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Estimation of Commercial Heterosis for Fiber Quality Traits in Cotton under Rainfed Conditions

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A B S T R A C T

The present investigation was carried out during 2012-13 at ARS, Siruguppa with an objective of determine the extent of commercial Heterosis for fiber quality traits in F_1 hybrids obtained by crossing 10 parents in half dialle fashion. Several hybrid combinations showed very good *per se* performance for all the traits under study and commercial Heterosis for 2.5% span length. These lines can sever as a potential donor for genetic improvement of cotton after further evaluation, fixation and selection.

Introduction

Cotton (*Gossypium spp*.) is the world's leading fiber crop, is grown on 33.45 million hectares in more than 80 countries and supplies approximately 35% of the total fiber used (USDA-ERS 2013; USDA-FAS 2013). China is the largest raw cotton producer and consumer, followed by India and the United States. Together, these three countries produce two-thirds of the world's cotton (USDA-ERS 2009). In India cotton is grown on area of 121.91 lakh hectares with the production of 371.20 lakh bales during 2011-12. Average productivity is 481 kg lint per hectare (AICCP, 2011). Among the four cultivated species, upland cotton (*G. hirsutum* L.) is known for high yield potential, wide adaptation, fuzzed seed, and high lint percentage and contributes 95% of the world total cotton production with maximum number of released varieties and hybrids.

Heterosis is the superiority in performance of hybrid individuals compared with their parents. Several studies have been carried out to estimate the Heterosis and genetics for seed cotton yield and its related traits while only few attempts were made for fiber quality traits (Usharani, 2015). With the Advent of modern ginning and spinning systems, the textile industry demands an optimum combination of fiber properties suitable for every class of fiber length. Hence, the genotype must possess a matching strength to length ratio (s/l) *i.e.*, variation in fiber length results in excessive floating fibers with a negative impact on both the yarn uniformity and strength. Thus the demands of modern spinning system have imposed the breeders to realization the development of productive genotypes having optimum fiber strength matching the length and counts for which the yarn is spun. In order to meet the needs of textile industry the present investigation is carried out to estimate the commercial heterosis for fibre quality traits in cotton under rainfed conditions.

Materials and Methods

Materials used in the study consists of ten parental *hirsutum* genotypes viz., GSHV 99/307, Pusa 9127, ARB 904, Surabhi, CCH 510, BS 277, BS 2170, H 1462, TSH 0250, TCH 1728, performance of these genotypes was systematically followed during All India Coordinated Cotton Improvement Project (AICCIP) trials representing diverse cotton growing regions having consistent productivity coupled good fiber quality traits were picked during 2010-11, Forty five intra *hirsutum* hybrids were developed at ARS, Siruguppa during 2011-12 by following half diallel design.

Seeds of 45 hybrids and their parents were planted in the field during July 2013-14. Each entry was sown in two replications following randomized complete block design.

The seeds were dibbled to ensure uniform plant population in single row plot having 20 plants spaced 60 cm within and 90 cm between the rows with length of 6 meters. Two border rows were grown around the experiment to avoid border effects.

All cultural practices were carried out as per recommended package of practices for cotton production to raise good crop and maintained under a uniform agronomic package to discourage environmental variability to the maximum possible extent. Observations were recorded on the middle five competitive plants and Seed cotton sample of about 300g was collected from each treatment in each replication and these were ginned to 100g lint weight. Fiber quality properties *viz*, 2.5% Span length (mm), Fibre strength (g tex^{-1}), Fibre elongation (%), Fibre strength to length ratio were measured by utilizing High Volume Instrument (HVI) at Central Institute for Research on Cotton Technology (CIRCOT), Main Station at Mumbai (India); data analysis carried out by using WINDOSTAT 8.0 software to estimate the magnititude of Heterosis over commercial parent Bunny and expressed as percentage increase (+) or decrease (-) respectively.

Results and Discussion

Per se performance

Selection of genotype based on field performance used as a one of the criteria for selection of F_1 hybrids (Kumar, 2007). *Per se* performance of commercial check Bunny and F_1 hybrids were represented in tables 1 and 2 respectively. Mean performance of commercial check (Bunny) for 2.5% span length is varied from 8mm to 27.1mm and its expression is affected by environment (Geddam *et al.*, 2011; Usha rani *et al.*, 2015). Among Cross combinations shows variation from 25.8mm to 31.6mm.

