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COMBINING ABILITY ASSESSMENT IN TOMATO (*SOLANUM LYCOPERSICUM* L.) FOR GROWTH AND YIELD

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ABSTRACT

The current study conducted Vegetable Research Farm, Dr. RPCAU, Pusa attempted to determine the general and specific combining ability variances as their effects for various quantitative characteristics in tomato. Line × Tester analysis including ten lines and three testers illustrated the preponderance SCA over GCA for all the characteristics studied. Combining ability effects (GCA & SCA) were estimated using thirteen parents consisting their thirty hybrids developed through Line × Tester method. The results indicated that the lines, Kashi Hemant was found to be good general combiner with high *per se* performance may be used the best parents a donor to enhance the plant height, number of flowers cluster^{-1}, polar as well as equatorial diameter of fruit, average fruit weight, acidity of the fruit and fruit yield plant^{-1}. In case of tester, Bhilai was found to be a good general combiner and high *per se* performance for traits like plant height, number of flowers cluster^{-1}, acidity of the fruit and fruit yield plant^{-1}. EC 177371 × PKM-1 best hybrid to enhance the number of fruits cluster^{-1}, polar as well as equatorial diameter of fruit, average fruit weight and fruit yield plant^{-1} and plant height, number of primary branches plant^{-1}, number of fruits cluster^{-1}, TSS content of fruit S-12 × PDT-3-1 were show highest SCA effects as well as high *per se* performance.

***Keywords* :** GCA, SCA and Line x Tester, Tomato

Introduction

Tomato (*Solanum lycopersicum* L.) is widely cultivated crop due to its adaptability, high yielding potential and enormous demand by the consumers. Tomato ranks second after potato but tops the list of processed vegetables in the world. It is most popular warm season and day- neutral vegetable which is globally grown either fresh market or processing and considered as a high value crop. Global demand for tomato production is increasing tremendously due to its diverse utility in raw, cooked and processed form of food. India tomato production is 16,089.32 tonnes, in that Bihar share 4.68% of production with tenth position in India (NHB 2021-22 1st Adv. Estimate). This necessitates the continued supply of highly nutritious and better yielding improved cultivars to the producers, that to under the rapid changing agro-climatic conditions. Hence, there is continuous need to strengthen the crop improvement programmes in tomato and ultimately developing new varieties/ hybrids satisfying to the present day needs of farmers and consumers as well.

Hence tomato breeding strategies not only used for increasing fruit yield but also for the quality attributes. The Line × Tester analysis provides information for selection of superior parents and crosses with their GCA and SCA effects respectively. The term GCA is used to designate the average performance of a line in hybrid combination whereas, SCA is used to designate those cases in which certain combinations do selectively better or worse than would be expected based on average performance of the lines involved. GCA indicate the occurrence of additive gene action while SCA as non-additive type of gene action. Additionally, information concerning GCA and SCA enables the plant breeders to choose parental material and a suitable breeding procedure for maximum character amelioration. With this objective, the present research was done to estimate combining ability effects by utilizing Line × Tester mating design in tomato.

Materials and Methods

The present investigation was undertaken at the Vegetable Research Farm, Department of Horticulture, Dr. RPCAU Samastipur during rabi season of 2020-21. The experimental material for present study Thirty F_1 hybrids consisting ten lines and three testers of tomato. In Line × Tester mating design for identifying heterotic with GCA effects of parent and SCA effects performance resulting from crossing of genetically divergent genotypes (Kempthorne, 1957). The material created was evaluated in *rabi* 2021 by laying out in Randomized Block Design (RBD) with hybrids and parents along with check. Recommended practices were followed for successful cultivation. The observations were recorded on five plants taken at random in each entry over the replications on plant height (cm), number of primary branches plant^{-1}, number of days to first flower initiation, number of flowers cluster^{-1}, number of fruits cluster^{-1}, number of clusters plant^{-1}, number of days to first picking, polar diameter of fruit (cm), equatorial diameter of fruit (cm), average fruit weight (g), fruit yield plant^{-1} (kg), TSS content of the fruit (°brix), acidity of the fruit (%). Data for various quality components and yield in tomato was collected from the F_1's, parents and standard check. *Per se* performance of the F_1's and parents were assessed and magnitude of heterosis, combining ability, additive and dominance gene action was estimated.

