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COMBINING ABILITY AND GENE ACTION ANALYSIS IN INTRASPECIFIC HYBRIDS OF COTTON (*GOSSYPIUM HIRSUTUM* L.)

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ABSTRACT

This study aimed to determine the general combining ability of the parents and the specific combining ability of hybrids and gene action for various traits of cotton (*Gossypium hirsutum* L.). The crossing programme was conducted during *Kharif* 2020-21 at Main Cotton Research Station, Na*vs*ari Agricultural University, Surat, Gujarat, India. The experimental material consisted of thirteen parents (3 females and 10 males) and their thirty resulting crosses with a control GN. Cot. Hy-18 was evaluated in a randomized block design with three replications by using line × tester analysis. Among parents, GSHV-01/1338 was a good general combiner bolls per plant and ginning outturn. GISV-323 was a good general combiner for boll weight, seed index, fiber strength, protein content and phenol content. ARBC-1351 was a good general combiner for sympodia per plant, bolls per plant, seed cotton yield per plant and oil content. The crosses GISV-323 × G. Cot-16 and GJHV-566 × GISV-216 were promising hybrids having high SCA effects for seed cotton yield per plant. The ratio of σ²gca /σ²sca is less than unity for all traits except for sympodia per plant, bolls per plant and boll weight which indicated the preponderance of non-additive gene action in the inheritance of those traits.

Key words : Seed cotton yield, General combining ability, Specific combining ability, Gene action

Introduction

Cotton is one of the most important cash crops and accounts for approximately 21% of the total global fiber production. It is also known as the "King of Fiber Crop" and "White Gold". *Gossypium arboreum*, *Gossypium herbaceum*, *Gossypium hirsutum* and *Gossypium barbadense* are widely cultivated species among the fifty cultivated species of cotton. The leading cotton-producing country is China (6684'000 MT) followed by India (5661'000 MT) and the United States (3150'000MT). The consumption of cotton is approximately 316 lakh bales (170 kg each) per year. India occupies the first position in the world in cotton acreage with around 119.10 lakh hectares under cotton cultivation, which is around 36% of the world area of 326.36 lakh hectares. India is the 3rd largest exporter with a share of 4.6% of Textiles and Apparel in the world. During 2021-22, India's productivity was around 445 kg/ha. India has emerged as one of the largest producers, consumers and exporters of cotton in the World (2022-23).

The selection of parents for a hybridization programme is an important step in the improvement of the genetic makeup of any crop. Every effective breeding programme must begin with a proper selection of parents based on their combining ability. Such studies reveal information on parental selection and identify the kind and magnitude of gene action involved in the inheritance of economic traits. The combining ability analysis was performed to obtain the information for the identification of better parents for use in the hybridization programme and cross combinations for the exploitation of commercial hybrids. The information about the nature and magnitude

of gene action is useful in determining breeding strategies for exploiting fixable (additive) and non-fixable (non-additive) genetic variations. Line × Tester analysis is the simple method for the identification of parents and superior hybrids by GCA and SCA, respectively.

Materials and Methods

The experimental materials comprised of thirteen diverse genotypes of cotton in which three lines (females) *viz.*, GSHV-01/1338, GJHV-566, GISV-323 were crossed with ten testers (males) *viz.*, ARBC-1351, Phule Yamuna, GSHV 213, TCH-1716, H-1452, BS-27, H 401/2014, GISV-216, G. Cot-16, DELTA-15 of *Gossypium hirsutum* L. Thus, thirty crosses were obtained along with parental genotypes and one standard check (GN. Cot. Hy-18) was evaluated at Main Cotton Research Station, Navsari Agricultural University, Surat during *kharif* 2021 to determine general combining ability of the parents and specific combining ability of hybrids for different traits *viz.*, plant height (cm), days to 50% flowering, sympodia per plant, bolls per plant, boll weight (g), seed cotton yield per plant (g), ginning outturn (%), seed index (g), fiber length (mm), fiber strength (g/tex), fiber fineness (mv), oil content (%), gossypol content (%), protein content (%) and phenol content (%).

The experimental plot-wise mean values of five randomly selected plants were used in each statistical analysis. Analysis of variance was carried out to test the significance of each character as per the methodology suggested by Panse and Sukhatme (1985). The variation among the hybrids was partitioned further into sources attributable to general and specific combining ability components by the procedure suggested by Kempthorne (1957).

