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Combining ability analysis in double cross hybrids of tomato (*Solanum lycopersicum* L.)

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Abstract
An experiment was conducted on "Combining ability analysis in double cross hybrids of tomato" at the University of agricultural Sciences, Dharwad, India, during *rabi* 2021. Crossing was done using half diallel mating design using ten single cross F_1's to obtain 45 double cross hybrids. Ten single cross F_1's, 45 double cross F_1's, one commercial check and one local check were used to study combining ability analysis in double cross hybrids of tomato. The estimates of GCA variance was higher for the characters number of branches per plant, fruit length and fruit width. The estimates of SCA variance was higher for the characters plant height, fruit length, fruit width, single fruit weight and yield per hectare. Parents, 'Varuna' (0.24) and 'Indus 11-05' (0.21) for yield per plant, 'JK Desi' (3.80) and 'Mithili-NTH-1348' (1.46) for number of fruits per plant, 'Mahy-701' (3.17) for plant height, 'Mahy-701' (0.39) exhibited highest significant positive *gca* effects. For plant height, the highest significant positive *sca* effect was depicted by 'Swathy × Indam 1006' (17.03). For number of flowers per inflorescence, *sca* effect was found to be highest in the cross 'S-85 × Varuna' (1.26). For number of fruits per cluster, the highest significant positive *sca* effect was exhibited by 'Abhilash × Indam Rohini' (1.06). For number of fruits per plant, the positive *sca* effect was found in the cross Abhilash × Varuna. For yield per plant, *sca* effect was found to be highest in Varuna × Indam Rohini (0.97).

Keywords: Double cross, combining ability, general combining ability and specific combining ability, half diallel mating

Introduction
Tomato (*Solanum lycopersicum* L.) is an important vegetable crop and a commercial crop grown all over tropical, sub-tropical and temperate regions of the world for both fresh and processing purpose. It's fruits are available year round and eaten either cooked or raw. Large quantities of tomatoes are processed to produce soup, juice, ketchup, puree, paste and powder. It supplies ascorbic acid and adds variety of colours and flavors to the food. It ranks second after potato. Tomato belongs to Solanaceae family having chromosome number 2n = 2x = 24. It has originated in the Peru-Equador-Bolivia region of South America.

The success story of any breeding programme lies in the choice of appropriate parents and the breeding method. For exploitation of heterosis, choice of parents is important. Combining ability analysis facilitates partitioning of genotypic variation of crosses into variation. The study of combining ability is one of the powerful tool to discriminate good as well as poor combiners for choosing appropriate parental material in plant breeding programme. Combining ability is the value of genotypes which is based on the performance of the offsprings in a definite mating design. When the potent offspring are produced by the parental plants, then it indicates that they have good combining ability. General combining ability (GCA) and Specific combining ability (SCA) are the two important concepts which have influence on population development in tomato crop breeding. GCA is defined as the average performance of a genotype in a series of combinations (Sprague and Tatum, 1942). They defined SCA as hybrid combinations showing better or poorer results and they would be estimated on the basis of performance of parental lines. GCA shows additive gene action whereas SCA shows non-additive gene action.

Most of the studies of combining ability and the heterosis were conducted only on the single cross F_1's which involved the purelines or the inbreds as the parents. Instead of using purelines, the single cross F_1's were used to produce the double cross hybrids because the purelines will be homozygous and homogenous. If the purelines will be used, the offspring produced will be the homogenous, hence no variation will be produced in the next generation. As the SCF_1's will have two inbred lines, by crossing them we get the double crosses with the

characters of both the lines, hence creating the variation. If the double cross hybrid shows higher performance with all the consumers requirements, then it is useful for breeder to isolate transgressive segregants. The information of combining ability is got by the diallel analysis from the combining ability studies. Hence, the present investigation using SCF_1's as parents, DCF_1's were developed to generate information on combining ability in tomato and obtain recombinants in subsequent generations.

