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Stabilized Heterosis Studies for Seed Cotton Yield and Component Traits in Upland Cotton (*Gossypium hirsutum* L.)

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ABSTRACT

Keywords

Gossypium hirsutum (L.), line x tester, seed cotton yield, standard heterosis

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The study was undertaken to evaluate the magnitude of heterosis in 36 cotton hybrids developed by crossing 3 lines and 12 testers in L x T design at three different locations of Maharashtra State *viz*., Akola, Amravati and Nagpur during *kharif*, 2017-18. The cross AKH 8828 x AKH 9916 exhibited highest and significant heterosis over the check PKV Hy-2 for seed cotton yield/plant (60.30 %), number of bolls/plant (23.55 %) and fibre strength (10.43 %) across the environments. The cross AKH 081 x AKH 09-5 exhibited higher and significant standard heterosis (54.05 %) for seed cotton yield/plant in association with other economically important traits. Similarly, other crosses *viz.*, AKH 84635 x SURAJ (47.76 %), AKH 8828 x AKH 2006-2 (47.12 %) and AKH 8828 x DHY 286 (45.79 %) also exhibited higher significant heterosis over the check hybrid PKV Hy-2 for seed cotton yield/plant in association with other yield contributing characters. The cross AKH 84635 x AKH 2012-8 exhibited considerable heterosis for seed cotton yield/plant and fibre quality parameters. These promising crosses have immense value to exploitation at commercial level after thorough multilocation testing.

Introduction

Cotton *(Gossypium hirsutum* L.) is the king of fibre and an important cash crop of India which exercise profound influence on economics and social affairs. Cotton is the most important raw material for Indian textile industry, which makes up 70 per cent of its raw material needs. In cotton, now the yield levels have reached a plateau. So, the increased productivity of cotton could be achieved by selection of parents on the basis of combining ability effects and exploitation of hybrid vigour adopting promising high yielding hybrid cotton cultivars that has been a line of approach in cotton improvement since after release of first cotton hybrid H4 in India (Patel, 1971[b]). Application of biometrical techniques like line x tester analysis has appeared to be the best and vastly useful breeding tool, which gives generalized picture of genetics of the characters under study. The study of heterosis has a direct bearing on the breeding methodology to be employed for hybrid/varietal improvement and also provides useful information about usefulness of the parents in breeding programs. The commercial usefulness of the hybrid primarily depends on its performance in comparison with the best commercial variety of the region concerned. Verma and Kumar (1974) and Joshi (1979) emphasized that the success of development of superior varieties and/or hybrids depend on the choice of parents for hybridization. Exploitation of heterosis on commercial scale has revolutionized the production in cotton. Hence, the present investigation was undertaken to measure the extent of heterosis over standard check (PKV HY 2) for seed cotton yield and component traits to identify the best suitable cross combinations which can be utilized for exploitation of heterosis in upland cotton.

Materials and Methods

In the present study, three lines *viz.*, AKH 84635, AKH 8828 and AKH 081 were crossed with twelve testers *viz.*, AKH 10-2, AKH 10-5, AKH 10-10, AKH 11-7, AKH 2006-2, AKH 2012-8, AKH 2012-9, AKH 09-5, AKH 976, AKH 9916, DHY 286 and SURAJ in a line x tester m a t i n g design (Kempthorne, 1957) to develop 36 hybrids during *kharif*, 2016 at Cotton Research Unit, Dr. PDKV, Akola. The 15 parents and the 36 hybrids along with 1 check (PKV Hy 2) were evaluated to study the extent of heterosis in randomized block design with three replications across 3 environments at Cotton Research Unit, Dr. PDKV, Akola (lat. 20.41^0N and Long. 77.3^0E), Regional Research Centre, Amravati (lat. 20.96^0 N and long. 77.85^0 E) and ICAR-Central Institute for Cotton Research, Nagpur (lat. 23.03^0 N and long. 72.40^0 E) during *kharif*, 2017-18. The spacing of 60 x 60 cm for hybrids and parents was adopted at all the three environments. The observations in each genotype per replication were recorded for number of sympodia per plant, number of bolls per plant, boll weight (g), seed index (g), ginning percentage (%), seed cotton yield per plant (g), lint index (g), 2.5 % span length (mm), fibre strength (g/tex), fibre fineness (µg/inch), uniformity index (%) and elongation percentage (%). 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 (Briggle, 1963), better parent (Bitzer *et al.*, 1968) and standard parental value (Meredith and Bridge, 1972), respectively. The data was analyzed to find out the extent of heterosis according to the model given by Kempthorne, 1957).