Out of forty five hybrids, only twenty six hybrids manifested significantly higher mean value than grand mean value. The range of mean value varied from 48.5% (CCH 510 x TSH 0250) to 54.5% (Pusa 9127 x Surabhi) for Uniformity ratio between the hybrids. 25/45 hybrids were shown significantly higher means value than grand mean value. Highest values (54.5%) were observed for four cross combinations (Pusa 9127 x Surabhi, BS 277 x H 1462, ARB 904 x TSH 0250, BS 277 x H 1462). Similar kind of findings was made by Sekhar *et al.,* (2012) for diploid cotton hybrids.

Table.1 *Per se* performance and heterosis for 2.5% span length, uniformity ratio and micronaire in 10 x 10 half diallel set of crosses

Crosses	2.5% span length (mm)		Uniformity ratio (%)		Micronaire (µg/ inch)	
	Mean	Hcc	Mean	Hcc	Mean	Hcc
GSHV 99/ 307 x Pusa 9127	29.1	7.2	52.5	-0.94	3.8	-2.56
GSHV 99/ 307 x ARB 904	28.3	4.24	51.5	-2.83	4.1	5.13
GSHV 99/ 307 x Surabhi	29.9	10.15 *	51.5	-2.83	4.4	11.54
GSHV 99/ 307 x CCH 510	28.6	5.54	51.5	-2.83	3.9	0
GSHV 99/ 307 x BS 277	28.9	6.46	52	-1.89	3.9	-1.28
GSHV 99/ 307 x BS 2170	27.8	2.58	51	-3.77	4.2	6.41
GSHV 99/ 307 x H 1462	28.3	4.43	51.5	-2.83	4.1	5.13
GSHV 99/ 307 x TSH 0250	29.2	7.56	51	-3.77	4	1.28
GSHV 99/ 307 x TCH 1728	29.2	7.56	52.5	-0.94	3.7	-5.13
Pusa 9127 x ARB 904	28.8	6.09	52	-1.89	3.9	-1.28
Pusa 9127 x Surabhi	30.3	11.62 *	54.5	2.83	3.5	-11.54
Pusa 9127 x CCH 510	30.4	12.18 *	52.5	-0.94	4.1	5.13
Pusa 9127 x BS 277	28.1	3.51	51.5	-2.83	4.1	5.13
Pusa 9127 x BS 2170	28.4	4.61	52	-1.89	4.1	3.85
Pusa 9127 x H 1462	31.5	16.05 **	52	-1.89	3.6	-8.97
Pusa 9127 x TSH 0250	30	10.70 *	52	-1.89	3.3	-16.67 *
Pusa 9127 x TCH 1728	29.5	8.67	51.5	-2.83	3.7	-6.41
ARB 904 x Surabhi	29.1	7.38	52.5	-0.94	3.3	-16.67 *
ARB 904 x CCH 510	28	3.32	54	1.89	3.6	-8.97
ARB 904 x BS 277	29	7.01	52.5	-0.94	3.9	0
ARB 904 x BS 2170	30.4	11.99 *	52	-1.89	3.4	-14.1
ARB 904 x H 1462	29	6.83	51.5	-2.83	3.3	-15.38 *
Bunny (Ch)	27.1		53		3.9	
Mean	28.9	6.98	52	-1.84	3.71	-4.84
Range	25.8 – 31.6	-4.80 – 16.61	48.5 – 54.5	-84.9 – 2.83	3.2 – 4.4	-19.23 – 11.54
S.Ed	1.36	1.36	1.65	1.65	0.28	0.28
CD at 5%	2.73	2.73	3.3	3.3	0.55	0.55
CD at 1%	3.64	3.64	4.4	4.4	0.74	0.74

