Research Article

Combining Ability Analysis for Yield and its Components in Tomato (*Solanum lycopersicum* L.)

TA Vekariya¹*, GU Kulkarni¹, DM Vekaria², AP Dedaniya¹ and JT Memon³

¹Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India
²Wheat Research Station, Junagadh Agricultural University, Junagadh, Gujarat, India
³Department of Genetics and Plant Breeding, B. A. College of Agriculture, AAU, Anand, Gujarat, India

*Corresponding Author: TA Vekariya, Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India.

Abstract

The present investigation was undertaken to study the combining ability of parents and crosses for fruit yield and quality components in tomato using 40 hybrids involving 10 lines and 4 testers in line x tester fashion. Thus, the forty crosses along with their fourteen parents and one check variety (JT-3) consisted the experimental material for the present study. The genotypes were evaluated in randomized block design with 3 replications, at Vegetable Research Station, Junagadh Agricultural University, Junagadh, during Rabi 2017-18. The present study revealed that, analysis of variance for combing ability and the estimates of variance components indicated that the mean squares due to lines were significant for all characters which revealed significant contribution of lines towards general combining ability variance components for most of traits. The mean squares due to testers were also found significant for all the characters except number of fruits per cluster suggesting the larger contribution of testers towards component of gca variance. The mean sum of squares due to lines × testers interaction observed significant for all yield attributing traits which revealed the significant contribution of hybrids for specific combining ability variance components. This indicated the involvement of additive as well as non-additive type of gene actions in the inheritance of these characters. The best general combiners for various characters were GP-5 for plant height; GP-18 for number of branches per plant; GP-17 for number of fruits per cluster; GP-32 for days to 50% fruit set, days to 50% flowering, total number of fruits per plant, days to marketable maturity and number of clusters per plant; GP-39 for average fruit weight and number of locules per fruit; GP-12 for marketable yield per plant and pericarp thickness; GP-3 for total soluble solid. Best cross combinations viz., GP-5 × JT-3, GP-29 × AT-3 and GP-18 × AT-3 were found to be best specific combiners for marketable yield per plant.

Keywords: *Solanum lycopersicum* L; General Combining Ability; Specific Combining Ability

Introduction

Vegetables play an important role in the balanced diet by providing not only energy but also vital protective nutrients like vitamins, minerals and antioxidants "Eating of plateful vegetables keeps doctor away" is universal truth due to presence of phytochemicals like carotenoids, inosital phosphate, phytosterols etc. Tomato (*Solanum lycopersicum* L.) is one of the most important fruit vegetable, which has achieved tremendous popularity during the last century. Tomato is a member of the Solanaceae family. Its consumption has increased tremendously due to its multifarious uses like raw for salad, cooked as vegetable and processed in many forms as soup, sauces, ketchups, preserves, paste and puree [1].

The combining ability study is a powerful tool to discriminate good as well as poor combiners for choosing appropriate parental material in plant breeding programme. Moreover, information regarding general and specific combing ability enables the plant breeders to evaluate parental material and to decide a suitable breeding procedure for maximum character improvement. The knowledge of nature and magnitude of fixable and non-fixable types of gene effects governing the yield and its components is essential in order to formulate an efficient and a sound breeding programme to achieve the maximum genetic improvement in tomato.

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Material and Methods

The experimental material for the present study consists of 40 crosses (F1s) developed through line x tester mating design involving 10 lines and 4 testers. Ten lines (females) namely, GP-3, GP-5, GP-12, GP-14, GP-17, GP-18, GP-29, GP-32, GP-37, GP-39 and four testers (males) i.e. GT-1, JT-3, DVRT-2, AT-3 of tomato were selected on the basis of their phenotypic variability. Forty crosses were prepared during Rabi 2016-17 using ten lines as female and four testers as male. Thus, the forty crosses along with their fourteen parents and one check variety (JT-3) consisted the experimental material for the present study. The genotypes were evaluated in Randomized Block Design with 3 replications, at Vegetable Research Station, Junagadh Agricultural University, Junagadh, during Rabi 2017-18. Geographically, Junagadh is situated at 21.5°N latitude and 70.5°E longitude with an altitude of 60 meters above the mean sea level. The soil of the experimental site is medium black, alluvial in origin and medium in organic matter.