Analysis

The first step in Line × Tester analysis is need to perform analysis of variance for Randomized Block Design to test the significance of difference among different genotypes along with their parents and checks. The analysis of variance was done for all the parameters as per the method given by Kempthorne (1957) and emphasized by Arunachalam (1974).

Results and Discussion

Combining ability analysis has the capability to be used to assess the genetic worth of inbred and to identify eligible parents for hybridization. Breeders use these variance components to infer the gene action and to assess the genetic potentialities of the parents in hybrid combination.

Analysis of variances for combining ability

Analysis of variance for combining ability was carried out for all characters to test the significant of differences among different lines and tester as well as crosses. Table 1 shows the analysis of variance on combining ability. The mean sum of squares of crosses shows highly significant. The mean sum of squares due to lines were highly significant for all traits. The mean sum of squares due to tester were highly significant for all characters except number of days to first flower initiation and number of days to first picking. However, the mean sum of squares due to Line × Tester was found significant for all traits excluding number of flowers per cluster. These estimations showed significant variance in lines, testers as well as lines *vs*. testers. Yadav *et al.* (2013) confirmed these results from the ANOVA for combining ability analysis. These observations were shown to be similar with that of an investigation conducted by Yadhav *et al.* (1991), Kumari & Sharma (2011), Agarwal *et al.* (2014) for the ascorbic acid and total soluble solids.

General combining ability effects

General combining ability reflect genetic worth of the parental line for use in combination breeding. The line with high GCA effects for the character are expected to be more useful donors than those with poor GCA. GCA effects of all the parental lines and tester are summarized in Table 2

Kashi Hemant exhibited positively significant GCA effects compressing high *per se* performance the plant height, number of flowers cluster^{-1}, polar as well as equatorial diameter of fruit, average fruit weight, acidity of the fruit and fruit yield plant^{-1} so this genotype may be used the best parent to donor above mentioned characters. Saidi *et al.* (2008) observed good general combiner additive gene action in plant height and dominant gene action with yield. Sekhar *et al.* (2010) observed similar results for a good general combiner in terms of fruit yield plant^{-1}, primary branch number plant^{-1} and fruit cluster number plant^{-1}. Whereas Agarwal *et al.* (2014), Chauhan *et al.* (2014) and Saleem *et al.* (2013) also reported good general combiners for high fruit yield plant^{-1}.

Positive and significant GCA effects with high *per se* performance estimates were observed for number of clusters plant^{-1}, polar diameter of fruit, equatorial diameter of fruits and average fruit weight in Kashi Vishesh indicating that this parent may be a good general combiner for high fruit yield. EC 177516 best general combiner for these traits namely; number of days to first flower initiation, number of flowers cluster^{-1}, number of fruits cluster^{-1}, number of days to first picking. The combining ability analysis confirmed that additive gene activity predominated in the manifestation of this trait. Similar findings were discovered by Kumari and Sharma (2012), Ramdan *et al.* (2014) and Basavaraj *et al.* (2016).

Bhilai was observed to be the significant as well as high *per se* performance good general combiner tester for number of flowers cluster^{-1}, number of clusters plant^{-1}, acidity of the fruit and fruit yield plant^{-1}. Similar finding was reported by Zengin *et al.* (2015) for days to first blooming. Same manner observation reported by Gautam *et al.* (2016).

Positively significant with high *per se* performance were observed for TSS and acidity of the fruit in PKM-1 indicating that this parent may be a good general combiner for quality parameter. The observations of the respective investigators were found to be similar to the current outcome; Mondal *et al.* (2009), Gautam *et al.* (2018) was reported good general combiner for acidity and TSS for fruit.

Analysis of specific combining ability effects

Specific combining ability is the expression of a nonadditive component of genetic variance and is associated with interaction effects, which may be related to dominance and epistatic components of genetic variation both of which are unfixable in nature**.** The SCA effects of the crosses are shown in Table 3 for all characteristics.

Every breeding programme strives for maximum fruit yield as well as superior quality. EC 177371 × PKM-1 exhibited positively significant SCA effects as well as *per se* performance so this cross may be used as a best hybrid to enhance the number of fruits cluster^{-1}, polar as well as equatorial diameter of fruit, average fruit weight and fruit yield plant^{-1}. The observations of the respective investigators were found to be like the current outcome; Shankar *et al.* (2013), Bhavna *et al.* (2014), Ebenezer and Babu (2014), Renuka *et al.* (2015), Kumar *et al.* (2018) for production enhancement traits. Soresa *et al.* (2021) observed similar finding that non-additive gene action in fruit yield plant^{-1}.