Table.1 Continued

Crosses	2.5% span length (mm)		Uniformity ratio (%)		Micronaire (µg/ inch)	
	Mean	**Hcc**	**Mean**	**Hcc**	**Mean**	**Hcc**
ARB 904 x TSH 0250	25.8	-4.8	54.5	2.83	3.5	-11.54
ARB 904 x TCH 1728	29.5	8.67	51.5	-2.83	3.9	0
Surabhi x CCH 510	27.9	2.95	52	-1.89	3.7	-6.41
Surabhi x BS 277	30.3	11.62 *	52	-1.89	3.5	-10.26
Surabhi x BS 2170	28.7	5.72	52.5	-0.94	3.7	-6.41
Surabhi x H 1462	30.9	14.02 **	51	-3.77	3.6	-7.69
Surabhi x TSH 0250	29.8	9.78	52.5	-0.94	3.9	0
Surabhi x TCH 1728	29.4	8.3	50.5	-4.72	4.1	3.85
CCH 510 x BS 277	28.7	5.9	52	-1.89	4	2.56
CCH 510 x BS 2170	28.7	5.72	54	1.89	3.4	-12.82
CCH 510 x H 1462	29.5	8.86	50.5	-4.72	3.8	-3.85
CCH 510 x TSH 0250	31.6	16.61 **	48.5	-8.49 **	3.3	-16.67 *
CCH 510 x TCH 1728	27.1	-0.18	53	0	4.3	8.97
BS 277 x BS 2170	30.8	13.47 **	52	-1.89	3.7	-6.41
BS 277 x H 1462	26.6	-1.85	54.5	2.83	3.9	0
BS 277 x TSH 0250	29.8	9.78	52	-1.89	3.5	-10.26
BS 277 x TCH 1728	29.3	8.12	51	-3.77	3.5	-10.26
BS 2170 x H 1462	29.1	7.2	52.5	-0.94	3.5	-10.26
BS 2170 x TSH 0250	28	3.32	52	-1.89	3.3	-16.67 *
BS 2170 x TCH 1728	27.5	1.48	54	1.89	3.3	-16.67 *
H 1462 x TSH 0250	28	3.14	50.5	-4.72	3.6	-7.69
H 1462 x TCH 1728	26.4	-2.58	51	-3.77	4.1	5.13
TSH 0250 x TCH 1728	30.7	13.10 *	51.5	-2.83	3.2	-19.23 **
Bunny (Ch)	27.1		53		3.9	
Mean	28.9	6.98	52	-1.84	3.71	-4.84
Range	25.8 – 31.6	-4.80 – 16.61	48.5 – 54.5	-84.9 – 2.83	3.2 – 4.4	-19.23 – 11.54
SEd	1.36	1.36	1.65	1.65	0.28	0.28
CD at 5%	2.73	2.73	3.3	3.3	0.55	0.55
CD at 1%	3.64	3.64	4.4	4.4	0.74	0.74

Hmp = Heterosis over mid parent

Hcc = Heterosis over commercial check.

* significant at 1% and ** significant at 5% level

Table.2 *Per se* performance and heterosis for fibre strength, elongation and strength to length ratio in 10 x 10 half diallel set of crosses