Results and Discussion

Pooled analysis of variance over the three environments revealed that the source of variation due to environment showed highly significant differences for all the characters indicating the validity of conduct of experiment in these environments (Table 1). The parents showed highly significant differences for all the characters except number of sympodia/plant. The variances due to crosses were found highly significant for all the characters. There was a highly significant difference among parents and hybrids for most of the characters under study except number of sympodia/plant, lint index and elongation percentage which indicated the presence of variability in the parental lines selected for the study. The average heterosis (H_1), heterobeltiosis (H_2) and standard heterosis (H_3) over the three environments were studied for 12 characters. The extent of heterosis was studied for all the traits against the standard check hybrid PKV Hy 2. The values for the standard heterosis for individual crosses recorded for different characters (Table 2). The range of standard heterosis for seed cotton yield/plant was from 20.94 to 60.30 per cent. Seventeen hybrids recorded significant superior performance over the check for this trait. The important crosses which showed highest heterotic effect were AKH 8828 x AKH 9916 (60.30 %) followed by AKH 081 x AKH 09-5 (54.05 %), AKH 84635 x SURAJ (47.76 %), AKH 8828 x AKH 2006-2 (47.12 %) and AKH 8828 x DHY 286 (45.79 %). These hybrids need special attention to exploit heterosis for seed cotton yield. Several earlier workers *viz.*, Sanjay *et al.*, (2010), Patil *et al.*, (2012), Monicashree *et al.*, (2017[b]), Chinchane *et al.*, (2018) and Bilwal *et al.*, (2018) also reported the heterosis for this trait in American cotton.

Among the other characters, the standard heterosis for number of sympodia/plant ranged from -13.78 to 9.61 per cent over the check PKV Hy 2. Only one hybrid AKH 081 x AKH 10-10 (9.61 %) showed significant positive heterosis for number of sympodia/plant over the check hybrid.

The standard heterosis for number of bolls/plant was ranged from 18.38 to 36.99 per cent. Eleven hybrids recorded significant positive superior performance over the check.

The cross AKH 8828 x AKH 2006-2 (36.99 %) exhibited maximum heterosis over check for number of bolls/plant followed by AKH 8828 x DHY 286 (36.08 %) and AKH 081 x DHY 286 (27.99 %). Out of 36 hybrids, only one hybrid AKH 081 x AKH 09-5 (13.60 %) exhibited significant and positive heterosis for boll weight over the check PKV Hy-2. Twelve hybrids showed significant superiority over the check PKV Hy-2 for seed index.

The hybrid AKH 081 x AKH 09-5 (24.03 %) followed by AKH 84635 x SURAJ (19.09 %) and AKH 081 x DHY 286 (17.0 %) showed considerable amount of standard heterosis for seed index. Ten hybrids exhibited significant and positive standard heterosis for ginning percentage to the tune of -15.67 to 7.59 per cent. The hybrid AKH 84635 x AKH 10-2 (7.59 %) showed highest significant heterosis followed by AKH 84635 x AKH 2012-8 (6.82 %) and AKH 081 x AKH 10-10 (5.95 %). Fourteen hybrids showed significant positive heterosis for lint index over the check PKV Hy 2. The cross AKH 84635 x AKH 2012-8 (26.0 %) exhibited highest positive standard heterosis followed by crosses AKH 081 x AKH 10-10 (25.47 %) and AKH 84635 x AKH 10-2 (23.05 %) for lint index.

Total 18 hybrids showed significant superiority over the check PKV Hy-2 for fibre quality trait. The hybrid AKH 081 x AKH 10-10 (7.35 %) ranked first for standard heterosis followed by AKH 84635 x AKH 09-5 (7.27 %) and AKH 081 x SURAJ (6.09 %) for 2.5 % span length.

The cross AKH 081 x AKH 10-10 (15.88 %) showed maximum heterosis for fibre strength over check. The negative heterosis is desirable for fibre fineness. The cross AKH 84635 x AKH 09-5 and AKH 081 x AKH 976 (-11.11 %) showed highest negative heterosis over standard check followed by AKH 081 x AKH 2012-9 (-10.08 %) and AKH 8828 x SURAJ (-9.04 %). The cross AKH 8828 x AKH 2006-2 (19.81 %) exhibited highest heterosis for elongation percentage followed by the crosses AKH 8828 x DHY 286 (12.04 %) and AKH 081 x AKH 10-10 (11.26 %).

Table.1 Pooled analysis of variance for experimental design over the three environments for various traits in cotton

