The Pharma Innovation Journal 2022; 11(11): 2050-2056

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(11): 2050-2056

www.thepharmajournal.com
Received: 12-09-2022
Accepted: 16-10-2022

Heterosis, combining ability and gene action for seed cotton yield and its contributing characters in cotton (*Gossypium hirsutum* L.)

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Abstract

This study was conducted to estimate heterosis, combining ability and gene action for seed cotton yield and its contributing characters by using line × tester mating design. Total 45 crosses were produced and tested along with one standard check at Cotton Research Station, JAU, Junagadh. The highest and positive standard heterosis for seed cotton yield per plant was recorded in the cross GTHV-15/220 × G.Cot-20 (73.92%) followed by GSHV-172 × G.Cot-38 (22.09%) and GTHV-15/220 × GJ.Cot-101 (20.21%). These crosses also recorded significant standard heterosis for the other four characters also. The results thus, showed that the heterosis for seed cotton yield per plant was associated with heterosis for its component characters. Good heterotic responses were accompanied by desirable and significant sca effects for different component characters. The highest yielding hybrid GTHV-15/220 × G.Cot-20 had also registered the highest positive sca effect for seed cotton yield per plant involved good x good general combiners for seed cotton yield per plant. The cross GSHV-172 × G.Cot-38 depicted a significantly desirable sca effect for the number of bolls per plant. Similarly, another best performing cross is GTHV-15/220 × GJ.Cot-101 exhibited a desirable and significant sca effect for the three characters. The result of combining ability revealed that days to flowering character followed additive gene action and remaining characters depicted non-additive gene action.

Keywords: Standard heterosis, GCA effect, SCA effect, additive gene action, non-additive gene action

Introduction

Being the main raw material for a thriving textile industry, cotton, also known as the "King of Apparel Fibre," maintains a dominant position among all cash crops in the nation. Because it is used in both the textile and non-textile industries, cotton occupies a special place in both domestic and international trade. The "silver fibre," still known as cotton, is a marvel of nature that produces a variety of useful goods. No other fibre can match cotton's remarkable combination of properties, which allows it to clothe people all over the world.

The cotton plant is a member of the *Gossypium* genus, Malvaceae family, Malvales order, and *Gossypleae* tribe. Within this dicotyledonous genus, which has the basic chromosomal number x=13, fifty species have been discovered. These species come in 45 diploid (2n=2x=26) and 5 allotetraploid (2n=4x=52) varieties. Diploid species have been divided into eight cytogenetic groups (A, B, C, D, E, F, G, and K) based on chromosomal and morphological similarities, and tetraploid species belong to groups A and D. (Smith, 1995) [31].

According to Simpson (1954) [30], cotton is primarily a self-pollinated and often a cross-pollinated crop that is receptive to heterosis breeding. Because hybrid cotton has a high yield potential, strong fibre characteristics, a larger range of adaptability, and a high level of tolerance to biotic and abiotic challenges, the introduction of the Bt gene in cotton has increased its significance. In addition, hybrid cultivars are more uniform than landrace varieties. Additionally, hybrid production creates jobs, earns more money through export surpluses, and supports the growth of the nation's seed business. In order for India's cotton industry to become self-sufficient, hybrids have been crucial. The introduction of the first cotton hybrid in the world, Hybrid-4, by Patel in 1971 [35] at the Main Cotton Research Station, GAU, Surat, helped India's cotton output pick up steam. Throughout the early and late 1970s, further high yielding hybrids were then introduced. The cotton plant not only produces fibre for the textile industry but also contributes to the feed and oil sectors thanks to its seed, which is a significant source of protein (20–40%) and oil (18–24%). Earlier on a farm or in transportation, ginning, baling, and storage, cotton production employs an estimated 350 million people.

The Indian cotton growers face numerous difficulties that are not directly within their control, including a labour shortage, stagnant output levels, shifting pest situations, and irregular rainfall patterns during the previous five years. There is an urgent need to place more attention on the degree of heterosis, per se performance, and genotype stability in order to bring Indian cotton productivity up to level with that of nations like the United States and China.