Results and Discussion

The analysis of variance showed highly significant differences among the genotypes for all the traits, indicating that considerable variability was observed among experimental material. Analysis of variance showing the mean sum of squares for fifteen quantitative traits is presented in Table 1. The genotypic variance was further partitioned into parents, hybrids and parents *vs* hybrids. The differences among parents are highly significant for all traits under investigation except sympodia per plant, bolls per plant, seed cotton yield per plant (g) and protein content (%). Hybrids were also found to be highly significant for all traits except sympodia per plant. Differences due to parents *vs* hybrids were also

Table 1 : Analysis of variance for experimental design for different traits in cotton.

Source of variation	df	Plant height (cm)	Days to 50% flowering	Sympodia per plant	Bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)	Ginning outturn (%)
Replications	2	85.90	8.85	26.44*	323.54	0.46**	1689.65	2.74
Treatments	42	956.36**	13.43**	11.30	683.73**	0.72**	8724.60**	9.86**
Parents	12	1726.66**	10.92*	12.11	232.01	0.96**	3211.23	13.39**
Parents *vs* Crosses	1	6124.53**	118.91**	7.13	15689.96**	2.35**	191987.27**	99.12**
Crosses	29	459.41**	10.83**	11.11	353.19**	0.56**	4686.60**	5.32**
Error	84	183.51	4.55	8.40	124.98	0.07	2021.66	1.37

Source of variation	df	Seed index (g)	Fiber length (mm)	Fiber strength (g/tex)	Fiber fineness (mv)	Oil content (%)	Gossypol content (%)	Protein content (%)	Phenol content (%)
Replications	2	0.03	7.65**	38.85**	1.81**	0.06	0.00**	11.27**	0.01**
Treatments	42	3.07**	1.64**	1.31**	0.3**	17.46**	0.00**	16.05**	0.02**
Parents	12	1.48**	1.44*	2.16**	0.53**	10.08**	0.01**	2.93	0.00**
Parents *vs* Crosses	1	1.81**	6.26**	0.13	0.04	20.32**	0.03**	30.97**	0.00
Crosses	29	3.77**	1.57**	1.00**	0.21**	20.41**	0.00**	20.97**	0.03**
Error	84	0.06	0.76	0.42	0.07	0.55	0.00	1.86	0.00

* and ** indicate significance at 5% and 1% levels of probability, respectively.

Table 2 : Analysis of variance for combining ability and variance components for different traits in cotton.

Source of variation	df	Plant height (cm)	Days to 50% flowering	Sympodia per plant	Bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)	Ginning outturn (%)
Replications	2	23.91	3.63	19.62	169.33	0.15	1625.38	6.10 *
Crosses	29	459.41 **	10.83 *	11.11	353.19 **	0.56 **	4686.60 **	5.32**
Error	58	193.90	5.56	8.47	106.06	0.06	2099.54	1.33
Variance components								
σ²gca		14.71*	0.79**	0.40**	34.96**	0.11**	78.17	0.50**
σ²sca		28.87	1.40*	-0.31	32.50	0.02	820.09*	0.80**
σ²gca/σ²sca		0.51	0.57	1.31	1.08	7.07	0.09	0.62

Source	df	Seed index (g)	Fiber length (mm)	Fiber strength (g/tex)	Fiber fineness (mv)	Oil content (%)	Gossypol content (%)	Protein content (%)	Phenol content (%)
Replications	2	0.01	5.84**	23.69**	1.72**	0.61	0.0038**	7.09*	0.01**
Crosses	29	3.77**	1.57**	1.00*	0.21**	20.41**	0.0016**	20.97**	0.03**
Error	58	0.03	0.74	0.52	0.05	0.43	0.0001	1.91	0.00
Variance components									
σ²gca		0.32**	0.09*	0.07**	0.01	0.69	0.0000	2.34**	0.00*
σ²sca		0.91**	0.09	0.08	0.05**	6.19**	0.0006**	3.72**	0.01**
σ²gca/σ²sca		0.36	0.10	0.84	0.17	0.11	0.0613	0.63	0.20

* and ** indicate significance at 5% and 1% levels of probability, respectively.

found significant for all the traits under study except for sympodia per plant, fiber strength (g/tex), fiber fineness (mv) and phenol content (%).

