	-7.40*	-7.12*	7.15**	3.78	21.67**	-8.52**	-9.71**	-10.50**	-16.39**	-18.55**	-1.85	-0.85	-0.93	3.88	68.72**	61.02**	25.19**
CPD 420 X LRA 5166	-0.17	-1.42	-1.12	5.49*	3.65	21.51**	-8.72**	-10.25**	-11.02**	-7.8	-9.78	2.9	-4.32	-9.17*	5.83	42.92**	30.76**	22.50*
CPD 420 X L 761	3.89	3.79	4.09	-0.67	-3.23	19.59**	4.24	0.33	-0.54	-6.12	-7.35	8.71	2.84	2.13	8.40*	4.84	-10.5	-1.63
Galama X HAG 1055	4.47	-0.55	-3.24	5.66*	-3.22	25.62**	1.41	-4.21	-9.42**	-0.37	-9.68	-6.33	0.51	-2.67	11.99**	89.16**	67.85**	25.92**
Galama X LK 861	-3.4	-9.67**	-8.71**	0.84	-5.86*	22.19**	0.62	-6.21*	-8.76**	-1.87	-9.23	-10.03	2.64	1.27	16.50**	36.38**	0.67	22.84*
Galama X L 604	5.14	1.84	-4.44	-1.59	-10.28**	16.43**	8.25**	0.68	-1.59	0.89	-8.71	-5.01	6.18	3.94	19.56**	39.62**	10.37	10.39
Galama X JK 344	3.57	-5.56	0.82	1.78	-10.25**	16.47**	6.90**	-1.08	-2.25	5.09	-4.13	-2.11	1.91	-2.67	11.99**	44.42**	15.08	12.64
Galama X 4084	-0.22	-10.50**	-0.85	-0.31	-11.17**	15.31**	2.58	-4.7	-6.63*	4.72	-9.38	4.49	-4.04	-9.70**	3.88	25.30**	-4.87	6.64
Galama X IC 356932	8.24*	6.37	-6.44*	4.08	-3.91	24.71**	0.96	-5.57*	-8.82**	-8.04	-21.84**	-5.8	1.25	-3.23	11.31**	113.14**	94.23**	37.23**
Galama X LRA 5166	-0.7	-5.7	-7.77*	1.02	-5.45*	22.71**	1.66	-4.57	-8.57**	4.73	-7.25	1.32	-2.45	-3.06	12.96**	90.69**	54.50**	44.73**
Galama X L 761	5.92	-0.51	-0.41	-0.67	-3.04	25.82**	5.70*	1.3	-7.11**	-4.23	-17.70**	-3.43	5.05	0.98	16.17**	18.40*	-9.5	-0.53
NA 1325 X HAG 1055	5.98*	2.54	6.71*	7.85**	6.32*	14.83**	-2.23	2.91	-6.91**	6.67	5.18	8.97	-3.44	-3.73	4.37	-9.93	-23.74**	-17.49*
NA 1325 X LK 861	0.86	-0.6	3.44	5.06*	1.5	14.23**	-4.78*	-5.46*	-8.03**	2.46	1.66	2.37	-5.87	-7.37*	3.74	-22.01**	-26.43**	-10.22
NA 1325 X L 604	3.41	-1.69	2.32	4.49	3.54	10.67**	-1.17	-2.11	-4.32	1.55	-0.08	3.96	-3.48	-4.26	5.49	49.96**	44.30**	56.12**
NA 1325 X JK 344	-3.32	-4.53	1.91	7.27**	4.29	9.43**	0.95	-0.54	-1.73	3.77	3.01	5.28	-2.96	-4.63	3.4	-6.45	-10.91	-3.61
NA 1325 X 4084	1.03	-2.02	8.53**	2.74	1.07	6.07	3.59	2.49	0.4	7.74	0.92	16.36*	-2.39	-5.52	2.43	32.45**	30.15**	45.89**
NA 1325 X IC 356932	0.35	-8.90**	-5.18	4.58	2.25	12.31**	-7.45**	-7.77**	-10.96**	0.08	-8.11	10.55	-0.15	-1.79	6.46	7.77	-10.93	-3.63
NA 1325 X LRA 5166	-1.36	-4.34	-0.44	4.56	0.77	14.03**	-2.46	-2.49	-6.51*	6.24	2.09	11.61	-5.47	-8.75*	6.31	35.24**	26.16**	36.51**
NA 1325 X L 761	-6.30*	-8.10*	-4.33	3.81	-4.02	18.63**	-3.43	-5.54*	-9.42**	-2.5	-9.38	6.33	2.11	1.04	9.56*	-10.9	-11.59	-2.83
L 389 X HAG 1055	7.20*	6.77*	4.74	1.87	-3.95	17.11**	1.49	-2.25	-7.57**	0.47	-0.68	2.9	-1.93	-2.94	6.8	-0.15	-18.91*	-2.55
L 389 X LK 861	-1.63	-3.07	-2.03	7.10**	2.99	25.54**	-3.59	-8.40**	-10.90**	0.79	-0.26	1.06	-3.79	-4.62	6.8	0	-0.76	21.10*
L 389 X L 604	4.52	2.24	0.29	3.94	-2.47	18.91**	5.48*	0	-2.25	-4.46	-5.75	-1.85	3.31	3.23	13.74**	-22.30**	-28.81**	-14.45
L 389 X JK 344	1.99	-2.14	4.47	0.4	-8.99**	10.95**	-0.11	-5.78*	-6.91**	-4.28	-4.73	-2.64	3.69	1.18	11.31**	-26.20**	-33.05**	-19.54*
L 389 X 4084	3.15	-2.75	7.74*	0.73	-7.70**	12.55**	2.71	-2.73	-4.72	-1.79	-7.78	6.33	5.43	1.32	11.50**	-25.20**	-27.72**	-13.14
L 389 X IC 356932	5.84	-1.28	-3.15	3.31	-1.8	19.71**	0.4	-4.26	-7.57**	-6.83	-14.24**	3.17	8.58*	6.03	16.65**	8.66	-13.73	3.68
L 389 X LRA 5166	4.01	3.84	1.88	-0.45	-4.03	16.99**	2.32	-2.08	-6.18*	-4.97	-8.45	0	-0.71	-3.47	12.48**	-5.69	-16.09*	0.84
