Website : www.asthafoundation.in
Frontiers in Crop Improvement
Vol 9 (2) : 136-140 (July-2021) Print ISSN : 2393-8234 Online ISSN : 2454-6011
Astha Foundation, Meerut (U.P.) India

Heterosis for Fibre Quality Traits in Cotton (*Gossypium hirsutum* L.)

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Abstract

Nine parental genotypes and 20 F_1 hybrids derived from crossing the parental genotypes in LxT design were sown in randomized complete block design along with standard check Suvin.It was observed thatline × tester interactions made greater contribution to the total variance for all the fibre quality traits studied. Proportional contribution of lines to total variance was very low for all the traits, while testers also followed similar pattern and contributed a minimum to the total variance. Out of evaluated 20 hybrids, the cross combinations namely, TCH1716 × GJHV 516, BGDS 1033 × HYPS 152 and TCH 1716 x HYPS152 were found to be promising for Upper half mean length of the fibre as they showed higher mean performances and significant positive heterosis. Further, the hybrid F2423 x HYPS152 was found to be having fine fibre and exhibited thehighest heterosis. However, the most promising hybrids for strength were TCH 1716 x L766 and TCH 1716 x HYPS152, while the highest heterotic effect elongation per cent was shown by TCH1716 x GJHV 516.These promising cross combinations showing desirable heterosis over standard check can be advanced for isolation for further exploitation to improve fibre quality traits.

Key words : *cotton, heterosis, heterobeltiosis, standard heterosis, fibre quality traits*

Introduction

Cotton (*Gossypium* spp.) popularly called “White Gold” is the most important renewable natural fibre crop of global importance. World cotton production is estimated at 118.93 million bales of 480 lb (1). India is maintaining the position of leading cotton growers in the world, China leading in terms of cotton production. Although cotton is cultivated in 77 countries; the five countries - China, India, United States, Brazil and Pakistan, produces 78% of the total world production from 72% of the world gross cotton area. China and Bangladesh are being the largest net importers of cotton (19% each) of the total world import, followed by Vietnam (17%), Indonesia (8%) and Pakistan (7%). The United States maintaining leading exporter of cotton (36%) of the total world export, followed by Brazil (14%), India (10%) and Australia (9%). And the productivity front Australia leading with yield of 1814 kg/ha, followed by China (1726) and Brazil (1636) and India way behind at 507 kg lint/ha (1).

Development of new variety with high yield and fibre quality is the primary objective of all cotton breeders. Heterosis breeding is an important genetic tool to facilitate yield enhancement and help to enrich many other desirable quantitative and qualitative traits in crops. Heterosis or hybrid vigour is the increment in performance of a hybrid (F_1 generation) in relation to parental average and can assume positive or negative values.Exploitation of heterosis as hybrids and systematic varietal improvement through hybridization are the main tools to increase the cotton production in India. It is an often cross pollinated crop and amenable for both heterosis breeding as well as hybridization followed by selection in subsequent generations. The phenomenon of heterosis has proven to be the most important genetic tool in boosting the yield of self as well as cross pollinated crops and is considered as the most important breakthrough in the field of crop improvement (2). The exploitation of hybrid vigour in cotton on commercial scale has become feasible and economical due to easy hand emasculation and pollination. The identification of specific parental combinations capable of producing the desired level of F_1 heterotic effect is important in improving the yield potential of this crop (3). Line × Tester analysis provides a systematic approach for thedetection of appropriate parents and crosses in terms of investigated traits. This method was applied to improve self and cross-pollinated plants (4). Hence, the present study was undertaken with an aim to identify high heterotic cross combinations for fibre quality traits.

Materials and Methods

Thepresent study of estimation of heterosisof *G. hirsutum* L. genotypes and F_1 hybrids of cotton was carried out at RARS, Lam, Guntur, ANGRAU during 2017-18 and 2018-19.Out of nine genotypes chosen for the study, four were designated as lines (Females) and five as testers (Males). During *Kharif*, 2017-18, the parents (four lines and five testers) were sown in a crossing block at a spacing of 105 x 60 cm. Crosses were effected in a line x tester (4 x 5)design to produce 20hybrid combinations. Hybridization was carried out following hand emasculation and pollination method. Crossing was taken up one week after flower initiation. Flower buds, likely to open the next

Received : July-2021; Revised : July-2021; Accepted : July-2021

Table-1 : Analysis of variance (mean squares) for combining ability for yield, yield components and quality parameters in cotton.