Sources of variation	d.f.	Mean sum of squares											
		Number of sympodia	Number of bolls/plant	Boll weight	Seed index	Ginning percentage	Seed cotton yield/plant	Lint index	2.5 % Span length	Fibre strength	Fibre fineness	Uniformity index	Elongation percentage
Environments	2	255.14**	33217.83**	9.47**	25.36**	204.60**	334810.34**	4.25**	90.57**	892.63**	50.62**	118.44**	24.74**
Genotypes	50	6.28**	127.87**	0.74**	3.44**	41.23**	1906.78**	2.44**	12.41**	20.20**	0.99**	10.54**	1.22**
Parents	14	2.09	58.28**	0.71**	3.42**	60.23**	796.64**	2.92**	12.63**	14.06**	1.31**	15.22**	2.22**
Crosses	35	7.99**	118.59**	0.75**	3.33**	32.23**	1749.83**	2.32**	11.73**	20.65**	0.63**	7.44**	0.85**
Parents Vs crosses	1	5.07	1427.03**	0.68**	7.33**	90.07**	22941.98**	0.06	33.06**	90.49**	9.16**	53.25**	0.02
Environments x genotypes	100	4.79**	63.56**	0.40**	1.20**	10.04**	1107.42**	0.54**	4.91**	9.69**	0.55**	5.93**	0.81**
Environments x parents	28	5.00**	47.30**	0.55**	1.17**	7.91**	797.85**	0.46**	4.12**	12.68**	0.67**	7.03**	0.59**
Environments x crosses	70	4.60**	70.34**	0.34**	1.20**	10.75**	1187.45**	0.57**	4.84**	7.40**	0.49**	5.15**	0.90**
Environments x parent Vs crosses	2	8.56*	53.84	0.23	1.19*	14.73**	2640.26**	0.54*	18.10**	47.99**	1.20**	17.60**	0.79**
Error	300	2.62	23.29	0.08	0.26	1.75	216.79	0.12	0.1	0.24	0.01	0.76	0.01

*****- Significant at 5 % level of significance ******- Significant at 1 % level of significance

Table.2 Average heterosis (H_1), heterobeltiosis (H_2) and standard heterosis (H_3) (%) estimated over the three environments for different quantitative traits

Sr. No.	Crosses	Number of sympodia			Number of bolls/plant			Boll weight		
		H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3
1	AKH 84635 X AKH 10-2	4.86	2.09	1.78	26.18**	17.60*	15.23	9.40*	7.76	-6.3
2	AKH 84635 X AKH 10-5	-12.44**	-13.51**	-13.78**	5.97	3.26	1.18	-1.58	-9.58*	-8.94*
3	AKH 84635 X AKH 10-10	3.24	2.8	3.37	7.08	6.05	3.91	-3.21	-10.23**	-11.44**
4	AKH 84635 X AKH 11-7	4.37	4.05	3.74	24.28**	17.83*	15.46	10.37**	3.94	-0.77
5	AKH 84635 X AKH 2006-2	-13.07**	-13.55**	-12.86**	2.27	1.45	1.03	5.64	4.55	-9.96*
6	AKH 84635 X AKH 2012-8	5.11	2.95	2.63	14.07	11.94	13.94	14.03**	7.73	2.15
7	AKH 84635 X AKH 2012-9	3.6	0.86	0.55	18.22*	13.91	20.39*	4.05	1.19	-9.68*
8	AKH 84635 X AKH 09-5	-3.43	-4.91	-5.21	-3.69	-6.4	-8.28	-6.06	-17.96**	-7.33
9	AKH 84635 X AKH 976	-1.24	-2.46	-2.76	10.45	8.57	6.38	3.25	-2.82	-7.1
10	AKH 84635 X AKH 9916	3.62	1.97	1.65	1.73	-6.44	9.23	-6.65	-7.65	-20.41**
11	AKH 84635 X DHY 286	5.65	4.44	6.55	26.68**	20.81*	18.38*	6.13	-0.3	-4.31
12	AKH 84635 X SURAJ	0.76	-2.58	-2.88	25.37**	23.72**	21.23*	9.08*	-1.65	3.28
13	AKH 8828 X AKH 10-2	0.97	0.26	-3.98	-6.17	-16.27*	-9.68	-20.15**	-26.90**	-23.50**
14	AKH 8828 X AKH 10-5	1.4	0.63	-2.14	1.1	-5.88	1.52	-14.92**	-16.52**	-12.63**
15	AKH 8828 X AKH 10-10	7.42*	4.87	5.45	19.07**	12.57	21.42*	-6.47*	-9.15*	-4.92
16	AKH 8828 X AKH 11-7	-3.21	-4.82	-5.7	10.09	-0.14	7.71	-4.79	-8.97*	-4.73

