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Studies on heterosis and combining ability analysis for yield, yield contributing and fibre quality traits in BT cotton (BG I) (*Gossypium hirsutum* L.)

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Abstract

The present experiment was conducted by using thirty one cotton genotypes along with two standard checks at Cotton research station, Nanded, Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani. The investigation was carried out during *kharif* 2022-23 in randomized block design with two replications. A set of thirty one genotypes were used to estimate heterosis and combining ability for yield, yield contributing and fibre quality traits along with the sucking pest tolerance using Line x Tester mating design. The observations were noted on twenty traits. Yield and yield contributing traits included days to 50% flowering, days to maturity, plant height, number of sympodia per plant, number of bolls per plant, seed cotton yield per plant and boll weight. While economic traits comprised traits i.e. seed index and lint index. Fibre and fibre quality traits included ginning percentage, upper half mean length, micronaire value, fibre strength and fibre uniformity ratio. Experiment also consisted sucking pest tolerance traits i.e. number of jassids per three leaves, number of thrips per three leaves, number of whiteflies per three leaves, number of aphids per three leaves, leaf trichome density and leaf thickness. These traits must be given weightage in selection for improvement of cotton in future breeding programmes.

Keywords: Heterosis, heterobeltiosis, combining ability and trichome density

1. Introduction

Cotton is a member of the Malvaceae family, specifically the *Gossypium* tribe. Currently, *Gossypium* contains 50 species in which only four species are cultivated, namely *Gossypium arboreum*, *Gossypium herbaceum*, *Gossypium hirsutum* and *Gossypium barbadense*. The first two species are diploid ($2n=26$) and belong to the Old World. They are also referred to as Asian cotton because they are grown in Asia. The two remaining species are tetraploid ($2n = 52$) also known as New World cotton. *G. hirsutum* is also known as American cotton or upland cotton, whereas *G. barbadense* is referred to as Egyptian cotton, Sea Island cotton, Peruvian cotton, or quality cotton. *G. hirsutum* is the major species, accounting for around 90% of global production. Perhaps India is the only country in the world where all four cultivated species are grown commercially.

The world's most extensively grown cotton species is *Gossypium hirsutum*, also known as upland cotton or Mexican cotton. *Gossypium hirsutum* is divided into multiple kinds or cross-bred cultivars, each having a different fibre length and tolerance to diverse growth conditions. *G. hirsutum* L. (American cotton) and *G. barbadense* L. (Egyptian cotton) are known for their high fiber quality. *Gossypium hirsutum* accounts for 99.9% of hybrid cotton in India, and all current Bt cotton hybrids are *G. hirsutum* or interspecific hybrids with *G. barbadense*.

2. Materials and Methods

The experimental material constituted thirty one cotton genotypes acquired from Cotton Research Station, Nanded, VNMKV, Parbhani (Table 1). The sowing was done with spacing 120 x 45 for hybrid and 60 x 30 for parents with a plot size of 2.4 x 6 m.sq. The seeds were sown on 16th July, 2022-23 these genotypes were sown in Randomized Block Design with two replications. five competitive plants per genotype in each replication were selected randomly and observations are recorded.

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2.1 Statistical Analysis

The mean values of each genotype were employed for statistical analysis. The combining ability was estimated as per the procedure given by Kempthorne (1957) [5].

ANOVA was calculated by using formula given by Panse and Sukhatme (1961). Line x Tester analysis was carried out as suggested by Arunachalam (1974).

3. Results and Discussion

3.1 Analysis of variance

Analysis of variance for Line x Tester for different traits of cotton genotypes are indicated in table 2. Analysis of variance revealed that all the genotypes differed significantly high for all the characters viz, days to 50 per cent flowering, days to maturity, plant height, number of sympodia per plant, number of bolls per plant, boll weight, seed cotton yield per plant, seed index, lint index, ginning percentage, upper half mean length, fibre fineness/ micronaire, fibre strength, uniformity ratio, number of aphids/3 leaves, number of jassids/3 leaves, number of thrips/ 3 leaves, number of white fly/3 leaves, trichome density, leaf thickness (Table 2). Twenty cross combinations obtained by crossing five lines and four testers into line x tester (L X T) analysis. The significant differences were observed among traits.

