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Combining Ability Studies for Growth and Quality Characters in Tomato (*Solanum lycopersicum* L.)

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A B S T R A C T

General and specific combining abilities (GCA and SCA) were estimated using six lines of tomato (*Solanum lycopersicum* L.) and three testers and their F_1 hybrids, bred in line x tester fashion. The present study revealed that none of the parent was best combiner for all the traits indicating differences in genetic variability for different characters among the parents. Line x tester effect was found significant for all the characters under the study except for plant height. The magnitude of *gca* and *sca* variances indicated importance of additive as well as non-additive gene action with predominance non-additive action for all the traits except plant height. Lines, LE-56 was found good general combiner for ascorbic acid, total carotenoids, reducing sugars, total sugars and lycopene content; LE-62 for plant height, TSS, reducing sugars and total sugars. Similarly tester, Punjab Chhuhara for total carotenoids and lycopene; tester Pusa Gaurav was found to be good combiner for plant height, reducing sugars and total sugars. F_1 hybrids from cross combinations, LE-62 × Punjab Chhuhara were recorded with good specific combiner for number of primary branches per plant, total carotenoids, reducing sugars, total sugars and lycopene; LE-64 × Punjab Chhuhara for ascorbic acid, total carotenoids and lycopene; EC-165749 X Pusa Gaurav for TSS, reducing sugars and total sugars.

Introduction

Tomato (*Solanum lycopersicum* L.) an important vegetable crop grown throughout the world, is not only used as a fresh vegetable but also for processing. Combining ability is an effective tool, which gives genetic information for the choice of parents in terms of performance of their hybrids (Chezhian *et al.*, 2000). For developing hybrids, the most important task for the plant breeder is the choice of parental lines. The selection of parents on the basis of per se performance does not necessarily lead to desirable results (Allard, 1960). It is, therefore essential to find out the combining ability of desirable genotypes to be involved in breeding programme for effective transfer of desirable genes in the resultant progenies. The objective of present investigation was undertaken to identify the best parental combination for growth and quality characters in tomato.

Materials and Methods

The present investigation was carried out at the experimental farm of Vegetable Research Station, Dr. Y.S. R. Horticultural University, Rajendranagar, Hyderabad during 2010 - 2011. The parental material used in the line x tester model, consisted of six lines *viz*., EC-165749, LE-56, LE-62, LE-64, LE-65, LE-67 and three testers *viz*., d Punjab Chhuhara, Pant T-3 and Pusa Gaurav. Crosses were made manually using the standard procedure of hand emasculation and pollination. All the 18 hybrids along with their corresponding nine parents and three standard checks *viz*; Lakshmi, US-618 and Arka vikas were evaluated in a randomized block design with three replications. Combining ability analysis was done as per Kempthorne (1957).

Observations were recorded for plant height (cm), number of primary branches per plant, total soluble solids (ºBrix), ascorbic acid (mg/100 g), total carotenoids (mg/100 g), teducing sugars (%), total sugars (%) and lycopene content (mg/100 g) to study the gene action, general combining ability (*gca*) effects of parents and specific combining ability (*sca*) effects of hybrids in tomato.

Results and Discussion

Analysis for combining ability was carried out for growth and quality characters and mean sum of squares were presented in Table 1. The analysis of variance revealed that the treatments exhibited highly significant differences among themselves. The parents as well as crosses exhibited significant differences for all the traits studied, whereas parents vs. crosses exhibited significant differences only for plant height, number of primary branches per plant and ascorbic acid. The interaction effects (Lines × Testers) were found to be significant for all the traits except for plant height.