Material and Methods

An investigation on "Combining ability analysis in double cross hybrids of tomato (*Solanum lycopersicum* L.)" was carried out at the Hi-tech Horticulture unit, Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, India, during *rabi*, 2021.

Ten parents used in the crossing programme were single cross F_1's (Commercial hybrids). These were maintained at the Department of Genetics and Plant breeding, UAS, Dharwad. All ten single cross F_1's were from diverse background. The single cross F_1's had the requirements of regional preferences in terms of size, shape and other quality parameters like TSS. All these are from different parental combination.

Evaluation

The experiment was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The material generated was laid out in randomized block design (RBD) with two replications. In each row 15 seedlings were transplanted for each entry in each replication. All the 45 double cross F_1's with ten single cross F_1's, a commercial check and a local check were planted with 45 cm × 60 cm spacing. Observations on characters like plant height, number of flowers per inflorescence. Number of clusters per plant, single fruit weight, number of locules, pericarp thickness, number of fruits per cluster, number of fruits per plant, yield per plant, total soluble solids and disease index for early blight, late blight and leaf curl virus.

Results and Discussion

GCA (variance) indicated that the parents exhibited significant *gca* effects for all the traits. SCA (variance) point out that, hybrids registered significant *sca* effects for all the characters. The estimates of GCA variance was higher for the characters number of branches per plant, fruit length and fruit width. The estimates of SCA variance was higher for the characters plant height, fruit length, fruit width, single fruit weight and yield per hectare. The estimates of ratio of GCA variance to SCA variance was higher for number of days to 50% flowering, fruit length, fruit width, number of fruits per plant and yield per hectare.

Table 1: Salient features of ten parents (single cross F_1's)

Sl. No.	Parent	Features	Company
1.	S – 85	Green shouldered and has resistance to tomato leaf curl virus (ToLCV)	Sungro seeds Ltd.
2.	Abhilash	Semi-determinate	Seminis Pvt. Ltd.
3.	Mithili - NTH -1348	Tolerant to ToLCV and high heat tolerant	Nuziveedu seeds Pvt. Ltd.
4.	Mahy -701	Hot set and tolerant to leaf curl virus (LCV)	MAHYCO Pvt. Ltd.
5.	Indus 11-05	Tolerant to ToLCV and good heat set	Indus Valley Agro seeds Pvt. Ltd.
6.	Varuna	High heat tolerant and tolerant to ToLCV	Nuziveedu seeds Pvt. Ltd.
7.	Swathy	Fruits are very firm and acidic taste.	Vijaya seeds
8.	JK Desi	High tolerance to ToLCV	JK Agri Genetics Ltd.
9.	Indam 1006	Tolerant to mid bacterial wilt (BW) and nematode.	Indo-American Hybrid Seeds Pvt. Ltd.
10.	Indam Rohini	Determinate type	Indo-American Hybrid Seeds Pvt. Ltd.

Table 2: Analysis of variance for combining ability and variance components in respect of various characters in tomato