Results and Discussion

With the advancement in biometrical genetics, several techniques are now available which permit analysis and selection of promising parents and crosses for further exploitation. Among them line × tester cross analysis is one of the principal techniques available for estimating combining ability when the genetic worth of relatively small number of parents are to be tested with great precision. Combining ability analysis is a powerful technique to discriminate good as well as poor combiners and for choosing appropriate parental material in the breeding programme of crop plants. At the same time, it also elucidates the nature of gene action involved in the inheritance of characters. The relative amount of gca and sca effects play a vital role in planning the appropriate and sound breeding programme. Therefore, the present investigation has been carried out to estimate general and specific combining ability of parents and hybrids, respectively and to know the type of gene action governing marketable yield and its component traits.

In autogamous crop species, the breeder is interested primarily in identifying the parental combinations that are likely to produce superior homologous lines. The possibility of such superior true breeding genotypes is supported by the preponderance of additive genetic variance. For improving yield potential of varieties and hybrids, decision should be made about the choice of right type of parents for hybridization. This is the importance of testing the parents for their combining ability because many times, high yielding parents may not combine well to give good segregants. The information on the type of gene action and combining ability of parents is helpful in planning future breeding programme.

General combining ability is attributed to additive genetic effect and additive × additive interaction effect and is, theoretically, fixable. On the other hand, specific combining ability attributable to non-additive gene action may be due to either dominance or epistasis or both and is unfixable. The presence of non-additive genetic variance is the primary justification to initiate the hybridization programmed.

Analysis of variance for combining ability

The analysis of variance for combining ability and the estimates of variance components (Table 1) indicated that the mean squares due to lines were significant for all characters studied. This indicated significant contribution of lines towards general combining ability variance components for all the traits. The mean sums of squares due to testers were also significant for all the characters except number of fruits per cluster, suggesting larger contribution of testers towards component of general combining ability variance. The mean sum of squares due to line × testers interaction were significant for all the yield attributing traits which revealed the significant contribution of hybrids for specific combining ability variance components.

The magnitude of gca variance were higher than the sca variance for the characters, viz., days to 50% flowering, days to 50% fruit set, which indicated preponderance of additive gene action in the inheritance of these traits. Therefore, selection for these traits in early generations would be effective for developing the varieties in tomato breeding programme. This was further supported by high magnitude of $\sigma^2 gca/ \sigma^2 sca$ ratios. Preponderance of additive variance in expression of these traits in tomato has also been reported by Sharma., *et al.* [2], Ahmed., *et al.* [3] and Singh., *et al.* [4] for days to 50% flowering.

The magnitude of sca variance were higher than gca variance for the characters, viz., plant height, number of branches per plant, number of clusters per plant, number of fruit per cluster, total number of fruits per plant, average fruit weight, number of locules per fruit, marketable yield per plant, pericarp thickness, fruit shape index, days to marketable maturity, number of cluster per plant, total soluble solid, acidity, which indicated preponderance of non-additive gene action in the inheritance of these traits. Therefore, heterosis breeding is used if commercially feasible. Similar findings were also reported by Gaikwad., *et al.* [5], Sharma., *et al.* [2], Ahmed., *et al.* [3] and Mali and Patel [6] for plant height (cm), Gaikwad., *et al.* [5] and Angadi., *et al.* [7] for number of branches per plant, Angadi., *et al.* [7] for number of clusters per plant, Gaikwad., *et al.* [5], Angadi., *et al.* [7] and Yadav., *et al.* [8] for number of fruits per plant, Gaikwad., *et al.* [5], Angadi., *et al.* [7], Agarwal., *et al.* [9] and El- Gabry., *et al.* [10] for average fruit weight (g), Gaikwad., *et al.* [5], Singh and Asati [11] and Kumari and Sharma [12] for marketable yield per plant, Gaikwad., *et al.* [5], Kumari and Sharma [12], for pericarp thickness, Ahmad., *et al.* [3] and Souza., *et al.* [13] for total soluble solids, Souza., *et al.* [13] and Shankar., *et*