L 389 X L 761	2.09	1.08	1.15	-2.09	-2.75	20.19**	-1.63	-3.84	-11.81**	2.58	-4.43	12.14	-3.59	-5.29	4.22	-26.85**	-29.98**	-15.85
IC 357063 X HAG 1055	5.05	0.4	-2.3	4.96	3.84	12.15**	-1.16	-4.22	-3.45	12.13*	9.76	18.73**	7.68*	7.36	15.68**	-32.55**	-37.00**	-45.55**
IC 357063 X LK 861	-2.49	-8.44*	-7.47*	4.7	1.5	14.23**	-3.72	-5.40*	-4.64	1.65	-2.6	5.28	3.25	1.01	13.11**	-4.62	-18.53*	-0.59
IC 357063 X L 604	2.45	-0.35	-6.50*	-0.9	-1.45	5.31	2.94	1.38	2.19	4.77	2.76	11.08	1.86	0.44	10.68**	-29.90**	-34.66**	-34.65**
IC 357063 X JK 344	-1.37	-9.70**	-3.59	0.01	-3.1	2.39	-2.59	-3.56	-2.79	14.88**	11.71*	20.84**	3.28	2.11	9.37*	4.79	-1.34	-3.43
IC 357063 X 4084	-1.97	-11.73**	-2.24	-4.23	-6.12*	-0.77	5.64*	4.15	4.98	-2.24	-5.26	9.23	4.27	1.51	8.74*	-29.09**	-37.21**	-29.61**
IC 357063 X IC 356932	-0.93	-3.05	-14.01**	6.07*	4.07	14.31**	-7.81**	-9.75**	-9.02**	-4.35	-9.2	9.23	6.11	4.98	12.48**	13.8	3.41	-10.61
IC 357063 X LRA 5166	6.80*	1.84	-0.41	7.79**	4.23	17.95**	-1.86	-4.28	-3.53	5.34	4.83	14.51*	4.92	0.68	17.33**	-6.09	-9.72	-15.43
IC 357063 X L 761	8.75**	2.57	2.65	-0.27	-7.50**	14.31**	4.45	-0.26	0.54	5.74	1.65	19.26**	5.46	4.98	12.48**	-17.47*	-26.29**	-18.98*
BC 68-2 X HAG 1055	7.25*	2.83	0.06	4.38	0.85	8.91**	-0.96	-3.65	-3.65	3.06	-0.08	3.43	2.14	0.3	8.11*	91.00**	85.86**	39.43**
BC 68-2 X LK 861	-1.63	-7.36*	-6.39	2.13	-3.26	8.87**	-1.25	-2.59	-2.59	-2.73	-3.64	-4.49	7.05*	3.18	15.53**	21.99**	-3.52	17.72*
BC 68-2 X L 604	2.77	0.29	-5.89	3.73	0.72	7.63*	-1.21	-2.32	-2.33	-2.75	-5.92	-2.11	8.39*	5.29	16.02**	19.90*	2.49	2.51
BC 68-2 X JK 344	5.29	-3.32	3.21	2.32	1.52	2.23	-1.4	-1.99	-1.99	-4.5	-6.8	-4.75	9.85**	9.43*	14.56**	1.51	-12.44	-14.3
BC 68-2 X 4084	4.96	-5.22	5	-5.28	-5.67	-4.25	4.12	3.05	3.05	6.33	-1.98	12.93*	5.75	4.52	8.59*	15.45	-5.72	5.68
BC 68-2 X IC 356932	8.87**	6.2	-5.18	4.02	-0.32	9.51**	-5.14*	-6.77**	-6.77**	-12.81*	-21.18**	-5.01	8.68*	8.18*	13.45**	8.43	8.18	-23.21**
BC 68-2 X LRA 5166	2.67	-1.79	-3.94	3.14	-2.55	10.27**	-2.54	-4.58	-4.58	-0.68	-6.12	2.64	6.31	0.56	17.14**	46.02**	28.33**	20.22*
BC 68-2 X L 761	2.57	-2.96	-2.88	-0.56	-9.77**	11.51**	-0.1	-4.25	-4.24	-0.53	-9	6.6	10.02**	8.84*	15.53**	37.37**	13.04	24.25**
AKH 9331 X HAG 1055	9.47**	6.70*	9.36**	12.03**	3.41	11.67**	-5.00*	-10.04**	-4.84	-3.16	-13.83**	14.51*	5.76	3.45	11.50**	75.05**	74.19**	30.68**
AKH 9331 X LK 861	1.48	0.78	3.3	9.26**	-1.02	11.39**	-6.02**	-9.79**	-4.58	-9.70*	-21.18**	4.75	1.58	-2.46	9.22*	12.39	-9.6	10.31
AKH 9331 X L 604	2.84	-1.5	0.97	9.46**	1.52	8.51**	-2.64	-6.34**	-0.94	-11.06*	-20.71**	5.28	3.19	-0.15	10.05*	-24.11**	-33.87**	-33.86**
AKH 9331 X JK 344	3.27	1.2	8.03*	4.22	0.15	-0.73	-3.8	-6.97**	-1.59	-4.45	-15.49**	12.4	6.85*	6.03	11.02**	-32.57**	-40.70**	-41.96**
AKH 9331 X 4084	7.90**	3.87	15.07**	3.03	-2.13	-0.65	-0.4	-4.08	1.45	-3.61	-9.99*	19.53**	4.59	3.77	6.94	2.87	-14.48	-4.13
AKH 9331 X IC 356932	12.78**	3.1	5.68	14.01**	4.42	14.71**	-5.55*	-9.67**	-4.44	-10.21*	-14.43**	13.72*	9.42**	8.49*	13.74**	-11.06	-13.24	-35.55**
AKH 9331 X LRA 5166	13.29**	10.69**	13.45**	9.97**	-0.61	12.47**	-2.64	-7.22**	-1.85	-5.12	-13.57**	14.78*	-5.97	-11.39**	3.25	23.58*	10.79	3.79
AKH 9331 X L 761	7.26*	6	8.65**	4.26	-9.33**	12.07**	-6.72**	-12.93**	-7.91**	-8.79*	-14.16**	13.98*	0.54	-0.91	5.19	-6.95	-22.03**	-14.3