	Combining ability			Variance components (Random effect)					
Source	General combining ability (GCA)	Specific combining ability (SCA)	Error	Variance of GCA (σ^2 GCA)	Variance of SCA (σ^2 SCA)	Variance of GCA / Variance of SCA (σ^2 GCA/σ^2 SCA)	Variance of additive gene (σ^2 A)	Variance of dominance gene (σ^2 D)	Variance of additive gene / Variance of dominance gene (σ^2 A/ σ^2 D)
Df	9	45	54						
Plant height	78.28**	97.27**	0.74	-1.58	96.53	-0.01	-3.16	96.53	-0.03
No. of flowers per inflorescence	0.42**	0.27**	0.02	0.01	0.25	0.05	0.02	0.25	0.10
No. of clusters per plant	5.83**	4.62**	0.15	0.10	4.47	0.02	0.20	4.47	0.04
Single fruit weight	296.72**	329.04**	2.29	-2.69	326.75	0.00	-5.38	326.75	-0.07
No. of locules	0.36**	0.28**	0.01	0.00	0.27	0.02	0.01	0.27	0.04
Pericarp thickness	1.94**	0.69**	0.01	0.10	0.68	0.15	0.20	0.68	0.30
No. of fruits per cluster	0.14**	0.26**	0.01	0.00	0.24	-0.04	-0.01	0.24	-0.08
No. of fruits per plant	43.81**	21.24**	1.61	1.88	19.62	0.09	3.76	19.62	0.19
Yield per plant	0.31**	0.16**	0.00	0.01	0.15	0.07	0.02	0.15	0.15
Total soluble solids	0.43**	0.29**	0.04	0.01	0.24	0.04	0.02	0.24	0.09
Early blight	95.20**	28.78**	0.42	5.53	28.36	0.19	11.07	28.36	0.39
Late blight	14.67**	14.00**	0.16	0.05	13.84	0.00	0.11	13.84	0.00
Tomato leaf curl virus	30.30**	40.20**	0.10	-0.82	40.10	-0.02	-1.64	40.10	-0.04

Table 3: Estimation of general combining ability effects of parents for dfferent traits in tomato

Sl. No.	F_1 Parents	General combining ability (GCA)												
		Plant height	Number of flowers per inflorescence	Number of clusters per plant	Single fruit weigth	Number of locules	Pericarp thickness	Number of fruits per cluster	Number of fruits per plant	Yield per plant	Total soluble solids	Early blight	Late blight	Tomato leaf curl virus
1	S-85	-3.15	-0.23**	-0.68**	7.30**	0.29**	0.19**	0.00	-3.23**	-0.24**	0.25**	-6.30**	-0.97**	0.52**
2	Abhilash	0.95**	0.12**	0.33**	6.27**	0.08*	0.07*	0.07*	-0.34	0.11**	-0.30**	-2.43**	-1.53**	-1.83**
3	Mithili - NTH - 1348	3.03**	0.13**	0.22*	4.37**	-0.20**	-0.28**	0.12**	1.46**	0.07**	-0.04	-0.58**	0.26*	-0.57**
4	Mahy -701	3.17**	0.39**	-0.21	-4.38**	-0.14**	0.33**	-0.04	0.97**	0.01	0.02	-0.85**	-0.56**	1.17**
5	Indus 11-05	2.44**	-0.12**	0.49**	-8.34**	-0.28**	0.68**	0.01	-1.54**	0.21**	0.17**	-0.14	0.56**	1.00**
6	Varuna	0.73**	0.09*	-0.42**	1.87**	-0.02	0.22**	-0.10**	-0.05	0.24**	-0.08	0.52**	-1.28**	1.10**
7	Swathy	-1.67**	-0.11**	1.39**	-0.87*	0.15**	-0.04	0.07*	-1.21**	-0.02	-0.04	2.57**	0.38**	-2.16**
8	JK Desi	-2.96**	-0.18**	0.39**	-0.35	0.02	-0.45**	0.13**	3.80**	-0.09**	0.04	2.79**	0.28*	-0.89**
9	Indam 1006	-3.17**	-0.08*	-0.67**	-3.21**	0.08**	-0.70**	-0.08*	0.71*	-0.17**	-0.26**	2.49**	0.71**	-1.20**
10	Indam Rohini	0.61*	-0.01	-0.84**	-2.66**	0.02	-0.03	-0.19**	-0.561	-0.11**	0.24**	1.93**	2.14**	2.85**
	CD Comparisons for GCA	**	**	**	**	**	**	**	**	**	**	**	**	**
	Gi <> 0 at 95%	0.53**	0.09**	0.24**	0.93**	0.07**	0.07**	0.07**	0.78**	0.05**	0.13**	0.40**	0.24**	0.19**
	Gi <> 0 at 99%	0.76**	0.13**	0.34**	1.34**	0.10**	0.10**	0.10**	1.13**	0.07**	0.19**	0.57**	0.35**	0.28**
	Gi--Gj at 95%	0.79**	0.13**	0.36**	1.39**	0.10**	0.10**	0.11**	1.17**	0.07**	0.20**	0.60**	0.37**	0.29**
	Gi--Gj at 99%	1.14**	0.19**	0.51**	2.00**	0.15**	0.15**	0.16**	1.65**	0.11**	0.29**	0.86**	0.53**	0.42**