3.2 Estimation of heterosis

The genetic characteristics for the characters under study includes standard and better parent heterosis as shown in the Table 3. In the present investigation large differences in mean values for all the traits were observed. Out of twenty crosses, the crosses the crosses showed highest and desirable significant

standard heterosis for various traits viz., cross NH 22397 Bt x NH 22293Bt for days to 50 per cent flowering, NH 22275 Bt x NH 22293 Bt for number of sympodia per plant, NH 22259 Bt x NH 22362 Bt for boll weight, NH 22426 Bt x NH 22498 Bt for lint index, NH 22259 Bt x NH 22362 Bt for upper half mean length, NH 22426 Bt x NH 22498 Bt for fibre fineness, NH 22397 Bt x NH 22293Bt for fibre strength and NH 22259 Bt x NH 22293 Bt for uniformity ratio these were found most superior cross combinations for respective characters. The present findings are in confirmation with results of Ashokkumar *et al.* (2013) [1], Usharani *et al.* (2015) [11], Monicashree *et al.* (2017) [8], Bilwal *et al.* (2018) [2] and Islam *et al.* (2021) [4].

3.3 Estimation of combining ability

Combining ability plays an important role in crop breeding. The knowledge on combining ability will assist the breeder develop a future breeding program to utilize both additive and non-additive components of genetic diversity in the material. Estimation of combining ability were calculated among all characters under investigation (Table 4). Combining ability is the ability of a genotype to pass on desired genotypes to its offspring during the hybridization process.

General combining ability refers to a genotype average performance in a series of cross combinations involving a group of genotypes. It is particular to the collection of lines and the testing environment. Specific combining ability is the performance of a specific cross combination reported as a deviation from the population mean. The present findings are in confirmation with results of Kumar *et al.* (2014) [7], Srinivas *et al.* (2014) [9], Solanke *et al.* (2015) [10] and Kencharaddi *et al.* (2015) [6].

Table 1: Morphological characteristics of parental lines

Sr. No	Genotypes	Character	Source
Male (Testers)			
1	NH 22293 Bt	Short internodes, ground to top bearing	CRS, Nanded
2	NH 22294 Bt	Tall, chain bearing, oval bolls	CRS, Nanded
3	NH 22362 Bt	Extended sympodia, sucking pest tolerance	CRS, Nanded
4	NH 22498 Bt	Big bolls, sucking pest tolerance	CRS, Nanded
Female (lines)			
1	NH 22259 Bt	Semi-tall, chain bearing	CRS, Nanded
2	NH 22266 Bt	Big boll size, chain bearing	CRS, Nanded
3	NH 22275 Bt	Open plant type, elliptical bolls, chain bearing	CRS, Nanded
4	NH 22397 Bt	Big boll size, open plant type	CRS, Nanded
5	NH 22426 Bt	Short internodes, cluster bearing	CRS, Nanded
Checks			
1	Suraj Bt	High yielding	CICR, Nagpur
2	NHH 44 BG II	Chain bearing and sucking pest tolerance	CRS, Nanded

Table 2: Analysis of variance for Randomized Block Design

Source of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height	Number of sympodia/plant	Number of bolls/plant	Boll weight	Seed cotton yield/plant
Mean sum of squares								
Replications	1	2.72	17.56	34.12	5.05	5.60	0.001	146.51
Treatments	30	11.87**	44.31**	44.71*	11.60**	14.71**	0.45**	573.47**
Error	30	4.42	17.86	16.66	1.98	3.75	0.05	37.25

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

Source of variation	d.f.	Seed index	Lint index	Ginning percentage	Upper half mean length	Fibre fineness	Fibre strength	Uniformity ratio
Mean sum of squares								
Replications	1	1.16	0.04	2.79	1.64	0.06	0.37	0.60
Treatments	30	2.16**	0.07**	5.19**	5.22**	0.55**	3.64**	2.16**
Error	30	0.28	0.01	0.72	0.59	0.05	0.09	0.81

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

Table 3a: Percent heterosis over better parent, standard checks for days to 50% flowering and days to maturity.