Source of variation	DF	DFF	PH (cm)	No. of mono-pods	No. of Sym-podia	No. of Bolls/ Plant	Boll wt (g)	Lint Index (g)	Seed index (g)	GOT (%)
Replications	1	0.27	177.25	0.12	2.16	0.01	0.62*	0.3	0.58	8.55
Treatments	2.8	9.59**	779.66**	0.51**	7.04**	135.73**	0.36**	0.87**	1.43	10.22*
Parents	8	7.37**	153.68	0.59**	0.66	54.05	0.23*	0.92**	0.41	12.33*
Parents vs Crosses	1	13.04*	2568.37**	0.06	6.02	188.73*	1.98**	1.02	1.12	37.56**
Crosses	19	10.34**	949.09**	0.5**	9.78**	167.34**	0.32**	0.84**	1.87	7.89
Lines	3	27.75*	1044.9	0.44	14.13	213.77	0.57	0.19	3.64	12.37
Testers	4	8.27	1017.64	0.488	13.3	275.3	0.37	0.73	0.57	13.22
Lines x Testers	12	6.67**	902.27**	0.527**	7.51**	119.74**	0.24**	1.04**	1.86**	5
Error	28	1.88	251.4	0.056	1.75	35.21	0.1	0.27	0.82	4.16
Total	57	5.64	509.6	0.28	4.36	83.97	0.24	0.56	1.11	7.22
^{2} GCA		1.79	86.65	0.045	1.329	23.25	0.041	0.057	0.143	0.959
^{2} SCA		2.39	325.4	0.235	2.881	42.26	0.070	0.021	0.520	0.419
^{2} GCA/ ^{2} SCA		0.749	0.266	0.1914	0.4619	0.552	0.5871	0.275	0.295	2.289

Table-1 : Contd...

Source of variation	SCY (Kg/ha)	Lint yield (Kg/ha)	UHML (mm)	ML (mm)	UI (%)	Mic (ug/ inch)	Bundle strength (g tex)	E (%)
Replications	4027.3	7473.2	10.09	20.52**	11963.6**	0.00017	18.77*	7.96**
Treatments	226740.9**	40968.2**	8.83**	8.91**	912.95	0.206**	7.2*	0.32
Parents	150653.2*	33041.9*	12.99**	13.5**	2.12	0.278**	6.17	0.13
Parents vs Crosses	1100797**	254300.1**	11.88*	20.22**	25511.72**	0.42**	3.93*	0.98
Crosses	212774.9**	33077.6**	6.92**	6.39**	1.78	0.16**	7.8	0.36
Lines	455755.3	28916.4	11.46	9.99	1.73	0.21	11.42	0.53
Testers	132348.5	3769.57	8.42	7.7	1.75	0.28	14.56	0.43
Lines x Testers	178838.6*	32580*	5.29	5.05**	1.81	0.11**	4.65	0.3
Error	63765.36	10931.2	2.57	1.16	944.56	0.03	3.66	0.83
Total	142775.5	25625.6	5.78	5.31	1122.35	0.119	5.67	0.71
^{2} GCA	25587.3	2485.8	0.8188	0.853	-104.75	0.0239	1.036	-0.038
^{2} SCA	57536.6	10824.3	1.359	1.942	-471.4	0.037	0.492	-0.264
^{2} GCA/ ^{2} SCA	0.448	0.0079	0.6025	0.439	-0.2222	0.6128	0.0210	-0.1445

day were chosen for emasculation and anthers of selected buds were removed gently with the help of nail and covered with red colored straw tube to prevent natural out crossing. Emasculation was carried out between 3 and 6 P.M.

The emasculated buds were pollinated on next day with pollen of male parent between 9 and 11 A.M. Four to five flower buds of female parent were pollinated by one flower of male parent. After pollination, the staminal column was covered with white colored straw tube for prevention of crosspollination with undesirable pollen. A label with details of the cross was also tied on the pedicel for identification at harvest. The white colored straw tubes were removed after completion of fertilization *i.e.*, four days after pollination. Sufficient care was taken to ensure nicking of parents and all recommended practices were adopted to obtain sufficient number of crossed bolls for each cross combination.

During 2018-19, the nine parents and 20 hybrids and standard check (Suvin) were sown in four rows measuring six meters in a RCB design with two replications along with parents and standard hybrid check RCH 659. The row and plant spacings adopted were 105 and 60 cm, respectively. Recommended cultural practices were carried out and the crop was grown under uniform field condition to minimize environmental variations to the maximum possible extent. The data were recorded from 10 plants/entry/replication for the traits *viz.*, upper half mean length(mm) (UHML), mean length (mm) (ML), fibre uniformity index (%) (UI), micronaire value (g/inch) and fibre strength (g/tex). Forty well developed open bolls were randomly hand harvested from each row of parents and F_1's. The bulked bolls from each genotype were ginned. The L x T analysis of heterosis was performed as suggested by (4). Heterosis was calculated in terms of percent increase (+) or decrease (-) of the F_1 hybrids against its mid parent, better parent and standard parent value as suggested by (5).