General combining ability and specific combining ability effects

Nature and magnitude of combining ability effects provide guide line in identifying the better parents and their utilization. The summary of the *gca* effects of the parents (Table 3) revealed that none of the parent found to be good general combiner for all the characters. Line, LE-56 was found good general combiner for ascorbic acid (11.719), total carotenoids (0.854), reducing sugars (0.367), total sugars (0.353) and lycopene (1.005). Line, LE-62 was observed good combiner for plant height (24.524), TSS (0.641), reducing sugars (0.613) and total sugars (0.621). None of the lines exhibited positive and negative significant *gca* effects for number of primary branches per plant. Among the testers, Punjab Chhuhara was observed good combiner for total carotenoids (0.569) and lycopene (0.662). Tester, Pusa Gaurav was found to be good combiner for plant height (6.835), reducing sugars (0.135) and total sugars (0.140). None of the testers exhibited positive and negative significant *gca* effects for ascorbic acid.

In the case of *sca* effects, none of the hybrids exhibited favourable *sca* effect for all the characters (Table 4). Of all the crosses studied none of the crosses found to be significant, except LE-64 × Punjab Chhuhara (-16.03) which recorded significant negative *sca* effect for plant height. Hybrid, LE-62 × Punjab Chhuhara was recorded with good specific combiner for number of primary branches per plant (1.388), total carotenoids (1.051), reducing sugars (0.454), total sugars (0.430) and lycopene (1.587). Cross combination, LE-64 × Punjab Chhuhara was found to be good specific combiner for ascorbic acid (6.559), total carotenoids (1.288) and lycopene (1.478). Cross, EC-165749 X Pusa Gaurav reflected good sca for TSS (0.893), reducing sugars (1.054) and total sugars (0.733).

Table.1 Analysis of variance for combining ability for growth and quality characters in tomato

Source	df	Mean Sum of Squares							
		Plant height (cm)	No. of primary branches/ plant	TSS (ºBrix)	Ascorbic acid (mg/100 g)	Total carotenoid (mg/100 g)	Reducing sugars (%)	Total sugars (%)	Lycopene (mg/100 g)
Replications	2	41.3091	0.0640	0.0448	3.8258	0.1816	0.1485	0.0402	0.1276
Treatments	26	1316.7109**	3.7655**	0.8985**	188.8397**	6.6041**	1.0354**	0.8921**	7.3981**
Parents	8	855.5489**	3.1379**	1.0657**	76.4032**	7.5321**	1.1842**	1.1233**	5.9124**
Parents (Line)	5	1200.2116**	2.6036**	1.0062**	112.0482**	10.7523**	0.9204**	0.9392**	7.7579**
Parents (Testers)	2	211.1054	5.0411**	1.5511**	16.4444	3.2288**	2.2639**	1.9880**	4.0224**
Parents (L vs T)	1	421.1230	2.0030**	0.3919*	18.0961	0.0379	0.3440*	0.3143*	0.4648
Parents vs Crosses	1	3399.3677**	1.7735**	0.0089	65.0433**	0.3326	0.0214	0.0045	0.6309
Crosses	17	1411.2190**	4.1781**	0.8721**	249.0330**	6.5363**	1.0250**	0.8355**	8.4952**
Line Effect	5	3706.9396**	0.5265	1.2803	526.7154	4.2635	1.5803	1.4675	3.8586
Tester Effect	2	1377.4990*	3.6239	0.5469	6.7761	8.8826	0.3214	0.3020	9.6413
Line * Tester Eff.	10	270.1027	6.1148**	0.7331**	158.6432**	7.2035**	0.8881**	0.6262**	10.5843**
Error	52	166.7301	0.2422	0.0756	7.4309	0.2903	0.0503	0.0707	0.2734
Total	80	537.3383	1.3828	0.3423	66.2986	2.3395	0.3729	0.3369	2.5853

* Significant at 5% level ** Significant at 1 % level

Table.2 Analysis of variance for combining ability for growth and quality characters in tomato