Table 4: Estimation of specific combining ability effects of parents for dfferent traits in tomato

Sl. No.	Double cross hybrids	Specific Combining Ability												
		Plant height	Number of flowers per inflore scence	Number of clusters per plant	Single fruit weight	Number of locules	Pericarp thickness	Number of fruits per cluster	Number of fruits per plant	Yield per plant	Total soluble solids	Early blight	Late blight	Tomato leaf curl virus
1	S-85 × Abhilash	8.18**	-0.96***	-1.78**	8.49**	-0.61**	0.44**	-0.03	3.65**	-0.04	-0.92**	1.64**	-8.69**	0.81**
2	S-85 × Mithili – NTH- 1348	6.10**	0.12	-0.66	15.59**	-0.73**	-0.11	-0.38**	1.45	-0.10	-0.04	-1.09	-1.19**	3.14**
3	S-85 × Mahy -701	7.16**	0.46**	0.56	5.94**	0.40**	-0.10	-0.41**	1.84	0.00	0.11	-0.92	0.63	-3.30**
4	S-85 × Indus 11-05	-1.90*	0.08	0.46	-1.69	0.35**	-0.72**	-0.67**	3.85**	-0.12	0.08	0.05	-1.44**	-2.23**
5	S-85 × Varuna	-0.59	1.26**	0.47	-8.11**	-0.70**	-0.07	0.75**	0.66	0.00	0.43*	-2.81**	5.25**	-7.18**
6	S-85 × Swathy	0.11	0.07	-0.33	32.93**	0.10	0.76**	-0.43**	-4.16**	-0.35**	-0.02	-2.86**	0.53	0.09
7	S-85 × JK Desi	0.20	0.64**	0.66	-38.98**	-0.55**	0.03	0.31**	-2.99*	0.39**	-0.10	-1.88**	0.98*	-3.73***
8	S-85 × Indam 1006	-6.68	-0.36*	-0.37	-0.31	-0.22*	0.88**	-0.17	-4.29**	-0.11	-0.05	-4.18**	3.25**	2.18**
9	S-85 × Indam Rohini	-0.97	-0.32*	0.10	-28.77**	0.04	-0.39**	-0.05	-4.92**	-0.21**	0.72***	-0.37	0.87*	3.51**
10	Abhilash × Mithili – NTH-1348	-1.30	0.36**	1.21**	-29.07**	-0.01	0.99**	-0.26*	-4.24***	-0.12	0.54*	-1.21*	1.40**	-0.94**
11	Abhilash × Mahy -701	-4.33***	0.30*	1.24**	-4.21**	-0.17	0.71**	0.60**	-1.44	0.02	0.14	-2.09**	2.44**	4.45**
12	Abhilash × Indus-1105	-13.31**	0.22	0.03	-15.15***	-0.23*	-0.5***	-0.45**	-3.33**	-0.42**	0.64**	-7.20**	3.06**	5.77**
13	Abhilash × Varuna	-6.90**	0.30*	3.45**	-2.28	-0.39**	-0.70**	0.36**	8.07**	0.22**	0.47*	3.87**	-2.14**	0.92**
14	Abhilash × Swathy	-2.49**	-0.38**	-2.66**	13.67**	0.22*	-0.25*	-0.01	6.64**	0.58**	0.51*	-1.27*	-1.21**	4.95**
15	Abhilash × JK Desi	-14.00**	-0.21	-0.06	5.55**	-0.64**	-0.30**	-0.57**	-6.98**	-0.52**	0.28	8.55**	-6.66**	-5.97**
16	Abhilash × Indam 1006	-10.18**	-0.11	-2.69**	-0.58	0.00	-2.09**	-0.65**	-6.89**	-0.95**	0.12	0.80	-0.34	-6.00**

