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A COMPARATIVE STUDY OF HETEROSIS IN GMS BASED AND CONVENTIONAL INTRA *ARBOREUM* COTTON HYBRIDS

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ABSTRACT

A comparative study of heterosis over better parent was carried out during 1995 in GMS based and corresponding conventional hybrids, which were generated by utilising two genetic male sterile lines viz. DS-5 and GAKA-423 and their male fertile counter lines as female parents respectively. The GMS based hybrids exhibited high heterosis over better parent for seed cotton yield and its component characters compared to conventional hybrids. The high yielding GMS based crosses showed simultaneous heterosis for seed cotton yield and its component characters like number of bolls/plant, boll weight and number of seeds/boll. However the GMS based hybrids failed to exhibit heterosis over better parent for ginning out turn except one cross, as against three conventional hybrids. The higher ginning out-turn of conventional hybrids was mainly contributed by their lower seed index values, as large proportion of conventional hybrids exhibited negative heterosis for seed index. Three GMS based hybrids viz., DS-5 x 30802, DS-5xNo.2631 and DS-5 x B-Desh are potential hybrids for exploitation of hybrid vigour utilizing DS-5 male sterile line.

Key Words : Gossypium arboreum, genetic male sterility, conventional and GMS based hybrids and heterosis

Heterosis breeding in cotton has paid rich dividends in increasing production and productivity of cotton in central and southern zones of the country. One of the chief factors contributing to the increased production and productivity in cotton is the development of hybrids in tetraploids and their successful cultivation in about 28.2 percent of cotton area of the country. Although, desi cottons were predominant during 1930's and 1940's have now declined to 30 percent of total cotton area under cultivation. The desi cottons are known for their inherent ability to resist major pest and diseases in addition to high ginning out turn, low cost of management and wide adoptability under rainfed conditions due to deep root system [1]. The area under desi cotton hybrids is not significant due to uneconomic hybrid seed production.

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The stylar portions of flowers of cultivated diploid cotton breaks easily at the time of emasculation due to its brittle and fragile nature, resulting in low percentage of boll setting during hybrid seed production.

Use of genetic male sterility can considerably reduce the cost of hybrid seed production atleast by 30 percent by avoiding labour cost required for intensive emasculation [2]. Several workers have reported genetic and cytoplasmic male sterility in American cotton. In desi cotton, although petaloidy nature has been reported in *G.arboreum*. L in which anthers are transformed to petal like leafy structures [3], the petaloidy nature has not been utilized for hybrid seed production due to its unstable and partially male sterile behaviour. Recently Singh and Kumar [4] and Mesharam *et al.,* [5] reported different genetic male sterile sources in *G. arboreum* L, controlled by two different single recessive genes. Information on interaction of cytoplasms or genomes of lines, affecting the hybrid performance is prerequisite for practical use of any male sterility system in exploitation of hybrid vigour. The hybrids developed by utilizing these two sources and also their fertile counter part lines as females by crossing them with selected genotypes of *G. arboreum* formed the material for the present investigation, to study the extent of heterosis over better parent in GMS based hybrids as compared to corresponding conventional hybrids.

MATERIAL AND METHODS

Two genetic male sterile lines viz., DS-5 and GAKA-423 belonging to *G.arboreum* were used as females. Each of male sterile line was crossed with eighteen selected varieties of G. arboreum to obtain 2×18 intra-*arboreum* GMS based hybrids and similarly using maintainer line of each source, 2 × 18 intra-arboreum conventional hybrids were obtained by hand emasculation.

The following parents were used in the study.

a. Male sterile and fertile counterpart lines were used as female parents.

1. DS-5 2. GAKA-423

b. Male parents. 1. TKA-332 2. CIMA-302 3. NO.2631 4. No. 2708 5. No. 2463

6. A-82-1-1 7. Virnar 8. AK-235 9. CNA-4 10. No.22 11. No. 23 12. Shreeshailum 13. AKH-4 14. 30843 15. B-Desh. 16. 30802 17. GAO- CB-3 18. 30815.