Table-2 : Estimates of Mean performance and heterosis for 20 F_1 hybrids for fibre quality parameters in cotton (*Gossypium hirsutum* L.)

Cross combination	UHML (mm)				ML (mm)				Mic (ug/inch)			
	Mean	MP	BP	SC	Mean	MP	BP	SC	Mean	MP	BP	SC
TCH1716 × L 765	29.1	-0.68	-3.16	15.02*	24.1	-1.33	3.79	17.56**	4	-1.23	-4.76	2.56
TCH1716 × GJHV 516	30.7	11.13*	7.53	21.34**	25.65	12.25**	7.77	25.12**	3.7	-8.64*	-11.9*	-5.13
TCH1716 × GISV 164	27.35	-8.68	-12.76*	8.1	22.6	-10.05*	-14.56**	10.24	4.3	2.38	2.38	10.26*
TCH1716 × L 766	29.3	4.46	2.63	15.81*	24.3	4.52	2.1	18.54**	4.3	-3.37	-8.51*	10.26*
TCH1716 × HYPS 152	29.65	-3.42	-9.74	17.19*	24.75	-3.6	-10.16*	20.73**	4.1	2.5	-2.38	5.13
GSHV179 × L 765	29.2	-0.26	-2.83	15.42*	24.3	-0.1	-2.99	18.54**	4.3	4.88	0	10.26*
GSHV179 × GJHV 516	27.65	0.18	-2.98	9.29	22.9	0.66	-2.97	11.71*	4.1	0	-4.65	5.13
GSHV179 × GISV 164	28.35	-5.26	-9.57	12.06	23.5	-6.09	-11.15*	14.63*	4.1	-3.53	-4.65	5.13
GSHV179 × L 766	28.75	2.59	0.88	13.64*	23.9	3.24	1.27	16.59**	4.4	-2.22	-6.38	12.828
GSHV179 × HYPS 152	27.45	-10.51	-16.44*	8.8	22.65	-11.44**	-17.79**	10.49	4.15	2.47	-3.49	6.41
BGDS 1033 × L 765	25.85	-15.38	-16.75**	2.17	21.1	-21.2**	-25.97**	2.93	4.4	7.32	2.33	12.82*
BGDS 1033 × GJHV 516	29.25	1.3	-5.8	15.61*	24.35	-3.37	-14.56**	18.78**	4.4	7.32	2.33	12.82*
BGDS 1033 × GISV 164	24.85	-20.35	-20.73	-1.78	20.15	-26.66**	-29.3**	-1.71	4.85	14.12**	12.79**	24.36**
BGDS 1033 × L 766	29.9	2.05	-3.7	18.18**	24.95	-2.54	-12.46**	21.71**	4.3	-4.44	-8.51*	10.26*
BGDS 1033 × HYPS 152	30.6	-4.23	-6.85	20.95**	25.7	-8.3*	-9.82*	25.37**	4	-1.23	-6.98	2.56
F 2453 × L 765	28.55	4.29	-4.99	12.85	23.95	4.36	-4.39	16.83**	4.5	23.29**	15.38**	15.38**
F 2453 × GJHV 516	24.65	-4.09	-7.68	-2.57	19.8	-7.37	-9.59	-3.41	4.35	19.18**	11.54*	11.54*
F 2453 × GISV 164	24.95	-10.97	-20.41	-1.38	20.15	-14.8**	-23.82**	-1.71	4.9	28.95**	16.67**	25.64**
F 2453 × L 766	28.55	9.28	3.63	12.85	23.6	8.38	3.96	15.12**	4.2	3.7	-10.64*	7.69
F 2453 × HYPS 152	26.45	-8.08	-19.48	4.55	21.85	-9.71*	-20.69**	6.59	3.9	8.33	2.63	0

Table-2 : Contd....