17	Abhilash × Indam Rohini	-2.18**	0.51**	-0.52	-5.84**	-0.14	0.90**	1.06**	1.58	0.14	0.10	3.66**	-1.86**	2.67**
18	Mithili-NTH-1348 × Mahy-701	-2.22**	0.59**	0.86*	-7.21**	0.10	0.24*	-0.54**	1.74	0.16*	-0.17	-0.49	-7.85**	0.93**
19	Mithili-NTH-1348 × Indus 11-05	-0.49	0.30*	2.05**	-7.85**	0.05	0.44**	0.39**	-1.74	-0.18*	-0.18	1.29*	6.46**	-1.64**
20	Mithili-NTH-1348 × Varuna	-11.08**	-0.21	-0.33	-5.98**	-0.20	0.32**	0.31**	3.16**	-0.36**	0.40	1.12	-7.29**	-3.09**
21	Mithili-NTH-1348 × Swathy	-3.88**	0.49**	3.35**	1.77	-0.29**	-1.40**	0.33**	-1.96	-0.13	0.04	3.97**	-2.56**	4.28**
22	Mithili-NTH-1348 × JK Desi	-11.68**	0.06	-3.04**	26.95**	0.64**	-0.32**	0.87**	-4.19**	-0.49**	0.33	1.85*	-2.51**	-1.09**
23	Mithili-NTH-1348 × Indam 1006	-19.47**	-0.13	-3.78**	-1.28	0.47**	-1.67**	0.29*	-9.49**	-0.46**	-0.26	3.95**	1.06**	-2.87**
24	Mithili-NTH-1348 × Indam Rohini	3.63**	-0.30*	0.29	6.85**	0.04	0.16	0.01	0.57	0.26**	-0.33	3.91**	-1.31**	1.40**
25	Mahy-701 × Indus 11-05	-0.03	-0.15	-1.31**	-3.90**	1.09**	-0.54**	-0.44**	-3.44**	-0.05	-0.33	4.51**	-2.80**	-2.44**
26	Mahy-701 × Varuna	-0.72	0.03	0.90*	-35.75***	-0.06	-0.25*	0.58**	-2.54*	-0.46**	-0.33	0.69	-3.10**	3.25**
27	Mahy-701 × Swathy	-10.81**	-0.06	-0.91*	7.97**	0.15	0.93**	0.40**	-6.87**	-0.11	0.00	1.04	1.82**	-1.56**
28	Mahy-701 × JK Desi	0.37	0.00	0.88*	16.70**	-0.31**	0.50**	-0.05	1.00	0.10	0.20	-1.17	0.07	7.50**
29	Mahy-701 × Indam 1006	-0.10	0.40**	-0.64	14.17**	-0.58**	-0.35**	0.06	-1.00	-0.159*	0.46*	1.92**	-2.95**	6.27**
30	Mahy-701 × Indam Rohini	-3.59**	-0.06	1.42**	-5.78**	-0.31**	-0.32**	0.17	-0.23	-0.34**	-0.29	5.43**	-1.63**	-4.29**
31	Indus 11-05 × Varuna	0.90	0.24	-2.30**	-4.36**	-0.22*	-0.97**	0.32**	0.47	0.07	0.16	4.48**	0.81*	2.12**
32	Indus 11-05 × Swathy	10.11**	0.05	4.87**	-11.31**	-0.70**	0.29*	0.14	3.14*	0.33**	-0.40	3.38**	0.28	-0.99**
33	Indus 11-05 × JK Desi	6.60**	-0.07	1.77**	-26.73**	-0.27*	1.55**	0.98**	1.41	0.45**	0.36	2.51**	-0.95*	1.32**