Materials and Methods

Plant material

The test submissions consisted of 60 total, including 45 hybrids created from nine female lines and five male parents, 14 parents, and one standard check (GN.Cot.Hy-14). The crosses were created during *Kharif* 2019 at the Cotton Research Station, Junagadh Agricultural University, Junagadh, using a line × tester mating scheme.

Field trial

In a Randomized Block Design with three replications, the entire set of 60 genotypes—45 hybrids, 14 parents, and one standard check (GN.Cot.Hy-14)—were assessed at the Cotton Research Station of the Junagadh Agricultural University in Kharif 2020. Each submission was accommodated in a single row plot of 6.3 meters long, with a gap between each row and plant of 120 and 45 cm, respectively. For growing a successful crop, all advised agronomic procedures and plant protection techniques were used. The observations were recorded on five randomly selected plants from each genotype in each replication for days to flowering, days to boll opening, plant height (cm), number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight (g), seed cotton yield per plant (g), seed index (g) and lint index (g).

Statistical analysis

The analysis of variance was performed to test the significance of difference among the genotypes for all the characters based on the fixed-effect statistical model as suggested by Panse and Sukhatme (1985) [17]. Different heterosis estimates were calculated as suggested by Fonseca and Patterson (1968) [7]. Analysis of variance for combining ability was performed according to the model given by Kempthorne (1957) [11], which is related to North-Carolina design-II (Comstock and Robinson, 1952) [5] in terms of covariance of half-sibs (H.S.) and full-sibs (F.S.).

Results and Discussion

The present study was planned to elucidate the information on the magnitude of heterosis, combining ability and gene action for seed cotton yield and its component traits in cotton, through line × tester analysis by involving nine female and five male parents. The findings of the present investigation are discussed below.

Analysis of variance for experimental design

The analysis of variance showed highly significant differences among the genotypes for all the traits revealed that a considerable amount of variability was observed among experimental material. This validated that the material was appropriate for the present study. The genotypic variance was further partitioned into parents, hybrids and parents *vs* hybrids. The differences among the parents and hybrids were also found significant for all characters suggesting the presence of sufficient diversity among parents and hybrids themselves. The mean squares due to parents *vs* hybrids were also found significant for the number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight and seed cotton yield per plant indicated that heterosis could be exploited for most of the characters under study. Analysis of variance depicting the mean sum of squares for ten quantitative traits is presented in Table1.

Mean performance of parents and hybrids

The success of breeding and development of high yielding variety/hybrid depends upon the selection of parental lines to be used in the hybridization programme. Therefore, the performance of parents should be determined before starting the breeding programme. Accordingly, in the present investigation, the mean performance of 14 parents and 45 hybrids in terms of their seed cotton yield and yield contributing characters was studied. A perusal of mean values of different parents and their cross combinations for various traits revealed that most of the hybrids were found superior to their parents in respect of seed cotton yield and most of its component characters.

Among lines, GJHV-583, GJHV-581 and GJHV-574 and among testers, G.cot.-38 exhibited higher *per se* performance for seed cotton yield. Considering *per se* performance of hybrids, the superior cross combinations for seed cotton yields per plant were GTHV-15/220 × G.Cot-20, GSHV-172 × G.Cot-38, GTHV-15/220 × GJ.Cot-101, GSHV-172 × G.Cot-20 and GSHV-172 × GN.Cot-22. These cross combinations also despite high *per se* performance for one or more yield contributing traits.

Magnitude of heterosis

The development of better hybrids using stable and high yielding new lines will raise the yield ceiling of this crop. In order to achieve a high yielding cross combination, it is essential to evaluate available promising diverse lines in their hybrid combinations for seed cotton yield and its components. In the present study, per cent increase or decrease over mid-parent, better parent (heterobeltiosis) and standard check (GN.Cot.Hy-14) was used as a measure of heterosis.