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Source	d.f.	Days to 50% flowering	Days to 50% fruit set	Plant height	No. of Branches per plant	No. of fruits per cluster	Total number of fruits per plant	Average fruit weight	No. of locules per fruit
Replications	2	5.108	4.633	17.034	1.304**	0.506	2129.740	0.039	0.038
Lines	9	35.670**++	37.337**++	4172.241**	9.514**	4.979**	33063.030**	1615.340**++	1.391**
Testers	3	55.967**++	70.030**++	3342.910**	18.302**	0.271	39514.080**	2033.100**+	1.096**
Lines× Testers	27	7.435	8.826*	2287.760**	9.726**	4.107**	14856.890**	460.710**	1.209**
Error	78	5.005	5.231	5.838	0.238	0.205	730.540	0.113	0.082
Variance Components									
$\sigma^2 l$		2.555**	2.675**	347.200	0.773	0.397	2694.370	134.602**	0.109
$\sigma^2 t$		1.698**	2.160**	111.230	0.602	0.002	1292.780	67.766*	0.033
$\sigma^2 lt$		0.810	1.198*	760.640**	3.162**	1.300**	4708.780**	153.533**	0.375**
$\sigma^2 gca$		1.943**	2.307**	178.650**	0.650*	0.115	1693.230**	86.862**	0.055
$\sigma^2 sca$		0.810	1.198	760.640**	3.162**	1.300**	4708.780**	153.533**	0.375**
$\sigma^2 gca/ \sigma^2 sca$		**2.399**	**1.925**	**0.234**	**0.205**	**0.088**	**0.360**	**0.565**	**0.147**

Source	d.f.	Marketable yield per plant	Pericarp thickness(mm)	Fruit shape index	Days to marketable maturity	No. of clusters per plant	Total Soluble solids (%)	Acidity (%)
Replications	2	1.407*	0.007	0.001	0.325	19.989	0.114	0.013**
Lines	9	9.580**	2.180**	0.236**	24.149**	1261.588**+	4.304**	0.008**
Testers	3	22.087**	1.317**	0.511**	46.808**+	1850.112**+	4.542**	0.018**
Lines× Testers	27	13.672**	1.278**	0.206**	12.833**	533.135**	2.858**	0.010**
Error	78	0.315	0.009	0.004	0.897	12.280	0.0926	0.001
Variance Components								
$\sigma^2 l$		0.772	0.181	0.002	1.937	104.108*	0.351	0.001
$\sigma^2 t$		0.725	0.043	0.002	1.530*	61.261*	0.148	0.001
$\sigma^2 lt$		4.452**	0.423**	0.006**	3.978**	173.617**	0.921**	0.003**
$\sigma^2 gca$		0.738	0.082*	0.002**	1.646**	73.503**	0.206*	0.001
$\sigma^2 sca$		4.452**	0.423**	0.006**	3.978**	173.617**	0.921**	0.003**
$\sigma^2 gca/ \sigma^2 sca$		**0.166**	**0.195**	**0.284**	**0.827**	**0.423**	**0.223**	**0.186**

Table 1: Analysis of variance for combining ability and variance components for different characters in tomato

*, ** Significant at 5% and 1% against error, respectively

+, ++ Significant at 5% and 1% levels, respectively against line × tester interaction.

The estimation of genetic variance contributed by lines ($\sigma 2l$) and testers ($\sigma 2t$).

al. [14] for acidity. Gaikwad., *et al.* [5] and Tanvi., *et al.* [15] for average fruit weight (g). Angadi and Dharmati [7] and Souza., *et al.* [13] for number of locules per fruit.

In a view of these studies, it could be concluded that marketable yield is a complex character as compared to its components. Thus,

as the quantitative character becomes complex, the contribution of non-additive gene action would be more. Under such situation, it would be worthwhile to resort to breeding methodologies, such as biparental mating and diallel selective mating than to conventional pedigree or backcross techniques which would leave the unfixable components of genetic variances which are usually exploited for yield and its components.

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General and specific combining ability effects

Selection of parents for hybridization programme is an important aspect in the crop improvement. In any sound breeding programme, the proper choice of parents based on their combining ability is a pre-requisite. Such studies not only provide necessary information regarding the choice of parent but, also illustrate the nature and magnitude of gene action involved in the inheritance of the characters of economics interest.