S. No.	Character	σ^2 *GCA*	σ^2 *SCA*	σ^2 *GCA*/ σ^2*SCA*
1	Plant height	175.9622	34.4575	5.1066
2	No. of primary branches per plant	0.1358	1.9575	0.069
3	TSS (ºBrix)	0.0621	0.2192	0.5665
4	Ascorbic acid (mg/100 g)	19.2085	50.4041	0.3811
5	Total carotenoids (mg/100 g)	0.4654	2.3044	0.2020
6	Reducing sugars (%)	0.0667	0.2793	0.2389
7	Total sugars (%)	0.0603	0.1852	0.3257
8	Lycopene (mg/100 g)	0.4797	3.4370	0.1396

Table.3 Estimates of general combining ability *(gca)* effects of parents for growth and quality characters in tomato

	Plant height (cm)	No. of primary branches/ plant	TSS (ºBrix)	Ascorbic acid (mg/100 g)	Total carotenoid (mg/100 g)	Reducing sugars (%)	Total sugars (%)	Lycopene (mg/100 g)
Lines								
EC - 165749	-16.581**	0.179	-0.326**	-8.262**	-0.451*	-0.342**	-0.272**	-0.133
LE - 56	-14.102**	0.055	0.196*	11.719**	0.854**	0.367**	0.353**	1.005**
LE - 62	24.524**	-0.291	0.641**	-3.392**	-0.250	0.613**	0.621**	-0.094
LE - 64	-1.524	-0.018	-0.137	5.719**	0.649**	-0.199*	-0.178	0.355*
LE - 65	25.664**	0.329	-0.004	-6.503**	0.160	0.020	-0.084	-0.155
LE - 67	-17.980**	-0.254	-0.370**	0.719	-0.962**	-0.460**	-0.439**	-0.978**
$SE_{(i)}$	4.304	0.164	0.092	0.909	0.180	0.075	0.089	0.174
SE(i-j)	6.087	0.232	0.130	1.285	0.254	0.106	0.125	0.247
Testers								
Punjab Chhuhara	-9.859**	-0.217	-0.198**	0.108	0.569**	-0.132*	-0.116	0.662**
Pant T - 3	3.024	0.516**	0.069	-0.660	-0.785**	-0.002	-0.024	-0.786**
Pusa Gaurav	6.835*	-0.299*	0.130	0.552	0.216	0.135*	0.140*	0.124
$SE_{(i)}$	3.044	0.116	0.065	0.643	0.127	0.053	0.063	0.123
SE (i-j)	4.304	0.164	0.092	0.909	0.180	0.075	0.089	0.174

* Significant at 5% level ** Significant at 1 % level

Table.4 Estimates of specific combining ability *(sca)* effects of hybrids for growth and quality characters in tomato

