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HETEROSIS AND GENE ACTION STUDIES IN *BT* COTTON (BG I) (*GOSSYPIUM HIRSUTUM* L.)

Bhaarat Sharma[1*], K.S. Baig[2], S.S. Deshmukh [1] and G. Praveenkumar[1]
[1]Department of Genetics and Plant breeding, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani 431402, Maharashtra, India
[2]Cotton Research Station, Nanded, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani 431402, Maharashtra, India
*Corresponding author E-mail: bhabuddha99@gmail.com
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ABSTRACT

Heterosis and combining ability analysis is one of the most prominent and conventional tools for improvement in Cotton (*Gossypium* spp.). In this context an experiment was conducted in *Kharif* 2023-24 using five lines, four tester and two checks in Randomized Block Design (RBD) at Cotton Research Station, Nanded, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. Objectives of this research were to assess heterobeltiosis, useful and standard heterosis and to identify superior parents and cross combinations based on their combining ability. In addition, assessment of sucking pest tolerance was also carried out using simple correlation studies. Fourteen observations were recorded based on yield and yield contributing traits *viz.* Days to 50% flowering, days to maturity, plant height, number of sympodia per plant, number of bolls per plant, boll weight, seed cotton yield, seed index, lint index, fibre quality traits *viz.* ginning outturn, upper half mean length, micronaire value, fibre strength and uniformity ratio. Crosses NH 22340 Bt x NH 22308 Bt, NH 22482 Bt x NH 22384 Bt, NH 22482 Bt x NH 22308 Bt and NH 22279 Bt x NH 22254 Bt exhibited highest heterobeltiosis, heterosis over standard check variety and standard check hybrid for traits *viz.* number of sympodia per plant, number of bolls per plant, boll weight and seed cotton yield. Crosses NH 22340 Bt x NH 22384 Bt, NH 22482 Bt x NH 22308 Bt, NH 22482 Bt x NH 22254 Bt, NH 22340 Bt x NH 22294 Bt and NH 22316 Bt x NH 22308 Bt reported highest heterobeltiosis, heterosis over standard check variety and over standard hybrid for given fibre quality traits such as UHML, micronaire value, fibre strength and uniformity ratio. Among the parents, NH 22257 Bt, NH 22279 Bt, NH 22340 Bt, NH 22384 Bt and NH 22308 Bt proved to be good general combiners for yield, yield contributing and fibre quality traits. Crosses NH 22279 Bt x NH 22254 Bt, NH 22316 Bt x NH 22384 Bt, NH 22340 Bt x NH 22384 Bt, NH 22279 Bt x NH 22308 Bt and NH 22257 Bt x NH 22384 Bt displayed high estimates of SCA effects for different traits. Experiment showed that there was predominance of non-additive variance for all characters suggesting of heterosis breeding in future.
***Keywords* :** Heterosis, Heterobeltiosis, GCA, SCA, Cotton

Introduction

Cotton (*Gossypium* spp.) is an important cash crop in the world. Cotton is divided in four species based on economic importance. *Gossypium arboretum* (*desi* cotton) and *Gossypium herbaceum* (Tree cotton) are two diploid (2n=2x=26) species while *Gossypium hirsutum* (Upland cotton) and *Gossypium barbadense* (Egyptian cotton) are two allo-tetraploid (2n=4x=52) species. Heterosis breeding is an important conventional tool for improvement of cotton as it is easy to develop hybrids in cotton due to its simple floral structure. Mell (1894) and Balls (1908) reported heterosis in tetraploid cotton. It was Patel (1971) who demonstrated the heterosis at commercial level and the first intra-*hirsutum* hybrid H-4 (G-67 x American

Nectariless) was developed by him. The introduction of genetically modified (GM) cotton in 1996 in the US and its worldwide spread later rejuvenated cotton production in many parts of the world. The GM cotton introduced in 1996 was simple *Bt* cotton that expressed a single *Cry1Ac* gene, the later generation carried multiple *Cry* genes along with the genes controlling herbicide tolerance. (Qandeel-e-arsh *et al.,* 2021). Infestation of insect pests and infection by diseases are the main causes of low yield in cotton. Protection to chewing pests was largely achieved by incorporating *Cry* genes (Rahman *et al.,* 2012). The Line x Tester design for crossing different genotypes is a valuable tool for plant breeders. It helps in identifying superior genotypes and promising recombinants by evaluating General Combining Ability (GCA) and Specific Combining Ability (SCA). Sprague and Tatum (1942) described combining ability to clarify the nature and extent of gene action involved in the inheritance of yield and its component traits. Among these, the line x tester analysis (Kempthorne, 1957) is a valuable technique for identifying good parents and cross combinations for use in breeding programs. In this context twenty crosses were made between five female lines and four male testers of *hirsutum* cotton in line x tester mating design. Two standard checks along with twenty crosses were used as control. Study aimed to investigate heterosis and combining ability of these twenty cross combinations, nine parents and two checks.

Material and Methods

The experimental material included five female lines *viz.* NH 22257 Bt, NH 22279, NH 22316 Bt, NH 22340 Bt and NH 22482 Bt and four male testers *viz.* NH 22254 Bt, NH 22294 Bt, NH 22308 Bt and NH 22384 Bt. These five lines and four testers was crossed in L x T mating design and resulted in twenty crosses. Two checks *viz.* NHH 44 BG II a check hybrid and Suraj Bt a check variety were grown as control. All above parents are not used in any hybridization programme till now.

This experiment was carried out at Cotton Reseach Station, Nanded which is under Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2023-24. The experimental material was grown in Randomized Block Design with two replications. A spacing of 120 x 45 cm for crosses and checks and 60 x 30 cm was adopted for parents. Two rows of crosses and checks and four rows of parents were laid out in a single plot. Each plot had a size of 2.4 x 6 square meters. Data was recorded from each replication from five randomly selected plants in each plot for major traits *viz.* Days to 50% flowering, Days to maturity, Plant height (cm), Number of sympodia per plant, Number of bolls per plant, Boll weight (g), Seed cotton yield (kg ha^{-1}), Seed index (g), Lint index (g), Ginning outturn (%), Upper half mean length (mm), Fibre fineness/ Micronaire value (µg inch^{-1}), Fibre strength (g tex^{-1}) and Fibre uniformity ratio (%). Heterosis was estimated over better parent and over both cheks. Combining ability analysis for L x T design was carried out according to Kempethorne (1957) with the help of RStudio software. The crop was cultivated in rainfed conditions following the recommended agronomic practices. Appropriate plant protection measures were implemented at the right times to manage pests and diseases.