The first important step in the exploitation of heterosis is to know its magnitude and direction. The nature and magnitude of heterosis either help in identifying superior cross combinations for their exploitation commercially or to get better transgressive segregants in segregating generations. In the present study, considerable high heterosis in certain crosses and low in others revealed that the nature of gene action varied according to the genetic makeup of the parents. The significant level of positive and negative relative heterosis, heterobeltiosis and standard heterosis in several crosses for almost all the characters also indicated the genetic diversity of parents used in the present investigation. The range of heterosis as well as the number of crosses exhibiting significant positive or negative heterosis is presented in Table 2.

With respect to the performance of hybrids for seed cotton yield per plant, it was observed that 37 hybrids over mid-parent, 28 hybrids over better parent and 8 hybrids over standard check exhibited significant and positive heterosis. The range of heterosis over mid-parent was observed from -36.11 to 234.55%, over better parent -43.47 to 185.76% and over standard check -55.56 to 73.92%. The hybridGTHV-15/220 × G.Cot-20 ranked first as it depicted the highest, significant and positive relative heterosis (234.55%), heterobeltiosis (185.76%) and standard heterosis (73.92%) as well as the highest seed cotton yield per plant (348.30 g). The cross GTHV-15/220 × GJ.Cot-101 secured second position for relative heterosis (182.01%) and heterobeltiosis (178.85%).Moreover. the cross GSHV-172 × G.Cot-22 secured the third position for both relative heterosis and heterobeltiosis. These results matched with findings of Preetha and Raveendran (2008) [22], Patil *et al.* (2010) [20], Basal *et al*. (2011) [3], Shekhara Babu *et al.* (2011) [28], Geddam *et al*. (2011) [8], Patil *et al.* (2011) [21], Jaiwar *et al.* (2012) [9], Pandit *et al.* (2012) [16], Ranganatha *et al*. (2013) [24], Kaliyaperumal and Ravikesavan (2013) [10], Muhammad *et al.* (2014) [14], Nakum *et al.* (2014) [15], Solanki *et al.* (2014) [32], Sawarkar *et al.* (2015) [27], Srinivas and Bhadru (2015) [33], Pushpum *et al.* (2015) [23], Sharma *et al.* (2016) [29], Chhavikant *et al.* (2017) [4], Lingaraja *et al.* (2017) [13], Dhamyanthi and Rathinavel (2017) [6], Arbad *et al.* (2017) [2], Khokhar *et al*.(2018) [12] and Ankit *et al.* (2018) [1].

The hybrids exhibited marked heterosis, heterobeltiosis and standard heterosis for various characters. Significant estimates of positive heterosis, heterobeltiosis and standard heterosis were observed in 37, 28 and 8 cross combinations, respectively for seed cotton yield per plant. The range of heterosis, heterobeltiosis and standard heterosis for seed cotton yield per plant were from -36.11 to 234.55%, -43.47 to 185.76% and -55.56 to 73.92%, respectively. The highest and positive standard heterosis for seed cotton yield per plant was recorded in the cross GTHV-15/220 × G.Cot-20 (73.92%) followed by GSHV-172 × G.Cot-38 (22.09%) and GTHV-15/220 × GJ.Cot-101 (20.21%). These crosses also recorded significant standard heterosis for number of monopodia per plant, number of sympodia per plant, number of bolls per plant and seed index. The results thus, showed that the heterosis for seed cotton yield per plant was associated with heterosis for its component characters.

Analysis of variance for combining ability

Partitioning of variances due to the crosses (Table 3) showed that the mean squares due to lines were significant for almost all characters except the lint index. While in the case of testers, the mean squares were significant for all characters except plant height and lint index. In the case of line × tester interaction, the mean squares were significant for all the characters.