The resulting 36 GMS based, 36 conventional hybrids and parents were evaluated in RBD with three replications during *kharif* 1995 under rainfed situation at Agricultural Research station Dharwad. Five competitive plants were tagged at random in each replication and in each entry for recording observations on 13 quantitative traits.

The heterosis over better parent was calculated by the method of Turner [6] and Hayes *et al.*, [7]. The average heterosis of hybrids was worked out on the basis of mean value of 20 parents and 36 hybrids.

RESULTS AND DISCUSSION

The magnitude of heterosis over better parent for 13 characters is presented in Table-1 for GMS based hybrids and Table 2 for conventional hybrids and abstracted information in Table 3. For effective presentation and discussion of the results, the 13 characters are grouped into maturity related, plant morphological, yield and its components and economic traits.

Maturity related characters

In the present study, only two characters viz., days to 50 percent flowering and node number are related to maturity. Out of 36 GMS based hybrids, none of the hybrids exhibited significant heterosis over better parent in negative direction for both the traits. However under conventional cross combinations, one hybrid DS-5 × 30802 (1 × 16) for days to 50% flowering and two hybrids viz. GAKA 423 × GAO CB-3 (2 × 17) and GAKA-423 × A-82-1-1 (2 × 6) for node number were heterotic in desirable direction. In general the GMS based hybrids were comparatively late in attaining days to 50% flowering than conventional hybrids as indicated by the range of better parent heterosis. There are no reports available involving GMS based crosses in desi cotton, however Tomar and Singh [8] reported significant heterosis over better parent in conventional *G. arboreum* crosses.

Plant morphological traits

Plant height is an important morphological character in cotton which provides seat for nodes and internodes ultimately determining the total yielding potential of a genotype. There were as many as four GMS based and four conventional crosses, which exhibited significant positive heterosis over better parent for plant height. Out of these hybrids, one viz., DS-5 × 30815 (1 × 18) exhibited highest heterosis by involving shortest male and female parents in both cross combinations. Sandhu and Kooner [9] and Waldia and Tomer [10] also observed remarkable heterosis for plant height in conventional intervarietal crosses of *G. arboreum*.

High sympodia per plant with minimum number of monopodial branches is an indication of higher productivity. None of the GMS based and conventional hybrids were heterotic over better parent in desirable direction for number of

Table 1. Percentage of heterosis over better parent for 13 quantitative characters in GMS based crosses of *G. arboreum* L.