Pant T-3 × PKM-1 exhibited positively significant SCA effects as well as high *per se* performance so this cross may be used as a best hybrid to enhance number of fruits cluster^{-1}, number of clusters plant^{-1}, number of days to first picking, total soluble solid and acidity of fruit. Agarwal *et al.* (2014), Dishri *et al.* (2017), Reddy *et al.* (2020) were observed similar finding for nonadditive dominance gene action for quality parameter.

Positive significant SCA estimate for plant height, number of primary branches plant^{-1}, number of fruits cluster^{-1} and TSS content of fruit in S-12 x PDT-3-1; indicating that this cross may be a good specific combiner for these traits. Joshi and Kohli (2006) and Hannan *et al.* (2007) reported similar results that suggested non-additive gene activity was involved in the greater plant height as well as number of primary branches plant^{-1}. Yadav *et al.* (2013) reported similar performance with substantial positive SCA impacts for plant height, number of primary branches plant^{-1} and TSS. Muttappanavar *et al.* (2014), Baban *et al.* (2015) reported similar observation with present study. Table 5 show the Ranking of genotype as high *per se* performance GCA and SCA.

Contribution to Total Variance

Proportional contribution of lines towards different traits ranged from 24.25 % (acidity of the fruit) to 86.12 % (number of days to first picking) and that for tester ranged from 0.19 % (number of days to first flower initiation) to 22.63 % (acidity of the fruit). The contribution of crosses towards different parameters varied from 13.21 % (number of days first picking) to 53.12 % (acidity of the fruit). Among the line maximum contribution of variance reported in number of days to 1st picking and tester as well as L × T interaction maximum variance contribute in acidity of fruit. The traits when the contribution of lines is greater than that of Line × Tester indicate that there is more fixable genetic variation and may thus be used in varietal development and improvement programmes. Indicate in Table 4. The traits with the highest interaction due to Line × Tester suggest that the prevalence of greater non fixable genetic variation, which may thus be utilised in the breeding programme.

Conclusion

The combining ability analysis gives an indication of the variance due to GCA and SCA which represent a relative measure of additive and non-additive gene actions, respectively. Most of the yield components are known to be under polygenic control, so plant breeder would need a close genetic characterization of as many parents as possible through phenotypic measurements. The combining ability effects, general (GCA) and specific (SCA) are some realistic parameters to serve this purpose.

Kashi Hemant, Kashi Vishesh and Bhilai were identified as top GCA combiners while, the cross combinations EC 177371 × PKM-1 and S-12 × PDT-3-1 were identified as top SCA combiners for multiple traits in tomato for fruit yield and its contributing characters.

Table 1: Anova for Combing Ability for thirteen traits of Tomato

Characters	d.f.	Plant height (cm)	No. of primary branches plant^{-1}	No. of days to first flower initiation	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	No. of clusters plant^{-1}	No. of days to first picking	Polar diameter of fruit (cm)	Equatorial diameter of fruit (cm)	Average fruit weight (g)	TSS content of the fruit °Brix	Acidity of the fruit (%)	Fruit yield plant^{-1} (kg)
Replicates	2	6.27	0.36	15.62	0.65	0.10	0.63	4.43	0.02	0.05	2.31	0.04	0.0002	0.0008
Crosses	29	1215.13**	5.83**	67.46**	3.41**	1.63**	5.32**	261.80**	0.79**	1.03**	132.07**	2.67**	0.0142**	0.0198**
Line(c)	9	3046.24**	10.84**	186.56**	7.23**	2.65**	9.44**	726.46**	1.92**	2.73**	316.07**	4.99**	0.0111**	0.0318**
Tester(c)	2	1248.89**	0.91**	1.83	4.92**	0.95**	5.26**	25.57	0.50**	0.20**	30.83**	0.91**	0.0467**	0.0219**
L X T (c)	18	295.82**	3.87**	15.21*	1.34	1.20**	3.26**	55.72**	0.26**	0.27**	51.32**	1.70**	0.0122**	0.0135**
Error	58	51.05	0.47	10.98	0.52	0.14	0.50	21.16	0.05	0.09	9.01	0.02	0.0004	0.0038

*Significant at 5%, **significant at 1%

Table 2 : Estimate of general combining ability effects of the parents for various thirteen traits in Tomato