Crosses	Fibre strength (g/tex)		Elongation (%)		Strength to Length ratio	
	Mean	Hcc	Mean	Hcc	Mean	Hcc
GSHV 99/ 307 x Pusa 9127	21.6	0.94	5.4	0.93	0.74	-6.33
GSHV 99/ 307 x ARB 904	20.7	-3.28	5.3	-1.87	0.74	-6.96
GSHV 99/ 307 x Surabhi	22	2.81	5.6	3.74	0.74	-6.96
GSHV 99/ 307 x CCH 510	21.7	1.41	5.5	2.8	0.76	-4.43
GSHV 99/ 307 x BS 277	21.3	-0.23	5.6	3.74	0.74	-6.33
GSHV 99/ 307 x BS 2170	20.9	-2.34	5.5	1.87	0.75	-5.06
GSHV 99/ 307 x H 1462	21.3	-0.23	5.4	0.93	0.76	-4.43
GSHV 99/ 307 x TSH 0250	20.8	-2.81	5.4	0	0.71	-10.13
GSHV 99/ 307 x TCH 1728	22.2	3.98	5.8	8.41	0.76	-3.8
Pusa 9127 x ARB 904	22.9	7.26	5.5	2.8	0.8	0.63
Pusa 9127 x Surabhi	21.1	-1.17	4.3	-19.63	0.7	-11.39
Pusa 9127 x CCH 510	22.6	5.62	5.6	3.74	0.75	-5.7
Pusa 9127 x BS 277	20.8	-2.58	5.5	2.8	0.74	-6.33
Pusa 9127 x BS 2170	22.1	3.28	5.5	2.8	0.78	-1.27
Pusa 9127 x H 1462	23.8	11.48	5.7	6.54	0.76	-4.43
Pusa 9127 x TSH 0250	21.3	-0.23	5.4	0	0.71	-10.13
Pusa 9127 x TCH 1728	22.5	5.39	4.8	-11.21	0.77	-3.16
ARB 904 x Surabhi	23.5	9.84	5.8	7.48	0.81	1.9
ARB 904 x CCH 510	21.4	0.23	5.2	-2.8	0.77	-3.16
ARB 904 x BS 277	20.1	-6.09	5.3	-1.87	0.7	-12.03
ARB 904 x BS 2170	22.4	4.92	6.1	13.08	0.74	-6.33
ARB 904 x H 1462	23.9	11.71	5.9	10.28	0.83	4.43
Bunny (Ch)	21.4		5.4		0.79	
Mean	21.7	1.81	5.5	2.87	0.75	-4.92
Range	20.1 – 23.9	-6.09 – 11.71	4.3 – 6.1	-33.65	0.69 – 0.88	-13.29 – 10.76
S.Ed	1.35	1.35	0.58	0.58	5.07	5.07
CD at 5%	2.7	2.7	1.17	1.17	10.16	10.16
CD at 1%	3.59	3.59	1.56	1.56	13.54	13.54

Table.2 Continued

Crosses	Fibre strength (g/tex)		Elongation (%)		Strength to Length ratio	
	Mean	Hcc	Mean	Hcc	Mean	Hcc
ARB 904 x TSH 0250	21.4	0.23	5.5	1.87	0.83	4.43
ARB 904 x TCH 1728	21.5	0.47	5.7	5.61	0.73	-8.23
Surabhi x CCH 510	20.1	-5.85	5.1	-4.67	0.72	-8.86
Surabhi x BS 277	21.2	-0.94	5.9	10.28	0.7	-11.39
Surabhi x BS 2170	20.7	-3.04	5.3	-0.93	0.73	-8.23
Surabhi x H 1462	23.4	9.6	5.7	5.61	0.76	-4.43
Surabhi x TSH 0250	22	2.81	5.9	10.28	0.74	-6.96
Surabhi x TCH 1728	20.1	-5.85	5.6	4.67	0.69	-13.29
CCH 510 x BS 277	21.5	0.47	5.7	6.54	0.75	-5.06
CCH 510 x BS 2170	23.2	8.67	4.4	-18.69	0.81	2.53
CCH 510 x H 1462	21	-1.87	5.7	5.61	0.72	-9.49
CCH 510 x TSH 0250	22.5	5.39	5.5	2.8	0.71	-10.13
CCH 510 x TCH 1728	20.9	-2.11	5	-6.54	0.77	-2.53
BS 277 x BS 2170	21.7	1.64	5.9	9.35	0.71	-10.76
BS 277 x H 1462	22.3	4.45	6.1	14.02	0.84	6.33
BS 277 x TSH 0250	22.6	5.62	5.7	5.61	0.76	-3.8
BS 277 x TCH 1728	21.7	1.64	5.7	6.54	0.74	-6.33
BS 2170 x H 1462	21	-1.64	5.4	0	0.73	-8.23
BS 2170 x TSH 0250	21.2	-0.94	5.9	9.35	0.76	-4.43
BS 2170 x TCH 1728	21	-1.87	5.4	0	0.76	-3.8
H 1462 x TSH 0250	21.7	1.64	5.4	0.93	0.78	-1.9
H 1462 x TCH 1728	23	7.49	6.1	14.02	0.88	10.76
TSH 0250 x TCH 1728	22.6	5.62	6	12.15	0.74	-6.33
Bunny (Ch)	21.4		5.4		0.79	
Mean	21.7	1.81	5.5	2.87	0.75	-4.92
Range	20.1 – 23.9	-6.09 – 11.71	4.3 – 6.1	-19.63-14.2	0.69 – 0.88	-13.29 – 10.76
SEd	1.35	1.35	0.58		5.07	5.07
CD at 5%	2.7	2.7	1.17	1.17	10.16	10.16
CD at 1%	3.59	3.59	1.56	1.56	13.54	13.54