The mean squares due to lines were also found significant for days to flowering, days to boll opening, the number of monopodia per plant and seed cotton yield per plant when tested against mean square due to line × tester interaction. Similarly, the mean squares due to testers were also found significant for days to flowering, days to boll opening and seed cotton yield per plant when tested against mean square due to line × tester interaction. These results indicated that both additive and non-additive genetic variances played a vital role in the inheritance of all these traits.

The estimated variances due to lines (σ^2l) were higher than the corresponding variances due to testers (σ^2t) for days to flowering, days to boll opening, plant height, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight, seed cotton yield per plant and seed index. On the other hand, lines (σ^2l) were lower than the corresponding variances due to testers (σ^2t) for the lint index. The estimates of σ^2gca were higher than the corresponding σ^2sca for days to flowering. It indicated the preponderance of additive gene action. Similar results have been also reported by Rauf *et al*. (2005) [25] and Preetha and Raveendran (2008) [22].

For remaining characters, σ^2sca was higher than σ^2gca*viz*., days to boll opening, plant height, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight, seed cotton yield per plant, seed index and lint index, indicated the preponderance of non-additive gene action. Similar results were obtained by Preetha and Raveendran (2008) [22], Saravanan *et al.* (2010) [26], Patel *et al.* (2012) [19], Sawarkar *et al.* (2015) [27], Usharani *et al.* (2016) [34] and Khokhar *et al*. (2018) [12].

Looking at the significance of both the types of gene actions in the expression of seed cotton yield per plant and other characters under study, it is suggested that biparental mating with reciprocal recurrent selection should be employed so that additive, as well as non-additive gene actions, could be exploited simultaneously for population improvement. However, in view of the preponderance of non-additive gene action and high heterosis observed for seed cotton yield and its attributing characters, it is suggested that heterosis breeding could profitably be used for exploitation of hybrid vigour in cotton on a commercial scale.

General combining ability effects

As such studies intended to determine the combining ability provide not only necessary information regarding the choice of parents but also illustrate the nature and magnitude of gene action involved. Accordingly, the present investigation was undertaken on combining ability for seed cotton yield and yield components in cotton with a view to identifying good combiners, which may be used to create a population with favourable genes for yield and component characters in cotton. However, on an overall basis, the results of the gca effect of the parents were categorized as good, average and poor combiners based on their gene effect for different traits. The parents showing desirable and significant gca effects were considered as good general combiners, while those with non-significant gca effects as average general combiners and parents with significant but undesirable gca effects were considered as poor general combiners. The gca effect of the parents presented in Table 5 has also been discussed here.

The line GSHV-172 had given the desired gca effect for six characters *viz*., days to flowering, days to boll opening, number of sympodia per plant, number of bolls per plant, boll weight and seed cotton yield per plant. The line GBHV-185 showed desired gca effect for four characters *viz*., days to flowering, days to boll opening, the number of mononpodia per plant and boll weight. Also, a line GJHV-589 estimated desired gca effect for four characters *viz*., days to flowering, days to boll opening, number of monopodia per plant and number of bolls per plant. Apart from this, GSHV-173 had desired gca effects for two characters *viz*., boll weight and seed cotton yield per plant. These were some promising lines for the production of good hybrids.

Among the testers, two testers were good combiners. GJ.Cot-101 had given desired gca effects for four different characters *viz*., the number of monopodia per plant, boll weight, seed index and lint index. Tester G.Cot-10 had given desired gca effects for days to flowering, days to boll opening and number of monopodia per plant.

The results indicated that the parents (lines and/or testers) showing desirable gca for a greater number of components possessed a high concentration of favourable genes for a greater number of traits and should be utilized in multiple crossing programs in order to combine important attributes and to develop high yielding types in cotton. Therefore, these parents were identified as good general combiners and could be preferred in the breeding programme as these parents upon crossing, are expected to give desirable segregants in the succeeding generation.

The majority of the parents exhibiting good gca effect for different traits also had acceptable *per se* performance, which suggested that the *per se* performance can be considered as a reliable criterion for selecting parents for hybridization.