S. N.	Parents	Plant height (cm)	No. of primary branches plant^{-1}	No. of days to first flower initiation	No. of flowers Cluster^{-1}	No. of fruits Cluster^{-1}	No. of clusters Plant^{-1}	No. of days to first picking	Polar diameter of fruit (cm)	Equatorial diameter of fruit (cm)	Average fruit weight (g)	TSS content of the fruit °Brix	Acidity of the fruit (%)	Fruit yield Plant^{-1} (kg)
	Line													
1	EC 177516	14.14**	0.07	-2.46*	1.43**	0.45**	0.27	-7.29**	-0.10	-0.13	-3.40**	-0.37**	0.01	-0.03
2	EC 177371	13.56**	1.25**	3.10**	0.12ns	0.18	0.75**	4.32**	-0.17*	-0.30**	1.50	0.07	0.02**	-0.04
3	EC 177343	23.75**	0.39	2.38*	0.35ns	0.11	1.17**	-1.20	-0.38**	-0.44**	-3.90**	0.90**	0.00	0.01
4	Pant T-3	-16.90**	0.46*	-8.57**	0.63*	-0.77**	0.22	-15.76**	-0.18*	-0.10	-2.45*	-0.79**	0.03**	0.02
5	Pant T-5	-8.54**	-0.89**	-4.88**	-1.15**	-0.12	0.05	-9.79**	-0.34**	-0.36**	0.82	0.10*	0.01	0.02
6	NDT-4	-28.83**	0.50*	6.28**	0.53*	1.19**	-1.65**	12.59**	0.12	0.05	-0.29	-0.06	0.01	0.02
7	NF 375-B-8	5.02*	-2.20**	-1.98	-0.50*	-0.32*	0.05	-1.89	-0.12	0.01	0.42	0.81**	-0.04**	0.00
8	Kashi Vishesh	-21.83**	-1.00**	3.15**	-1.45**	-0.32*	1.23**	5.17**	0.84**	0.96**	8.94**	-1.09**	-0.02**	0.07**
9	Kashi Hemant	20.17**	0.00	3.76**	0.62*	0.02	-0.37	10.40**	0.80**	0.96**	9.15**	-0.64**	0.05**	0.07**
10	S-12	-0.55	1.41**	-0.79	-0.58*	-0.42**	-1.74**	3.44*	-0.47**	-0.67**	-10.78**	1.07**	-0.07**	-0.14**
	Tester													
1	Bhilai	6.09**	0.18	-0.26	0.41**	-0.16*	0.39**	0.36	-0.02	-0.08	0.85	-0.03	0.01**	0.03*
2	PDT-3-1	0.67	-0.01	0.23	-0.02ns	0.19**	0.05	0.69	0.14**	0.08	0.28	-0.15**	-0.04**	0.00
3	PKM-1	-6.76**	-0.17	0.02	-0.40**	-0.03	-0.44**	-1.05	-0.12**	0.00	-1.12*	0.19**	0.03**	-0.03*
	SE (gca line)	2.382	0.229	1.104	0.240	0.123	0.236	1.533	0.074	0.100	1.000	0.050	0.007	0.021
	SE (gca tester)	1.305	0.126	0.605	0.132	0.068	0.129	0.840	0.040	0.055	0.548	0.028	0.004	0.011
	SE (bet gca line)	3.368	0.324	1.562	0.340	0.174	0.334	2.168	0.104	0.141	1.415	0.071	0.009	0.029
	SE (bet gca tester)	1.845	0.177	0.855	0.186	0.096	0.183	1.188	0.057	0.077	0.775	0.039	0.005	0.016

*Significant at 5%, **significant at 1%

Table 3 Estimates of specific combining ability effects of hybrids for thirteen traits in Tomato

S. N.	Hybrids	Plant Height (cm)	No. of primary branches plant^{-1}	No. of days to first flower initiation	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	No. of clusters plant^{-1}	No. of days to first picking	Polar diameter of fruit (cm)	Equatorial diameter of fruit (cm)	Average fruit weight (g)	TSS content of the fruit °Brix	Acidity of th fruit (%)	Fruit yield Plant^{-1} (kg)
1	EC 177516 X Bhilai	0.34	0.80 *	2.84	0.07	0.00	-0.08	4.22	-0.17	-0.26	-2.80	0.82**	0.02	-0.04
2	EC177516 X PDT-3-1	-1.13	0.16	-1.04	-0.03	-0.19	0.60	-2.70	0.29 *	0.18	2.31	-1.06**	-0.02 *	0.02
3	EC 177516 X PKM-1	0.79	-0.96 *	-1.80	-0.03	0.19	-0.52	-1.52	-0.12	0.08	0.49	0.24**	0.01	0.02
4	EC 177371 X Bhilai	16.02 **	0.52	1.15	-0.34	-0.31	-0.69	0.73	-0.26 *	-0.35 *	-4.78 **	1.13 **	0.06 **	-0.07 *