parent, better parent and standard check. These results are in conformity with the findings of Tuteja *et al.* (2005), Natera *et al.* (2007), Iraddi and Kajjidoni (2009), Karademir and Gencer (2010), Karademir *et al.* (2011), Tuteja and Banga (2011) and Ashokkumar *et al.* (2013).

For the trait uniformity ratio, the distribution of heterosis over mid parental value was found within the range of -8.72 (CPD 420 x LRA 5166) to 8.25 per cent (Galama x L 604). Only six crosses exhibited significantly positive relative heterosis, while 12 crosses showed significantly negative heterosis over mid parent. None of the crosses exhibited significant and positive heterosis over better parent and standard check. 21 hybrids over better parent and 25 hybrids over standard check recorded significant negative heterosis for this trait. These results are in conformity with the findings of Niagun and Khadi (2001), Karademir *et al.* (2009) and Ashokkumar *et al.* (2013).

Significant positive mid parental and better parental heterosis was observed only in two and one crosses respectively for the trait micronaire value, whereas eleven crosses recorded positive values over check. The heterosis ranged from -16.39 (CPD 420 x IC 356932) to 14.88 per cent (IC 357063 x JK 344) over mid parent and from -21.84 (Galama x IC 356932) to 11.71 per cent (IC 357063 x JK 344) over better parent. While, seven hybrids over mid parent and fifteen hybrids over better parent recorded significant heterosis in negative direction which indicates that the greater the micronaire value, the lower the fineness. Punitha *et al.* (1999), Rauf *et al.* (2005), Tuteja *et al.* (2005), Karademir and Gencer (2010) Karademir *et al.* (2011) and Ashokkumar *et al.* (2013) reported varying degrees of positive and negative heterosis, heterobeltiosis and standard heterosis for this trait.