The estimates of σ²gca were significant for all the traits except seed cotton yield per plant, fiber fineness, oil content and gossypol content (Table 2). The significant values for gca variances were also noted by Vaid *et al.* (2022) for days to 50% flowering, boll weight, ginning outturn, seed index, fiber length and fiber strength, Roy *et al.* (2018) for bolls per plant, boll weight, ginning outturn and seed index. The estimates of σ²sca were significant for seed cotton yield per plant, ginning outturn, seed index, fiber fineness, oil content, gossypol content, protein content and phenol content. The ratio of σ²gca /σ²sca revealed that all the traits manifested values less than unity except sympodia per plant, bolls per plant and boll weight indicating a preponderance of additive gene effects for these traits. For other traits *viz.*, plant height, days to 50% flowering, seed cotton yield per plant, ginning outturn, seed index, fiber length, fiber strength, fiber fineness, oil content, gossypol content, protein content and phenol content having higher SCA variance than their respective GCA variance which indicated the preponderance of non-additive gene action in the inheritance of these traits. Similar results have been reported by Sawarkar *et al.* (2015), Usharani *et al.* (2016) Monicashree *et al.* (2017)

and Vaid *et al.* (2022).

General combing ability

Among three lines and ten testers, none of the parents were good general combiners for all the traits under study (Table 3). Among parents, GSHV-01/1338 was a good general combiner for bolls per plant and ginning outturn. GISV-323 was a good general combiner for boll weight, seed index, fiber strength, protein content and phenol content. ARBC-1351 was a good general combiner for sympodia per plant, bolls per plant, seed cotton yield per plant and oil content. GSHV-213 was a good general combiner for plant height, seed index, oil content and gossypol content. H-1452 was a good general combiner for oil content. TCH-1716 was a good general combiner for seed index, gossypol and protein content. GISV-216 had good general combining ability for seed index. Phule Yamuna was a good general combiner for fiber strength, oil and protein content. BS-27 was a good general combiner for boll weight, seed index, fiber length and oil content. H 401/2014 was a good general combiner for days to 50% flowering, ginning outturn, gossypol, protein and phenol content. G. Cot-16 was a good general combiner for ginning outturn and phenol content. None of the parents was a good general combiner for fiber fineness. Similar results have been reported by Bilwal *et al.* (2018), Bandhavi *et al.* (2019), Mudhalvan *et al.*

Table 3 : General combining ability effect of parents for different traits in cotton.

S. no.	Parents	Plant height (cm)	Days to 50% flowering	Sympodia per plant	Bolls per plant	Boll weight (g)	Seed cotton yield per plant(g)	Ginning outturn (%)
Lines								
1	GSHV-01/1338	0.14	-0.46	0.76	5.75**	-0.36**	-2.32	0.63**
2	GJHV-566	0.09	1.33**	-0.62	0.94	0.03	7.23	-0.80**
3	GISV-323	-0.23	-0.66	-0.13	-6.69**	0.33**	-4.91	0.16
	SE(g$_i$)	2.47	0.38	0.52	2.04	0.05	8.20	0.21
Testers								
1	ARBC-1351	6.56	-1.01	2.63**	11.97**	-0.07	45.15**	0.43
2	GSHV-213	13.50**	1.65*	1.09	4.93	0.15	29.13	0.12
3	H-1452	1.22	0.21	0.39	3.68	-0.25**	0.06	-0.07
4	DELTA-15	-1.27	1.54*	-1.19	-3.27	-0.15	-25.58	-0.48
5	TCH-1716	-0.88	0.43	-1.45	-7.59*	-0.02	-28.04	-0.89*
6	GISV-216	-11.88*	-1.01	-1.69	-7.09	0.12	-24.84	0.58
7	Phule Yamuna	-1.49	0.32	-0.30	0.09	-0.28**	-21.93	-0.37
8	BS-27	-21.16**	0.10	-1.14	-9.85*	0.66**	-1.06	-1.41**
9	H401/2014	8.22	-1.78*	0.96	1.59	0.14	19.41	1.26**
10	G. Cot -16	7.17	-0.45	0.69	5.53	-0.30**	7.70	0.83*
	SE(g$_j$)	4.51	0.71	0.96	3.72	0.09	14.98	0.39

* and ** indicate significance at 5% and 1% levels of probability, respectively.