Sr. No.	Hybrids	Days to 50% flowering			Days to maturity		
		B.P. Heterosis (%)	% standard heterosis over		B.P. Heterosis (%)	% standard heterosis over	
			Suraj Bt	NHH 44 BG II		Suraj Bt	NHH 44 BG II
1	NH 22259 Bt x NH 22293 Bt	-4.20	-9.87 **	-8.05 **	-10.41**	-3.82	-4.94
2	NH 22259 Bt x NH 22294 Bt	-2.10	-7.89 **	-6.04 *	-7.12**	-0.29	-1.45
3	NH 22259 Bt x NH 22362 Bt	-0.70	-6.58 *	-4.70	-6.58**	0.29	-0.87
4	NH 22259 Bt x NH 22498 Bt	-2.10	-7.89 **	-6.04 *	-8.22**	-1.47	-2.62
5	NH 22266 Bt x NH 22293 Bt	-5.37	-7.24 *	-5.37	-7.18**	-1.18	-2.33
6	NH 22266 Bt x NH 22294 Bt	-7.38*	-9.21 **	-7.38 *	-11.05**	-5.29	-6.40 *
7	NH 22266 Bt x NH 22362 Bt	-6.04*	-7.89 **	-6.04 *	-5.80*	0.29	-0.87
8	NH 22266 Bt x NH 22498 Bt	-6.04*	-7.89 **	-6.04 *	-6.91**	-0.88	-2.03
9	NH 22275 Bt x NH 22293 Bt	-3.95	-3.95	-2.01	-5.65*	-1.76	-2.91
10	NH 22275 Bt x NH 22294 Bt	-10.53**	-10.53 **	-8.72 **	-6.50*	-2.65	-3.78
11	NH 22275 Bt x NH 22362 Bt	-3.95	-3.95	-2.01	-2.82	1.18	0.00
12	NH 22275 Bt x NH 22498 Bt	-9.87**	-9.87 **	-8.05 **	-8.47**	-4.71	-5.81 *
13	NH 22397 Bt x NH 22293Bt	-10.00**	-11.18 **	-9.40 **	0.29	0.29	-0.87
14	NH 22397 Bt x NH 22294 Bt	-5.33	-6.58 *	-4.70	0.00	-1.76	-2.91
15	NH 22397 Bt x NH 22362 Bt	-6.00*	-7.24 *	-5.37	1.80	0.00	-1.16
16	NH 22397 Bt x NH 22498 Bt	-8.67**	-9.87 **	-8.05 **	0.00	-1.76	-2.91
17	NH 22426 Bt x NH 22293 Bt	-2.11	-8.55 **	-6.71 *	-0.59	-0.59	-1.74
18	NH 22426 Bt x NH 22294 Bt	1.44	-7.24 *	-5.37	3.01	0.59	-0.58
19	NH 22426 Bt x NH 22362 Bt	3.55	-3.95	-2.01	2.10	0.29	-0.87
20	NH 22426 Bt x NH 22498 Bt	2.92	-7.24 *	-5.37	0.00	-2.94	-4.07
	S.E.±		2.07			4.33	
	CD at 5%		4.34			9.07	
	CD at 1%		5.93			12.4	

*and** indicated significance at 5 and 1 per cent respectively

Table 3b: Percent heterosis over better parent, standard heterosis for plant height and number of sympodia per plant.