Crosses	Plant height (cm)	No. of primary branches/ plant	TSS (°Brix)	Ascorbic acid (mg/100 g)	Total carotenoid (mg/100 g)	Reducing sugars (%)	Total sugars (%)	Lycopene (mg/ 100 g)
EC -165749 × Punjab Chhuhara	0.336	-0.672*	-0.346*	5.540**	0.062	-0.589**	-0.381*	-0.414
EC -165749 × Pant T-3	0.098	1.262**	-0.546**	-2.635	0.756*	-0.465**	-0.352*	0.731*
EC -165749 × Pusa Gaurav	- 0.434	-0.590*	0.893**	-2.905	-0.818*	1.054**	0.733**	-0.317
LE-56 × Punjab Chhuhara	- 4.586	-0.459	0.165	-1.775	0.696*	0.109	0.034	0.962**
LE-56 × Pant T-3	1.699	0.159	-0.069	0.994	-1.239**	-0.114	-0.153	-1.607**
LE-56 × Pusa Gaurav	2.887	0.300	-0.096	0.781	0.543	0.005	0.119	0.646*
LE-62 × Punjab Chhuhara	10.039	1.388**	0.354*	-1.330	1.051**	0.454**	0.430**	1.587**
LE-62 × Pant T-3	- 9.927	-0.001	0.387*	-7.229**	1.015**	0.277*	0.166	1.215**
LE-62 × Pusa Gaurav	- 0.112	-1.386**	-0.741**	8.559**	-2.066**	-0.730**	-0.596**	-2.802**
LE-64 × Punjab Chhuhara	-16.030*	0.425	0.198	6.559**	1.288**	0.268*	0.302	1.478**
LE-64 × Pant T-3	8.688	-2.331**	-0.235	5.660**	-1.554**	-0.269*	-0.359*	-1.741**
LE-64 × Pusa Gaurav	7.343	1.907**	0.037	-12.219**	0.266	0.001	0.057	0.262
LE-65 × Punjab Chhuhara	3.582	-0.555	-0.069	-2.886	-2.449**	-0.114	-0.166	-2.858**
LE-65 × Pant T-3	-6.134	-0.405	0.065	4.549**	0.945**	0.166	0.193	1.036**
LE-65 × Pusa Gaurav	2.551	0.960**	0.004	-1.664	1.504**	-0.051	-0.028	1.822**
LE-67 × Punjab Chhuhara	6.659	-0.126	-0.302	-6.108**	-0.647*	-0.128	-0.220	-0.755*
LE-67 × Pant T-3	5.576	1.317**	0.398*	-1.340	0.077	0.406**	0.506**	0.366
LE-67 × Pusa Gaurav	-12.235	-1.191**	-0.096	7.448**	0.570	-0.278*	-0.286	0.389
SE(i)	7.455	0.284	0.159	1.574	0.311	0.130	0.154	0.302
SE(ij-kl)	10.543	0.402	0.225	2.226	0.440	0.183	0.217	0.427
SE (ij-ik)	16.105	0.614	0.343	3.400	0.672	0.280	0.332	0.652

* Significant at 5% level ** Significant at 1 % level

Hybrid, LE-65 × Pant T-3 was recorded with good specific combiner for ascorbic acid (4.549), total carotenoids (0.945) and lycopene (1.036). Cross combination, LE-67 × Pant T-3 was found to be good specific combiner for number of primary branches per plant (1.317), reducing sugars (0.406) and total sugars (0.506).

The estimates of general combining ability (*gca*) and specific combining ability (*sca*) variances, their ratios and gene action are presented in Table 2. In the present study, the results revealed that the variance due to *sca* were higher in magnitude than the variance due to *gca* for the characters number of primary branches per plant, TSS, ascorbic acid, total carotenoids, reducing sugars, total sugars and lycopene, which indicated the predominance of non-additive gene action. The results of the present investigation on components of heritable variation indicated the predominance of non-additive gene action over the additive component for growth characters and quality parameters under study, which is ideal for exploitation through heterosis breeding and recombination breeding. These results are in accordance with the findings of Dharmatti *et al.*, (2001), Pandey *et al.*, (2006) and Singh *et al.*, (2010) for number of primary branches per plant, Mondal *et al.*, (2009) for TSS, carotenoid content and total sugars, Joshi and Kohli (2006) and Pandey *et al.*, (2006) for ascorbic acid, Roopa *et al.*, (2001) and Kumari and Srivastava (2007) for lycopene.

The ratio of *gca* variance to *sca* variance is more than unity (>1) for plant height indicating the preponderance of additive gene action involved in the inheritance of these traits. The present results are in line with the earlier reports of Premlakshmi *et al.*, (2005) and Saidi *et al.*, (2008).

It can be concluded that a particular line and tester parent or hybrid cultivar cannot be used to evaluate all the characters with equal efficiencies. Thus, parents selection should be made after detailed evaluation of *gca* and *sca* effects. The results indicated that the cross, LE-62 × Punjab Chhuhara was a good specific combiner for number of primary branches per plant, total carotenoids, reducing sugars, total sugars and lycopene; LE-64 × Punjab Chhuhara for ascorbic acid, total carotenoids and lycopene; EC-165749 X Pusa Gaurav for TSS, reducing sugars and total sugars.

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