Table 3 continues…

S. no.	Parents	Seed index (g)	Fiber length (mm)	Fiber strength (g/tex)	Fiber fineness (mv)	Oil content (%)	Gossypol content (%)	Protein content (%)	Phenol content (%)
Lines									
1	GSHV-01/1338	-0.54**	-0.26	-0.00	-0.06	0.00	-0.00	-1.58**	-0.02**
2	GJHV-566	0.06	-0.05	-0.26*	0.10*	-0.13	0.00	0.14	-0.01**
3	GISV-323	0.47**	0.31	0.27*	-0.04	0.12	0.00	1.43**	0.03**
	SE(g$_i$)	0.04	0.15	0.11	0.04	0.13	0.00	0.24	0.00
Testers									
1	ARBC-1351	-0.87**	-0.07	-0.02	-0.16	0.65*	-0.00	-1.11*	-0.03**
2	GSHV-213	0.79**	0.10	-0.06	0.09	1.08**	-0.01**	-1.17*	0.00
3	H-1452	-0.44**	-0.82**	0.40	-0.05	0.64*	0.00	-1.64**	0.14**
4	DELTA-15	-0.38**	0.01	-0.02	-0.01	-2.13**	-0.00	-1.22**	-0.05**
5	TCH-1716	0.28**	-0.20	-0.43	-0.00	-0.03	-0.01**	1.92**	-0.09**
6	GISV-216	0.69**	-0.20	-0.13	0.26**	-0.67**	-0.00	-0.48	-0.03**
7	Phule Yamuna	-0.40**	0.30	0.87**	-0.17	2.73**	-0.00	1.37**	-0.01*
8	BS-27	1.31**	1.06**	0.04	-0.03	1.47**	-0.01**	0.46	-0.01
9	H401/2014	-0.21**	-0.54	-0.13	0.22*	-0.49	-0.01*	3.35**	0.03**
10	G. Cot -16	-0.76**	0.36	-0.51*	-0.13	-3.24**	0.02**	-1.46**	0.07**
	SE(g$_j$)	0.08	0.29	0.21	0.09	0.24	0.00	0.45	0.00

* and ** indicate significance at 5% and 1% levels of probability, respectively.

(2021) and Parmar *et al.* (2023).

Specific combining ability

The cross GSHV-01/1338 × GSHV-213 for Days to 50% flowering, GISV-323 × G. Cot-16 and GJHV-566 × GISV-216 for seed cotton yield per plant, GJHV-566 × DELTA-15 for Ginning outturn, GSHV-01/1338 × ARBC-1351, GSHV-01/1338 × Phule Yamuna, GJHV-566 ×

Table 4 : Specific combining ability effect of crosses for different traits in cotton.

S. no.	Crosses	Plant height (cm)	Days to 50% flowering	Sympodia per plant	Bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)	Ginning outturn (%)
1	GSHV-01/1338 × ARBC-1351	-4.97	0.91	1.25	4.41	0.27	34.35	-0.54
2	GSHV-01/1338 × GSHV-213	-7.75	-2.75*	-0.84	-9.84	0.01	-42.12	0.08
3	GSHV-01/1338 × H-1452	-0.81	1.02	1.02	-2.53	-0.04	-14.99	0.80
4	GSHV-01/1338 × DELTA-15	-0.47	0.35	0.03	3.75	-0.17	-4.06	0.42
5	GSHV-01/1338 × TCH-1716	9.30	-0.20	0.58	7.71	0.10	38.38	1.27
6	GSHV-01/1338 × GISV-216	2.96	-0.42	0.31	9.53	-0.37*	20.46	0.03
7	GSHV-01/1338 × Phule Yamuna	11.24	0.24	1.36	-3.47	0.21	0.34	-0.68
8	GSHV-01/1338 × BS-27	-5.75	-1.20	-0.46	-1.35	0.15	15.85	-1.32
9	GSHV-01/1338 × H 401/2014	2.18	1.68	-1.74	1.74	0.00	3.71	-0.52
10	GSHV-01/1338 × G. Cot-16	-5.92	0.35	-1.54	-9.95	-0.15	-51.93	0.45
11	GJHV-566 × ARBC-1351	-10.59	-0.68	-0.99	-6.77	-0.24	-44.36	0.50
12	GJHV-566 × GSHV-213	7.46	1.64	-1.38	11.24	0.00	47.76	0.49
13	GJHV-566 × H-1452	-1.92	1.42	1.53	1.85	-0.07	0.72	0.38
14	GJHV-566 × DELTA-15	-10.09	0.08	0.07	-9.21	0.26	-21.12	1.35*
15	GJHV-566 × TCH-1716	1.18	0.20	0.34	-3.30	0.06	-9.77	-1.80*
16	GJHV-566 × GISV-216	6.35	1.97	-0.29	8.82	0.21	53.69*	-1.10
17	GJHV-566 × Phule Yamuna	-5.37	-2.35	1.28	-3.74	0.02	-19.87	-0.18

* and ** indicate significance at 5% and 1% levels of probability, respectively.

Table 4 continues….