Results

A. Mean performance

For days to 50% flowering, line NH 22257 Bt (69.00), tester NH 22384 Bt (75.50) and cross NH 22316 Bt x NH 22294 Bt (61.50) were the earliest in flowering. For days to maturity line NH 22482 Bt (178.00 days), tester NH 22294 Bt (171.50 days) and crosses NH 22257 Bt x NH 22294 Bt, NH 22257 Bt x NH 22308 Bt (157.00 days) were earliest to mature. Crosses NH 22482 Bt x NH 22384 Bt (72.54 cm) followed by NH 22316 Bt x NH 22308 Bt (83.60 cm), NH 22482 Bt x NH 22308 Bt (86.81 cm) had least height among all crosses. Line NH 22316 Bt (13.40), tester NH 22294 Bt (8.95) had maximum number of sympodia per plant. While cross NH 22340 Bt x NH 22308 Bt (15.76) followed by cross NH 22316 Bt x NH 22384 Bt (13.93) and NH 22316 Bt x NH 22308 Bt (12.84) had maximum number of sympodia per plant. For number of bolls per plant line NH 22316 Bt (19.70) and tester NH 22384 Bt (15.30) had highest number of bolls per plant. Among crosses NH 22279 Bt x NH 22294 Bt (24.00) recorded maximum number of bolls per plant. Line NH 22316 Bt (4.18 g), tester NH 22308 Bt (3.16 g) and cross NH 22340 Bt x NH 22384 Bt (4.50 g) had maximum boll weight. For seed cotton yield, line NH 22316 Bt (647.80 kg ha^{-1}), tester NH 22384 Bt (395.75 kg ha^{-1}) exhibited maximum seed cotton yield. While cross NH 22279 Bt x NH 22254 Bt exhibited highest seed cotton yield of 811.83 kg ha^{-1} followed by crosses NH 22316 Bt x NH 22384 Bt (808.45 kg ha^{-1}), NH 22340 Bt x NH 22384 Bt (771.17 kg ha^{-1}). Line NH 22316 Bt (7.75 g), tester NH 22308 Bt (8.00 g) and cross (NH 22279 Bt x NH 22308 Bt (10.00 g) recorded highest seed index. In case of lint index line NH 22257 Bt (5.24 g), tester NH 22308 Bt (5.60 g) and cross NH 22257 Bt x NH 22254 Bt (6.18 g) exhibited highest lint index. Line NH 22257 Bt (41.62%), tester NH 22294 Bt (41.67%) and cross NH 22257 Bt x NH 22384 Bt (41.33 %) observed highest ginning percentage. In case of female parents fibre length was maximum of 29.62 mm (NH 22340 Bt) followed by 28.89 mm (NH 22482 Bt), 27.30 mm (NH 22316 Bt). And tester NH 22308 Bt (29.07 mm) recorded highest mean fibre length. Cross NH 22340 Bt x NH 22384 Bt (33.58 mm) recorded highest mean upper half mean length among all crosses. Line NH 22279 Bt (4.41 µg $inch^{-1}$), tester NH 22384 Bt (4.63 µg $inch^{-1}$) and cross NH 22279 Bt x NH 22254 Bt (4.73 µg $inch^{-1}$) recorded highest micronaire value. Line NH 22340 Bt (26.02 g tex^{-1}), tester NH 22308 Bt (25.81 g tex^{-1}) and cross NH 22482 Bt x NH 22254 Bt (29.67 g tex^{-1}) observed maximum fibre tenacity. In case of fibre uniformity ratio line NH 22257 Bt (86.77%), tester NH 22308 Bt (85.09%) and cross NH 22316 Bt x NH 22308 Bt (86.60 %) recorded highest fibre uniformity ratio.

B. Heterosis

Heterosis over better parent termed as heterobeltiosis (BPH) while over standard check variety (Suraj Bt) termed as useful heterosis (UH) and heterosis over standard check hybrid (NHH 44 BG II) is termed as standard heterosis (SH). Cross NH 22482 Bt x NH 22308 Bt ranked first in terms of seed cotton yield (BPH= 105.85%, UH= 79.36%, SH= 27.38%). This cross also showed heterobeltiosis (28.12%) for number of bolls per plant and useful heterosis (-22.10%) for micronaire value. Cross NH 22340 Bt x NH 22384 Bt ranked second for seed cotton yield (BPH= 94.86%, UH= 87.22%, SH= 32.96%). This cross was also desirable for boll weight (BPH= 43.31%, UH= 73.08%, SH= 47.06%), seed index (BPH= 31.03%, UH= 52.00%, SH= 31.03%) and fibre length (BPH= 13.35%, UH= 38.65%, SH= 31.82%). Cross NH 22279 Bt x NH 22254 Bt ranked third for seed cotton yield (BPH= 76.45%, UH= 97.09%, SH= 39.98%). It also exhibited desirable useful heterosis (59.62%), standard heterosis (35.62%) for boll weight.

Cross NH 22340 Bt x NH 22308 Bt ranked fourth in term of seed cotton yield (BPH= 66.74%, UH= 45.28%). This cross also showed desirable heterosis for number of sympodia per plant (BPH= 53.36%, UH= 35.51%, SH= 41.85%), micronaire value (UH= -19.02%) and fibre strength (UH= 24.93%, SH= 20.54%). Cross NH 22279 Bt x NH 22308 Bt ranked fifth in terms of seed cotton yield (BPH= 66.67%, UH= 86.16%, SH= 32.22%). This cross also showed desirable heterosis for seed index (BPH= 25.00%, UH= 60.00%, SH= 37.93%), fibre strength (UH= 18.75%, SH= 14.58%) and fibre uniformity ratio (UH= 4.61%, SH= 3.71%).

C. Combining ability

Analysis of variance of combining ability with respect to fourteen characters is given in Table 7. Mean sum of squares of genotypes for all the characters were significant. Variance of GCA was lower than variance of SCA for all fourteen characters which showed the predominance of dominance variance and non-additive gene action (Table 7). General combining ability effects (Table 8) showed that line NH22257 Bt was the best combiner for traits *viz.,* days to 50 % flowering (-2.27), days to maturity (-4.1), boll weight (0.20), lint index (0.62), ginning outturn (2.54) and uniformity ratio (0.48). Line NH 22279 Bt was second best combiner for number of bolls per plant (1.79), seed cotton yield per plant (11.79), seed index (0.68) followed by line NH 22482 Bt which was the best combiners for plant height (-10.03) (compactness), micronaire value (-0.21). NH 22316 Bt was found to be best general combiner for number of sympodia per plant (0.46) and fibre strength (0.48). NH 22340 Bt was found to be best general combiner for fibre length (1.05). Among testers NH 22254 Bt was the best general combiner for seed index (0.35), lint index (0.03) and fibre strength (0.48). While NH 22384 Bt was the second best general combiner for plant height (-1.64) (compactness), boll weight (0.14), seed cotton yield per plant (10.55), and fibre length (0.79) followed by NH 22308 Bt for number of sympodia per plant (1.10), number of bolls per plant (1.00), micronaire value (-0.12) and uniformity ratio (1.03). NH 22294 Bt was found to be best general combiner male parent for days to maturity (-1.8) and ginning outturn (1.22).

Specific combining ability effects (Table 9) revealed that cross NH 22316 Bt x NH 22294 Bt (-6.8) (poor x good) exhibited highest SCA significant effects for days to for 50% flowering. Cross NH 22482 Bt x NH 22384 Bt (-9.51) (good x poor) showed significant negative SCA effect for plant height which is desirable in compact plant type. For number of sympodia per plant, cross NH 22340 Bt x NH 22308 Bt (2.75) showed significant and positive SCA effects which is a combination of good x good combining parent. In case of number of bolls per plant cross combination NH 22257 Bt x NH 22384 Bt (3.94) (poor x poor) exhibited significant and positive SCA effect. Cross NH 22340 Bt x NH 22384 Bt (0.65) (poor x good) exhibited significant and positive combining ability effects for boll weight. For seed cotton yield, crosses NH 22482 Bt x NH 22308 Bt (12.48) (poor x good) and NH 22279 Bt x NH 22254 Bt (10.92) (good x poor) recorded significant SCA effects. For seed index significant and positive SCA effects were exhibited by crosses NH 22340 Bt x NH 22308 Bt (poor x poor)

(1.9) and NH 22279 Bt x NH 22308 Bt (good x poor) (1.56). Cross NH 22340 Bt x NH 22384 Bt (3.54) (good x good) showed significant and positive SCA effect for fibre length. For fibre strength, cross NH 22482 Bt x NH 22254 Bt (3.03) showed significant SCA effect which was a combination of good x good parent. For uniformity ratio three crosses *viz.* NH 22340 Bt x NH 22294 Bt (2.62) (good x poor), NH 22482 Bt x NH 22384 Bt (1.92) (good x poor) and NH 22316 Bt x NH 22308 Bt (1.72) (poor x good) exhibit significant and positive SCA effects.