Sr. No.	Hybrids	Plant height (cm)			Number of sympodia /plant		
		B.P. Heterosis (%)	% standard heterosis over		B.P. Heterosis (%)	% standard heterosis over	
			Suraj Bt	NHH 44 BG II		Suraj Bt	NHH 44 BG II
1	NH 22259 Bt x NH 22293 Bt	6.56	0.91	-8.64 *	5.63	2.90	-3.33
2	NH 22259 Bt x NH 22294 Bt	-6.56	3.64	-6.17	3.96	10.00	3.33
3	NH 22259 Bt x NH 22362 Bt	-12.30**	-2.73	-11.93 **	24.11*	12.90	6.06
4	NH 22259 Bt x NH 22498Bt	-9.84**	0.00	-9.47 *	20.00*	27.74**	20.00*
5	NH 22266 Bt x NH 22293 Bt	0.00	-0.91	-10.29 **	24.50*	21.29*	13.94
6	NH 22266 Bt x NH 22294 Bt	1.39	-0.45	-9.88 **	11.59	18.06	10.91
7	NH 22266 Bt x NH 22362 Bt	2.27	2.27	-7.41 *	28.57**	16.13	9.09
8	NH 22266 Bt x NH 22498 Bt	-7.59*	-5.91	-14.81 **	16.97	24.52*	16.97
9	NH 22275 Bt x NH 22293 Bt	-6.72	0.91	-8.64 *	44.19**	44.19**	35.45**
10	NH 22275 Bt x NH 22294 Bt	-7.56*	0.00	-9.47 *	31.10**	38.71**	30.30**
11	NH 22275 Bt x NH 22362 Bt	-9.24*	-1.82	-11.11 **	29.68**	29.68**	21.82*
12	NH 22275 Bt x NH 22498 Bt	-5.04	2.73	-7.00	13.94	21.29*	13.94
13	NH 22397 Bt x NH 22293Bt	4.04	5.45	-4.53	41.06**	37.42**	29.09
14	NH 22397 Bt x NH 22294 Bt	-3.14	-1.82	-11.11 **	14.02	20.65*	13.33
15	NH 22397 Bt x NH 22362 Bt	6.28	7.73	-2.47	27.14*	14.84	7.88
16	NH 22397 Bt x NH 22498 Bt	-5.36	-3.64	-12.76 **	3.03	9.68	3.03
17	NH 22426 Bt x NH 22293 Bt	-11.02**	-4.55	-13.58 **	22.52*	19.35*	12.12
18	NH 22426 Bt x NH 22294 Bt	-6.78	0.00	-9.47 *	22.56*	29.68**	21.82*
19	NH 22426 Bt x NH 22362 Bt	-0.42	6.82	-3.29	34.25**	26.45**	18.79*
20	NH 22426 Bt x NH 22498 Bt	-5.93	0.91	-8.64 *	12.12	19.35*	12.12
	S.E.±		4.10			1.40	
	CD at 5%		8.58			2.94	

*and** indicated significance at 5 and 1 per cent respectively

Table 3c: Percent heterosis over better parent, standard heterosis for number of bolls per plant and boll weight