17	AKH 8828 X AKH 2006-2	2.06	-0.49	0.31	32.08**	27.01**	36.99**	11.10**	1.26	5.98
18	AKH 8828 X AKH 2012-8	-2.59	-2.69	-6.8	4.6	1.65	9.65	-12.89**	-16.98**	-13.11**
19	AKH 8828 X AKH 2012-9	7.02	6.27	1.78	10.9	9.79	18.42*	-1.67	-8.91*	-4.66
20	AKH 8828 X AKH 09-5	0.06	-0.38	-3.74	12.68	4.65	12.88	-5.73	-9.19**	2.57
21	AKH 8828 X AKH 976	4.82	4.03	1.16	17.82*	10.6	19.29*	6.26	1.66	6.4
22	AKH 8828 X AKH 9916	5.48	5.08	1.41	10.01	5.82	23.55**	-4.97	-13.36**	-9.32*
23	AKH 8828 X DHY 286	6.13	2.88	4.96	38.31**	26.16**	36.08**	-10.45**	-14.16**	-10.16**
24	AKH 8828 X SURAJ	7.13	5.63	1.16	4.52	-1.51	6.23	-13.97**	-14.11**	-9.80*
25	AKH 081 X AKH 10-2	0.32	-0.13	-4.84	24.26**	22.56*	6.68	2.24	-2.26	-6.81
26	AKH 081 X AKH 10-5	1.15	0.13	-2.63	15.32	11.64	3.8	4.12	1.34	2.06
27	AKH 081 X AKH 10-10	11.94**	9.01*	9.61*	5.02	0.08	-3.84	-3.73	-5.34	-6.62
28	AKH 081 X AKH 11-7	-5.48	-7.29	-8.14*	8.6	8.13	-5.05	-6.27	-6.33	-10.58**
29	AKH 081 X AKH 2006-2	-6.43	-8.99*	-8.27*	0.37	-5.95	-6.34	-2.71	-7.42	-11.73**
30	AKH 081 X AKH 2012-8	-1.19	-1.35	-5.7	2.33	-5.07	-3.38	4.36	4.08	-0.77
31	AKH 081 X AKH 2012-9	1.48	1.03	-3.74	-6.52	-14.77	-9.91	-13.01**	-15.78**	-19.70**
32	AKH 081 X AKH 09-5	2.11	1.39	-2.02	28.96**	25.17**	15.76	9.07**	0.57	13.60**
33	AKH 081 X AKH 976	7.89*	6.8	3.86	38.25**	32.70**	25.60**	-20.30**	-20.41**	-23.92**
34	AKH 081 X AKH 9916	-0.77	-1.4	-4.84	2.83	-10.25	4.79	-2.85	-7.52	-11.83**
35	AKH 081 X DHY 286	-3.54	-6.72	-4.84	45.48**	43.96**	27.99**	-11.93**	-12.22**	-15.75**
36	AKH 081 X SURAJ	6.89	5.66	0.67	6.54	1.87	-2.81	-0.43	-5.02	-0.26
	SE(m)±	0.64	0.74	0.74	2.11	2.43	2.43	0.12	0.13	0.13
	CD (5%)	1.26	1.45	1.45	4.15	4.79	4.79	0.23	0.26	0.26
	CD (1%)	1.66	1.92	1.92	5.48	6.32	6.32	0.30	0.35	0.35

*****- Significant at 5 % level of significance ******- Significant at 1 % level of significance

Table.2 Cont…

Sr. No.	Crosses	Seed index			Ginning percentage			Seed cotton yield/plant		
		H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3
1	AKH 84635 X AKH 10-2	5.55*	3.15	11.18**	12.31**	8.93**	7.59**	20.21*	14.28	4.88
2	AKH 84635 X AKH 10-5	-5.34*	-9.50**	2.08	9.18**	8.22**	0.47	8.67	7.13	1.19
3	AKH 84635 X AKH 10-10	-7.30**	-15.32**	5.36	7.76**	5.30**	2.42	4.23	-3.11	3.51
4	AKH 84635 X AKH 11-7	3.02	-2.19	11.96**	6.67**	3.4	2.26	49.14**	47.97**	37.97**
5	AKH 84635 X AKH 2006-2	-3.88	-5.76	0.91	9.52**	1.95	-5.36**	0.07	-0.13	-8.34
6	AKH 84635 X AKH 2012-8	5.47*	0.95	13.60**	13.33**	11.64**	6.82**	32.06**	13.83	44.32**
7	AKH 84635 X AKH 2012-9	-4.07	-4.26	-1.49	-3.45*	-7.71**	-6.03**	49.35**	40.13**	28.61**
8	AKH 84635 X AKH 09-5	-8.82**	-13.26**	-1.13	-1.7	-2.12	-9.14**	-2.45	-10.72	-1.33
9	AKH 84635 X AKH 976	-7.72**	-10.92**	-8.35**	10.69**	9.49**	1.64	61.55**	56.12**	43.28**
10	AKH 84635 X AKH 9916	0.95	-2.13	0.7	6.46**	1.46	3.96*	44.19**	32.45**	45.20**
11	AKH 84635 X DHY 286	0.91	-0.33	5.14	-8.57**	-9.16**	-15.67**	30.21**	28.68**	20.94*
12	AKH 84635 X SURAJ	7.97**	1.17	19.09**	-3.85*	-9.87**	-4.36*	57.08**	53.35**	47.76**
13	AKH 8828 X AKH 10-2	-6.53*	-9.16**	-2.09	-8.55**	-12.94**	-4.88**	26.76*	24.85*	6.48
14	AKH 8828 X AKH 10-5	-6.56*	-11.14**	0.22	-3.52*	-11.49**	-3.3	-0.9	-5.7	-10.94
15	AKH 8828 X AKH 10-10	-4.74	-13.43**	7.71*	-4.98**	-10.20**	-1.89	34.15**	20.63*	28.87**
16	AKH 8828 X AKH 11-7	-0.19	-5.74*	7.90*	-8.26**	-12.61**	-4.52*	14.72	9.83	2.41
17	AKH 8828 X AKH 2006-2	2.72	0.15	7.24*	6.78**	-7.52**	1.04	66.51**	60.92**	47.12**
18	AKH 8828 X AKH	-6.08*	-10.59**	0.61	2.2	-4.15*	4.72**	9.59	-8.34	16.2