Crosses	Days to 50% flowering	Node number	Plant height	No. of sympodial branches	No. of monopodial branches	Yield of seed cotton/plant	Boll weight	No. of bolls/plant	No. of seeds/boll	Ginning out-turn (%)	Seed index	Lint index	Halo length
1×1	3.0	21.85*	–1.10	–1.40	14.86	24.39*	24.19**	39.87*	7.59	–2.76	–5.26	–0.40	–20.67**
1×2	9.44	13.45	3.14	–17.42	65.52	72.56**	–4.80	67.31**	–4.96	–3.94	–15.00*	–6.96	–16.10*
1×3	0.00	7.56	7.05	22.75	–7.79	72.10**	13.49	52.05**	5.79	3.94	0.00	16.35*	–13.97**
1×4	5.78	–3.36	18.58*	2.59	32.65	36.78**	20.97**	37.81**	12.23	0.00	0.00	4.80	–12.95*
1×5	2.49	3.36	–7.49	–13.14	32.11	42.28**	17.42*	66.67**	16.67*	0.79	–5.56	0.88	–2.71
1×6	1.15	39.92*	–4.53	–32.77**	14.61	–16.24	–1.67	–20.87	7.73	–2.36	–5.26	1.44	–23.55**
1×7	–0.78	11.76	6.76	13.46	–5.41	2.16	26.32**	–16.96	12.74	–11.81**	10.53	0.08	–17.42**
1×8	7.11	10.08	–3.95	20.86	4.11	16.52	8.80	23.47	9.34	0.00	–10.53	–0.16	–12.21*
1×9	9.73	5.88	3.25	–25.72	–9.83	–2.39	7.81	–9.06	5.08	–1.57	–18.42*	–13.52	–15.32**
1×10	4.28	12.61	20.00*	28.71	12.05	63.19**	2.45	44.23	1.31	7.09*	0.00	16.12*	–17.57**
1×11	2.65	5.88	–21.00**	–24.54	37.50	–30.96*	4.51	5.43	8.10	2.36	–5.00	15.8**	–16.52**
1×12	–6.85	5.04	–13.04	1.61	12.07	44.45**	14.73*	34.55*	12.77*	–2.36	–5.56	–4.56	–5.97
1×13	1.98	5.17	–11.05	–7.06	–4.06	–4.46	6.02	79.78**	8.82	–1.57	–20.00**	–8.24	–13.06**
1×14	0.00	8.70	6.03	6.99	47.06	52.09**	9.85	38.85	9.18	0.00	–2.63	8.64	–18.43**
1×15	5.98	1.75	–6.70	–11.46	32.14	90.25**	17.83*	86.25**	15.86**	0.00	–9.52	11.36	–21.25**
1×16	14.47*	5.88	6.27	–14.23	–12.50	39.06**	21.21*	36.07*	2.53	–2.36	–10.53	–4.56	–5.97
1×17	0.00	–2.52	2.19	2.03	31.58	20.39*	2.41	5.95	5.73	1.57	0.00	8.57	–11.14*

(*Contd. on next page*)

1×18	-7.00	-11.69	73.84**	9.84	141.51**	5.32	1.08	-21.15	-13.33	-13.40**	0.00	-20.83**	3.23
2×1	2.15	-3.08	4.38	-4.49	19.40	0.28	-2.09	-8.67	-8.33	-3.48	10.53	10.19	-6.40
2×2	12.88*	-5.17	1.80	-22.04	109.20**	-16.90	17.07*	-32.74	4.67	-5.22	0.00	-3.23	-1.82
2×3	-0.43	-3.45	11.34	10.20	8.21	-14.60	9.12	-33.70	4.46	-15.00**	-5.26	-26.65**	-1.51
2×4	12.89*	-10.34	6.19	4.90	59.18	-3.87	-1.35	-10.36	-10.86	-5.83	-5.56	-13.63	8.92
2×5	2.07	-4.31	-0.23	-14.90	-17.43	-27.13	5 82	-21.09	-13.10*	-0.84	0.00	-1.35	-0.42
2×6	20.75**	18.10	-2.32	18.06	16.42	-1.00	14.35*	-14.44	9.23	2.61	-5.26	-4.93	-15.72**
2×7	2.90	5.69	14.40*	-7.65	28.36	7.21	3.89	-16.30	5.06	-6.09	-5.26	-9.83	-0.99
2×8	3.32	2.59	8.50	-0.10	7.46	-33.16**	9.42	-24.53	6.10	-4.24	-5.26	-10.59	-1.84
2×9	5.39	9.05	10.05	14.69	26.87	17.91	9.87	12.19	6.10	0.85	0.00	1.80	-6.52
2×10	7.05	4.31	6.00	-3.67	22.39	1.14	10.61	5.16	3.34	-0.80	0.00	-1.01	-7.08
2×11	5.31	-8.62	-3.83	8.88	23.21	-15.41	16.59*	-30.36	4.17	0.87	-5.00	-1.82	1.98
2×12	4.56	6.03	-1.30	0.00	20.69	0.21	15.10*	-4.06	6.40	-1.74	5.56	7.24	-5.10
2×13	-2.49	-3.23	-5.70	-12.24	-17.69	-27.19	0.95	-14.51	-7.44	-0.87	-10.00	-1.78	-56.56
2×14	-0.87	12.17	7.66	10.20	54.90	33.20	12.26	22.42	8.63	-1.74	0.00	1.23	-4.82
2×15	7.69	15.26	4.42	4.08	23.88	-14.75	19.58**	1.56	8.48	-9.30**	-2.38	-1.71	-6.39
2×16	0.00	4.74	4.90	-8.88	-10.00	-5.88	15.84*	-16.67	17.11**	-2.61	5.26	6.26	-3.23
2×17	-5.39	-10.34	1.26	-34.90**	0.00	-8.93	1.20	-22.62	-1.53	-4.88	-5.26	-13.20	-2.27
2×18	-2.49	-16.38	7.22	-13.27	0.00	32.22**	1.08	19.22	-24.90**	-0.60	8.33	15.05*	-10.76*
-SE	4.36	0.771	9.43	4.33	0.989	5.69	0.158	4.19	1.42	1.33	0.485	0.336	1.17