Sr.no.	Hybrids	Number of bolls/plant			Boll weight (g)		
		B.P. Heterosis (%)	% Standard heterosis over		B.P. Heterosis (%)	% Standard heterosis over	
			Suraj Bt	NHH 44 BG II		Suraj Bt	NHH 44 BG II
1	NH 22259 Bt x NH 22293 Bt	6.46	9.61	2.53	9.21	20.29 **	12.16
2	NH 22259 Bt x NH 22294 Bt	5.26	8.37	1.38	11.54	26.09 **	17.57 **
3	NH 22259 Bt x NH 22362 Bt	2.58	7.64	0.69	42.14**	44.20 **	34.46 **
4	NH 22259 Bt x NH 22498 Bt	26.32**	30.05**	21.66*	18.57**	20.29 **	12.16
5	NH 22266 Bt x NH 22293 Bt	14.66	7.88	0.92	17.11**	28.99 **	20.27 **
6	NH 22266 Bt x NH 22294 Bt	-4.43	-4.43	-10.6	10.26	24.64 **	16.22 *
7	NH 22266 Bt x NH 22362 Bt	7.98	13.30	5.99	32.61**	32.61 **	23.65 **
8	NH 22266 Bt x NH 22498 Bt	31.55**	33.50**	24.88*	10.00	11.59	4.05
9	NH 22275 Bt x NH 22293 Bt	13.03	4.68	-2.07	1.32	11.59	4.05
10	NH 22275 Bt x NH 22294 Bt	4.93	4.93	-1.84	-8.97	2.90	-4.05
11	NH 22275 Bt x NH 22362 Bt	1.64	6.65	-0.23	26.09**	26.09 **	17.57 **
12	NH 22275 Bt x NH 22498 Bt	14.08	15.76	8.29	-7.14	-5.80	-12.16
13	NH 22397 Bt x NH 22293 Bt	2.39	-5.17	-11.29	-13.82*	-5.07	-11.49
14	NH 22397 Bt x NH 22294 Bt	4.43	4.43	-2.30	-16.03**	-5.07	-11.49
15	NH 22397 Bt x NH 22362 Bt	-1.41	3.45	-3.23	-14.38*	-9.42	-15.54 *
16	NH 22397 Bt x NH 22498 Bt	1.46	2.96	-3.69	5.48	11.59	4.05
17	NH 22426 Bt x NH 22293 Bt	23.94*	14.78	7.37	-4.61	5.07	-2.03
18	NH 22426 Bt x NH 22294 Bt	31.53**	31.53**	23.04*	-15.38*	-4.35	-10.81
19	NH 22426 Bt x NH 22362 Bt	30.52**	36.95**	28.11**	30.28**	34.06 **	25.00 **
20	NH 22426 Bt x NH 22498 Bt	22.33*	24.14*	16.13	1.41	4.35	-2.70
	S.E.±		1.99			0.22	
	CD at 5%		4.18			0.47	
	CD at 1%		5.72			0.64	

*and** indicated significance at 5 and 1 per cent respectively

Table 3d: Percent heterosis over better parent, standard heterosis for seed cotton yield per plant and seed index