Specific combining ability effects

The estimates of sca effect revealed that none of the crosses was consistently superior for all the traits. Among 45 hybrids studied, 14 cross combinations exhibited a significant and positive sca effect for seed cotton yield per plant. The highest yielding hybrid GTHV-15/220 × G.Cot-20 had also registered the highest positive sca effect for seed cotton yield per plant involved good x good general combiners for seed cotton yield per plant. Likewise, the cross GSHV-172 × G.Cot-38 depicted a significantly desirable sca effect for seed cotton yield per plant and the number of bolls per plant. Similarly, another best performing cross is GTHV-15/220 × GJ.Cot-101, which involved good x poor general combining parents for seed cotton yield per plant. The cross GSHV-172 × G.Cot-20 showed a desirable and significant sca effect for characters *viz*., days to flowering, days to boll opening and the number of bolls per plant. Another cross GSHV-172 × GN.Cot-22 showed positive and significant standard heterosis for the number of bolls per plant and boll weight.

Comparative studies

The top five best performing crosses in terms of seed cotton yield per plant of undertaking breeding programme are depicted in Table 5. The outstanding performance of these crosses can be justified by their respective heterotic effect and specific combining compatibility. These out-performance causing qualities are calibrated in standard heterosis percentages and sca effects. From Table 5, it can be seen that significant and positive digits of standard heterosis and sca effect support the comparative higher yield. The data of table 5 is projected in Fig.-1 for visual comparison.

Table 1: Analysis of variance (mean square) for line × tester design for different characters in cotton

Sources	**d.f.**	**Mean square for**				
		Days to flowering	**Days to boll opening**	**Plant height (cm)**	**Number of monopodia per plant**	**Number of sympodia per plant**
Replications	2	19.02	13.85	178.85	0.06	2.47
Genotypes	58	191.77**	310.03**	400.73**	2.58**	11.42**
a) Parents	13	276.86**	454.20**	796.12**	2.29**	19.33**
b) Hybrids	44	170.79**	274.46**	286.84**	2.70**	6.49**
c) Parents vs. Hybrids	1	8.74	0.85	271.67	0.98**	125.64**
Error	116	8.54	9.71	127.21	0.04	1.76
Sources	**d.f.**	**Mean square for**				
		Number of bolls per plant	**Boll weight (g)**	**Seed cotton yield per plant (g)**	**Seed index (g)**	**Lint index (g)**
Replications	2	67.43**	0.02	131.85	1.74	0.59
Genotypes	58	249.58**	1.63**	7615.39**	3.03**	0.73**
a) Parents	13	202.42**	0.90**	1512.25**	3.33**	0.74**
b) Hybrids	44	258.65**	1.80**	7798.35**	3.00**	0.73**
c) Parents vs. Hybrids	1	463.88**	3.76**	78906.07**	0.36	0.64
Error	116	13.80	0.11	45.81	0.90	0.31

* and ** significant at 5% and 1% levels of probability, respectively

Table 2: Range of heterosis as well as number of crosses with response to heterotic effects for various characters in cotton