Hmp = Heterosis over mid-parent; Hcc = Heterosis over commercial check.; * significant at 1% and ** significant at 5% level

For micronaire mean value of commercial parent ranges from 2.1 to 3.7µg/inch, while in hybrids it varied from 3.2µg/inch (TSH 0250 x TCH 1728) to 4.4µg/inch (GSHV 99/ 307 x Surabhi). Twenty nine hybrids recorded significantly higher mean values than the grand mean values (Ashokkumar *et al.*, 2013) and Very much difference between the cultivars was extensively studied by Bolek *et al.*, (2010) for this trait. The range of mean value among the cross combinations varied from 20.1g/tex (Surabhi x CCH 510) to 23.9g/tex (ARB 904 x H 1462) while that of commercial check showed variation from 18.6 g/tex to 21.7g/tex for fiber strength. These results were in accordance with the findings of Karademir *et al.,* (2011). The mean fiber strength of commercial check was 21.4 g/tex and hybrids was 21.7 g/tex respectively. Findings of Ashokkumar *et al* (2013) for G. *hirsutum* crosses was 21.90 g/tex and this is slight-higher than the value of present study. Mean performance of commercial check Bunny recorded slight lower mean value (5.4%) than the hybrid grand mean (5.5%) whereas hybrid combinations shows range of mean varies from 4.3% (Pusa 9127 x Surabhi) to (ARB 904 x BS 2170) 6.1% respectively. Twenty seven hybrids recorded significantly higher mean values than the grand mean value. Between cross combinations variation ranges from 0.69 (Surabhi x TCH 1728) to (H 1462 x TCH 1728) 0.88 for Strength to Length ratio while of commercial check shows 0.79 which is higher than the grand mean value (0.75). 24 out of 45 hybrids exhibited higher mean value when compared to the grand mean value.

Manifestation of heterosis for fiber quality traits

Heterosis is common phenomenon occurring in almost all the characters and its magnitude varied among the traits. The estimated heterosis values were presented in tables 1 and 2 respectively. Four hybrids (Pusa 9127 x H 1462, Surabhi x H 1462, CCH 510 x TSH 0250, BS 277 x BS 2170) were recorded highly significantly commercial Heterosis over check Bunny in a positive direction. Similar kind of high heterosis over commercial check was reported by Potdukhe and Parmer (2005); Tuteja *et al.,* (2005). For uniformity ratio (%) none of the hybrid was manifested significant positive heterosis over commercial check. A value of (2.83) by the cross ARB 904 x TSH 0250 represented useful heterosis for trait, these findings were in concurrent with the previous reports of Sandip Patil *et al.,* (2012).

The magnitude of percent heterosis over commercial check was found to be the lowest for the cross TSH 0250 x TCH 1728 (-19.23%). Six out of the fifty five hybrids were depicted heterosis in negative direction of which the cross PUSA 9127 x TCH 0250 had desirable micronaire value. Negative heterosis for this trait to certain extent is found to be desirable as reported Tuteja *et al.,* (2000). None of the hybrids expressed significant positive heterosis over commercial check for Fibre strength while two crosses exhibited (ARB 904 x H 1462, Pusa 9127 x H 1462) highest Heterosis in desirable direction (Geddam *et al.*, 2011). Two out of 45 hybrids H 1462 x TCH 1728 (14.02) and BS 277 x H 1462 (14.02) showed positive Heterosis. Similarly Low percent elongation was also reported by Somashekhar (2006) and Nidagundi (2010). None of crosses recorded significant positive heterosis over commercial check. The cross H 1462 x TCH 1728 exhibited highest Heterosis among the hybrids for fiber strength.

In conclusion, the present investigation resulted in identification of hybrids possessing superior fiber Quality traits based on *per se* performance rather than over commercial check. The inherit problem of low quantity seed makes it impossible to carry out multi environment testing and these results were may not reliable estimates for appropriate selection of genotypes and needs to be retested in further generations and locations.

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