* and ** Significant at 5 and 1 per cent levels of probability respectively.

Table 2. **Percentage of heterosis over better parent for 13 quantitative characters in conventional crosses of *G. arboreum* L.**

Crosses	Days to 50% flowering	Node number	Plant height	No. of sympodial branches	No. of monopodial branches	Yield of seed cotton/plant	Boll weight	No. of bolls/plant	No. of seeds/boll	Ginning out-turn (%)	Seed index	Lint index	Halo length
1×1	11.16	25.21**	4.77	-14.77	-4.05	-7.85	20.97*	-10.67	3.32	-2.36	-5.26	1.28	-12.53*
1×2	17.17**	4.45	3.31	-19.21	45.98	17.89	-4.09	24.42	-1.87	-6.30*	-15.00*	-10.48	-13.77*
1×3	7.73	8.82	3.76	7.75	-2.60	56.13**	18.25*	27.40	11.90	4.72	5.26	12.58	-17.46**
1×4	11.11	4.20	12.90	41.41**	38.78	63.53**	20.97*	64.24**	21.32*	4.72	-8.33	4.88	-16.43**
1×5	0.00	-14.23	-14.52*	-22.25	10.09	56.72**	9.64	66.67**	12.22	1.57	0.00	8.64	-12.28*
1×6	0.00	25.84**	-2.67	-30.07*	-15.73	-27.51**	-9.85	-10.32	-4.17	0.00	-10.53	-0.40	-1.13
1×7	-2.23	8.40	7.30	-3.58	-8.11	-14.96	14.04	-27.50	10.19	-6.30*	-10.53	-10.88	0.97
1×8	0.00	15.97	-2.48	-1.08	8.22	1.74	14.40	2.67	10.28	2.36	-15.79*	-1.76	-8.64
1×9	7.39	26.05**	6.90	-17.27	-12.36	20.87	8.59	17.03	5.08	-2.36	-7.89	2.00	-9.68
1×10	2.33	16.81	8.09	9.68	1.20	66.60**	9.39	60.96*	4.50	7.09*	-5.56	11.45	-16.02*
1×11	7.96	-11.94	-15.02**	-14.02	17.86	-19.67	5.26	-20.16	8.59	0.79	-15.00*	1.04	-12.25*
1×12	-6.23	18.49	-7.61	-1.10	39.66	17.84	17.36*	9.69	11.25	5.51*	-2.78	13.52	-7.16
1×13	-6.23	11.21	-1.03	-4.47	-4.62	28.43	14.29	14.04	17.22	-0.79	-15.00*	-1.36	-20.14**
1×14	-1.95	11.30	-2.01	4.26	49.02	9.62	-2.27	8.08	4.82	-4.72	-10.53	-7.52	-21.69**
1×15	-10.51	1.75	-2.60	-5.45	3.57	72.67**	6.20	70.47**	6.56	-3.94	-4.76	9.49	-18.57**
1×16	-12.84*	1.60	4.74	-13.85	-16.25	14.82	17.42*	14.38	17.25	-5.51*	-10.53	-10.00	-15.99**
1×17	0.00	-6.15	-5.67	-3.10	5.26	-10.08	-2.41	-10.71	4.21	2.36	-5.26	4.25	-17.02**