Sr. No.	**Characters**	**Range of heterosis (%)**			**No. of crosses with significant heterosis**					
		H_1	**H_2**	**H_3**	**H_1**		**H_2**		**H_3**	
					+Ve	**-Ve**	**+Ve**	**-Ve**	**+Ve**	**-Ve**
1	Days to flowering	-16.05 to 16.09	-27.97 to 0.01	-10.99 to 27.47	07	11	00	20	22	03
2	Days to boll opening	-13.33 to 12.98	-20.61 to 12.31	-7.46 to 26.78	09	13	01	29	26	02
3	Plant height (cm)	-26.26 to 35.93	-37.80 to 26.40	-12.88 to 24.60	10	03	03	05	06	00
4	Number of monopodia per plant	-65.71 to 109.09	-70.00 to 64.29	-44.44 to 155.56	12	28	08	34	24	08
5	Number of sympodia per plant	-20.00 to 37.23	-23.48 to 36.59	-16.89 to 14.53	31	03	09	04	13	02
6	Number of bolls per plant	-43.70 to 118.06	-51.03 to 112.00	-36.17 to 69.15	21	05	12	15	13	08
7	Boll weight (g)	-41.18 to 54.95	-46.15 to 40.74	-47.76 to 26.12	24	07	14	06	05	17
8	Seed cotton yield per plant (g)	-36.11 to 234.55	-43.47 to 185.76	-55.56 to 73.92	37	04	28	08	08	36
9	Seed index (g)	-21.13 to 27.79	-25.29 to 15.34	-9.52 to 32.23	06	06	01	08	14	00
10	Lint index (g)	-22.82 to 29.42	-30.75 to 22.46	-19.46 to 22.82	06	01	02	04	03	01

H_1 = Relative heterosis H_2 = Heterobeltiosis H_3 = Standard heterosis

Table 3: Analysis of variance for combining ability for different characters in cotton

Source	**d.f.**	**Mean squares**				
		DF	**DBO**	**PH**	**NMPP**	**NSPP**
Line (L)	8	447.60**++	756.47**++	451.69**	8.99**++	5.41**
Tester (T)	4	486.27**++	477.25**+	269.80	0.44**	8.26**
Line × Tester (L× T)	32	62.16**	128.61**	247.76**	1.41**	6.54**
Error	88	9.91	10.55	122.23	0.04	1.69
Estimates of genetic components of variance						
σ^2l		29.18	49.73	21.96	0.60	0.25
σ^2t		17.64	17.28	5.47	0.01	0.24
σ^2lt (σ^2sca)		17.42	39.36	41.84	0.46	1.62
σ^2gca		21.76	28.87	11.36	0.22	0.24
σ^2gca/σ^2sca		1.25	0.73	0.27	0.48	0.15

* and ** significant at 5% and 1% levels when tested against error mean squares, respectively; +, ++ Significant at 5% and 1% levels when tested against line × tester interactions mean squares, respectively

DF	:	Days to flowering	**DBO**	:	Days to boll opening	**PH**	:	Plant height
NMPP	:	Number of monopodia per plant	NSPP	:	Number of sympodia per plant			

Table 3: Contd…

Source	**d.f.**	**Mean squares**				
		NBPP	**BW**	**SCYPP**	**SI**	**LI**
Line (L)	8	455.42**	1.15**	20366.53**++	2.56**	0.16
Tester (T)	4	467.09**	0.68**	11457.76**+	2.55**	0.45
Line × Tester (L× T)	32	216.76**	1.55**	4198.88**	3.18**	0.91**
Error	88	14.31	0.13	44.51	0.84	0.32
Estimates of genetic components of variance						
σ^2l		29.40	0.07	1354.80	0.11	-0.01
σ^2t		16.77	0.02	422.71	0.06	0.01
σ^2lt (σ^2sca)		67.48	0.47	1384.79	0.78	0.20
σ^2gca		21.28	0.04	755.60	0.08	-0.0004
σ^2gca/σ^2sca		0.32	0.09	0.54	0.10	-0.002

* and ** significant at 5% and 1% levels when tested against error mean squares, respectively; +, ++ Significant at 5% and 1% levels when tested against line × tester interactions mean squares, respectively

NBPP	:	Number of bolls per plant	**BW**	:	Boll weight	**SCYPP**	:	Seed cotton yield per plant
SI	:	Seed index	LI	:	Lint index			

Table 4: Classification of parents with respect to general combining ability (GCA) effects for various characters in cotton