S. no.	Crosses	Plant height (cm)	Days to 50% flowering	Sympodia per plant	Bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)	Ginning outturn (%)
18	GJHV-566 × BS-27	6.29	-0.80	-0.34	2.23	-0.17	-2.36	1.04
19	GJHV-566 × H 401/2014	8.73	-0.24	-0.06	-0.39	-0.07	-2.78	0.45
20	GJHV-566 × G. Cot-16	-2.03	-1.24	-0.16	-0.71	0.00	-1.90	-1.15
21	GISV-323 × ARBC-1351	15.57	-0.22	-0.26	2.36	-0.02	10.00	0.04
22	GISV-323 × GSHV-213	0.29	1.11	2.22	-1.39	-0.17	-5.64	-0.57
23	GISV-323 × H-1452	2.73	-2.44	-2.56	0.68	0.12	14.26	-1.19
24	GISV-323 × DELTA-15	10.57	-0.44	-0.10	5.45	-0.08	25.19	-1.77*
25	GISV-323 × TCH-1716	-10.48	0.00	-0.93	-4.41	-0.16	-28.60	0.52
26	GISV-323 × GISV-216	-9.31	-1.55	-0.02	-18.35**	0.15	-74.16**	1.06
27	GISV-323 × Phule Yamuna	-5.87	2.11	-2.65	7.21	-0.23	19.53	0.86
28	GISV-323 × BS-27	-0.53	2.00	0.80	-0.87	0.02	-13.49	0.27
29	GISV-323 × H 401/2014	-10.92	-1.44	1.80	-1.35	0.07	-0.92	0.07
30	GISV-323 × G. Cot-16	7.96	0.88	1.71	10.66	0.15	53.84*	0.70
	SE(S$_{ij}$)	7.82	1.23	1.67	6.45	0.16	25.96	0.67

Table 4 continues….

S. no.	Crosses	Seed index (g)	Fiber length (mm)	Fiber strength (g/tex)	Fiber fineness (mv)	Oil content (%)	Gossypol content (%)	Protein content (%)	Phenol content (%)
1	GSHV-01/1338 × ARBC-1351	1.10**	0.60	0.46	0.07	-1.72**	-0.01	-1.35	-0.00
2	GSHV-01/1338 × GSHV-213	-0.55**	-0.31	0.60	-0.19	-4.06**	-0.01	-1.88*	-0.04**

Table 4 continued...

Table 4 continued...

3	GSHV-01/1338 × H-1452	-0.51**	0.37	-0.09	-0.33*	2.73**	-0.01*	0.24	0.12**
4	GSHV-01/1338 × DELTA-15	0.28	-0.62	0.02	-0.01	1.22**	-0.02*	0.03	-0.01
5	GSHV-01/1338 × TCH-1716	-0.23	-0.20	0.20	0.10	0.18	-0.00	1.58*	0.08**
6	GSHV-01/1338 × GISV-216	0.07	-0.33	-0.19	0.30	3.61**	0.00	-2.58**	-0.03*
7	GSHV-01/1338×Phule Yamuna	0.45**	-0.47	-0.47	0.05	0.70	0.01	3.18**	0.01
8	GSHV-01/1338 × BS-27	-0.01	1.23*	-0.50	0.07	-2.59**	-0.02**	-2.19**	-0.03*
9	GSHV-01/1338 × H 401/2014	-0.43**	-0.36	0.14	-0.04	0.00	0.01	2.46**	0.04**
10	GSHV-01/1338 × G. Cot-16	-0.15	0.10	-0.18	-0.02	-0.07	0.06**	0.50	-0.14**
11	GJHV-566 × ARBC-1351	0.97**	0.18	0.21	-0.02	2.97**	0.01	-0.34	-0.02
12	GJHV-566 × GSHV-213	-0.81**	0.57	-0.13	-0.09	2.01**	0.00	-0.55	-0.00
13	GJHV-566 × H-1452	0.04	-0.49	0.13	-0.07	-3.36**	0.02**	-0.37	0.12**
14	GJHV-566 × DELTA-15	0.41**	0.22	-0.11	0.41**	-0.04	0.00	-0.75	0.04**
15	GJHV-566 × TCH-1716	-0.29	-0.01	0.37	0.07	2.53**	0.00	-2.13*	-0.06**
16	GJHV-566 × GISV-216	1.01**	0.11	-0.67	0.04	-1.88**	-0.00	1.36	0.00
17	GJHV-566 × Phule Yamuna	-1.41**	0.37	0.01	-0.21	-1.34**	-0.00	-0.52	-0.08**

* and ** indicate significance at 5% and 1% levels of probability, respectively.