Discussion

From the above cited results many insights can be obtained. Heterosis studies revealed that earliness is desirable in cotton. Hence significant and negative heterosis is beneficial for traits such as days to 50% flowering and days to maturity. Ganpathy *et al.,* (2008), Patel *et al.,* (2014) and Arbad *et al.,* (2017) reported same results for respective traits. Heterosis for trait plant height is also desirable in significant and negative direction. Hence compactness is beneficial for cotton as it makes intercultural operations easy. Similar results were reported by other workers *viz.* Dawod *et al.,* (2010), Guvercin *et al.,* (2011) and Kumar *et al.,* (2013). Traits such as number of sympodia per plant, number of bolls per plant, boll weitght and seed cotton yield are yield contributing traits. Significant and positive heterosis is required for these traits. Among twenty hybrids, many of them showed significant and positive heterosis for number of sympodia per plant, number of bolls per plant, boll weight and seed cotton yield per plant. Other workers *viz.* Tuteja *et al.,* (2011), Balu *et al.,* (2012), Monicashree *et al.,* (2017), Patil *et al.,* (2019), Solongi *et al.,* (2019) and Naik *et al.,* (2020). Significant and positive heterosis for seed index and lint index were reported by earlier workers *viz.* Kumar *et al.,* (2017), Gohil *et al.,* (2017) and Mangi *et al.,* (2019). Textile industry is dependent on cotton fibre quantity and quality. Cotton fibre properties such as ginning percentage, fibre length, fibre fineness, fibre strength and fibre uniformity ratio determine the quantity and quality of cotton fibre. Ginning percentage depends upon seed weight and lint weight. Hence positive and significant heterosis is desirable for these traits. Similar results were obtained by Rangnatha *et al.,* (2013) and Patel *et al.,* (2015). Significant and positive heterosis was reported by Kannan *et al.,* (2016) and Sirisha *et al.,* (2019). Fibre fineness is determined by micronire value. As the micronaire value increases, fineness of fibre decreases. Hence significant and negative heterosis is desirable in this trait. Similar results were obtained by Usharani *et al.,* (2015), Shakel *et al.,* (2016) and Bilwal *et al.,* (2018). Significant and positive heterosis was reported for fibre strength and fibre uniformity ratio by Kannan *et al.,* (2016) Sirisha *et al.,* (2019) and Udaya *et al.,* (2020). Ratio of GCA and SCA variance was less than unity for all the fourteen traits. It indicated the predominance of non-additive gene action and dominance variance. Several researchers, Ashokkumar *et al.,* (2010), Patil *et al.,* (2011), Deosarkar *et al.,* (2014), Faldu *et al.,* (2015), Patel *et al.,* (2015), Ali *et al.,* (2016), Rathava *et al.,* (2017), Sivia *et al.,* (2017), Chattha *et al.,* (2018), Bandhavi *et al.,* (2019) and Chapara *et al.,* (2020) has reported predominance of SCA variance in upland cotton for plant morphological, yield, yield contributing and fibre quality characters. The overall performance of general combiners and testers was better, as shown by the positive correlation between them. This suggests that parents can be chosen based on general combining ability (GCA), mean performance, or a combination of both. The positive GCA effects highlight the potential for enhancing yield and fiber quality traits by using these parents. Similar results were obtained by Tang *et al.,* (1993) and Meredith and Brown (1998).

Specific combining ability effects represent the performance of a parent in a particular cross. It does not always confer the high GCA effects of respective parents. Most of the crosses exhibiting high SCA effects had at least good general combiner parent. Kadams *et al.,* (1999) reported similar results where a hybrid with high SCA effects involved one or both of the good general combiners as parents while SCA effects are brought about the action of non-additive genes.

Conclusion

The cotton textile industry requires improved yield and higher-quality cotton. To address this, enhancing both yield and fiber quality is a key focus for cotton breeders. This study aimed to support the cotton breeding programme by facilitating the heterosis breeding and developing cotton varieties that deliver greater yield and superior fiber quality. In this study, dominance variance was predominant for all fourteen characters suggesting heterosis breeding strategy in future. Among the parents, line NH 22316 Bt and tester NH 22384 Bt can be used further in breeding programmes depending on their high *per se* performance. lines NH 22340 Bt, NH 22316 Bt, NH 22257 Bt and testers NH 22294 Bt can be trustworthy in terms of their *per se* performance for fibre quality traits. Hybrids NH 22279 Bt x NH 22254 Bt, NH 22316 Bt x NH 22384 Bt, NH 22340 Bt x NH 22384 Bt, NH 22279 Bt x NH 22308 Bt and NH 22257 Bt x NH 22384 Bt documented peak seed cotton yield among all crosses.

Table 1: Mean performance of Parents, crosses and checks for all characters in *Gossypium hirsutum* L.

S. No.	Treatment	DTF	DTM	PH (cm)	NS/P	NB/P	BW (g)	SCY (kg/ha)
		Mean	Mean	Mean	Mean	Mean	Mean	Mean
	Lines							
1	NH 22257 Bt	69.00	188.00	137.43	9.15	10.70	4.14	501.44
2	NH 22279 Bt	78.50	179.50	103.21	9.56	14.70	3.36	460.07
3	NH 22316 Bt	82.50	188.50	115.44	13.40	19.70	4.18	647.80
4	NH 22340 Bt	71.00	185.00	84.38	10.27	14.30	3.07	319.21
5	NH 22482 Bt	80.50	178.00	80.79	8.21	12.80	2.91	354.88
	Mean	**76.30**	**183.80**	**104.25**	**10.12**	**14.40**	**3.53**	**456.88**
	Range	**69 - 82.5**	**178 - 188.5**	**80.79 - 137.42**	**8.21 - 13.40**	**10.70 - 19.70**	**2.91 -4.18**	**354.88 - 647.80**
	Testers							
6	NH 22254 Bt	78.50	174.50	117.27	8.85	11.70	3.11	370.25
7	NH 22294 Bt	80.50	171.50	123.32	8.95	12.30	3.11	318.39
8	NH 22308 Bt	81.00	179.50	113.86	7.24	11.30	3.16	358.90
9	NH 22384 Bt	75.50	188.00	101.31	8.94	15.30	3.14	395.75
	Mean	**78.87**	**178.37**	**113.94**	**8.49**	**12.65**	**3.13**	**360.82**
	Range	**75.5 - 81**	**171.5 - 188**	**101.31 – 123.32**	**7.24 - 8.95**	**11.3 - 15.30**	**3.11 -3.16**	**318.39 – 395.75**
	Crosses							
10	NH 22257 Bt x NH 22254 Bt	63.50	159.00	116.26	11.42	18.30	4.17	631.55
11	NH 22257 Bt x NH 22294 Bt	68.50	157.00	110.72	10.99	18.30	3.64	579.87
12	NH 22257 Bt x NH 22308 Bt	65.50	157.00	107.45	10.78	17.10	4.35	571.63
13	NH 22257 Bt x NH 22384 Bt	65.00	165.00	102.62	12.64	22.20	3.65	763.43
14	NH 22279 Bt x NH 22254 Bt	71.00	162.00	93.92	11.71	22.20	4.15	811.83
15	NH 22279 Bt x NH 22294 Bt	67.50	162.00	96.86	11.41	24.00	4.22	705.54
16	NH 22279 Bt x NH 22308 Bt	71.50	165.50	90.89	11.73	21.40	3.80	766.83
17	NH 22279 Bt x NH 22384 Bt	72.00	167.50	106.50	11.10	18.30	3.55	706.49
18	NH 22316 Bt x NH 22254 Bt	69.00	167.00	93.79	11.00	19.80	3.79	572.69
19	NH 22316 Bt x NH 22294 Bt	61.50	164.50	87.16	10.18	17.80	3.31	442.84
20	NH 22316 Bt x NH 22308 Bt	71.50	163.00	83.60	12.84	22.30	3.79	627.99
21	NH 22316 Bt x NH 22384 Bt	72.00	167.50	87.95	13.93	22.30	3.94	808.45
22	NH 22340 Bt x NH 22254 Bt	63.50	168.00	88.79	10.14	17.70	3.69	433.18
23	NH 22340 Bt x NH 22294 Bt	69.50	161.00	89.48	11.63	18.00	3.13	501.88
24	NH 22340 Bt x NH 22308 Bt	65.50	162.00	104.91	15.76	19.40	3.51	598.44
25	NH 22340 Bt x NH 22384 Bt	70.00	159.50	94.82	10.05	16.60	4.50	771.17
26	NH 22482 Bt x NH 22254 Bt	65.50	171.50	91.25	10.47	19.00	3.52	503.56
27	NH 22482 Bt x NH 22294 Bt	71.50	164.50	87.17	9.97	19.50	3.07	488.52
28	NH 22482 Bt x NH 22308 Bt	70.50	169.50	86.81	12.05	22.80	3.39	738.81
29	NH 22482 Bt x NH 22384 Bt	63.50	159.00	73.54	10.69	15.00	3.81	626.35
	Mean	**67.90**	**163.60**	**94.72**	**11.53**	**13.64**	**3.75**	**501.88**
	Range	**61.50 - 72**	**157.00 - 171.5**	**83.60 – 116.25**	**10.05 - 15.76**	**16.6 – 24.00**	**3.13 - 4.5**	**433.18 – 811.83**
	Checks							
30	Suraj Bt	67.00	177.50	99.15	11.63	20.20	2.60	411.90
31	NHH 44 BG II	70.00	176.00	82.74	11.112	20.50	3.06	579.96
	SE±	**2.79**	**6.13**	**9.19**	**1.06**	**1.5**	**0.30**	**48.79**
	CD at 95%	**8.08**	**17.71**	**26.55**	**3.07**	**4.51**	**0.88**	**140.93**