5	EC 177371 X PDT-3-1	-21.77 **	0.81 *	-0.28	-0.35	-0.56 *	1.20 **	-1.99	-0.10	-0.11	-0.42	-0.16	-0.06 **	-0.02
6	EC 177371 X PKM-1	5.74	-1.33 **	-0.87	0.69	0.87 **	-0.51	1.27	0.36 **	0.47 **	5.20 **	-0.97 **	0.00	0.09 *
7	EC 177343 X Bhilai	-0.90	-1.58 **	-0.19	-0.96 *	0.79 **	-0.46	0.15	0.23	0.14	2.21	-0.55 **	-0.02	-0.07
8	EC 177343 X PDT-3-1	7.37	-1.33 **	0.95	0.46	-0.83 **	-0.70	-0.83	-0.28 *	-0.08	-2.30	0.56 **	-0.05 **	0.09 *
9	EC 177343 X PKM-1	-6.47	2.91 **	-0.76	0.51	0.04	1.16 **	0.68	0.05	-0.06	0.09	-0.01	0.06 **	-0.02
10	Pant T-3 X Bhilai	5.43	0.28	-1.27	0.12	-0.43 *	0.22	-4.05	-0.12	-0.08	2.99	-0.33 **	-0.01	0.05
11	Pant T-3 X PDT-3-1	-4.55	0.38	3.66	-0.01	-0.19	-1.28 **	9.60 **	0.51 **	0.61 **	5.44 **	0.14	-0.06 **	0.04
12	Pant T-3 X PKM-1	-0.89	-0.67	-2.40	-0.11	0.62 **	1.07 *	-5.55 *	-0.39 **	-0.53 **	-8.43 **	0.20 *	0.08 **	-0.08 *
13	Pant T-5 X Bhilai	6.93	-0.22	0.44	-0.33	-0.58 **	-0.77	-2.10	0.16	0.21	2.48	-0.81 **	-0.01	0.09 *
14	Pant T-5 X PDT-3-1	-7.67	-0.29	1.29	-0.17	0.21	0.73	4.32	0.06	-0.02	0.08	-0.03	0.03 *	-0.02
15	Pant T-5 X PKM1	0.74	0.51	-1.73	0.49	0.36	0.04	-2.21	-0.22	-0.19	-2.55	0.84 **	-0.01	-0.06
16	NDT-4 X Bhilai	-4.86	0.64	1.21	0.00	0.62 **	0.05	3.34	0.23	0.27	1.24	-0.57 **	0.03 **	0.02
17	NDT-4 X PDT-3-1	-2.04	-0.29	-2.46	-0.23	0.03	1.22 **	-3.68	-0.30 *	-0.25	-3.16	-0.42 **	-0.07 **	-0.04
18	NDT-4 X PKM-1	6.90	-0.35	1.25	0.23	-0.65 **	-1.27 **	0.33	0.06	-0.02	1.92	0.99 **	0.04 **	0.02
19	NF 375-B-8 X Bhilai	-5.69	0.42	-2.05	-0.59	-0.39	0.51	-1.65	0.32 *	0.22	3.40	0.62 **	-0.03 **	0.02
20	NF 375-B-8 X PDT-3-1	7.83	-0.58	-0.65	0.46	0.39	-0.69	-0.96	-0.23	-0.40 *	-5.50 **	-0.23 *	0.11 **	-0.11 **
21	NF 375-B-8 X PKM-1	-2.14	0.16	2.70	0.14	0.00	0.17	2.61	-0.10	0.19	2.10	-0.39 **	-0.08 **	0.08 *
22	Kashi Vishesh X Bhilai	-0.49	0.12	-0.82	0.24	0.35	-0.22	-3.63	-0.12	-0.07	-3.84 *	-0.68 **	0.01	-0.02
23	Kashi Vishesh X PDT-3-1	-2.38	0.08	-1.05	0.00	0.16	0.77	-2.25	0.08	0.04	2.86	0.46 **	0.06 **	0.06
24	Kashi Vishesh X PKM-1	2.87	-0.20	1.87	-0.24	-0.51 *	-0.56	5.88 *	0.04	0.03	0.97	0.22 *	-0.08 **	-0.04
25	Kashi Hemant X Bhilai	-7.51	0.14	-0.83	1.65 **	-0.18	1.69 **	-1.64	-0.11	0.03	-0.56	0.35 **	0.00	-0.01
26	Kashi Hemant X PDT-3-1	6.77	-0.43	2.15	-0.39	0.06	-1.15 **	2.25	-0.23	-0.05	2.95	0.08	0.05 **	0.02
27	Kashi Hemant X PKM-1	0.73	0.28	-1.32	-1.25 **	0.12	-0.54	-0.61	0.34 **	0.02	-2.39	-0.43 **	-0.05 **	-0.02
28	S-12 X Bhilai	-9.29 *	-1.12 **	-0.49	0.14	0.14	-0.25	4.63	-0.16	-0.11	-0.34	0.03	-0.05 **	0.02
29	S-12 X PDT-3-1	17.57 **	1.49 **	-2.57	0.27	0.91 **	-0.70	-3.75	0.19	0.09	-2.25	0.65 **	0.02	-0.04
30	S-12 X PKM-1	-8.28 *	-0.36	3.05	-0.41	-1.05 **	0.95 *	-0.88	-0.04	0.02	2.59	-0.68 **	0.03 **	0.02
	Se (sij)	4.125	0.397	1.913	0.42	0.214	0.409	2.656	0.128	0.173	1.733	0.087	0.011	0.036
	SE (sij-sik)	5.834	0.561	2.705	0.59	0.302	0.579	3.756	0.180	0.245	2.451	0.123	0.016	0.051