Sr. no.	**Sources**	**DF**	**DBO**	**PH**	**NMPP**	**NSPP**	**NBPP**	**BW**	**SCYPP**	**SI**	**LI**
Lines											
1	GJHV-574	G	G	G	G	A	P	A	P	A	A
2	GJHV-577	P	P	G	P	A	P	G	P	A	A
3	GJHV-581	P	P	A	P	P	A	P	P	A	A
4	GJHV-583	G	G	P	P	A	P	A	P	G	A
5	GJHV-589	G	G	A	G	A	G	P	A	P	A
6	GBHV-185	G	G	A	G	A	A	G	A	A	A
7	GSHV-172	G	G	A	P	G	G	G	G	A	A
8	GSHV-173	P	P	P	P	P	A	A	G	A	A
9	GTHV-15/220	P	P	A	G	P	G	A	G	A	A
Testers											
1	GJ.Cot-101	P	P	P	G	P	A	G	P	G	G
2	G.Cot-38	A	P	A	A	A	A	A	P	A	A
3	GN.Cot-22	G	G	G	G	A	P	G	A	A	A
4	G.Cot-20	P	P	A	P	G	G	P	G	P	P
5	G.Cot-10	G	G	A	G	A	P	A	P	A	A

*G = Good general combiner having significant gca effect in desirable direction *A = Average general combiner having either positive or negative but non-significant gca effect *P = Poor general combiner having significant gca effect in undesirable direction

DF	:	Days to flowering	**DBO**	:	Days to boll opening	**PH**	:	Plant height (cm)
NMPP	:	Number of monopodia per plant	NSPP	:	Number of sympodia per plant	NBPP	:	Number of boll per plant
BW	:	Boll weight (g)	SCYPP	:	Seed cotton yield per plant (g)	SI	:	Seed index (g)
LI	:	Lint index (g)						

Table 5: The best performing hybrids for seed cotton yield per plant along with *per se* performance, standard heterosis and sca effect for component characters in cotton

Sr. No.	Hybrids	*Per se* seed cotton yield per plant (g)		SCYPP	NMPP	NSPP	NBPP	BW	SI	LI
1	GTHV-15/220 × G.Cot-20	348.3	Std. heterosis	73.92**	11.11	3.04	53.72**	-13.43*	12.82	5.53
			sca effect	95.26**	-0.68**	-0.98	2.82	1.14**	0.09	0.28
2	GSHV-172 × G.Cot-38	244.5	Std. heterosis	22.09**	0.01	13.51*	53.37**	5.52	-5.13	-11.42
			sca effect	42.60**	-0.23	0.14	11.42**	0.20	-1.48**	-0.64
3	GTHV-15/220 × GJ.Cot-101	240.7	Std. heterosis	20.21**	66.67**	12.84*	49.65**	5.97	21.98*	13.27
			sca effect	23.00**	0.03	2.42**	8.95**	0.46**	0.12	0.33
4	GSHV-172 × G.Cot-20	240.3	Std. heterosis	19.97**	44.44**	11.49*	39.01**	-8.96	13.19	7.55
			sca effect	0.49	0.72**	-0.61	-1.15	-0.23	0.49	0.53
5	GSHV-172 × GN.Cot-22	228.3	Std. heterosis	14.24**	11.11	8.11	19.15**	22.39**	10.26	-1.81
			sca effect	21.78**	-0.16	-0.62	0.15	0.76**	0.11	-0.12