Cross combination	Strength (g tex)				Elongation (%)			
	Mean	MP	BP	SC	Mean	MP	BP	SC
TCH1716 × L 765	27.7	-5.78	-6.42	2.59		0	-1.89	8.33
TCH1716 × GJHV 516	31	11.31	4.73	14.81	5.2	21.15	18.87	31.25
TCH1716 × GISV 164	29.55	-3.27	-6.19	9.44	6.3	3.64	-3.39	18.75
TCH1716 × L 766	31.15	8.82	5.24	15.37*	5.7	20.79	22	27.08
TCH1716 × HYPS 152	31.1	8.74	5.07	15.19*	6.1	17.31	15.09	27.08
GSHV179 × L 765	30.65	6.15	4.97	13.52	6.1	15.09	15.09	27.08
GSHV179 × GJHV 516	30.3	10.89	6.13	12.22	6.1	9.43	9.43	20.83
GSHV179 × GISV 164	27.45	-8.58	-12.86*	1.67	5.8	-8.93	-13.56	6.25
GSHV179 × L 766	30.55	8.72	7.01	13.15	5.1	12.62	16	20.83
GSHV179 × HYPS 152	27.9	-0.62	-2.28	3.33	5.8	-7.55	-7.55	2.08
BGDS 1033 × L 765	27.85	-5.11	-5.59	3.15	4.9	0.47	0	10.42
BGDS 1033 × GJHV 516	30.7	10.43	4.07	13.7	5.3	11.85	11.32	22.92
BGDS 1033 × GISV 164	25.2	-17.38**	-20**	-6.67	5.9	-10.31	-15.25	4.17
BGDS 1033 × L 766	30.9	8.14	4.75	14.44	5	11.22	14	18.75
BGDS 1033 × HYPS 152	29.9	4.73	1.36	10.74	5.7	8.06	7.55	18.75
F 2453 × L 765	30.1	8.86	3.08	11.48	5.8	0	9.43	20.83
F 2453 × GJHV 516	27.8	6.51	6.51	2.96	5.2	-9.09	-1.89	8.33
F 2453 × GISV 164	25.2	-12.5**	-20**	-6.67	5	4.95	15.25	4.17
F 2453 × L 766	28.6	6.42	3.44	5.93	5.3	1.92	0	10.42
F 2453 × HYPS 152	26.1	-2.79	-5.43	-3.33	5.3	1.92	0	10.42

Results and Discussion

Significant differences were detected among parents and F_1 hybrids for fibre quality traits studied indicating the presence of sufficientgeneticvariability among them (Table-1). The proportional contributions of lines and testers and their interactions (Line×Tester) to the total variance were varied among the investigated characters. Results revealed that line × tester interactions made greater contribution to the total variance for all the fibre quality traits studied. Proportional contribution of lines to total variance was very low for all the traits, while testers also followed similar pattern and contributed a minimum to the total variance. However, maximum variance was extended by line x tester interaction for all the traits studied.

Estimation of heterotic effects is necessary to identify the new cross combinations that are suitable for direct exploitation. Presence of sizeable magnitude of heterosis is very crucial for its exploitation in crop improvement programme. Amount of heterosis in F_1 is indication of genetic diversity among the parents involved in crosses (6). Heterosis breeding has led to considerable yield improvements in a most of the cross as well as self-pollinated crops. Estimation of heterosis guides the breeder to identify thesuperior crosses that are likely to throw transgressive segregants (7). The directions and magnitude of heterosis and type of gene action determines the further scope of exploitation. The measures of heterosis over better parent (heterobeltiosis) and over standard check (standard heterosis) are better rational parameters for assessing its practical utility.

Upper half mean length (UHML) (mm)

Fibre fineness, uniformity, length and strength affect spinning efficiency. Fibre length is critical for textile processing and varies greatly for different cottons due to genetic differences. The fibres of long staple lengths produce smoother and stronger fabrics as cotton fibres of long staple lengths are finer, stronger and also more flexible than fibres of short staple length.

The mean performance of UHML ranged between 24.65mm (GSHV179 × GJHV 516`) to 30.70 (TCH1716 × GJHV 516). Out of 20 hybrids evaluated, nine hybrids manifested positive and significant heterosis over standard check and the maximum value was observed for the cross TCH1716 × GJHV 516 (21.34%) followed by BGDS 1033 × HYPS 152 (20.95%) and TCH1716 × HYPS 152 (17.19%). Similarly, heterobeltiosis for UHML ranged between-20.73 (GSHV179 × L 766) and 7.53 (TCH1716 × GJHV 516). Out of 20 cross combinations, six hybrids showed significant negative heterosis over better parent. However, the cross combination TCH1716 × GJHV 516 (11.13 %) also showed heterosis over mid parent. The results of heterosis are in conformity with the reports of (7,8,9,10).