DTF- Days to 50% flowering, DTM- Days to maturity, PH- Plant height, NS/P- Number of sympodia per plant, NB/P- Number of bolls per plant, BW- Boll weight, SCY- Seed cotton yield

Table 1 Contd… Mean performance of Parents, crosses and checks for all characters in *Gossypium hirsutum* L.

Sr. No.	Treatment	SI (g)	LI (g)	GOT (%)	UHML (mm)	MIC (µg/inch)	FS (g/tex)	UR (%)
		Mean	Mean	Mean	Mean	Mean	Mean	Mean
	Lines							
1	NH 22257 Bt	7.25	5.24	41.62	26.79	3.99	25.39	86.77
2	NH 22279 Bt	7.50	3.97	34.35	26.79	4.41	25.81	81.97
3	NH 22316 Bt	7.75	3.93	33.67	27.30	3.57	25.08	83.20

4	NH 22340 Bt	6.25	3.95	38.74	29.62	4.20	26.02	85.48
5	NH 22482 Bt	7.50	4.58	38.06	28.89	3.67	25.92	84.84
	Mean	**7.25**	**4.33**	**37.28**	**27.88**	**3.96**	**25.65**	**84.45**
	Range	**6.25 - 7.75**	**3.93 - 5.24**	**33.67 - 41.62**	**26.79 - 29.62**	**3.57 - 4.41**	**25.08 - 26.02**	**81.97 - 86.76**
	Testers							
6	NH 22254 Bt	7.75	3.615	31.68	27.47	3.67	25.39	84.59
7	NH 22294 Bt	6.00	4.30	41.67	23.92	3.26	23.93	83.84
8	NH 22308 Bt	8.00	5.60	41.12	29.07	3.67	25.81	85.09
9	NH 22384 Bt	7.25	5.45	40.96	27.82	4.63	25.29	81.22
	Mean	**7.25**	**4.74**	**38.85**	**27.07**	**3.81**	**25.11**	**83.68**
	Range	**6.00 - 8.00**	**3.61 - 5.60**	**31.68 - 41.67**	**23.92 - 29.07**	**3.26 - 4.63**	**23.93 - 25.81**	**81.22 - 85.09**
	Crosses							
10	NH 22257 Bt x NH 22254 Bt	8.75	6.18	40.45	27.99	3.93	25.27	83.83
11	NH 22257 Bt x NH 22294 Bt	80	5.46	40.57	25.07	4.31	23.91	83.95
12	NH 22257 Bt x NH 22308 Bt	8.50	5.88	40.83	26.61	4.09	24.77	86.38
13	NH 22257 Bt x NH 22384 Bt	7.00	4.93	41.33	27.82	4.20	24.87	83.95
14	NH 22279 Bt x NH 22254 Bt	8.75	4.30	32.73	28.35	4.73	25.50	82.58
15	NH 22279 Bt x NH 22294 Bt	7.25	4.30	37.39	26.62	3.99	24.04	82.48
16	NH 22279 Bt x NH 22308 Bt	10.00	5.5	35.53	27.47	4.13	26.95	86.19
17	NH 22279 Bt x NH 22384 Bt	8.75	5.61	39.17	26.45	4.41	25.16	82.46
18	NH 22316 Bt x NH 22254 Bt	8.00	4.43	36.20	28.17	4.09	25.39	84.84
19	NH 22316 Bt x NH 22294 Bt	8.25	4.95	39.59	30.00	4.17	26.74	80.26
20	NH 22316 Bt x NH 22308 Bt	7.50	4.98	36.90	30.00	4.30	26.89	86.60
21	NH 22316 Bt x NH 22384 Bt	7.50	4.26	36.31	28.53	4.41	25.92	83.20
22	NH 22340 Bt x NH 22254 Bt	8.00	5.15	39.16	28.00	3.99	25.29	81.35
23	NH 22340 Bt x NH 22294 Bt	6.75	4.61	40.61	25.96	4.63	24.24	86.38
24	NH 22340 Bt x NH 22308 Bt	5.75	3.71	39.17	29.44	3.92	28.35	85.40
25	NH 22340 Bt x NH 22384 Bt	9.50	5.14	35.14	33.58	4.31	26.98	84.46
26	NH 22482 Bt x NH 22254 Bt	8.25	5.04	35.37	30.57	3.78	29.67	85.29
27	NH 22482 Bt x NH 22294 Bt	8.75	5.66	39.19	28.17	3.98	24.77	83.95
28	NH 22482 Bt x NH 22308 Bt	7.00	4.85	41.20	26.45	3.77	23.62	81.35
29	NH 22482 Bt x NH 22384 Bt	7.75	4.8	38.14	28.53	4.31	26.55	86.07
	Mean	**8.00**	**4.99**	**38.25**	**28.19**	**4.18**	**25.74**	**84.05**
	Range	**5.75 – 10.00**	**3.71 - 6.18**	**32.72 - 41.33**	**25.07 - 33.58**	**3.77 - 4.73**	**23.91 - 29.67**	**80.25 - 86.60**
	Checks							
30	Suraj Bt	6.25	4.46	41.58	24.22	3.98	22.69	82.39
31	NHH 44 BG II	7.25	4.45	38.04	25.47	4.85	23.52	81.10
	SE±	**0.60**	**0.42**	**1.81**	**1.19**	**0.23**	**0.91**	**0.96**
	CD at 95%	**1.71**	**1.21**	**5.24**	**3.46**	**0.66**	**2.63**	**2.73**

SI- Seed index, LI- Lint index, GOT- Ginning outturn, UHML- Upper half mean length, MIC- Micronaire value, FS- Fibre strength, UR- Uniformity ratio

Table 2: Heterobeltiosis, useful and standard heterosis for different characters in *Gossypium hirsutum* L.