34	Indus 11-05 × Indam 1006	1.51	0.02	1.04**	9.43**	-0.44**	1.70**	0.70**	3.00*	0.56**	0.86**	2.86**	0.71	9.74**
35	Indus 11-05 × Indam Rohini	-0.97	0.15	1.61**	26.07**	0.12	0.19	0.21	2.28	-0.04	-0.43*	3.47**	4.53**	3.97**
36	Varuna × Swathy	1.61*	-0.06	-1.80**	11.56**	-0.56**	0.30**	-0.23*	-1.84	-0.11	-0.07	2.21**	-1.31**	4.00**
37	Varuna × JK Desi	7.31**	0.00	-4.10**	2.24	-0.53**	0.82**	-0.09	-6.67**	-0.17*	1.01**	5.74**	3.144**	10.97**
38	Varuna × Indam 1006	15.22**	0.30*	1.26**	-9.59**	0.30**	1.07**	-0.17	6.01**	0.42**	0.51*	6.59**	1.66**	7.34**
39	Varuna × Indam Rohini	16.20**	0.44**	3.06***	-18.94**	1.16**	-0.27*	-0.15	1.49	0.97**	-0.79**	-1.34*	3.03**	13.17**
40	Swathy × JK Desi	-0.28	0.61**	1.37**	-17.60**	0.38**	-0.11	-0.27*	-1.60	0.05	-0.27	-1.70**	-0.23	11.65**
41	Swathy × Indam 1006	17.03**	0.61**	2.04**	2.56	-0.48**	-0.57**	0.14	7.28**	0.28**	0.39	5.54**	0.93*	1.57**
42	Swathy × Indam Rohini	9.34**	0.54**	0.31	19.00**	-0.71**	0.02	-0.04	3.95**	0.05	-0.85**	3.25**	-1.29**	-3.44**
43	JK Desi × Indam 1006	13.42**	0.28*	3.54**	5.14**	0.15	-0.84**	0.48**	4.35**	-0.01	0.08	5.22**	0.24	2.69**
44	JK Desi × Indam Rohini	5.83**	-0.48**	-1.58**	17.78**	0.31**	-1.58**	-0.99**	5.73**	-0.47**	-0.21	4.33**	1.66**	-3.32**
45	Indam 1006 × Indam Rohini	1.15	0.61**	0.78*	15.85**	0.05	0.92**	-0.48*	0.72	0.61**	0.29	1.33*	-1.21**	-0.55
	C. D. Comparisons													
	Sij <> 0 at 95%	1.6	0.27	0.72	2.81	0.21	0.22	0.22	2.35	0.15	0.4	1.2	0.74	0.59
	Sij <> 0 at 99%	2.14	0.36	0.96	3.75	0.28	0.29	0.3	3.15	0.2	0.54	1.61	0.99	0.79
	Sij--Sik at 95%	2.35	0.39	1.06	4.13	0.31	0.32	0.33	3.46	0.22	0.6	1.77	1.09	0.87
	Sij--Sik at 99%	3.14	0.53	1.42	5.51	0.42	0.43	0.44	4.63	0.3	0.8	2.37	1.46	1.16
	Sij--Skl at 95%	2.24	0.37	1.01	3.93	0.3	0.3	0.31	3.3	0.21	0.57	1.69	1.04	0.83
	Sij--Skl at 99%	3	0.5	1.35	5.26	0.4	0.41	0.42	4.41	0.28	0.76	2.26	1.39	1.11