Sr. No.	Hybrids	Seed cotton yield/plant (g)			Seed index (g)		
		B.P. Heterosis (%)	% Standard heterosis over		B.P. Heterosis (%)	% Standard heterosis over	
			Suraj Bt	NHH 44 BG II		Suraj Bt	NHH 44 BG II
1	NH 22259 Bt x NH 22293 Bt	-9.55	16.35	2.19	33.95**	30.72**	33.13**
2	NH 22259 Bt x NH 22294 Bt	30.97**	68.47 **	47.96 **	28.07**	31.93**	34.36**
3	NH 22259 Bt x NH 22362 Bt	18.65*	52.63 **	34.05 **	20.71**	22.89**	25.15**
4	NH 22259 Bt x NH 22498 Bt	10.07	41.58 **	24.35 **	26.28**	18.67**	20.86**
5	NH 22266 Bt x NH 22293 Bt	50.76**	81.42 **	59.33 **	20.48**	20.48**	22.70**
6	NH 22266 Bt x NH 22294 Bt	11.08	33.66 **	17.39 *	8.77	12.05	14.11*
7	NH 22266 Bt x NH 22362 Bt	24.16**	49.50 **	31.30 **	13.61*	15.66**	17.79*
8	NH 22266 Bt x NH 22498 Bt	13.15	41.51 **	24.28 **	5.42	5.42	7.36
9	NH 22275 Bt x NH 22293 Bt	88.24**	90.10 **	66.96 **	26.54**	23.49**	25.77**
10	NH 22275 Bt x NH 22294 Bt	41.56**	68.62 **	48.09 **	8.19	11.45	13.50
11	NH 22275 Bt x NH 22362 Bt	13.41	36.56 **	19.93 *	21.30**	23.49**	25.77**
12	NH 22275 Bt x NH 22498 Bt	0.61	25.82 *	10.50	32.08**	26.51**	28.83**
13	NH 22397 Bt x NH 22293Bt	46.69**	36.86 **	20.20 *	23.78**	22.29**	24.54**
14	NH 22397 Bt x NH 22294 Bt	6.20	26.50 *	11.10	24.56**	28.31**	30.67**
15	NH 22397 Bt x NH 22362 Bt	-1.71	18.35	3.95	17.75**	19.88**	22.09**
16	NH 22397 Bt x NH 22498 Bt	-7.90	15.17	1.15	18.90**	17.47*	19.63**
17	NH 22426 Bt x NH 22293 Bt	78.87**	64.43 **	44.41 **	14.81*	12.05	14.11*
18	NH 22426 Bt x NH 22294 Bt	21.04*	44.17 **	26.62 **	14.62*	18.07*	20.25**
19	NH 22426 Bt x NH 22362 Bt	24.10**	49.43 **	31.24 **	27.81**	30.12**	32.52**
20	NH 22426 Bt x NH 22498 Bt	14.19	42.80 **	25.42 **	20.51**	13.25	15.34*
	S.E.±		6.16			0.53	
	CD at 5%		12.89			1.11	
	CD at 1%		17.62			1.52	

*and** indicated significance at 5 and 1 per cent respectively

Table 3e: Percent heterosis over better parent, standard heterosis for lint index and ginning percentage

Sr.no.	Hybrids	Lint index (g)			Ginning percentage (%)		
		B.P. Heterosis (%)	% Standard heterosis over		B.P. Heterosis (%)	% Standard heterosis over	
			Suraj Bt	NHH 44 BG II		Suraj Bt	NHH 44 BG II
1	NH 22259 Bt x NH 22293 Bt	8.10*	4.91	2.89	1.33	-6.07 *	-3.38
2	NH 22259 Bt x NH 22294 Bt	4.37	5.65	3.61	0.16	-3.10	-0.32
3	NH 22259 Bt x NH 22362 Bt	5.44	2.33	0.36	0.76	-4.29	-1.55
4	NH 22259 Bt x NH 22498 Bt	2.66	4.42	2.41	0.38	-6.80 **	-4.13
5	NH 22266 Bt x NH 22293 Bt	8.92*	1.97	0.00	-2.53	-9.64 **	-7.06 **
6	NH 22266 Bt x NH 22294 Bt	1.94	3.19	1.20	5.13*	1.71	4.62
7	NH 22266 Bt x NH 22362 Bt	6.38	2.46	0.48	8.61**	3.17	6.12 *
8	NH 22266 Bt x NH 22498 Bt	-4.11	-2.46	-4.34	9.77**	1.93	4.84 *
9	NH 22275 Bt x NH 22293 Bt	2.91	4.42	2.41	-6.10*	-10.93 **	-8.38 **
10	NH 22275 Bt x NH 22294 Bt	9.56**	11.18 **	9.04 **	-0.47	-3.70	-0.95
11	NH 22275 Bt x NH 22362 Bt	-1.21	0.25	-1.69	6.48**	1.15	4.04
12	NH 22275 Bt x NH 22498 Bt	2.78	4.55	2.53	-4.64*	-9.54 **	-6.95 **
13	NH 22397 Bt x NH 22293Bt	0.74	0.98	-0.96	-2.56	-9.35 **	-6.76 **
14	NH 22397 Bt x NH 22294 Bt	1.21	2.46	0.48	5.02*	1.61	4.52
15	NH 22397 Bt x NH 22362 Bt	3.43	3.69	1.69	3.15	-2.01	0.79
16	NH 22397 Bt x NH 22498 Bt	-7.49*	-5.9	-7.71 *	2.94	-4.24	-1.50
17	NH 22426 Bt x NH 22293 Bt	0.00	-1.23	-3.13	3.76	-1.77	1.04
18	NH 22426 Bt x NH 22294 Bt	2.91	4.18	2.17	4.97*	1.56	4.47
19	NH 22426 Bt x NH 22362 Bt	8.21*	6.88 *	4.82	5.51*	0.23	3.09
20	NH 22426 Bt x NH 22498 Bt	12.32**	14.25 **	12.05 **	6.65**	0.96	3.85
	S.E.±		0.12			0.87	
	CD at 5%		0.27			1.82	
	CD at 1%		0.37			2.49	