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1×18	–10.61	–3.15	65.41**	–12.42	32.08	–21.81	7.19	–40.38	–13.73*	5.69	11.76	11.19	15.65*
2×1	–4.56	0.00	–0.52	–10.71	13.43	7.02	27.06**	–5.87	11.46	3.48	5.26	17.34	–3.24
2×2	4.56	–11.20	5.15	–6.33	47.13	–34.33**	1.55	–25.77	–4.96	–8.70**	–7.50	–15.56	–1.04
2×3	0.86	–9.68	16.75*	4.08	27.61	–23.47	10.61	–31.51	–1.51	–5.41	7.89	–5.27	–6.85
2×4	0.89	–2.90	4.90	14.08	32.65	4.11	2.39	–9.11	–10.27	–7.50*	16.67*	3.09	9.07
2×5	4.56	–6.64	10.05	–8.37	30.28	–25.61	–5.08	–23.73	–13.54	–7.50*	–11.11	–9.64	–5.24
2×6	8.43	–22.81**	7.99	–9.12	14.93	–19.23	4.63	17.48	–3.27	0.84	–5.26	4.76	–12.18*
2×7	–5.81	7.76	12.34	–23.27	10.45	–22.37	5.38	–33.04*	5.65	–4.35	0.00	–1.70	–4.82
2×8	7.05	8.62	8.25	–6.43	40.30*	–56.65**	4.63	–31.33	–2.36	–1.69	5.26	3.28	–4.82
2×9	10.74	23.28*	21.65**	4.59	41.79	34.26	12.11	26.58	10.71	5.93*	–7.89	–2.21	–7.93
2×10	4.56	22.41	15.21*	31.63*	53.73**	22.89	6.88	14.06	–4.79	–1.60	0.00	–2.34	3.40
2×11	5.31	5.17	–12.64*	9.18	39.29	4.18	6.58	8.53	–3.12	0.87	–10.00	–6.25	–0.99
2×12	2.07	9.48	0.22	7.14	25.86	–26.69	–13.30	–22.72	–12.50	–6.96*	–5.56	–15.46	–2.27
2×13	–0.83	1.29	–8.13	–20.41	–12.69	–20.58	–3.89	–18.67	1.34	–1.74	–5.0	2.22	2.78
2×14	11.30	–4.74	–0.48	–14.49	–5.22	4.75	–0.60	7.12	–4.61	–2.61	–5.26	–5.55	–1.31
2×15	3.85	3.68	13.02	–4.02	58.04**	28.75	20.33**	28.91	7.59	–3.48	2.36	12.78	–2.97
2×16	8.77	9.48	6.96	–7.69	23.88	–3.76	10.61	–2.51	16.07	–1.74	–10.53	–8.22	–3.68
2×17	–3.73	–26.23**	3.27	–16.02	–24.56	–37.29**	–4.82	–39.29*	–3.31	2.44	–10.53	–6.68	–6.66
2×18	–1.24	–11.86	2.06	–5.10	37.74	59.86**	–5.39	43.24	–32.35**	–9.64**	16.67*	3.71	–13.60*
-	4.89	0.889	9.76	4.40	0.835	6.48	0.176	4.84	2.11	1.18	0.457	0.350	1.38

* and ** Significant at 5 and 1 per cent levels of probability respectively.

Table 3. Mean performance of parents and F_1s, average heterosis and range of better parent heterosis with number of heterotic crosses in desirable direction in respect of 13 quantitative characters in *G. arboreum* L.