	2012-8									
19	AKH 8828 X AKH 2012-9	-7.24**	-7.58*	-5.28	-4.96**	-8.19**	0.3	53.76**	49.39**	27.42**
20	AKH 8828 X AKH 09-5	-3.08	-8.29**	4.53	3.10*	-5.03**	3.76*	3.41	-8.4	1.24
21	AKH 8828 X AKH 976	-8.00**	-10.70**	-9.16**	-5.01**	-13.03**	-4.98**	24.28*	24.05*	6.19
22	AKH 8828 X AKH 9916	-0.5	-3.01	-1.34	-1.07	-4.14*	4.73**	64.48**	46.22**	60.30**
23	AKH 8828 X DHY 286	1.73	-0.08	5.4	0.29	-7.79**	0.74	62.65**	55.13**	45.79**
24	AKH 8828 X SURAJ	-9.52**	-15.66**	-0.73	-7.30**	-8.64**	-0.18	32.18**	24.59*	20.05
25	AKH 081 X AKH 10-2	8.70**	5.62	13.83**	4.94**	3.60*	4.99**	28.05**	8.57	29.08**
26	AKH 081 X AKH 10-5	-4.05	-8.79**	2.87	2.64	-2.49	-1.18	22.15**	9.59	30.29**
27	AKH 081 X AKH 10-10	1.4	-7.87**	14.62**	6.70**	4.55*	5.95**	0.76	-4.35	13.71
28	AKH 081 X AKH 11-7	-11.17**	-16.14**	-4.01	-9.47**	-10.56**	-9.37**	2.05	-8.96	8.24
29	AKH 081 X AKH 2006-2	-3.66	-6.10*	0.55	11.69**	-0.07	1.26	-13.2	-23.23**	-8.73
30	AKH 081 X AKH 2012-8	5.36*	0.27	12.83**	2.35	-0.51	0.83	-3.04	-6.06	19.1
31	AKH 081 X AKH 2012-9	-2.4	-2.79	-0.38	3.53*	3.29	5.16**	-8.66	-23.43**	-8.97
32	AKH 081 X AKH 09-5	15.04**	8.82**	24.03**	2.36	-2.35	-1.04	34.30**	29.58**	54.05**
33	AKH 081 X AKH 976	-7.68**	-10.35**	-8.87**	2.55	-2.78	-1.47	30.70**	12.4	33.63**
34	AKH 081 X AKH 9916	1.92	-0.61	1.03	-1.03	-1.57	0.85	-15.04	-18.35*	-2.93
35	AKH 081 X DHY 286	12.96**	10.91**	17.00**	-7.72**	-12.14**	-10.96**	28.27**	14.83	36.52**
36	AKH 081 X SURAJ	-5.52*	-11.96**	3.63	-0.02	-2.26	3.71*	5.23	-4.74	13.25
	SE(m)±	0.21	0.24	0.24	0.55	0.64	0.64	6.12	7.07	7.07
	CD (5%)	0.42	0.48	0.48	1.09	1.26	1.26	12.06	13.93	13.93
	CD (1%)	0.55	0.63	0.63	1.44	1.66	1.66	15.91	18.37	18.37