*and** indicated significance at 5 and 1 per cent respectively

Table 3f: Percent heterosis over better parent, standard heterosis for upper half mean length and fibre fineness.

Sr. No.	Hybrids	Upper half mean length (mm)			Fibre fineness (µg/inch)		
		B.P. Heterosis (%)	% Standard heterosis over		B.P. Heterosis (%)	% Standard heterosis over	
			Suraj Bt	NHH 44 BG II		Suraj Bt	NHH 44 BG II
1	NH 22259 Bt x NH 22293 Bt	-5.06*	22.45 **	13.64 **	15.28*	12.16	-15.31 **
2	NH 22259 Bt x NH 22294 Bt	-8.23**	18.37 **	9.85 **	22.97**	22.97 **	-7.14
3	NH 22259 Bt x NH 22362 Bt	-2.53	25.71 **	16.67 **	-2.44	8.11	-18.37 **
4	NH 22259 Bt x NH 22498 Bt	-5.70*	21.63 **	12.88 **	-12.00	18.92 **	-10.20
5	NH 22266 Bt x NH 22293 Bt	4.98	11.63 **	3.60	-21.11**	-4.05	-27.55 **
6	NH 22266 Bt x NH 22294 Bt	8.98**	13.88 **	5.68	6.67	29.73 **	-2.04
7	NH 22266 Bt x NH 22362 Bt	-3.11	7.96 *	0.19	-2.22	18.92 **	-10.20
8	NH 22266 Bt x NH 22498 Bt	-0.75	8.37 *	0.57	-6.00	27.03 **	-4.08
9	NH 22275 Bt x NH 22293 Bt	6.16*	-1.63	-8.71 **	-2.38	10.81	-16.33 **
10	NH 22275 Bt x NH 22294 Bt	1.45	14.29 **	6.06	0.00	13.51	-14.29 **
11	NH 22275 Bt x NH 22362 Bt	2.17	15.10 **	6.82 *	-4.76	8.11	-18.37 **
12	NH 22275 Bt x NH 22498 Bt	2.90	15.71 **	7.39 *	-8.00	24.32 **	-6.12
13	NH 22397 Bt x NH 22293Bt	13.79**	4.08	-3.41	-28.26**	-10.81	-32.65 **
14	NH 22397 Bt x NH 22294 Bt	10.98**	15.31 **	7.01 *	-23.91**	-5.41	-28.57 **
15	NH 22397 Bt x NH 22362 Bt	0.91	12.45 **	4.36	-15.22**	5.41	-20.41 **
16	NH 22397 Bt x NH 22498 Bt	7.46*	17.35 **	8.90 **	-14.00**	16.22 *	-12.24 *
17	NH 22426 Bt x NH 22293 Bt	8.05*	14.90 **	6.63 *	4.26	32.43 **	0.00
18	NH 22426 Bt x NH 22294 Bt	8.25**	14.90 **	6.63 *	3.19	31.08 **	-1.02
19	NH 22426 Bt x NH 22362 Bt	-1.28	10.20 **	2.27	2.13	29.73 **	-2.04
20	NH 22426 Bt x NH 22498 Bt	1.49	10.82 **	2.84	4.00	40.54 **	6.12
	S.E.±		0.77			0.24	
	CD at 5%		1.62			0.50	
	CD at 1%		2.22			0.68	