Characters	Hybrid combination	Mean performance Parents	Mean performance F_1S	Average Heterosis	Range of B.P. heterosis	No. of roses with significant heterosis in desirable direction	No. of crosses better than bets *perse* performance
Days to 50% flowering	GMS	81.48	82.88	1.72	–7.00 to 20.75	0	0(2)
	Con		82.57	1.33	–12.48 to 17.17	1	1(2)
Node Number	GMS	8.60	8.18	–4.88	–16.38 to 39.92	0	7
	Con		8.30	–3.48	–26.23 to 26.05	2	7
Plant height (cm)	GMS	125.72	136.00	8.17	–21.00 to 73.84	4	0(2)
	Con		136.52	8.59	–15.02 to 65.41	4	2(1)
No. of sympodial branches/plant	GMS	27.53	29.25	6.68	–34.90 to 28.71	0	3
	Con		29.10	5.70	–30.07 to 41.41	2	3
No. of monopodial branches/plant	GMS	4.61	5.05	9.54	–17.69 to 141.50	0	0(1)
	Con		4.86	5.42	–24.56 to 58.04	0	1
Yield of seed cotton/plant (g)	GMS	42.01	49.28	17.30	–33.16 to 90.25	12	8
	Con		46.76	11.30	–56.65 to 72.6	6	6
Boll weight (g)	GMS	2.20	2.46	11.82	–5.83 to 26.32	13	5
	Con		2.40	9.09	–13.30 to 27.06	7	2
No. of bolls/plant	GMS	22.30	25.62	14.88	–33.70 to 86.25	9	9
	Con		24.98	12.01	–39.29 to 66.67	4	6
No. of seeds/boll	GMS	22.15	23.69	6.95	–24.90 to 16.67	4	0
	Con		22.94	3.57	–32.35 to 21.32	2	0
Ginning out-turn (%)	GMS	38.33	39.94	4.20	–15.00 to 7.09	1	1(2)
	Con		40.44	5.50	–9.64 to 7.09	3	5
Seed index (g)	GMS	6.27	6.10	–2.71	–20.00 to 10.53	3	2(7)
	Con		6.03	–3.82	–15.00 to 16.67	4	3(11)
Lint index (g)	GMS	3.90	4.06	4.10	–26.65 to 16.35	4	7
	Con		4.10	5.12	–15.56 to 17.34	0	8
Halo length (mm)	GMS	22.05	21.27	–3.54	–21.25 to 8.92	0	0(2)
	Con		21.31	–3.36	–21.69 to 9.07	0	0(2)

Figures in the parenthesis indicate crosses nearer to the best parent sympodial and monoprodial branches per plant except two conventional hybrids viz., DS-5 x No. 2708 (1 x 4) and GAKA-423 x No. 22 (2 x 10) which were heterotic only for number of sympodial branches per plant. Out of these crosses one cross viz. DS-5 x No. 2708 had the highest mean seed cotton yield among conventional crosses, indicating importance of this trait to the productivity of the hybrid. Most of the GMS based crosses showed high better parent heterosis for number of monoprodial branches compared to their respective conventional hybrids in positive direction.

Yield and yield components

The magnitude of the average heterosis was high for seed cotton yield compared to remaining traits and it was closely followed by number of bolls per plant and boll weight. The boll number and boll weight in intraspecific hybrids and boll number in interspecific hybrids were reported as major components of yield heterosis in diploid cottons [11-13]. Among two sets of hybrids, the GMS based hybrids exhibited better average heterosis than conventional hybrids for seed cotton yield and its component characters. The range of heterosis for seed cotton yield was high (–33.16 to 90.25%) in GMS based hybrids than conventional hybrids (–56.55 to 72.6%). The same is also indicated by the significant interaction effect due to GMS based Vs conventional hybrids at 5 per cent level of probability when the data was subjected to analysis of variance. The superiority of GMS based hybrids for seed cotton yield was probably due to the cumulative action of component traits like number of bolls per plant, boll weight and number of seeds per boll for better expression of heterosis of seed cotton yield. Similar results were reported by Srinivasan and Gururajan [14] in reconstituted GMS based hybrids H4 and Varalaxmi compared to their respective conventional hybrids.