Table 4 continues…

S. no.	Crosses	Seed index (g)	Fiber length (mm)	Fiber strength (g/tex)	Fiber fineness (mv)	Oil content (%)	Gossypol content (%)	Protein content (mg/g)	Phenol content (%)
18	GJHV-566 × BS-27	-0.17	-0.45	0.38	-0.12	1.00*	-0.01	2.91**	0.04*
19	GJHV-566 × H 401/2014	0.23	-0.29	0.26	0.18	-2.00**	0.01	0.05	-0.02
20	GJHV-566 × G. Cot-16	0.02	-0.21	0.27	-0.19	0.10	-0.03**	0.33	-0.00
21	GISV-323 × ARBC-1351	-0.27**	-0.78	-0.68	-0.04	-1.25**	0.00	1.69*	0.03
22	GISV-323 × GSHV-213	1.36**	-0.25	-0.47	0.28	2.05**	0.00	2.43**	0.04**
23	GISV-323 × H-1452	0.47**	0.11	-0.03	0.40*	0.63	-0.00	0.13	-0.25**
24	GISV-323 × DELTA-15	-0.69**	0.39	0.08	-0.40*	-1.18**	0.01	0.71	-0.02
25	GISV-323 × TCH-1716	0.53**	0.21	0.16	-0.18	-2.72**	0.00	0.54	-0.01
26	GISV-323 × GISV-216	-1.09**	0.21	0.86*	-0.34*	-1.73**	0.00	1.22	0.03*
27	GISV-323 × Phule Yamuna	0.96**	0.10	0.45	0.16	0.64	-0.01	-2.65**	0.06**
28	GISV-323 × BS-27	0.19	-0.78	0.11	0.05	1.58**	0.03**	-0.72	-0.00
29	GISV-323 × H 401/2014	0.20	0.65	-0.40	-0.13	2.00**	-0.02**	-2.52**	-0.01
30	GISV-323 × G. Cot-16	0.13	0.11	-0.09	0.21	-0.02	-0.02**	-0.84	0.14**
	SE(S_{ij})	0.15	0.50	0.37	0.16	0.43	0.00	0.79	0.01

ARBC-1351, GJHV-566 × DELTA-15, GJHV-566 × GISV-216, GISV-323 × GSHV-213, GISV-323 × H-1452, GISV-323 × TCH-1716 and GISV-323 × Phule Yamuna for seed index, GSHV-01/1338 × BS-27 for fiber length, GISV-323 × GISV-216 for fiber strength, GSHV-01/1338 × H-1452, GISV-323 × DELTA-15 and GISV-323 × GISV-216 for fiber fineness, GSHV-01/1338 × H-1452, GSHV-01/1338 × DELTA-15, GSHV-01/1338 × GISV-216, GJHV-566 × ARBC-1351, GJHV-566 × GSHV-213, GJHV-566 × TCH-1716, GJHV-566 × BS-27, GISV-323 × GSHV-213, GISV-323 × BS-27 and GISV-323 × H 401/2014 for oil content, GSHV-01/1338 × H-1452, GSHV-01/1338 × DELTA-15, GSHV-01/1338 × BS-27,

GJHV-566 × G. Cot-16, GISV-323 × H 401/2014 and GISV-323 × G. Cot-16 for gossypol content, GSHV-01/1338 × TCH-1716, GSHV-01/1338 × Phule Yamuna, GSHV-01/1338 × H 401/2014, GJHV-566 × BS-27, GISV-323 × ARBC-1351 and GISV-323 × GSHV-213 for protein content, GSHV-01/1338 × H-1452, GSHV-01/1338 × TCH-1716, GSHV-01/1338 × H 401/2014, GJHV-566 × H-1452, GJHV-566 × DELTA-15, GJHV-566 × BS-27, GISV-323 × GSHV-213, GISV-323 × GISV-216, GISV-323 × Phule Yamuna and GISV-323 × G. Cot-16 for phenol content showed significant SCA effect in desired direction (Table 4). Similar results have been reported by Patel *et al*. (2012), Kumar *et al*. (2017),
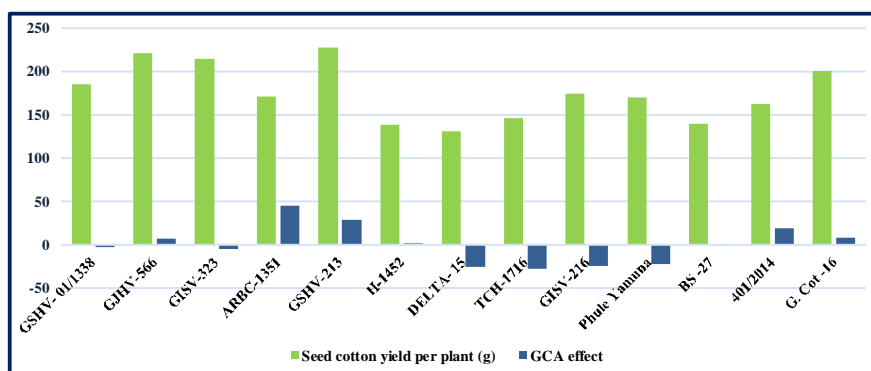
Fig. 1 : Mean values and GCA effects of parents for seed cotton yield in *G. hirsutum* L.
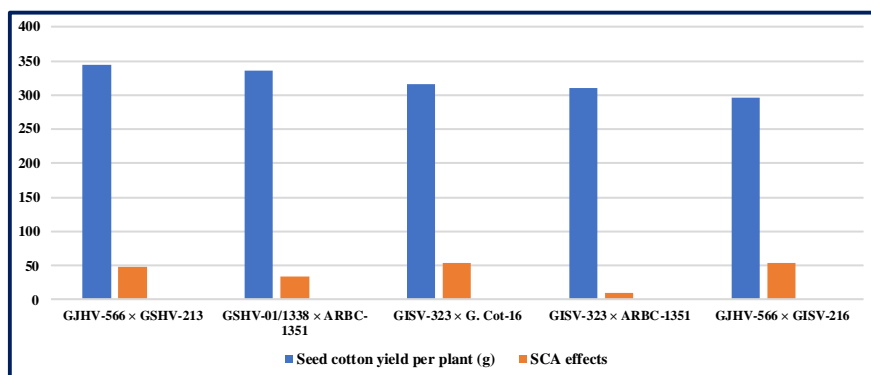