The combining ability analysis carried out to obtain useful information for selection of better parents and crosses for their future use in breeding programme. The information regarding nature and magnitude of gene action could also be obtained, which is useful in deciding breeding methodology aiming at exploitation of fixable (additive) and non-fixable (non-additive) genetic variances.

The summary of general combining ability effects (Table 2) of the parents revealed that none of the parents was found to be good general combiner for all the characters. General combining ability effects of the parents revealed that GP-12, GP-32 of the line and DVRT-2 of tester was found to be good general combiner for days to 50% flowering and GP-12, GP-32 of lines and DVRT-2 and JT-3 of testers was found to be good general combiner for days 50% fruit set. The good general combining ability effect was expressed by the female parent GP-3, GP-5, GP-14, GP-17 and GP-18 and male parent AT-3 for plant height. The estimate of general combining ability effect revealed that female parents GP-3, GP-18 and GP-29 and male parents JT-3 and AT-3 have good general combining ability effects for number of branches per plant. Female parents GP-14, GP-17, GP-18, GP-29 and GP-37 showed significant positive general combining ability effects for number of fruits per clusters. For total number of fruits per plant, female parents GP-5, GP-14, GP-32 and male parent GT-1, JT-3 registered as good general combiners. For average fruit weight, female parents GP-12, GP-29, GP-39 and male parents DVRT-2 and AT-3 showed significant positive general combining ability effects.

Female parentGP-12, GP-17, GP-29, GP-39 and male parents JT-3, DVRT-2 was considered as good general combiners for number of locules per fruit. For marketable yield per plant, female parents GP-12, GP-14, GP-32 and male parent JT-3, AT-3 were considered as good general combining ability combiners. For pericarp thickness, female parents GP-12, GP-32, GP-37, GP-39 and male parent DVRT-2, AT-3 showed significant positive general combining ability effect. For fruit shape index GP-32, GP-37 of lines and GT-1, DVRT-2, AT-3 of tester showed significant positive general combining ability effect. Female parents GP-18, GP-32 and male parent GT-1, JT-3 was considered as good general combiners for days to marketable maturity. Female parents GP-5, GP-3, GP-14, GP-32 and male parent GT-1 and JT-3 was considered as good general combiners for number of clusters per plant. Female parents GP-3, GP-5, GP-14, GP-37 and male parent GT-1, AT-3 was considered as good general combiners for total soluble solid. Whereas female parents GP-12, GP-29, GP-39 and male parents JT-3, AT-3 considered as good general combiners for titrable acidity.

As regards to specific combining ability effects (Table 3), eight crosses exhibited significant positive specific combining ability effects for marketable yield per plant. The highest sca effect for marketable yield per plant was exhibited by the cross GP-5 × JT-3 (poor × average) followed by GP-29 × AT-3 (poor × good), GP-18 × AT-3 (average × good). Considering the desired sca effects, the best cross combination were GP-14 × JT-3 for days to 50% flowering, GP-14 × JT-3 for days to 50% fruit set, GP-3 × DVRT-2 for plant height, GP-12 × JT-3 for Number of branches per plant, GP-39 × JT-3 for number of fruits per cluster, GP-32 × JT-3 for Total number of fruits per plant, GP-39 × DVRT-2 for average fruit weight, GP-5 × JT-3 for number of locules per fruit, GP-18 × AT-3 for pericarp thickness, GP-5 × GT-1 for fruit shape index, GP-12 × DVRT-2 for days to marketable maturity and GP-37 × JT-3 for number of clusters per plant, GP-17 × DVRT-2 for total soluble solids and GP-17 × JT-3 for acidity.