*****- Significant at 5 % level of significance ******- Significant at 1 % level of significance

Table.2 Cont…

Sr. No.	Crosses	Lint index			2.5 % span length			Fibre strength		
		H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3
1	AKH 84635 X AKH 10-2	24.63**	16.56**	23.05**	-7.53**	-9.25**	-2.83**	-2.94**	-8.11**	0.79
2	AKH 84635 X AKH 10-5	5.79	2.5	0.45	-6.38**	-7.03**	-2.79**	-1.57*	-7.01**	2.44**
3	AKH 84635 X AKH 10-10	5.54	-6.41	11.21**	-7.43**	-9.29**	-2.55**	-8.87**	-14.40**	-4.54**
4	AKH 84635 X AKH 11-7	12.76**	2.51	15.14**	-6.85**	-9.37**	-1.22*	3.34**	-2.26**	7.42**
5	AKH 84635 X AKH 2006-2	9.70*	1.09	-7.09	-7.67**	-7.85**	-4.99**	-9.92**	-15.29**	-5.76**
6	AKH 84635 X AKH 2012-8	27.98**	19.99**	26.00**	3.11**	1.75**	4.91**	0.23	-6.11**	5.32**
7	AKH 84635 X AKH 2012-9	-9.43**	-15.18**	-10.71**	-9.82**	-10.14**	-6.68**	-1.25	-7.37**	3.62**
8	AKH 84635 X AKH 09-5	-11.75**	-15.68**	-14.93**	4.72**	4.04**	7.27**	-3.11**	-5.80**	-2.27*
9	AKH 84635 X AKH 976	6.84	1.35	-6.86	0.94*	-0.04	3.06**	-6.12**	-8.43**	-5.63**
10	AKH 84635 X AKH 9916	12.71**	7.99*	8.31*	-3.48**	-6.02**	-3.10**	5.42**	3.84**	4.89**
11	AKH 84635 X DHY 286	-11.22**	-11.92**	-17.75**	-9.07**	-10.02**	-7.23**	2.18**	-1.61	4.14**
12	AKH 84635 X SURAJ	-0.33	-14.73**	10.21**	-3.90**	-6.36**	1.77**	8.37**	2.42**	12.74**
13	AKH 8828 X AKH 10-2	-17.31**	-21.29**	-8.07*	-5.19**	-10.86**	-4.56**	-6.85**	-9.39**	-0.61
14	AKH 8828 X AKH 10-5	-11.50**	-18.63**	-4.96	-6.01**	-10.64**	-6.56**	-10.53**	-13.15**	-4.32**
15	AKH 8828 X AKH 10-10	-11.02**	-11.78**	4.83	4.50**	-1.90**	5.38**	-10.08**	-13.22**	-3.23**
16	AKH 8828 X AKH 11-7	-12.94**	-14.61**	-0.26	-0.21	-6.96**	1.41**	-2.33**	-5.08**	4.32**
17	AKH 8828 X AKH 2006-2	11.63**	-7.16*	8.44*	5.88**	1.53**	4.28**	-3.63**	-6.90**	3.58**
18	AKH 8828 X AKH	-2.68	-7.59*	7.94*	0.04	-3.01**	-2.63**	-5.62**	-9.18**	1.88*

	2012-8									
19	AKH 8828 X AKH 2012-9	-14.19**	-18.42**	-4.72	0.08	-4.54**	-0.86	-12.45**	-15.64**	-5.63**
20	AKH 8828 X AKH 09-5	1.78	-5.15	10.79**	7.24**	3.28**	5.11**	0.65	0.63	4.41**
21	AKH 8828 X AKH 976	-16.20**	-28.52**	-16.51**	3.58**	0.08	1.18*	-2.81**	-3.11**	0.48
22	AKH 8828 X AKH 9916	-2.21	-9.12**	6.14	4.56**	2.74**	0.35	7.89**	6.48**	10.43**
23	AKH 8828 X DHY 286	1.58	-8.60*	6.75	2.13**	-1.25*	-0.31	1.02	1.04	5.85**
24	AKH 8828 X SURAJ	-19.25**	-23.14**	-0.66	3.16**	-3.69**	4.68**	-10.00**	-12.60**	-3.80**
25	AKH 081 X AKH 10-2	15.93**	14.91**	21.31**	3.02**	-0.99*	6.01**	-0.19	-4.89**	4.32**
26	AKH 081 X AKH 10-5	0.46	-2.31	1.32	0.43	-2.37**	2.08**	6.91**	1.66	12.00**
27	AKH 081 X AKH 10-10	12.76**	5.59	25.47**	4.14**	-0.07	7.35**	9.91**	3.91**	15.88**
28	AKH 081 X AKH 11-7	-23.44**	-26.37**	-17.30**	-4.07**	-8.58**	-0.35	1.92*	-2.98**	6.63**
29	AKH 081 X AKH 2006-2	12.97**	-1.32	2.35	-2.09**	-3.98**	-1.38**	-10.92**	-15.69**	-6.20**
30	AKH 081 X AKH 2012-8	7.09*	6.43	11.76**	2.45**	1.60**	2.00**	5.73**	-0.31	11.82**
31	AKH 081 X AKH 2012-9	1.63	0.88	6.2	3.88**	1.32**	5.23**	1.92*	-3.78**	7.64**
32	AKH 081 X AKH 09-5	18.93**	17.32**	21.68**	1.67**	0.15	1.93**	11.02**	8.66**	12.74**
33	AKH 081 X AKH 976	-3.77	-13.63**	-10.42**	0.63	-0.54	0.55	-3.43**	-5.17**	-2.27*
34	AKH 081 X AKH 9916	0.44	-1.22	2.45	1.74**	1.19*	-0.08	2.18**	1.34	2.36*
35	AKH 081 X DHY 286	0.4	-4.6	-1.05	1.77**	0.66	1.61**	0.11	-2.97**	2.71**
36	AKH 081 X SURAJ	-6.00*	-15.28**	9.49*	2.29**	-2.39**	6.09**	-3.21**	-7.93**	1.35
	SE(m)±	0.14	0.16	0.16	0.13	0.15	0.15	0.21	0.24	0.24
	CD (5%)	0.28	0.32	0.32	0.25	0.29	0.29	0.40	0.47	0.47
	CD (1%)	0.37	0.43	0.43	0.34	0.39	0.39	0.53	0.62	0.62