Fig. 2 : The top five crosses in terms of *per se* performance along with SCA effects for seed cotton yield in cotton.

Kumbhalkar *et al.* (2018) and Chakholoma *et al.* (2022).

Conclusion

Among parents, GSHV-01/1338 was good general combiner bolls per plant and ginning outturn. GISV-323 was a good general combiner for boll weight, seed index, fiber strength, protein content and phenol content. ARBC-1351 was a good general combiner for sympodia per plant, bolls per plant, seed cotton yield per plant and oil content. These parents are useful in hybridization programs for the improvement of such traits. The crosses GISV-323 × G. Cot-16 and GJHV-566 × GISV-216 were promising hybrids having high SCA effects for seed cotton yield per plant, these crosses could be exploited for commercial cultivation. The ratio of σ^2gca /σ^2sca is less than unity for all traits except for sympodia per plant, bolls per plant and boll weight, which indicated the preponderance of non-additive gene action in the

Table 5 : Summary of general combining ability effect of the parents for fifteen traits in cotton.

S. no.	Parents	PH (cm)	DFF	SPP	BPP	BW (g)	SCYPP (g)	GOT (%)	SI (g)	FL (mm)	FS (g/tex)	FF (mv)	OC (%)	GC (%)	PP (%)	PC (%)
Lines																
1	GSHV-01/1338	A	A	A	G	P	A	G	P	A	A	A	A	A	P	P
2	GJHV-566	A	P	A	A	A	A	P	A	A	P	P	A	A	A	P
3	GISV-323	A	A	A	P	G	A	A	G	A	G	A	A	A	G	G
Testers																
1	ARBC-1351	A	A	G	G	A	G	A	P	A	A	A	G	A	P	P
2	GSHV-213	G	P	A	A	A	A	A	G	A	A	A	G	G	P	A
3	H-1452	A	A	A	A	P	A	A	P	P	A	A	G	A	P	G
4	DELTA-15	A	P	A	A	A	A	A	P	A	A	A	P	A	P	P
5	TCH-1716	A	A	A	P	A	A	P	G	A	A	A	A	G	G	P
6	GISV-216	P	A	A	A	A	A	A	G	A	A	P	P	A	A	P
7	Phule Yamuna	A	A	A	A	P	A	A	P	A	G	A	G	A	G	P
8	BS-27	P	A	A	P	G	A	P	G	G	A	A	G	P	A	A
9	H401/2014	A	G	A	A	A	A	G	P	A	A	P	A	G	G	G
10	G. Cot -16	A	A	A	A	P	A	G	P	A	P	A	P	P	P	G

PH= Plant height, DFF= Days to 50% flowering, SPP= Sympodia per plant, BPP= Bolls per plant, BW= Boll weight, SCYP= Seed cotton yield per plant, GOT= Ginning outturn, SI= Seed index, FL= Fiber length, FS= Fiber strength, FF= Fiber fineness, OC= Oil content, GC= Gossypol content, PP= Protein percentage and PC= Phenol content.