Sr. No.	Parents	Days to 50% flowering	Days to 50% fruit set	Plant height	No. of branches per plant	No. of fruits per cluster	Total number of fruits per plant	Average fruit weight	No. of locules per fruit	Marketable yield per plant	Pericarp thickness	Fruit Shape index	Days to marketable maturity	No. of clusters per plant	Total soluble solids	Acidity
Lines																
1	GP-3	-0.967	-1.208	6.207**	0.355*	-0.900**	-18.707*	-13.473**	-0.381**	-1.925**	-0.460**	0.019	0.108	2.553**	0.840**	-0.027**
2	GP-5	0.533	0.292	26.09**	-0.595**	-0.367**	31.503**	-9.906**	0.103	-0.475**	-0.336**	-0.063**	-0.142	8.537**	0.467**	-0.022*
3	GP-12	-1.467*	-1.458*	-8.61**	-0.162	-0.700**	-24.47**	12.519**	0.236**	1.370**	0.865**	-0.058**	-0.308	0.920	0.048	0.018
4	GP-14	-0.133	0.125	15.873**	0.238	0.400**	71.737**	-7.198**	-0.156	0.510**	-0.447**	0.001	1.525**	12.553**	0.600**	0.031**
5	GP-17	-0.967	-0.375	2.223**	-1.278**	1.050**	9.263	-5.339**	0.319**	-0.235	-0.165**	-0.034*	0.442	-5.68**	-0.548**	-0.020*
6	GP-18	0.033	-0.042	15.473**	1.738**	0.317*	-15.947*	-0.198*	-0.198*	0.236	0.017	0.02	-1.558**	-5.83**	-0.036	-0.037**
7	GP-29	0.367	0.625	-6.543**	0.905**	0.250*	-69.093**	4.653**	0.228**	-0.390*	-0.289**	0.025	-0.725**	-16.93**	-0.395**	0.021*
8	GP-32	-2.550**	-2.958**	-1.843**	-0.995**	0.167	80.953**	-2.223**	-0.389**	0.882**	0.407**	0.055**	-2.642**	14.853**	-0.353**	0.006
9	GP-37	1.450*	1.375*	-7.127**	-0.312*	0.533**	11.62	-4.323**	-0.348**	-0.185	0.155**	0.064**	1.442**	0.620	0.452**	-0.005
10	GP-39	3.700**	3.625**	-41.743**	0.105	-0.750**	-76.86**	25.486**	0.586**	0.212	0.252**	-0.028	1.858**	-11.597**	-1.075**	0.034**
	SE(gi) ±	**0.645**	**0.660**	**0.697**	**0.140**	**0.130**	**7.802**	**0.097**	**0.082**	**0.162**	**0.027**	**0.017**	**0.273**	**1.011**	**0.087**	**0.010**
	CD at 5%	**1.258**	**1.314**	**1.388**	**0.280**	**0.260**	**15.533**	**0.193**	**0.164**	**0.323**	**0.055**	**0.034**	**0.544**	**2.014**	**0.175**	**0.020**
Testers																
1	GT-1	-0.217	-0.242	0.803	-1.098**	0.110	31.961**	-10.733**	-0.281**	-0.926**	-0.271**	0.013*	-0.875**	6.66**	0.477**	-0.032**
2	JT-3	-0.517	-1.108**	-10.55**	0.315**	-0.103	25.772**	-1.986**	0.103*	0.318**	-0.06	-0.06	-1.108**	6.573**	-0.289**	0.019**
3	DVRT-2	-1.217**	-0.875*	-4.477**	0.062	-0.050	-46.175**	7.644**	0.136**	-0.426**	0.157**	0.013*	0.392*	-8.84**	-0.345**	-0.007
4	AT-3	1.95**	2.225**	14.223**	0.722**	0.043	-11.559*	5.074**	0.043	1.034**	0.174**	0.034**	1.592**	-4.393*	0.157**	0.020**
	SE(gi) ±	0.408	0.417	0.441	0.089	0.082	4.934	0.061	0.052	0.102	0.017	0.010	0.173	0.639	0.055	0.006
	CD at 5%	0.813	0.831	0.878	0.177	0.164	9.824	0.122	0.104	0.204	0.035	0.021	0.344	1.273	0.110	0.01

Table 2: General combining ability effects for different characters in tomato*, ** Significant at 5% and 1% against error, respectively.