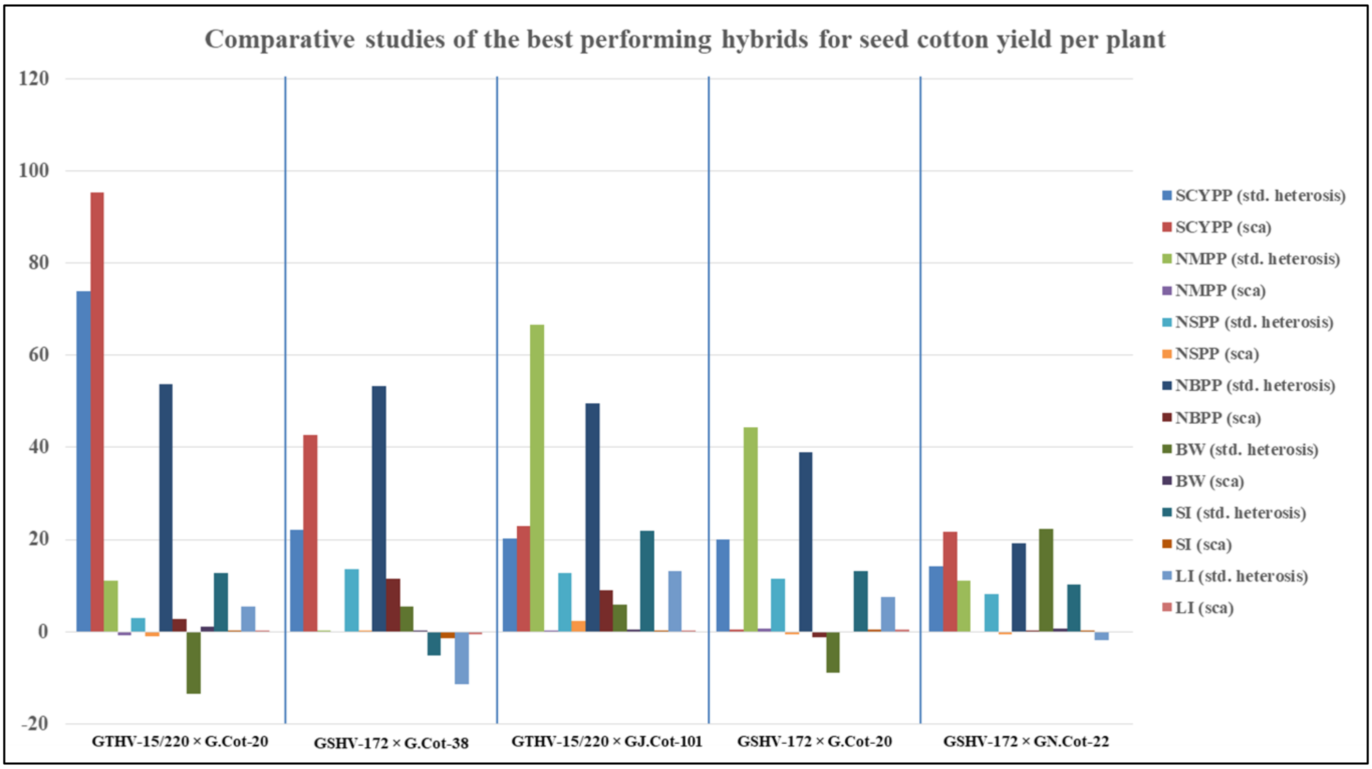

Fig 1: Graphical representation of best features of the best performing hybrids for seed cotton yield per plant

Conclusion

From the present findings, it can be concluded that both additive and non-additive genetic variances were found important in the inheritance of all the traits. The preponderance of non-additive genetic variance was observed in the inheritance of days to boll opening, plant height, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight, seed cotton yield per plant, seed index and lint index. This suggested that heterosis breeding would be more suitable for the improvement of seed cotton yield per plant and its components in cotton. On the basis of *per se* performance, heterotic response, combining ability estimate and gene action involved in the expression of seed cotton yield and its components, five crosses *viz*., GTHV-15/220 × G.Cot-20, GSHV-172 × G.Cot-38, GTHV-15/220 × GJ.Cot-101, GSHV-172 × G.Cot-20 and GSHV-172 × GN.Cot-22 appeared to be the most suitable for the exploitation of heterosis in practical plant breeding programs in cotton. These hybrids recorded significant, positive and higher standard heterosis along with significant sca effect (except cross GSHV-172 × G.Cot-20) in a desirable direction for seed cotton yield per plant and some of its component traits. Therefore, these five crosses could be exploited for heterosis breeding program to boost the seed cotton yield in cotton.

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