GCA effect

The *gca* effects indicated that none of the parents was a good general combiner for all the characters, suggesting that specific parents will have to be used for genetic improvement depending on the characters under considerations. Following parents have good general combining ability for various traits. Parents, 'Varuna' (0.24) and 'Indus 11-05' (0.21) for yield per plant, 'JK Desi' (3.80) and 'Mithili-NTH-1348' (1.46) for number of fruits per plant, 'S-85' (7.30) and 'Abhilash' (6.27) for single fruit weight, 'Indus 11-05' (0.68) and 'Mahy-701' (0.33) for pericarp thickness, 'S-85' (0.29) and 'Swathy' (0.15) for number of locules. 'S-85' (0.25) and 'Indus 11-05' (0.17) for TSS, 'Mahy-701' (3.17) and 'Mithili-NTH-1348' (3.03) for plant height, 'Swathy' (1.39) and 'JK Desi'(0.39) for number of clusters per plant. Similar results were expressed by Veer *et al*. (2006), Singh *et al.* (2006) and Bhatt *et al*. (2004) for yield per plant and number of fruits per plant, while Pandey *et al.* (2006), Umesh and Ramangouda (2021) and Singh *et al.* (2006) for pericarp thickness in single crosses.

SCA effect

Out of 45 DCF_1's, the major economic heterotic double crosses ('Varuna × Indam Rohini', 'Abhilash × Swathy' and 'Indus-11-05 × Indam 1006') showed *sca* effects in significant desirable direction for yield per plant. Cross 'Varuna × Indam Rohini' (0.97) involved parents 'Varuna' has highest significant *gca* effect and 'Indam Rohini' has significant negative *gca* effects. This was followed by 'Abhilash × Swathy' (0.58) had parental combination of significant positive × non-significant negative general combiners and the cross 'Indus-11-05 ×Indam 1006' (0.56) had the parental combination of significant positive and significant negative general combiners. Some form of recurrent selection or full sib selection was to be adopted under such conditions since both additive and non-additive components were important in the inheritance of the characters. This will lead to upgrading of genetic ceiling by accumulating favourable genes and simultaneously exploiting dominance variance.

The double cross F_1 hybrid combinations with maximum significant *sca* effect for different traits are 'Varuna × Indam Rohini' for yield per plant, 'Abhilash × Varuna' (8.07) for number of fruits per plant, 'Indus-11-05 × JK Desi' for number of fruits per cluster, 'Indus-11-05 ×Indam 1006' for pericarp thickness, 'Varuna × Indam Rohini' (1.16) for number of locules, 'Varuna × Indam 1006' (13.39) for fruit width and 'Indus-11-05 × Swathy' (8.73) for fruit length. 'Indus-11-05 × Swathy' (4.87) for number of clusters per plant, 'Varuna × JK Desi' for TSS.

Conclusion

The variance attributable to GCA and SCA, which provide a relative measure of additive and non-additive gene effect, respectively, is estimated using the combining ability analysis. Dominance is a component of additive genetic variance, according to several researchers. If the *sca* effect is the primary reason of a cross advantage, it follows that the cross' superiority cannot be fixed through selection. As a result, combining ability is required, which aids in the selection of possible parents for hybridization and potential crosses based on their specific combining ability.

Parents, 'Varuna' (0.24) and 'Indus 11-05' (0.21) for yield per plant, 'JK Desi' (3.80) and 'Mithili-NTH-1348' (1.46) for number of fruits per plant, 'S-85' (7.30) and 'Abhilash' (6.27) for single fruit weight, 'Mahy-701' (3.17) and 'Mithili-NTH-1348' (3.03) for plant height, 'Swathy' (1.39) and 'JK Desi'(0.39) for number of clusters per plant. 'Varuna × Indam Rohini', 'Abhilash × Swathy' and 'Indus-11-05 × Indam 1006') showed *sca* effects in significant desirable direction for yield per plant. Cross 'Varuna × Indam Rohini' (0.97) involved parents 'Varuna' has highest significant *gca* effect and 'Indam Rohini' has significant negative *gca* effects.

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