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Sr. No.	Hybrids	Days to 50% flowering	Days to 50% fruit set	Plant height	No. of branches per plant	No. of fruits per cluster	Total number of fruits per plant	Average fruit weight	No. of locules per fruit
1	GP-3 × GT-1	-1.7	-2.092	-21.52**	0.532	-0.293	-32.701*	13.033**	1.131**
2	GP-3 × JT-3	1.267	1.442	6.3**	-1.548**	1.453**	66.782**	1.219**	-0.519**
3	GP-3 × DVRT-2	1.967	1.542	46.027**	0.305	-0.600*	16.768	-2.478**	-0.219
4	GP-3 × AT-3	-1.533	-0.892	-30.807**	0.712*	-0.560*	-50.848**	-11.774**	-0.393*
5	GP-5 × GT-1	-0.533	-0.925	-16.47**	-0.585*	0.640*	81.502**	-0.001	-1.153**
6	GP-5 × JT-3	2.1	1.275	-6.517**	1.135**	0.053	44.638**	19.453**	1.664**
7	GP-5 × DVRT-2	0.133	0.042	14.61**	2.522**	0.800*	9.011	-12.378**	-0.569**
8	GP-5 × AT-3	-1.7	-0.392	8.377**	-3.072**	-1.493**	-135.15**	-7.074**	0.057
9	GP-12 × GT-1	1.8	2.158	22.297**	0.782**	-0.493	-8.138	0.108	0.248
10	GP-12 × JT-3	-0.567	-1.642	7.983**	2.768**	0.920**	-14.815	2.494**	0.264
11	GP-12 × DVRT-2	-1.867	-1.208	-12.69**	-3.178**	-0.267	52.638**	-15.903**	-0.303
12	GP-12 × AT-3	0.633	0.692	-17.59**	-0.372	-0.160	-29.685	13.301**	-0.209
13	GP-14 × GT-1	1.467	0.908	8.28**	0.382	-0.593*	39.402*	1.458**	-0.061
14	GP-14 × JT-3	-3.233*	-3.558**	0.7	-1.832**	-0.780**	-69.755**	5.011**	0.456**
15	GP-14 × DVRT-2	0.467	1.208	2.827*	-0.112	0.300	-8.329	-4.519**	0.289
16	GP-14 × AT-3	1.3	1.442	-11.807**	1.562**	1.073**	38.682*	-1.949**	-0.684**
17	GP-17 × GT-1	-2.033	-0.258	-23.403**	-1.835**	0.690**	28.742	8.199**	0.164
18	GP-17 × JT-3	-0.4	-2.058	14.95**	-0.248	0.437	-34.548*	-3.281**	-0.352*
19	GP-17 × DVRT-2	1.633	2.042	4.077**	-0.062	-1.017**	-4.829	-4.611**	-0.453**
20	GP-17 × AT-3	0.8	0.275	4.377**	2.145**	-0.110	10.635	-0.307	0.641**
21	GP-18 × GT-1	1.3	0.408	20.347**	1.015**	0.357	-30.594*	-6.176**	-0.119
22	GP-18 × JT-3	-0.067	1.275	-17.833**	0.335	-2.23**	-92.074**	6.878**	-0.236
23	GP-18 × DVRT-2	-0.367	0.042	-35.44**	-1.012**	0.650*	32.755*	-8.719**	-0.136
24	GP-18 × AT-3	-0.867	-1.725	32.927**	-0.338	1.223**	89.913**	8.018**	0.491**
25	GP-29 × GT-1	1.633	1.742	-4.637**	2.115**	-1.310**	-57.381**	-9.959**	-0.578**
26	GP-29 × JT-3	0.267	0.942	-15.083**	1.102**	-1.163**	-60.645**	-6.539**	-0.128
27	GP-29 × DVRT-2	-0.7	-1.292	3.377*	-0.912**	1.250**	14.528	4.798**	0.306
28	GP-29 × AT-3	-1.2	-1.392	16.343**	-2.305**	1.223**	103.499**	11.701**	0.399*
29	GP-32 × GT-1	-1.45	-1.008	27.863**	-1.652**	-0.493	37.945*	3.683**	0.373*
30	GP-32 × JT-3	0.85	0.858	43.15**	-0.265	1.12**	141.362**	-10.898**	-1.044**
31	GP-32 × DVRT-2	-0.783	-1.375	-14.59**	2.388**	0.333	-74.919**	6.373**	0.523**
32	GP-32 × AT-3	1.383	1.525	-56.423**	-0.472	-0.96**	-104.39**	0.842**	0.149
33	GP-37 × GT-1	0.883	1.325	-9.453**	-1.402**	0.607*	-40.695**	7.016**	0.231
34	GP-37 × JT-3	-0.817	-0.475	5.700**	0.918**	-1.447**	29.815	-2.398**	-0.086
35	GP-37 × DVRT-2	0.217	-0.042	-30.773**	-0.295	-0.100	-51.105**	0.339	0.081
36	GP-37 × AT-3	-0.283	-0.808	34.527**	0.778**	0.940**	61.985**	-4.958**	-0.226
37	GP-39 × GT-1	-1.367	-2.258	-3.303*	0.648*	0.890**	-18.081	-17.359**	-0.236
38	GP-39 × JT-3	0.600	1.942	-39.35**	-2.365**	1.637**	-10.758	-11.939**	-0.019
39	GP-39 × DVRT-2	-0.700	-0.958	22.577**	0.355	-1.35**	13.481	37.098**	0.481**
40	GP-39 × AT-3	1.467	1.275	20.077**	1.362**	-1.177**	15.359	-7.799**	-0.226
	SE±	1.291	1.320	1.395	0.281	0.261	15.605	0.194	0.165
	CD at 5%	2.571	2.629	2.777	0.561	0.521	31.067	0.386	0.329