Mean Length (mm) : The mean performance for mean length of fibre ranged from 19.80 (F 2453 × GJHV 516) to 25.65 (TCH1716 × GJHV 516). The estimate of heterosis for mean length over standard check varied between -3.41 (F 2453 × GJHV 516) and 25.37 per cent (BGDS 1033 × HYPS 152). Out of 20 hybrids evaluated, 13 hybrids registered positive and significant standard heterosis for mean length. The highest value was observed for the cross BGDS 1033 × HYPS 152 (25.37%) followed by TCH1716 × GJHV 516 (25.12%) and BGDS 1033 × L 766 (21.71%). The results of heterosis are in agreement with the earlier findings of (7,8,9,10).

Micronaire value (ug/inch) : Fibre fineness or micronaire and fibre strength are very important characteristic of the fibre quality of cotton and are extremely useful for textile industry. Negative heterosis is desirable for this trait as more micronaire value indicates the roughness of the fibre. Lower the micronaire value, the finer would be the fibre. In the present study, the fibre fineness ranged between 3.70ug/inch (TCH1716 × GJHV 516) and 4.90ug/inch (F 2453 × GISV 164). Among hybrids tested, 11 hybrids showed significant and negative heterosis over standard check,which indicated that the greater the micronaire value, the lower the fineness. These results are in the accordance with earlier research findings of (7,8,11,12) who reported varying degree of heterosis and heterobeltiosis for micronaire. Significant positive standard heterosis of 14.29% was evident in the hybrid MCU 12 x TCH 1646 for microanire value and considered to be inferior with respect to fineness. The cross combinations TCH1716 × GJHV 516 (-21.28%), F 2453× HYPS 152 (-17.02%) and TCH1716 × L 765 and BGDS 1033 × GISV 164 (-14.89%) showed significant and negative standard heterosis. However, the hybrids TCH1716 × GJHV 516, TCH1716 × L 766, GSHV179 × GISV 164, BGDS 1033 × L 766 expressed heterobeltiosis and mid parental heterosis formicronaire value. These results were supported by earlier studies (13). Many researchers (9,10,11) have reported varying degrees of heterosis for micronaire.

Fibre Strength (g/tex) : Fibre strength is one of the most important fibre properties and it is quantitatively inherited. Stronger, longer, finer and more uniform cotton fibres are desired for modern textile industries. The mean strength of hybrids stretched between 25.20 (F 2453 × GISV 164) and 31.15 (TCH1716 × L 766). Out of 20 hybrids, the cross combination TCH1716 × L 766 expressed significant standard heterosis in positive directionfor fibre strength (15.37 %) followed by TCH1716 × HYPS 152 (15.19%).

No other hybrids could realize the positive heterosis of any kind in the present study. Hybrid vigour was also observed by (7,12). (15) observed positive standard heterosis in all the conventional hybrids, and few of male sterility based hybrids for fibre strength, and these are conformed in the present study results.

Elongation (%) : The mean performance for elongation per cent of fibre ranged from 4.90 (BGDS 1033× GJHV 516) to 6.3 % (TCH1716 × GJHV 516). The estimate of heterosis for elongation per cent over standard check varied between 2.80 (BGDS 1033× GJHV 516) and 31.25per cent (TCH1716 × GJHV 516). All the hybrids evaluated registered positive standard heterosis for elongation per cent. Further, it is observed that none of the hybrid could record significant superiority of heterosis of any type.However, positive heterobeltiosiswas registered by13 hybrids and 12 hybrids recorded positive heterosis over mid parent indicating that improvement in elongation of the fibre is a little. Similarly, low percent elongation was also reported by (16,17). None of crosses recorded significant positive heterosis over commercial check.

Conclusion

Fibre quality parameters of cotton, fibre length and fineness have a vital influence on the yarn strength. The increasing fibre length results in improved yarn strength because a long fibre generates a greater frictional resistance to an external force. High fibre length and the tensile strength of the fibres becomes the controlling factor of yarn strength. The developing high fibre length and strength cultivars or hybrids are essential to current modernized spinning mills. Therefore, the present study was carried out for improving fibre quality traits from upland cotton by line x tester design. Out of evaluated 20 hybrids, the cross combinations namely, TCH1716 × GJHV 516, BGDS 1033 × HYPS 152 and TCH 1716 x HYPS152 were found to be promising for Upper half mean length mean length of the fibre as they showed highest mean performance and significant positive heterosis. Further, the hybrid F2423 x HYPS152 was found to be more fine fibre and showed maximum heterosis. However, the most promising hybrids for strength were TCH 1716 x L766 and TCH 1716 x HYPS152 while the highest heterotic effect elongation per cent was TCH1716 x GJHV 516. It indicates larger scope for heterosis breeding for commercial exploitation of heterosis. These promising cross combinations showing desirable heterosis over standard check can be advanced for isolation for further exploitation to improve fibre quality traits.

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