As many as twelve GMS based and six conventional hybrids exhibited significantly superior heterosis over better parent for seed cotton yield in positive direction. The mean performance of hybrids along with heterosis will serve as useful guide in selecting potential hybrids. From this point of view, eight GMS based and six conventional hybrids were better for seed cotton yield than best *per se* performance (58.20 g./plant). Out of these, two GMS hybrids viz., DS-5 x 30802 (1 x 16) and DS-5 x No. 2631 (1 x 3) exhibited simultaneous heterosis for seed cotton yield, boll weight and number of bolls per plant, where as other hybrid DS-5 x B- Desh (1 x 15) exhibited simultaneous heterosis for yield and all the yield components including number of seeds per boll. These are potential hybrids for exploitation of heterosis using DS-5 genetic male sterile line. There are no reports available on exploitation of heterosis using male sterility systems in cultivated diploid species. However, Srinivasan and Gururajan [15] observed better parent heterosis of 70-80 per cent in Gregg male sterile (GMS) based crosses of *G. hirsutum* cotton. Bhale and Bhat [16] observed the superiority of GMS based hybrids over CMS hybrids of *G. hirsutum* in respect of seed cotton yield.

Among conventional hybrids, six were heterotic for seed cotton yield, seven for boll weight, four for number of bolls per plant and one for number of seeds per boll. Out of these, DS-5 × No.2708 (1 × 4) exhibited simultaneous heterosis for all the three yield component traits with highest mean seed cotton yield per plant (87.43 g). This was closely followed by other three crosses viz., DS-5 × B-Desh (1 × 15) DS-5 × No. 2463 (1 × 5) and DS-5 × No. 2631 (1 × 3) exhibiting simultaneous heterosis for seed cotton yield and number of bolls per plant and seed cotton yield and boll weight respectively.

Economic traits

Among four economic traits included in the study, ginning out- turn per cent primarily depends on seed weight and lint weight. Lint index represents the absolute weight of lint produced per seed and this trait is more important in breeding work than ginning out turn as it is highly correlated with lint yield. Three conventional and one GMS based hybrids exhibited significant better parent heterosis in desirable direction for ginning out turn percent. In general the conventional hybrids were superior in ginning out turn compared to GMS based hybrids as indicated by the range of heterosis over better parent (Table 3) and also by the significant mean sum of squares due to interaction effect between GMS based and conventional hybrids at 5% level of probability. The higher ginning out-turn of conventional hybrids was mainly contributed by the lower seed index values of conventional hybrids, as large proportion of conventional hybrids exhibited negative heterosis for seed index compared to GMS based crosses. As many as nineteen and eleven conventional hybrids exhibited lower and higher better parent heterosis for seed index compared to their respective GMS based hybrids respectively. Similar observations were also made by Soddi [17] in *G.hirsutum* male fertile counter part lines of "Gregg" male sterile line. Kowosalya and Raveendran [18] observed higher ginning out-turn percentage in the hybrids of B lines of *G. hirsutum* compared to the hybrids of A lines with *G.harknessii* cytoplasm.

Out of the hybrids identified for significant heterosis over better parent in positive direction for ginning out turn percent, two conventional hybrids viz, DS-5 ×No.2708 (1 × 4) and DS-5 × No. 2631 (1 × 3) were top yielders with mean seed cotton yield better than best *per se* performance. These crosses could be considered as potential crosses for high lint yield with simultaneous exploitation of hybrid vigour for seed cotton yield and ginning out turn. Similarly for lint index trait none of the conventional hybrids were heterotic over their better parent, whereas four GMS based hybrids exhibited significant better parent heterosis in positive direction. Failure of conventional hybrids to record significant heterosis for lint index was mainly due to their lower seed index values, since lint index is complemented by high ginning out turn per cent and high seed index values.