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Sr. No.	Hybrids	Marketable yield per plant	Pericarp thickness	Fruit shape index	Days to marketable maturity	No. of clusters per plant	Total Soluble Solids	Acidity
1	GP-3 × GT-1	1.205**	0.784**	-0.051	-0.875	-3.160	-0.267	0.038
2	GP-3 × JT-3	0.688*	0.313**	0.016	-1.308*	2.460	0.306	-0.040*
3	GP-3 × DVRT-2	0.592	-0.113*	0.073*	2.192**	9.473**	0.268	0.001
4	GP-3 × AT-3	-2.485**	-0.984**	-0.038	-0.008	-8.773**	-0.307	0.002
5	GP-5 × GT-1	-0.612	-0.506**	0.111**	-1.958**	11.79**	0.460**	0.019
6	GP-5 × JT-3	5.438**	0.717**	-0.259**	0.275	14.41**	-2.254**	-0.039*
7	GP-5 × DVRT-2	-1.085**	-0.117*	0.085*	0.442	-4.043*	0.388*	-0.003
8	GP-5 × AT-3	-3.741**	-0.094	0.063	1.242*	-22.157**	1.407**	0.023
9	GP-12 × GT-1	0.371	-0.040	-0.037	-0.458	4.007*	0.658**	0.012
10	GP-12 × JT-3	0.457	0.726**	0.033	3.775**	-11.373**	0.398*	-0.079**
11	GP-12 × DVRT-2	-0.279	-1.014**	0.040	-4.058**	13.573**	-0.347*	0.004
12	GP-12 × AT-3	-0.549	0.328**	-0.035	0.742	-6.207**	-0.709**	0.063**
13	GP-14 × GT-1	-0.322	-0.398**	0.064	-0.958	13.84**	-0.56**	-0.044*
14	GP-14 × JT-3	-0.373	0.207**	-0.052	0.608	-7.873**	0.799**	0.065**
15	GP-14 × DVRT-2	0.148	0.291**	-0.025	0.775	-4.993*	-0.626**	0.085**
16	GP-14 × AT-3	0.548	-0.100	0.013	-0.425	-0.973	0.386*	-0.106**
17	GP-17 × GT-1	1.696**	0.206**	0.018	2.458**	-0.860	-1.279**	-0.026
18	GP-17 × JT-3	-1.315**	0.125*	0.025	-2.642**	-9.707**	-0.599**	0.110**
19	GP-17 × DVRT-2	-0.231	0.029	-0.024	0.192	5.507**	1.930**	-0.038
20	GP-17 × AT-3	-0.150	-0.359**	-0.019	-0.008	5.060*	-0.052	-0.045*
21	GP-18 × GT-1	-1.772**	-0.989**	-0.025	2.458**	-9.577**	0.243	-0.026
22	GP-18 × JT-3	-1.849**	0.123*	0.058	-0.975	-3.957	-0.258	-0.047*
23	GP-18 × DVRT-2	-0.255	-0.223**	-0.018	-0.475	2.923	-0.149	-0.044*
24	GP-18 × AT-3	3.876**	1.089**	-0.016	-1.008	10.610**	0.163	0.118**
25	GP-29 × GT-1	-1.852**	0.157**	-0.007	0.292	-6.543**	1.422**	-0.017
26	GP-29 × JT-3	-2.443**	-0.568**	0.053	-1.142*	-8.857**	-1.166**	-0.031
27	GP-29 × DVRT-2	-0.249	0.196**	-0.043	-0.642	-0.310	-0.371*	-0.005
28	GP-29 × AT-3	4.545**	0.215**	-0.004	1.492**	15.710**	0.115	0.054**
29	GP-32 × GT-1	1.669**	0.814**	-0.037	0.542	15.740**	0.193	0.024
30	GP-32 × JT-3	-0.289	-1.247**	0.036	2.775**	14.093**	1.613**	-0.030
31	GP-32 × DVRT-2	0.469	0.244**	0.080*	-0.725	-17.427**	-0.892**	0.020
32	GP-32 × AT-3	-1.848**	0.189**	-0.078*	-2.592**	-12.407**	-0.914**	-0.015
33	GP-37 × GT-1	0.349	0.3**	-0.019	0.458	-14.893**	-0.458**	0.005
34	GP-37 × JT-3	0.158	0.276**	0.001	-3.642**	23.06**	0.761**	0.035
35	GP-37 × DVRT-2	-0.878**	-0.297**	-0.002	1.858**	-12.327**	-0.497**	0.024
36	GP-37 × AT-3	0.372	-0.278**	0.020	1.325*	4.160*	0.195	-0.064**
37	GP-39 × GT-1	-0.731*	-0.328**	-0.017	-1.958**	-10.343**	-0.412*	0.016
38	GP-39 × JT-3	-0.469	-0.672**	0.089**	2.275**	-12.257**	0.401*	0.055**
39	GP-39 × DVRT-2	1.769**	1.005**	-0.167**	0.442	7.623**	0.296	-0.042*
40	GP-39 × AT-3	-0.568	-0.006	0.095**	-0.758	14.977**	-0.285	-0.030
	SE±	0.324	0.055	0.034	0.547	2.023	0.175	0.020
	CD at 5%	0.646	0.111	0.068	1.089	4.028	0.349	0.040