S. No.	Cross	DTF			DTM			PH			NS/P			NB/P		
		BPH	UH	SH	BPH	UH	SH	BPH	UH	SH	BPH	UH	SH	BPH	UH	SH
1	NH 22257 Bt x NH 22254 Bt	**-19.11****	-5.22	-9.29	**-15.43****	**-10.17***	-9.66	-15.41	17.26	**40.51***	24.73	-1.79	2.79	**56.41****	-9.4	-10.73
2	NH 22257 Bt x NH 22294 Bt	**-14.91****	2.24	-2.14	**-16.49****	**-11.30***	**-10.80***	**-19.43***	11.68	**33.82***	20.07	-5.46	-1.04	**48.78***	-9.4	-10.73
3	NH 22257 Bt x NH 22308 Bt	**-19.14****	-2.24	-6.43	**-16.49****	**-11.30***	**-10.80***	**-21.81***	8.38	29.86	17.76	-7.28	-2.94	**51.32***	-15.34	-16.58
4	NH 22257 Bt x NH 22384 Bt	**-13.91***	-2.99	-7.14	**-12.23***	-6.78	-6.25	**-25.33***	3.51	24.02	**38.12***	8.74	13.83	**45.09****	9.9	8.29

5	NH 22279 Bt x NH 22254 Bt	-9.55	5.97	1.43	-9.75	-8.47	-7.95	-19.91	-5.27	13.51	22.413	0.69	5.41	51.02**	9.9	8.29
6	NH 22279 Bt x NH 22294 Bt	-16.15**	0.75	-3.57	-9.75	-8.47	-7.95	-21.46	-2.3	17.06	19.351	-1.81	2.77	63.26**	18.81	17.07
7	NH 22279 Bt x NH 22308 Bt	-11.73*	6.72	2.14	-7.8	-6.5	-5.97	-20.17	-8.32	9.85	22.71	0.94	5.66	45.57**	5.94	4.39
8	NH 22279 Bt x NH 22384 Bt	-8.28	7.46	2.86	-10.90*	-5.37	-4.83	3.19	7.42	28.72	16.03	-4.54	-0.08	19.6	-9.4	-10.73
9	NH 22316 Bt x NH 22254 Bt	-16.36**	2.99	-1.43	-11.41*	-5.65	-5.11	-20.02	-5.39	13.36	-17.84	-5.34	-0.91	0.5	-1.98	-3.41
10	NH 22316 Bt x NH 22294 Bt	-25.45**	-8.21	-12.14*	-12.73**	-7.06	-6.53	-29.32**	-12.09	5.34	-24.01*	-12.44	-8.34	-9.64	-11.88	-13.17
11	NH 22316 Bt x NH 22308 Bt	-13.33**	6.72	2.14	-13.53**	-7.91	-7.39	-27.58*	-15.67	1.04	-4.16	10.42	15.58	13.19	10.39	8.78
12	NH 22316 Bt x NH 22384 Bt	-12.73*	7.46	2.86	-11.14*	-5.37	-4.83	-23.82*	-11.29	6.29	4.01	19.85	25.45	13.19	10.39	8.78
13	NH 22340 Bt x NH 22254 Bt	-19.11**	-5.22	-9.29	-9.19	-5.08	-4.55	-24.29*	-10.44	7.31	-1.24	-12.74	-8.65	23.77	-12.37	-13.65
14	NH 22340 Bt x NH 22294 Bt	-13.66**	3.73	-0.71	-12.97*	-9.04	-8.52	-27.44*	-9.74	8.15	13.21	0.04	4.72	25.87	-10.89	-12.19
15	NH 22340 Bt x NH 22308 Bt	-19.14**	-2.24	-6.43	-12.43**	-8.47	-7.95	-7.86	5.82	26.8	53.36**	35.51*	41.85**	35.66*	-3.96	-5.36
16	NH 22340 Bt x NH 22384 Bt	-7.28	4.48	0	-15.16*	-9.89	-9.38	-6.41	-4.36	14.6	-2.2	-13.58	-9.53	8.49	-17.81	-19.02
17	NH 22482 Bt x NH 22254 Bt	-18.63**	-2.24	-6.43	-3.65	-3.11	-2.56	-22.19	-7.96	10.28	18.36	-9.91	-5.7	48.43**	-5.94	-7.31
18	NH 22482 Bt x NH 22294 Bt	-11.18*	6.72	2.14	-7.58	-7.06	-6.53	-29.31**	-12.07	5.35	11.46	-14.21	-10.2	52.34**	-3.46	-4.87
19	NH 22482 Bt x NH 22308 Bt	-12.96*	5.22	0.71	-5.57	-4.24	-3.69	-23.76*	-12.44	4.92	46.80*	3.65	8.5	78.12**	12.87	11.21
20	NH 22482 Bt x NH 22384 Bt	-21.12**	-5.22	-9.29	-15.43**	-10.17*	-9.66	-27.42*	-25.82	-11.12	19.58	-8.01	-3.7	-1.96	-25.74*	-26.82*
	SE±	**3.95**			**8.67**			**13**			**1.5**			**2.21**		
	CD at 95%	**8.05**			**17.7**			**26.54**			**3.06**			**4.51**		
	CD at 99%	**10.86**			**23.84**			**35.74**			**4.12**			**6.07**		

*, **- Significant at 5 per cent and 1 per cent level, respectively, DTF- Days to 50% flowering, DTM- Days to maturity, PH- Plant height, NS/P- Number of sympodia per plant, NB/P- Number of bolls per plant

Table 2 Contd.. Heterobeltiosis, useful and standard heterosis for different characters in *Gossypium hirsutum* L.

S. No.	Cross	BW			SCY			SI			LI			GOT		
		BPH	UH	SH	BPH	UH	SH	BPH	UH	SH	BPH	UH	SH	BPH	UH	SH
1	NH 22257 Bt x NH 22254 Bt	0.72	60.38**	36.27*	25.94	53.32**	8.89	12.90	40**	20.69	18.03	38.68**	38.99**	-2.8	-2.72	6.34
2	NH 22257	-12.08	40.00*	18.95	15.64	40.77*	-0.01	10.34	28*	10.34	4.2	22.42	22.7	-2.64	-2.44	6.64