Table 4 : Proportional Contribution of Lines, Tester and Crosses

S.N.	Traits	Contribution of Line (%)	Contribution of Tester (%)	Contribution of Line: Tester (%)
1	Plant height (cm)	77.80	7.09	15.11
2	Number of primary branches plant^{-1}	57.70	1.07	41.23
3	Number of days to first flower initiation	85.82	0.19	13.99
4	Number of flowers cluster^{-1}	65.72	9.95	24.34
5	Number of fruits cluster^{-1}	50.35	4.03	45.62
6	Number of clusters plant^{-1}	55.12	6.82	38..06
7	Number of days to first picking	86.12	0.67	13.21
8	Polar diameter of fruit	75.35	4.31	20.34
9	Equatorial diameter of fruit	82.17	1.36	16.47
10	Average fruit weight	74.27	1.61	24.12
11	TSS content of the fruit	58.05	2.35	39.60
12	Acidity of the fruit	24.25	22.63	53.12
13	Fruit yield plant^{-1}	49.85	7.64	42.51

Table 5 Ranking of genotype as high *per se* performance gca and sca

S.N.	Traits	Best general combiners	Best specific combiners
1	Plant height (cm)	EC 177371, Kashi Hemant, EC 177516, EC 177343, Bhilai, NF 375-B-8	EC 177371 x Bhilai, S-12 x PDT-3-1
2	Number of primary branches per plant	S-12, EC 177371, NDT-4, Pant T-3	EC 177343 x PKM-1, S-12 x PDT-3-1, EC 177371 x PDT-3-1, EC 177516 x Bhilai
3	Number of days to first flower initiation	Pant T-3, Pant T-5, EC 177516	None of the cross significant reported
4	Number of flowers per cluster	EC 177516, Kashi Hemant, Pant T-3, Bhilai, NDT-4	Kashi Hemant x Bhilai
5	Number of fruits per cluster	PDT-3-1, EC 177516, NDT-4	NDT-4 x Bhilai, EC 177371 x PKM-1, EC 177343 x Bhilai, S-12 x PDT-3-1, Pant T-3 x PKM-1
6	Number of clusters per plant	Kashi Vishesh, Bhilai, EC 177343, EC 177371	Kashi Hemant x Bhilai, NDT-4 x PDT-3-1, EC 177371 x PDT-3-1
7	Number of days to first picking	Pant T-3, Pant T-5, EC 177516	Pant T-3 x PKM-1,
8	Polar diameter of fruit	Kashi Hemant, Kashi Vishesh, PDT-3-1	Kashi Hemant x PKM-1, Pant T-3 x PDT-3-1, EC 177516 x PDT-3-1, NF 375-B-8 x Bhilai, EC 177371 x PKM-1
9	Equatorial diameter of fruit	Kashi Vishesh, Kashi Hemant	Pant T-3 x PDT-3-1, EC 177371 x PKM-1
10	Average fruit weight	Kashi Vishesh, Kashi Hemant	EC 177371 x PKM-1, Pant T-3 x PDT-3-1
11	TSS content of the fruit	PKM-1, EC 177343, NF 375-B-8, S-12	S-12 x PDT-3-1, NF 345-B-8 x Bhilai, EC 177343 x PDT-3-1, NDT-4 x PKM-1, Pant T-5 x PKM-1
12	Acidity of the fruit	Kashi Hemant, Bhilai, EC 177371, PKM-1, Pant T-5	Pant T-3 x PKM-1, EC 177371 x Bhilai, EC 177343 x PKM-1, NDT-4 x PKM-1, NF 375-B-8 x PDT 3-1,
13	Fruit yield per plant	Kashi Vishesh, Kashi Hemant, Bhilai	EC 177371 x PKM-1, EC 177343 x PDT-3-1, Pant T-5 x Bhilai, NF 375-B-8 x PKM-1