Table 3: Specific combining ability effects of various characters in tomato*, ** Significant at 5% and 1% against error, respectively.

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The *gca* effects of the parents and *sca* effects of their crosses in the present study indicated that the crosses between two high general combiners were not always the best their *sca* effects. The best specific cross combinations for different characters in present study were the combinations of good × good, good × average, average × average, average × poor, poor × poor and good × poor general combiners. The marked desirable specific combining ability effects in crosses between poor × poor combiners includes, GP-3 × GT-1 for number of locules per fruit, GP-5 × JT-3 for average fruit weight; poor × average combiner e.g., GP-39 × JT-3 for number of fruits per cluster; average × average combiner e.g., GP-14 × JT-3 Days to 50% flowering; average × good e.g., GP-14 × JT-3 for days to 50% fruit set, GP-12 × JT-3 for number of branches per plant; good × good e.g., GP-39 × DVRT-2 for average fruit weight and GP-32 × JT-3 for total number of fruits per plant, GP-12 × AT-3 for average fruit weight; good × poor e.g., GP-3 × DVRT-2 for plant height.

In fact, in majority of cases, the best specific combinations for different characters were either poor × poor, good × poor, average × poor, average × average and vise versa general combiners. This suggested that information on *gca* effects should be supplemented by *sca* effects and hybrid performance of cross combinations to predict the transgressive type possibly made available in segregating generations. Selection is rapid if gca effects of parents and *sca* effects of crosses are in same direction. If crosses showing high *sca* effects involve at least one parent possessing good gca effect and high mean value, they could be exploited for practical breeding. However, high *sca* effects would not necessarily mean a high performance by the hybrid and the estimation of sca effects seemed to be superfluous, as no additional information was obtained by doing so. Therefore, it is suggested that the selection of parents for further breeding programme should be based on *gca* effects and due consideration should be given to mean value of the cross combinations while selecting crosses for specific combining ability effects.

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