*and** indicated significance at 5 and 1 per cent respectively

Table 4: Estimation of general combining ability (GCA) for lines

Line	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of sympodia/plant	Number of bolls/plant	Boll weight (g)	Seed cotton yield/plant (g)	Seed index (g)
NH 22259 Bt	-0.25	-0.03	-0.03	-1.37*	0.28	0.48**	-0.29	0.48*
NH 22266 Bt	-0.25	-0.78	-1.90	-0.35	0.00	0.37**	4.15	-0.57**
NH 22275 Bt	0.50	-1.15	-0.03	1.74**	-0.92	-0.17*	6.62**	0.08
NH 22397 Bt	-0.75	0.85	1.60	-0.25	-2.26**	-0.54**	-13.77**	0.15
NH 22426 Bt	0.72	1.10	0.35	0.23	2.90**	-0.14	3.29	-0.15
S.E. (G _i - G _j)Line	1.03	2.36	2.06	0.75	1.06	0.13	2.86	0.32
S.E. GCA Line	0.72	1.67	1.46	0.53	0.75	0.09	2.02	0.22
CD at 5%	2.15	4.94	4.32	1.56	2.23	0.27	5.99	0.66
CD at 1%	2.93	6.75	5.90	2.13	3.04	0.37	8.19	0.91

Line	Line index (g)	Ginning percentage (%)	Upper half mean length (mm)	Fibre fineness (µg/in)	Fibre strength (g/tex)	Uniformity ratio (%)	Seed cotton yield/plant (g)	Seed index (g)
NH 22259 Bt	0.04	-0.84*	2.05**	-0.04	1.10**	0.48	4.15	-0.57**
NH 22266 Bt	-0.09	0.89**	-0.79**	0.05	-1.12**	-0.32	6.62**	0.08
NH 22275 Bt	0.07	-1.11**	-0.69*	-0.09	0.38**	0.2	-13.77**	0.15
NH 22397 Bt	-0.13*	-0.22	-0.34	-0.56**	0.59**	-0.82*	3.29	-0.15
NH 22426 Bt	0.11*	1.27**	-0.24	0.63**	-0.95**	0.45	2.86	0.32
S.E. (G _i - G _j)Line	0.08	0.51	0.38	0.14	0.17	0.40	2.02	0.22
S.E. GCA Line	0.05	0.36	0.27	0.10	0.12	0.28	5.99	0.66
CD at 5%	0.16	1.07	0.79	0.28	0.36	0.83	8.19	0.91

*and ** indicated significance at 5 and 1 per cent respectively.

4. Conclusion

Based on mean performance, female line NH 22426 Bt, while male parent (tester) NH 22498 Bt and cross NH 22397 Bt x NH 22293Bt were found best for days to 50 per cent flowering. The hybrids NH 22266 Bt x NH 22293 Bt, NH 22275 Bt x NH 22362 Bt and NH 22275 Bt x NH 22293 Bt were found most heterotic for seed cotton yield per plant and yield contributing characters. The hybrids NH 22266 Bt x NH 22362 Bt, NH 22259 Bt x NH 22362 Bt, NH 22397 Bt x NH 22293Bt and NH 22259 Bt x NH 22293 Bt were found most heterotic for fibre quality traits. The crosses NH 22397 Bt x NH 22362 Bt, NH 22275 Bt x NH 22293 Bt and NH 22426 Bt x NH 22362 Bt were found most heterotic over standard checks for yield and yield contributing characters. The parental lines NH 22275 Bt, NH 22293 Bt, NH 22362 Bt and NH 22426 Bt were found good general combiners for seed cotton yield per plant and other yield contributing characters.

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