Among two sets of hybrids, none of the hybrids recorded significant heterosis over better parent for halo length however one hybrid, GAKA 423 × No. 2708 (2 × 4) in both cross combinations recorded highest heterosis in positive direction.

REFERENCES

1. L. D. Mesharm. 1992. Retrospect and prospects of rainfed cotton research in crossing yield barrier *In*: Proceedings of the First Vasantrao Naik Memorial National Seminar of Agri. Science. Cotton Development. pp 31-37, Punjabrao Krishi Vidyapeet. Akola.
2. M. G. Bhat. 1995. Advances in male sterility research in cotton. *In*: Genetic Research and Education: current trends and the next fifty years. Indian Society of Genetics and Plant Breeding, New Delhi: pp 1064-1075.
3. J. B. Hutchinson and R. L. M. Gose. 1973. Petaloidy in cotton. Curr. Sci., **6**: 99-100.
4. D. P. Singh and R. Kumar. 1993. Genetic male sterility in Asiatic cotton. Indian J. Genet., **53**: 99-100.
5. L. D. Meshram, R. A. Gongde and M. W. Marawar. 1994. Development of male sterile systems from various sources in cotton (*Gossypium* spp.) PKV Res. J., **18**: 83-86.
6. J. H. Turner Jr. 1953. A study of heterosis in upland cotton. I. Yield of hybrids compared with varieties 2. Combining ability and inbreeding effect. Agron. J., **45**: 484-490.
7. H. K. Hayes, F. F. Immer and D. C. Smith. 1955. Methods of plant breeding McGrad-Hill Book Co. Inc., New York.
8. S. K. Tomar and S. P. Singh. 1993. Heterosis for yield and yield components over environments in desi cotton (*Gossypium arboreum* L.). Indian J. Genet., **53**: 40-47.
9. B. S. Sandhu and A. S. Kooner. 1979. Inheritance of yield and its components in cotton (*G. arboreum* L.). Crop Improv., **6**: 43-52.
10. R. S. Waldia and Y. S. Tomer. 1980. Heterosis in desi cotton (*G. arboreum* L.) Haryana Agri. Univ. J. Res., **10**: 169-174.
11. T. H. Singh, H. S. Kandola and P. S. Negi. 1975. Hybrid vigour in intervarietal crosses of desi cotton. (*G. arboreum* L). J. Res. Punjab Agric. Univ., **12**: 218-223.
12. S. S. Bhatade. 1983. Environmental influences on the magnitude of heterosis in *Gossypium arboreum* L. Indian J. agric. Sci., **53**: 627-633.
13. S. K. Singh. 1987. Exploitation of heterosis in cotton. A review, M.Sc. dissertation (Unpublished) Nagpur University, Nagpur.

14. K. Srinivasan and K. N. Gururajan. 1983. Reconstitution of hybrid 4 and Varalaxmi cotton utilising male sterile base. ISCI. J., **8**: 15-18.

15. Srinivasan and K. N. Gururajan. 1973. Heterosis and combining ability in Intra-*hirsutum* crosses utilising male sterile cotton. Madras Agri. J., **40**: 1545-1549.

16. N. L. Bhale and M. G. Bhat. 1990. Investigations on exploitation of heterosis in cotton (*G. hirsutum* using male sterility. Indian J. Genet., **50**: 37-44.

17. R. R. Soddi. 1995. Histological and biochemical basis of male sterility in cotton (*G. hirsutum* L.) Unpubld. M.Sc. (Agri) Thesis, University of Agricultural Sciences, Dharwad, Karnataka.

18. R. Kowsalya and T. S. Raveendran. 1996. Comparative influence of *harknessii* and *hirsutum* plasmons on agronomic traits in cotton hybrids. Ann. plant Physiol., **10**: 4-10.