References

Agarwal, A., Arya, D.N., Ranjan, R. and Ahmed, Z.A.K.W.A.N. (2014). Heterosis, combining ability and gene action for yield and quality traits in tomato (*Solanum lycopersicum* L.). *Helix*, **2**, 511-515.

Anonymous (2021-22). Indian Data Base. National Horticulture Board 1st advance estimation Area and Production for Horticultural Crops, 2020-21.

Arunachalam, V. & Bandyopadhyay, A. (1979). "Multiple cross-multiple pollen hybrids' an answer for productive populations in *Brassica campestris* var. 'brown sarson'. *Theoretical and Applied Genetics*, ***54***(5), 203-207.

Baban, D.S., Nasibhai, N.J., Krishna, H., Mulshankar, V.B., Keshavbhai, D.L. and Virsanbhai, B.A. (2015). Estimating combining ability effect of the Indian and exotic lines of tomatoes by partial diallel analysis. *Turkish J. Agri*., **3**(9): 715-720.

Basavaraj, L.B., Vilas, D.G., Karadi, S.M., Vijayakumar, D.R., Nagesh, G.C. and Reshmika, P.K. (2016). Combining ability analysis for fruit yield and quality traits in tomato (*Solanum lycopersicum* L.). Green Farm., **1**: 26-30.

Bhavna, M. and Patel, A.I. (2014). Combining ability study in tomato (*Lycopersicon esculentum* Mill.). Trends in Biosciences, **7**: 245-56.

Chauhan, V.B.S., Behera, T.K. and Yadav, R.K. (2014). Studies on Heterosis for yield and its Attributing Traits in Tomato (*Solanum lycopersicum* L.). *International Journal of Agriculture*, Environment & Biotechnology **7**(1): 95.

Dishri, M., Sharma, M.K., Dikshit, A. and Sharma, V.R. (2017). Analysis of combining ability for yield and component traits in indeterminate tomato. *Journal of Hill Agriculture*, **8**:26-30.

Ebenezer, R. and Babu R. (2014). Studies on combining ability for yield and yield contributing traits in tomato (*Lycopersicon esculentum* Mill.). Plant Archives **14**(1): 541-544.

Gautam, N., Kumar, M., Kumar, D., Kumar, S., Vikram, A., Dogra, R. K. and Sharma, S. (2018). Combining ability and gene action studies for important quality traits in tomato (*Solanum lycopersicum* L.). *International Journal of Chemical Studies*, **6**(2): 1992-1996.

Gautam, N., Kumar, M., Kumar, S., Vikram, A., Dogra, R. K. and Bharat, N., (2016). Combining ability analysis and gene action for yield and its contributing traits in tomato (*Solanum lycopersicum* L.) under north western himalayan region. Eco. Environ. Cons., **22**(1): 345-349.

Hannan, M.M., Ahmed, M.B., Roy, U.K., Razvy, M.A., Haydar, A., Rahman, M.A., Islam, M.A. and Islam, R., (2007). Heterosis, Combining Ability and Genetics for Brix%, Days to First Fruit Ripening and Yield in Tomato (*Lycopersicon esculentum* Mill.). *Middle-East Journal of Scientific Research* **2**(3-4): 128-131.

Joshi, A. and Kohli, U.K. (2006). Combining ability and gene action studies for processing quality attributes in tomato (*Lycopersicon esculentum* Mill.). *Indian Journal of Horticulture, **63***(3): 289-293.