	Bt x NH 22294 Bt															
3	NH 22257 Bt x NH 22308 Bt	5.07	**67.31****	**42.16****	13.99	**38.77***	-1.43	6.25	**36***	17.24	5.09	**31.95***	**32.25***	-1.9	-1.82	7.32
4	NH 22257 Bt x NH 22384 Bt	-11.84	**40.38***	19.28	**52.24****	**85.34****	**31.63***	-3.45	12	-3.45	-9.45	10.65	10.9	-0.68	-0.6	8.65
5	NH 22279 Bt x NH 22254 Bt	23.51	**59.62****	**35.62***	**76.45****	**97.09****	**39.98****	12.9	**40****	20.69	8.44	-3.48	-3.26	-4.73	**-21.30****	**-13.97***
6	NH 22279 Bt x NH 22294 Bt	25.6	**62.31****	**37.91***	**53.35****	**71.28****	**21.65**	-3.33	16	0	0.12	-3.48	-3.26	-10.27	-10.09	-1.72
7	NH 22279 Bt x NH 22308 Bt	13.27	**46.38****	24.38	**66.67****	**86.16****	**32.22***	**25.00***	**60****	**37.93****	-1.79	23.32	23.6	**-13.59***	**-14.55***	-6.6
8	NH 22279 Bt x NH 22384 Bt	5.65	**36.54***	16.01	**53.56****	**71.51****	21.81	16.67	**40****	20.69	3.03	25.9	26.18	-4.37	-5.8	2.97
9	NH 22316 Bt x NH 22254 Bt	-9.33	**45.77***	23.86	-11.59	**39.03***	-1.25	3.23	**28***	10.34	12.85	-0.56	-0.34	7.5	**-12.95***	-4.85
10	NH 22316 Bt x NH 22294 Bt	-20.81	27.31	8.17	**-31.63****	7.51	-23.64	6.45	**32***	13.79	15.12	10.99	11.24	-4.99	-4.8	4.06
11	NH 22316 Bt x NH 22308 Bt	-9.33	**45.77***	23.86	-3.05	52.46**	8.28	-6.25	20	3.45	-10.98	11.77	12.02	-10.26	-11.26	-3
12	NH 22316 Bt x NH 22384 Bt	-5.74	**51.54****	28.76	**24.79***	**96.27****	**39.39****	-3.23	20	3.45	-21.74	-4.37	-4.16	-11.35	**-12.67***	-4.55
13	NH 22340 Bt x NH 22254 Bt	18.65	**41.92***	20.59	16.99	5.16	**-25.30***	3.23	**28***	10.34	30.38	15.47	15.73	1.08	-5.83	2.93
14	NH 22340 Bt x NH 22294 Bt	0.64	20.38	2.29	**57.22***	21.84	-13.46	8	8	-6.9	7.33	3.48	3.71	-2.53	-2.33	6.76
15	NH 22340 Bt x NH 22308 Bt	11.08	35	14.71	**66.74****	**45.28***	3.18	**-28.13***	-8	-20.69	**-33.66****	-16.7	-16.52	-4.74	-5.8	2.97
16	NH 22340 Bt x NH 22384 Bt	**43.31****	**73.08****	**47.06****	**94.86****	**87.22****	**32.96****	**31.03***	**52****	**31.03***	-5.69	15.25	15.51	**-14.21***	**-15.49***	-7.62
17	NH 22482 Bt x NH 22254 Bt	13.18	**35.38***	15.03	36	22.25	-13.17	6.45	**32***	13.79	10.15	13.12	13.37	-7.07	**-14.95***	-7.03
18	NH 22482 Bt x NH 22294 Bt	-1.29	18.08	0.33	37.65	18.6	-15.76	16.67	**40****	20.69	23.58	26.91	**27.19***	-5.94	-5.75	3.02
19	NH 22482 Bt x NH 22308 Bt	7.28	30.38	10.78	**105.85****	**79.36****	**27.38***	-12.5	12	-3.45	-13.3	8.86	9.1	0.18	-0.93	8.29
20	NH 22482 Bt x NH 22384 Bt	21.34	**46.54****	24.51	**58.26****	**52.06****	7.99	3.33	24	6.9	-11.93	7.62	7.87	-6.88	-8.27	0.26
	SE±		**0.43**			**7.09**			**0.84**			**0.59**			**2.56**	
	CD at 95%		**0.87**			**14.47**			**1.71**			**1.2**			**5.22**	
	CD at 99%		**1.18**			**19.49**			**2.3**			**1.62**			**7.03**	

*, **- Significant at 5 per cent and 1 per cent level, respectively, BW- Boll weight, SCY- Seed cotton yield, SI- Seed index, LI- Lint index, GOT- Ginning outturn

Table 2 Contd… Heterobeltiosis, useful and standard heterosis for different characters in *Gossypium hirsutum* L.

S.No.	Cross	UHML			MIC			FS			UR		
		BPH	UH	SH	BPH	UH	SH	BPH	UH	SH	BPH	UH	SH
1	NH 22257 Bt x NH 22254 Bt	1.89	**15.58***	9.89	-1.38	**-18.83****	-4.22	-0.5	11.34	7.43	**-3.39***	1.75	0.88
2	NH 22257 Bt x NH 22294 Bt	-6.41	3.52	-1.57	8	-11.1	4.89	-5.82	5.38	1.68	**-3.25***	1.9	1.03
3	NH 22257 Bt x NH 22308 Bt	-8.46	9.87	4.463	2.63	**-15.52***	-0.32	-4.06	9.14	5.3	-0.45	**4.84****	**3.94***
4	NH 22257 Bt x NH 22384 Bt	0.007	**14.87***	9.21	-9.32	-13.33	2.27	-2.06	9.6	5.75	**-3.25***	1.9	1.03
5	NH 22279 Bt x NH 22254 Bt	3.18	**17.05***	11.28	7.15	-2.37	15.19	-1.22	**12.37***	8.42	-2.37	0.23	-0.62
6	NH 22279 Bt x NH 22294 Bt	-0.62	9.91	4.49	-9.63	**-17.67***	-2.85	-6.88	5.92	2.2	-1.62	0.11	-0.75
7	NH 22279 Bt x NH 22308 Bt	-5.49	13.43	7.84	-6.31	**-14.64***	0.72	4.38	**18.75****	**14.58***	1.29	**4.61****	**3.71***
8	NH 22279 Bt x NH 22384 Bt	-4.91	9.22	3.84	-4.7	-8.91	7.48	-2.52	10.88	6.98	0.59	0.08	-0.77
9	NH 22316 Bt x NH 22254 Bt	2.54	**16.32***	10.59	11.35	**-15.52***	-0.31	8.16	**11.91***	7.97	0.3	2.97	2.09
10	NH 22316 Bt x NH 22294 Bt	9.87	**23.86****	**17.75***	16.99	**-13.87***	1.63	6.6	**17.82****	**13.68***	**-4.27***	-2.59	**-3.42***
11	NH 22316 Bt x NH 22308 Bt	3.19	**23.86****	**17.76***	17.25	-11.16	4.82	3.97	**18.29****	**14.13***	1.77	**5.11****	**4.21***
12	NH 22316 Bt x NH 22384 Bt	2.54	**17.78***	**11.98**	-4.71	-8.92	7.47	2.49	**14.22***	10.21	0	0.98	0.12
13	NH 22340 Bt x NH 22254 Bt	-5.492	**15.59***	9.9	-5	**-17.70***	-2.88	-2.82	11.44	7.53	**-4.83****	-1.26	-2.11
14	NH 22340 Bt x NH 22294 Bt	**-12.37***	7.17	1.89	10.25	-4.48	12.71	-6.84	6.84	3.09	1.05	**4.84****	**3.94***
15	NH 22340 Bt x NH 22308 Bt	-0.61	**21.55****	**15.56***	-6.52	**-19.02****	-4.44	8.92	**24.93****	**20.54****	-0.09	3.65	2.77
16	NH 22340 Bt x NH 22384 Bt	**13.35***	**38.65****	**31.82****	-7	-11.11	4.89	3.65	**18.88****	**14.71***	-1.19	2.51	1.63
17	NH 22482 Bt x NH 22254 Bt	5.8	**26.21****	**19.99****	2.82	**-21.99****	-7.94	**14.46****	**30.74****	**26.15****	0.84	3.52	2.64
18	NH 22482 Bt x NH 22294 Bt	-2.49	**16.31***	10.58	8.46	**-17.84***	-3.05	-4.45	9.14	5.3	0.14	1.9	1.03
19	NH 22482 Bt x NH 22308 Bt	-8.99	9.23	3.85	2.82	**-22.10****	-8.07	-8.86	4.09	0.44	**-4.40****	-1.27	-2.11
20	NH 22482 Bt x NH 22384 Bt	-1.25	**17.78***	11.98	-7	-11.11	4.89	2.44	**17.01****	**12.90***	4.36	**4.47****	**3.57***
	SE±	**1.69**			**0.32**			**1.29**			**1.34**		
	CD at 95%	**3.45**			**0.65**			**2.63**			**7.73**		
	CD at 99%	**4.64**			**0.87**			**3.54**			**3.68**		

*, **- Significant at 5 per cent and 1 per cent level, respectively, UHML- Upper half mean length, MIC- Micronaire value, FS- Fibre strength, UR- Uniformity ratio

Table 3: ANOVA for combining ability analysis for different traits in *Gossypium hirsutum* L.