G = Good general combiner having significant GCA effect in the desired direction

A = Average general combiner having either positive or negative but non-significant effects

P = Poor general combiner having significant GCA effect in an undesired direction

inheritance of those traits. Thus, heterosis breeding is useful for the exploitation of such traits.

Acknowledgment

References

Annual Report (2022-23). Ministry of Textiles (Government of India). Annual Report 2022-23 (ministryoftextiles.gov.in)

Bandhavi, R.D., Kalpande H.V., Khan R. and Panda S. (2019). Combining ability studies for fiber quality traits in desi cotton (*Gossipium arboreum* L.). *Int. J. Curr. Microbiol. App. Sci.*, **8(3)**, 415-421.

Bilwal, B.B., Vadodariya K.V., Rajkumar B.K., Lahane G.R. and Shihare N.D. (2018). Combining Ability Analysis for Seed Cotton Yield and Its Component Traits in Cotton (*Gossypium hirsutum* L.). *Int. J. Curr. Microbiol. App. Sci.*, **7(7)**, 3005-3010.

Chakholoma, M., Nimbal S., Jain A.J. and Kumar M. (2022). Combining Ability analysis for Yield and Fiber Quality Traits in American Cotton (*Gossypium hirsutum* L.) Genotypes. *Ekin J. Crop Bree. Gen.*, **8(1)**, 61-69.

Cotton production by country worldwide (2022/2023). Statista

Kempthorne, O. (1957) *An introduction to genetical statistics*. John Wiley and Sons. Inc. New York.

Kumar, A., Nirania K.S., Chhavikant and Bankar A.H. (2017). Combining ability for seed cotton yield and attributing traits in American cotton (*Gossypium hirsutum* L.). *J. Pharma Phytochem.*, **6(6)**, 376-378.

Kumbhalkar, H.B., Gawande V.L., Gotmare V. and Rathod T.H. (2018). Combining ability studies for yield, it's component traits and fibre properties through Line × Tester mating design in upland cotton (*Gossypium hirsutum* L.). *Int. J. Curr. Microbiol. App. Sci.*, **7(10)**, 1357-1370.

Monicashree, C., Amala P.B. and Gunasekaran M. (2017). Combining ability and heterosis studies on yield and fiber quality traits in upland cotton (*Gossypium hirsutum* L.). *Int. J. Curr. Microbiol. App. Sci.*, **6(8)**, 912-927.

Mudhalvan, S., Rajeswari S., Mahalingam L., Jeyakumar P., Muthuswami M. and Premalatha N. (2021). Combining ability estimates and heterosis analysis on major yield attributing traits and lint quality in American cotton (*Gossypium hirsutum* L.). *Ele. J. Pl. Breed.*, **12(4)**, 1111-1119.

Panse, V.G. and Sukhatma P.V. (1985). *Statistical method for agriculture workers*. 4th edn. P. & amp, I. Division, ICAR New Delhi.

Patel, N.A., Patel B.N., Bhatt J.P. and Patel J.A. (2012). Heterosis and combining ability for seed cotton yield and component traits in interspecific cotton hybrids (*G. hirsutum* × *G. barbadense* L.). *Madras Agric. J.*, **99(10)**, 649-656.

Roy, U., Paloti M.C., Patil R.S. and Katageri I.S. (2018). Combining ability analysis for yield and yield attributing traits in interspecific (*G. hirsutum* L. × *G. barabdense* L.) hybrids of cotton. *Ele. J. Pl. Br.*, **9(2)**, 458-464.

Sawarkar, M., Solanke A., Mhasal G.S. and Deshmukh S.B. (2015). Combining ability and heterosis for seed cotton yield, its components and quality traits in cotton (*Gossypium hirsutum* L.). *Indian J. Agri. Res.*, **49(2)**, 154-159.

Usharani, C.V., Manjula S.M. and Patil S.S. (2016) Estimating combining ability through line × tester analysis in upland cotton. *Res. Environ. Life Sci.*, **9(5)**, 628-633.

Vaid, R.R., Faldu G.O., Chaudhary N.B. and Chaudhary K.B. (2022). Combining ability and gene action analysis for yield traits, fiber quality, and biochemical traits of cotton (*Gossypium hirsutum* L.). *Pharma Innov. J.*, **11(1)**, 1313-1319.

Parmar, N., Faldu G.O., Sanghani A.O., Patel R.R. and Ramani H.R. (2023). Determination of gene action and combining ability for yield, its attributes, fiber quality and biochemical parameters in upland cotton (*Gossypium hirsutum* L). *Pharma Innov. J.*, **12(11)**, 389-395.