*****- Significant at 5 % level of significance ******- Significant at 1 % level of significance

Table.2 Cont…

Sr. No.	Crosses	Fibre fineness			Uniformity index			Elongation percentage		
		H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3
1	AKH 84635 X AKH 10-2	11.95**	-1.97	2.84*	-0.66	-2.09**	-2.09**	-0.2	-3.14**	-4.27**
2	AKH 84635 X AKH 10-5	13.05**	6.65**	11.89**	0.2	-1.05*	-1.44**	2.87**	0.19	4.47**
3	AKH 84635 X AKH 10-10	-6.78**	-8.62**	-4.13**	-1.39**	-3.12**	-2.48**	0.98	0.58	0.19
4	AKH 84635 X AKH 11-7	-4.44**	-12.56**	-8.27**	0.93*	-0.13	-0.92	12.16**	2.36*	1.17
5	AKH 84635 X AKH 2006-2	9.23**	1.97	6.98**	-3.60**	-6.12**	-3.79**	-3.13**	-6.25**	-0.97
6	AKH 84635 X AKH 2012-8	-7.15**	-8.87**	-4.39**	1.34**	0.93	-1.18*	-0.28	-6.23**	5.24**
7	AKH 84635 X AKH 2012-9	7.69**	-1.72	3.10*	1.07*	0.13	-0.92	0.38	-1.69	1.36
8	AKH 84635 X AKH 09-5	-3.23**	-15.27**	-11.11**	1.60**	0.39	-0.13	-0.9	-8.62**	6.99**
9	AKH 84635 X AKH 976	6.52**	-5.42**	-0.78	0.47	-0.53	-1.44**	-1	-3.14**	-4.27**
10	AKH 84635 X AKH 9916	7.42**	3.45**	8.53**	0.2	0.3	-2.88**	-2.54**	-6.65**	0.78
11	AKH 84635 X DHY 286	8.75**	7.14**	12.40**	-0.93*	-1.85**	-2.88**	4.73**	0.91	7.57**
12	AKH 84635 X SURAJ	7.18**	-4.43**	0.26	1.12**	-0.65	0.13	-1.69*	-6.08**	1.94*
13	AKH 8828 X AKH 10-2	16.79**	5.26**	3.36**	-1.19**	-2.61**	-2.61**	-0.1	-4.04**	-3.11**
14	AKH 8828 X AKH 10-5	2.16*	-0.53	-2.33	-2.46**	-3.67**	-4.05**	-0.28	-1.86*	2.33*
15	AKH 8828 X AKH 10-10	3.38**	2.05	2.84*	0.33	-1.43**	-0.78	-1.45	-2.12*	-1.17
16	AKH 8828 X AKH 11-7	8.23**	2.11	0.26	0.67	-0.4	-1.18*	12.98**	2.12*	3.11**
17	AKH 8828 X AKH 2006-2	1.37	-2.37	-4.13**	-0.98*	-3.57**	-1.18*	15.98**	13.42**	19.81**
18	AKH 8828 X AKH	-3.76**	-5.12**	-4.13**	0.54	0.13	-1.96**	-1.64*	-6.57**	4.85**