Kempthorne, O. and Curnow, R.N. (1957). The partial diallel cross. Mallick, Biometrics, 17: 229-250.

Kumar, K., Sharma, D., Singh, J., Sharma, T. K., Kurrey, V. K. and Minz, R. R. (2018). Combining ability analysis for yield and quality traits in tomato (*Solanum lycopersicum* L.). *J. Pharma cog. Phytochem*., **7**(6): 1002-1005.

Kumari, S. and Sharma, K.M. (2012). Line x Tester analysis to study combining ability effects in tomato (*Solanum lycopersicum* L.) Vegetable Science **39**(1): 65-69.

Kumari, S. and Sharma, M.K. (2011). Exploitation of heterosis for yield and its contributing traits in tomato (*Solanum lycopersicum* L.). *International Journal of Farm Sciences* **1**(2): 45-55.

Mondal, C., Sarkar, S. and Hazra, P. (2009). Line × Tester analysis of combining ability in tomato (*Lycopersicon esculentum* Mill.). *Journal of Crop and Weed*, **5**(1): 53-57.

Muttappanavar, R. D., Sadashiva, A. T., Vijendrakumar, R. C., Roopa, B. N. andVasantha, P. T. (2014). Combining ability analysis of growth, yield and quality traits in Cherry Tomato (*Solanum lycopersicum* var. *cersiforme*). Molecular Plant Breeding, **5**(4):18-23.

Ramadan, W. A., El-Afifi, S. T. and Abdelmalek, P. A. (2014). Combining ability analysis for yield and its attributing traits in tomato (*Solanum lycopersicum* L.). *Journal of Plant Production*, **5**:869-83.

Reddy, B. R., Singh, A. K., Pal, A., Reddy, Y. & Reddy, G. E. (2020). Combining ability and heterosis studies in tomato (*Solanum lycopersicum* L.) for quality traits and yield. *International Journal of Chemical Studies*, *8*, 2788-2792

Renuka, D. M., Singh, T. H., Geeta, S. V. and Malaghan, S. (2015). Combining ability analysis of growth, yield and quality traits in cherry tomato (*Solanum lycopersicum* var. *cersiforme*). *Int. J. Adv. Res*., **3**(7): 319-325.

Saidi, M., Warade, S.D. and Prabu, T. (2008). Combining Ability Estimates for Yield and its Contributing Traits in Tomato (*Lycopersicon esculentum* Mill.). *International Journal of Agriculture & Biology* **10**(2): 238-240.

Saleem, MY, Asghar M, Iqbal Q, Rehman A and Akram M. (2013). Diallel analysis of yield and some yield components in tomato (*Solanum lycopersicum* L.) *Pakistan Journal of Botany*, **45**(4): 1247-1250.

Sekhar, L., Prakash, B. G., Salimath, P. M., Channayya, P., Hiremath, Sridevi, O. and Patil, A. A. (2010). Implications of hesterosis and combining ability among productive single cross hybrids in tomato. *Electronic Journal of Plant Breeding*, **1**(4): 706-711.

Shankar, A., Reddy, R.V.S.K., Sujatha, M. and Pratap, M. (2013). Combining ability and gene action studies for yield and yield contributing traits in tomato (*Solanum lycopersicum* L.). Helix 6: 431-435.

Soresa, D. N., Nayagam, G., Bacha, N. & Jaleta, Z. (2021). Estimation of general and specific combining ability effect for yield and quality characters in tomato (*Solanum lycopersicum* Mill. L.). *African Journal of Agricultural Research*, **17**(2), 321-328

Yadav, S. K., Singh, B. K., Baranwal, D. K. and Solankey, S. S. (2013). Genetic study of heterosis for yield and quality components in tomato (*Solanum lycopersicum*). *African Journal of Agricultural Research*. **8**(44): 5585-5591

Yadhav, E. D., Wavhel, K. N. and Kale, P. N. (1991). Genetic analysis of pericarp thickness in tomato. *Journal-Maharashtra Agricultural Universities*. 16: 181.

Zengin, S., Kabas, A., Oguz, A., Eren, A. and Polat, E. (2015). Determining of general combining ability for yield, quality and some other traits of tomato (*Solanum lycopersicum* L.). inbred lines. Akdeniz Universitesi Ziraat Fakultesi Dergisi. **28**(1): 1-4.