Source of variation	df	DTF	DTM	PH	NS/P	NB/P	BW	SCY
Replications	**1**	0.27	102.22	0.15	5.92	0.22	0.069	30.24
Genotypes	**28**	**68.81****	**186.13****	**421.73***	**6.44****	**28.1****	**0.40***	**505.48****
Parents	**8**	**43.93***	78.72	**659.85****	**5.90***	**15.35***	0.44	**241.64****
Lines	**4**	25.83	56.33	**721.90****	1.77	15.78	0.33	358.73
Testers	**3**	11.20	23.00	24.00	6.85	5.21	0.36	**740.17***
L vs T	**12**	25.63	29.93	99.56	4.11	**12.14***	0.27	**432.33****
Parent vs Crosses	**1**	**1130.85****	**3928.27****	**2375.23****	**56.26****	**440.30****	**1.94****	**6271.325****
Crosses	**19**	23.40	34.40	218.65	4.05	**11.81***	0.30	**313.11****
Error	**28**	16.20	65.36	180.06	2.41	4.88	0.20	52.99
σ^2GCA		**0.098**	**0.195**	**5.214**	**0.003**	**0.015**	**0.001**	**43.25**
σ^2SCA		**7.342**	**11.779**	**31.252**	**0.562**	**3.908**	**0.024**	**74.57**
σ^2GCA/σ^2SCA		**0.013**	**0.017**	**0.167**	**0.005**	**0.004**	**0.049**	**0.57**

*, **- Significant at 5 per cent and 1 per cent level, respectively, DTF- Days to 50% flowering, DTM- Days to maturity, PH- Plant height, NS/P- Number of sympodia per plant, NB/P- Number of bolls per plant, BW- Boll weight, SCY- Seed cotton yield

Source of variation	df	SI	LI	GOT	UHML	MIC	FS	UR
Replications	**1**	0.03	0.76	20.70	0.40	0.05	0.01	2.61
Genotypes	**28**	**1.84***	**0.92****	**16.44***	**6.80***	**0.23***	**3.47***	**6.54****
Parents	**8**	0.93	**1.09***	**29.38****	5.72	**0.39****	0.81	**6.12****
Lines	**4**	1.53	1.25	**23.56***	9.60	0.14	3.62	1.71
Testers	**3**	0.78	0.009	13.08	6.33	0.15	4.64	6.41
L vs T	**12**	**2.39****	**0.77***	7.57	**6.80***	0.12	**5.08****	**9.00****
Parent vs Crosses	**1**	**6.98****	**2.79****	0.86	5.57	**0.94****	1.38	0.04
Crosses	**19**	**1.96***	**0.75***	11.81	**7.31***	0.13	**4.70****	**7.05****
Error	**28**	0.76	0.35	6.83	2.91	0.10	1.65	1.83
σ^2GCA		**0.091**	**0.009**	**0.186**	**0.022**	**0.001**	**0.016**	**0.085**
σ^2SCA		**0.83**	**0.245**	**0.529**	**1.943**	**0.018**	**1.765**	**3.863**
σ^2GCA/σ^2SCA		**0.11**	**0.037**	**0.351**	**0.012**	**0.028**	**0.009**	**0.022**

*, **- Significant at 5 per cent and 1 per cent level, respectively, SI- Seed index, LI- Lint index, GOT- Ginning outturn, UHML- Upper half mean length, MIC- Micronaire value, FS- Fibre strength, UR- Uniformity ratio

Table 4: General combining ability effect of parents for different characters in *Gossypium hirsutum* L.

S.No.	Genotypes	DTF	DTM	PH	NS/P	NB/P	BW	SCY
GCA of Lines								
1	NH 22257 Bt	-2.27	-4.1	**14.53****	-0.06	-0.62	0.203	0.41
2	NH 22279 Bt	2.6	0.65	2.31	-0.03	**1.87***	0.182	**11.84****
3	NH 22316 Bt	0.6	1.9	-6.59	0.46	0.95	-0.042	-2.01
4	NH 22340 Bt	-0.77	-0.97	-0.22	0.36	**-1.67***	-0.042	**-5.80***
5	NH 22482 Bt	-0.15	2.52	**-10.03***	-0.72	-0.52	-0.302	-4.44
	SE(d) GCA Line	**1.17**	**2.58**	**2.15**	**0.61**	**0.73**	**0.16**	**2.57**
	SE(d) Gi-Gj Line	**1.65**	**3.65**	**3.04**	**0.86**	**1.04**	**0.23**	**3.63**
	CD at 95%	**3.45**	**7.64**	**6.36**	**1.80**	**2.17**	**0.49**	**7.40**
	CD at 99%	**4.73**	**10.45**	**8.70**	**2.47**	**2.97**	**0.44**	**10.01**
GCA of Testers								
6	NH 22254 Bt	-1.4	1.9	2.07	-0.57	-0.20	0.115	-4.32
7	NH 22294 Bt	-0.2	-1.8	-0.44	-0.68	-0.08	-0.275	**-9.13****
8	NH 22308 Bt	1	-0.2	0.1	**1.10***	1.00	0.02	2.9
9	NH 22384 Bt	0.6	0.1	-1.64	0.15	-0.72	0.141	**10.55****
	SE(d) GCA Tester	**1.04**	**2.31**	**1.92**	**0.54**	**0.65**	**0.15**	**2.30**
	SE(d)Gi-Gj Tester	**1.48**	**3.27**	**2.72**	**0.77**	**0.93**	**0.21**	**3.25**
	CD at 95%	**3.09**	**6.83**	**5.69**	**1.61**	**1.94**	**0.44**	**6.63**
	CD at 99%	**4.23**	**9.35**	**7.78**	**2.21**	**2.66**	**0.60**	**8.97**

*, **- Significant at 5 per cent and 1 per cent level, respectively, DTF- Days to 50% flowering, DTM- Days to maturity, PH- Plant height, NS/P- Number of sympodia per plant, NB/P- Number of bolls per plant, BW- Boll weight, SCY- Seed cotton yield

S. No.	Genotypes	SI	LI	GOT	UHML	MIC	FS	UR
GCA of Lines								
1	NH 22257 Bt	0.06	**0.62****	2.54	**-1.31***	-0.04	**-1.03***	0.48
2	NH 22279 Bt	**0.68***	-0.05	-2.04	-0.96	0.14	-0.33	-0.62
3	NH 22316 Bt	-0.18	-0.33	-0.99	0.98	0.07	0.48	-0.32
4	NH 22340 Bt	-0.5	-0.33	0.27	1.05	0.03	0.47	0.35
5	NH 22482 Bt	-0.06	0.1	0.22	0.24	-0.21	0.41	0.12
	SE(d) GCA Line	**0.30**	**0.19**	**1.03**	**0.60**	**0.10**	**0.44**	**0.39**
	SE(d) Gi-Gj Line	**0.42**	**0.26**	**1.46**	**0.85**	**0.14**	**0.62**	**0.56**
	CD at 5%	**0.89**	**0.56**	**3.07**	**1.78**	**0.30**	**1.30**	**1.18**
	CD at 1%	**1.22**	**0.77**	**4.20**	**2.44**	**0.41**	**1.78**	**1.61**
GCA of Testers								
6	NH 22254 Bt	0.35	0.03	-1.46	0.42	-0.06	0.48	-0.47
7	NH 22294 Bt	-0.2	0.008	1.22	-1.02	0.04	**-1.00***	-0.64
8	NH 22308 Bt	-0.25	-0.002	0.47	-0.19	-0.12	0.36	**1.13***
9	NH 22384 Bt	0.1	-0.039	-0.22	0.79	0.15	0.15	-0.02
	SE(d) GCA Tester	**0.27**	**0.17**	**0.92**	**0.54**	**0.09**	**0.39**	**0.35**
	SE(d) Gi-Gj Tester	**0.38**	**0.24**	**1.31**	**0.76**	**0.13**	**0.55**	**0.50**
	CD at 95%	**0.80**	**0.50**	**2.74**	**1.59**	**0.27**	**1.16**	**1.05**
	CD at 99%	**1.09**	**0.68**	**3.75**	**2.18**	**0.37**	**1.59**	**1.44**

*, **- Significant at 5 per cent and 1 per cent level, respectively, SI- Seed index, LI- Lint index, GOT- Ginning outturn, UHML- Upper half mean length, MIC- Micronaire value, FS- Fibre strength, UR- Uniformity ratio

Table 5: Specific Combining ability effects of crosses for different characters in *Gossypium hirsutum* L.