	2012-8									
19	AKH 8828 X AKH 2012-9	2.1	-3.95**	-5.68**	0.11	-0.92	-1.96**	-1.24	-2.26*	0.78
20	AKH 8828 X AKH 09-5	14.16**	2.89*	1.03	0.53	-0.66	-1.18*	-11.49**	-17.58**	-3.50**
21	AKH 8828 X AKH 976	11.65**	2.11	0.26	1.00*	0.12	-0.92	-4.47**	-7.50**	-6.60**
22	AKH 8828 X AKH 9916	3.70**	3.16*	1.29	1.21**	1.21*	-1.70**	1.12	-2.16*	5.63**
23	AKH 8828 X DHY 286	-0.52	-2.28	-0.52	-0.8	-1.72**	-2.75**	7.95**	5.10**	12.04**
24	AKH 8828 X SURAJ	0.86	-7.37**	-9.04**	-1.26**	-2.99**	-2.35**	-3.24**	-6.62**	1.36
25	AKH 081 X AKH 10-2	10.38**	1.94	-5.17**	0.4	-0.78	-0.78	10.45**	8.45**	4.66**
26	AKH 081 X AKH 10-5	11.39**	11.39**	3.62**	0.6	-0.39	-0.78	4.06**	0.19	4.47**
27	AKH 081 X AKH 10-10	-0.8	-4.62**	-3.88**	0.46	-1.04*	-0.39	13.47**	11.70**	11.26**
28	AKH 081 X AKH 11-7	2.44*	-0.83	-7.75**	-0.13	-0.92	-1.70**	15.81**	6.84**	3.11**
29	AKH 081 X AKH 2006-2	15.17**	13.89**	5.94**	-3.85**	-6.12**	-3.79**	-0.29	-4.60**	0.78
30	AKH 081 X AKH 2012-8	-2.80**	-6.65**	-5.68**	0.94*	0.8	-1.31**	-7.53**	-14.01**	-3.50**
31	AKH 081 X AKH 2012-9	0.14	-3.33*	-10.08**	0.4	-0.26	-1.31**	-5.25**	-8.29**	-5.44**
32	AKH 081 X AKH 09-5	10.98**	2.5	-4.65**	0.66	-0.26	-0.78	-4.18**	-12.60**	2.33*
33	AKH 081 X AKH 976	1.93	-4.44**	-11.11**	-1.53**	-2.24**	-3.14**	3.05**	2.01*	-1.55
34	AKH 081 X AKH 9916	-1.9	-3.99**	-6.72**	0.11	-0.27	-2.61**	-2.18**	-7.37**	0.12
35	AKH 081 X DHY 286	10.61**	5.84**	7.75**	-1.73**	-2.38**	-3.40**	-5.93**	-10.38**	-4.47**
36	AKH 081 X SURAJ	12.39**	5.83**	-1.55	-1.65**	-3.12**	-2.48**	-5.11**	-10.38**	-2.72**
	SE(m)±	0.04	0.05	0.05	0.35	0.41	0.41	0.05	0.05	0.05
	CD (5%)	0.09	0.10	0.10	0.70	0.81	0.81	0.09	0.11	0.11
	CD (1%)	0.12	0.13	0.13	0.92	1.06	1.06	0.12	0.14	0.14

*****- Significant at 5 % level of significance ******- Significant at 1 % level of significance

Table.3 Mean yield performance and standard heterosis (H_3) of promising crosses over the environments

SN	Crosses	Mean yield performance for Seed cotton yield/plant (g)	Standard heterosis (H_3) for seed cotton yield (%)	Significant standard heterosis for other characters in desirable direction
1	AKH 8828 x AKH 9916	110.09**	60.30**	2, 9
2	AKH 081 x AKH 09-5	105.80**	54.05**	2, 3, 4, 7
3	AKH 84635 x SURAJ	101.48**	47.76**	2, 4, 7, 8, 9
4	AKH 8828 x AKH 2006-2	101.04**	47.12**	2, 7, 8, 9, 10, 12
5	AKH 8828 x DHY 286	100.09**	45.79**	2, 9, 12

*****- Significant at 5 % level of significance ******- Significant at 1 % level of significance

1: Number of sympodia/plant 2: Number of bolls/plant 3: Boll weight
4: Seed index 5: Ginning percentage 6: Seed cotton yield/plant
7: Lint index 8: 2.5 % span length 9: Fibre strength
10: Fibre fineness 11: Uniformity index 12: Elongation percentage

Heterosis for different economically important characters were already reported by Alkuddsi *et al.*, (2013), Chhavikant *et al.*, (2017), Chinchane *et al.*, (2018), Sawarkar *et al.*, (2015), Kannan and Saravanan (2016), Pushpam *et al.*, (2015), Lingaraja *et al.*, (2017) and Karademir and Gencer (2010).

The cross AKH 8828 x AKH 9916 exhibited highest significant heterosis (60.30 %) over the check PKV Hy-2 for seed cotton yield/plant. This cross also recorded significant standard heterosis in desirable direction for number of bolls/plant and fibre strength over the environments. Similarly, the cross AKH 081 x AKH 09-5 exhibited higher and significant standard heterosis (54.05 %) for seed cotton yield/plant, number of bolls/plant, boll weight, seed index and lint index over the environments. This cross also exhibited significant heterobeltiosis for important fibre quality traits such as 2.5 % span length and fibre strength. Similarly, other crosses *viz.*, AKH 84635 x SURAJ (47.76 %), AKH 8828 x AKH 2006-2 (47.12 %) and AKH 8828 x DHY 286 (45.79 %) also exhibited higher significant heterosis over check hybrid for seed cotton yield/plant and other important yield contributing characters (Table 3). The presence of significant standard heterosis for seed cotton yield, its contributing traits and fibre properties in cotton has been reported by earlier workers viz., Bilwal *et al.*, (2018) and Chinchane *et al.*, (2018). The cross AKH 84635 x AKH 2012-8, though not ranked in top for seed cotton yield/plant based on standard heterotic performance, but, it exhibited satisfactory significant standard heterosis for fibre quality parameters in desirable direction *viz.*, 2.5 % span length, fibre strength, fibre fineness and elongation percentage. Thus, out of 36 hybrids, 3 hybrids *viz.*, AKH 081 x AKH 09-5, AKH 8828 x AKH 2006-2 and AKH 8828 x AKH 9916 were identified as promising over the environments which can be exploited for heterosis breeding programme after multi location testing over the years to confirm their performance.

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