For bundle strength, eleven crosses over mid parent and five crosses over better parent exhibited heterosis in desirable direction. The heterosis values were in the range of -5.97 (AKH 9331 x LRA 5166) to 10.02 per cent (BC 68-2 x L 761) and -11.39 (AKH 9331 x LRA 5166) to 9.43 per cent (BC 68-2 x JK 344) over mid parent and better parent respectively, whereas thirty eight crosses recorded positive and significant values over commercial check and standard heterosis values were ranged from 2.43 (NA 1325 X 4084) to 19.56 percent (Galama X L 604). The crosses BC 68-2 x JK 344, CPD 420 x JK 344 and BC 68-2 x L 761 recorded considerable heterosis over both mid parent, better parent as well as standard check. Khan (2002) and Ashokkumar *et al.* (2013) reported positive heterosis over mid parent and heterobeltiosis. Standard heterosis in desired direction for this trait was reported by Tuteja and Banga (2011) and Ashokkumar *et al.* (2013).

For seed cotton yield, a total of 24 crosses accounted for significant positive heterosis over mid parental and the relative heterosis values were recorded in between -32.57 (AKH 9331 x JK 344) and 113.14 per cent (Galama x IC 356932). The estimates of heterobeltiosis ranged from -40.70 (AKH 9331 x JK 344) to 94.23 per cent (Galama x IC 356932) and 14 crosses exhibited significant and positive values over better parent. Standard heterosis ranged from -45.55 (IC 357063 x HAG 1055) to 56.12 per cent (NA 1325 x L 604), 19 crosses were found to be positively significant. The crosses BC 68-2 x HAG 1055 and CPD 420 x HAG 1055 were exhibited considerable high heterosis over mid parent, better parent and standard check, while the crosses Galama x IC 356932 and BC 68-2 x HAG 1055 were recorded highest heterosis over both mid parent and better parent. Similar findings were reported by Ashokkumar *et al.* (2013), Yanal Alkuddsi *et al.* (2013) and Muhammad *et al.* (2014).

From the above results it is clear that, the magnitude of heterosis over mid parent, better parent and standard check varied for cross to cross for various traits studied. All the characters distinctly differed in heterosis range in desirable direction which indicates that in different crosses, different path ways are present for releasing heterotic effects. Considerable high heterosis in certain crosses and low in others revealed that nature of gene action varied with the genetic makeup of the parents involved in the crosses. As such, nature and magnitude of heterosis helps in identifying superior cross combinations to obtain better transgressive segregants. Hybrids that have shown high degree of relative heterosis, heterobeltiosis and standard heterosis for yield also exhibited considerable level of heterosis for one or more fiber properties. High heterosis might be obtained with parents of diverse origin in the presence of adequate favorable environment for expression of heterosis and in the absence of mutual cancellation of components of heterosis. Generally parents with high order of expression of the characters, when combined, produced hybrids with high expression (Gilbert, 1958).

Fiber quality parameters of cotton, fiber length and fineness have a vital influence on the yarn strength. The increasing fiber length results in improved yarn strength because a long fiber generates a greater frictional resistance to an external force. High fiber length and the tensile strength of the fibers becomes the controlling factor of yarn strength. The identification of cultivars or hybrids with high fiber length and strength is essential to current modernized spinning mills. Gutierrez *et al.* (1998) indicated that the most interesting crosses were those which exhibit heterosis or heterobeltiosis for seed cotton yield and for some fiber characters. In the present investigation some of the crosses exhibited significant heterosis for yield as well as for one or more fiber quality traits. The crosses Galama x L 604, Galama x JK 344 and Galama x L 761 recorded significant heterosis for uniformity ratio in positive direction which also recorded considerable positive heterotic values for yield. AKH 9331 x HAH 1055 exhibited good heterosis for both yield and ginning percentage. For 2.5 % span length and seed cotton yield, Galama x HAG 1055, AKH 9331 x HAG 1055, CPD 420 x JK 344, CPD 420 x IC 356932, CPD 420 x LK 861 and AKH 9331 x LRA 5166 exhibited significant positive heterosis. Whereas the crosses CPD 420 x L 604, CPD 420 x JK 344, BC 68-2 x LK 861, BC 68-2 x L 604, and BC 68-2 x L 761 exhibited significant positive heterosis for bundle strength and seed cotton yield. For the trait, micronaire value the crosses CPD 420 x IC 356932 and CPD 420 x JK 344 recorded negative heterosis values which is desirable also exhibited considerable level of heterosis for seed cotton yield. So these crosses‘ can be exploited to improve the yield along with one or more fiber quality traits through heterosis breeding.

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