S. No.	Genotypes	DTF	DTM	PH	NS/P	NB/P	BW	SCY
1	NH 22257 Bt x NH 22254 Bt	-0.72	-2.4	4.91	0.53	-0.47	0.1	3.79
2	NH 22257 Bt x NH 22294 Bt	3.07	-0.7	1.9	0.22	-0.59	-0.03	3.29
3	NH 22257 Bt x NH 22308 Bt	-1.12	-2.3	-1.82	-1.78	-2.87	0.37	-9.58
4	NH 22257 Bt x NH 22384 Bt	-1.22	5.4	-5	1.02	**3.94***	-0.44	2.49
5	NH 22279 Bt x NH 22254 Bt	1.9	-4.15	-5.19	0.79	0.92	0.1	**10.92***
6	NH 22279 Bt x NH 22294 Bt	-2.8	-0.45	0.26	0.61	2.60	0.56	4.8
7	NH 22279 Bt x NH 22308 Bt	0	1.45	-6.16	-0.85	-1.07	-0.14	-0.93
8	NH 22279 Bt x NH 22384 Bt	0.9	3.15	**11.09***	-0.54	-2.45	-0.52	**-14.79****
9	NH 22316 Bt x NH 22254 Bt	1.9	-0.4	3.58	-0.40	-0.55	-0.03	0.176
10	NH 22316 Bt x NH 22294 Bt	**-6.8***	0.8	-0.51	-1.12	-2.67	-0.12	-8.36
11	NH 22316 Bt x NH 22308 Bt	2	-2.3	-4.53	-0.25	0.75	0.06	-1.35
12	NH 22316 Bt x NH 22384 Bt	2.9	1.9	1.46	1.78	2.47	0.09	9.5
13	NH 22340 Bt x NH 22254 Bt	-2.25	3.47	-7.78	-1.17	-0.02	-0.13	-10.39
14	NH 22340 Bt x NH 22294 Bt	2.57	0.17	-4.57	0.42	0.15	-0.3	1.49

15	NH 22340 Bt x NH 22308 Bt	-2.62	-0.42	**10.4***	**2.75***	0.47	-0.21	-0.6
16	NH 22340 Bt x NH 22384 Bt	2.27	-3.22	1.95	-2.00	-0.60	**0.65***	9.5
17	NH 22482 Bt x NH 22254 Bt	-0.85	3.47	4.48	0.25	0.12	-0.04	-4.5
18	NH 22482 Bt x NH 22294 Bt	3.95	0.17	2.92	-0.13	0.50	-0.1	-1.23
19	NH 22482 Bt x NH 22308 Bt	1.75	3.57	2.1	0.14	2.72	**-0.7***	**12.48***
20	NH 22482 Bt x NH 22384 Bt	-4.85	-7.22	**-9.51***	-0.26	**-3.35***	0.22	-6.74
	SE(d) Sij	**2.32**	**5.17**	**4.30**	**1.22**	**1.47**	**0.33**	**5.14**
	SE(d) Sij-Skl	**3.30**	**7.31**	**6.08**	**1.72**	**2.08**	**0.47**	**7.27**
	CD at 95%	**6.91**	**15.28**	**12.72**	**3.61**	**4.35**	**0.99**	**14.83**
	CD at 99%	**9.46**	**20.91**	**17.41**	**4.94**	**5.95**	**1.36**	**20.06**

*, **- Significant at 5 per cent and 1 per cent level, respectively, DTF- Days to 50% flowering, DTM- Days to maturity, PH- Plant height, NS/P- Number of sympodia per plant, NB/P- Number of bolls per plant, BW- Boll weight, SCY- Seed cotton yield

S. No.	Genotypes	SI	LI	GOT	UHML	MIC	FS	UR
1	NH 22257 Bt x NH 22254 Bt	0.33	0.53	1.12	0.69	-0.13	0.08	-0.23
2	NH 22257 Bt x NH 22294 Bt	0.13	-0.16	-1.44	-0.77	0.13	0.21	0.07
3	NH 22257 Bt x NH 22308 Bt	0.68	0.27	-0.44	-0.07	0.08	-0.30	0.72
4	NH 22257 Bt x NH 22384 Bt	-1.16	-0.64	0.76	0.15	-0.08	0.01	-0.55
5	NH 22279 Bt x NH 22254 Bt	-0.28	-0.66	-2	0.69	**0.48***	-0.39	-0.38
6	NH 22279 Bt x NH 22294 Bt	-1.23	-0.63	-0.03	0.42	-0.37	-0.37	-0.30
7	NH 22279 Bt x NH 22308 Bt	**1.56***	0.57	-1.15	0.44	-0.05	1.17	1.62
8	NH 22279 Bt x NH 22384 Bt	-0.03	0.72	3.19	-1.56	-0.05	-0.40	-0.95
9	NH 22316 Bt x NH 22254 Bt	-0.16	-0.25	0.41	-1.42	-0.08	-1.31	1.59
10	NH 22316 Bt x NH 22294 Bt	0.63	0.28	1.11	1.84	-0.11	1.51	**-2.82****
11	NH 22316 Bt x NH 22308 Bt	-0.06	0.32	-0.82	1.01	0.18	0.25	**1.74***
12	NH 22316 Bt x NH 22384 Bt	-0.41	-0.32	-0.7	-1.44	0.01	-0.45	-0.51
13	NH 22340 Bt x NH 22254 Bt	0.15	0.46	2.1	-1.67	-0.15	-1.40	**-2.58***
14	NH 22340 Bt x NH 22294 Bt	-0.55	-0.04	0.87	-2.26	0.37	-0.96	**2.62****
15	NH 22340 Bt x NH 22308 Bt	**-1.5***	**-0.93***	0.17	0.39	-0.16	1.77	-0.13
16	NH 22340 Bt x NH 22384 Bt	**1.9****	0.52	-3.15	**3.54****	-0.05	0.60	0.08
17	NH 22482 Bt x NH 22254 Bt	-0.03	0.07	-1.63	1.71	-0.11	**3.03****	1.60
18	NH 22482 Bt x NH 22294 Bt	1.01	0.56	-0.5	0.76	-0.02	-0.38	0.43
19	NH 22482 Bt x NH 22308 Bt	-0.68	-0.23	2.24	-1.78	-0.05	**-2.89****	**-3.95****
20	NH 22482 Bt x NH 22384 Bt	-0.28	-0.25	-0.14	-0.69	0.19	0.24	**1.92***
	SE(d) Sij	**0.60**	**0.38**	**2.07**	**1.20**	**0.20**	**0.88**	**0.79**
	SE(d) Sij-Skl	**0.87**	**0.59**	**2.61**	**1.70**	**0.31**	**1.28**	**1.35**
	CD at 95%	**1.79**	**1.12**	**6.14**	**3.57**	**0.60**	**2.60**	**2.36**
	CD at 99%	**2.45**	**1.54**	**8.40**	**4.88**	**0.83**	**3.56**	**5.23**

*, **- Significant at 5 per cent and 1 per cent level, respectively, SI- Seed index, LI- Lint index, GOT- Ginning outturn, UHML- Upper half mean length, MIC- Micronaire value, FS- Fibre strength, UR- Uniformity ratio

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