

Combining ability analysis for yield and yield contributing traits in tomato (*Solanum lycopersicum* L.)

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ABSTRACT : A study was conducted in tomato using a line × tester mating design evolved thirty crosses with 10 genotypes as female parents (lines) and 3 genotypes as male parents (testers). The most promising general combiners were PT-2009-02 for fruit yield per hectare, fruit yield per plant, average fruit weight, S-816 for plant height PT-1 exhibited the highest General Combining Ability (GCA) for days to first harvest and days to last harvest. Most promising hybrids exhibiting significant Specific Combining Ability (SCA) effects were PT-19 × Punjab Chhuhara for fruit yield per hectare, fruit yield per plant and average fruit weight, PT-41 × Punjab Chhuhara for dwarfness, PT-41 × Roma tallness and PT-11 × PT-3 for earliness. The combining ability analysis indicated the importance of both additive and non-additive gene action for different growth, yield and fruit quality characters.

Key words: Combining Ability, Line × Tester, Tomato

Tomato (*Solanum lycopersicon* L.) is one of the most consumed vegetable in world because of its wider adaptability, high yielding potential and suitability for variety of uses in fresh as well as processed product. Tomato is a rich source of antioxidants (mainly lycopene and β-carotene), Vitamin A, Vitamin C and minerals like Ca, P and Fe in diet (Saleem *et al.* 2009). General Combining Ability (GCA) in parents and Specific Combining Ability (SCA) in F₁ crosses is imperative for crop improvement programme (Sprague and Tatum, 1942). GCA reveals the existence of additive gene effects while SCA reveals non-additive gene effects. Information about GCA effects are beneficial while choosing best combiner parents and SCA effects information reveals best cross combination for further improvement. Judicious application of information relevant to standard heterosis and SCA are fruitful for selecting best hybrids for desired traits. The main objective of this study were to identify good general combiner for desirable characters that utilized in commercial breeding programme as good donor for yield and its contributing traits and find out best cross combinations those will be used as a variety after evaluation. The present experiment was carried out to identify best combiner parents and best cross combination for developing promising hybrids for yield and its contributing traits using Line × Tester mating design.

MATERIALS AND METHODS

The present investigation was carried out during spring -summer season of 2012 and 2013 at Vegetable Research Centre (VRC) of the G.B. Pant University of

Agriculture and Technology, Pantnagar, Uttarakhand. Pantnagar is located at an altitude of 243.84 meters above mean sea level and at 29° N latitude and 79.3° E longitudes. Climate of Pantnagar is humid subtropical with maximum temperature ranging from 21° C to 41° C minimum ranging from 8.8° C to 27.1° C in summer. Soil type of the area is predominantly clay-loam. Genetically diverse 10 lines (PT-41, S-06-1, PT-2009-02, PT-11, PT-19, S-816, PT-20, PT-0906, PT-1 and PT-11) were crossed with three testers (PT-3, Roma and Punjab Chhuhara) in line × tester mating. The most desirable tester is one which provides maximum information about the performance of a line in cross combinations under different environmental conditions. The criteria for selecting tester are broad genetic base, wider adaptability and poor in the trait for which line are to be evaluated.

The resultant 33 F₁ was evaluated along with their parents. The experiment was laid out in a Randomized Block design (RBD) with three replications with inter and intra row spacing 50 cm. Five competitive plants were randomly selected for recording the observations on different characters such as fruit yield per plant (kg), average fruit weight (g), number of fruits per plant, fruit yield per hectare (t/ha), plant height (cm), days to first harvest and days to last harvest. Data collected during the two growing season for above characters were pooled and analysis of variance and combining ability analysis were done as suggested by Panse and Sukhatme (1967) and Kempthorne (1957), respectively.

RESULTS AND DISCUSSION

Analysis of variance (Table 1) for combining ability revealed that the variance due to line effects were significant for fruit weight (g), number of fruits per plant, fruit yield per hectare (t/ha) and plant height (cm) whereas mean square due to testers were non-significant for all traits except plant height, which indicated the existence of substantial genetic diversity in the parents for these traits. While variance due to line \times tester effects were highly significant for all traits except fruit yield per plant (kg), representing specific combining ability and suggested manifestation of parental genetic variability in their crosses for better selection of cross combination among all hybrids for these traits. Similar results with respect to analysis of variance was also reported by Chaudhary and Malhotra (2001), Kumar *et al.* (2003), Premalakshme *et al.* (2006) and Kumar *et al.* (2009).

General combining ability refers to the average performance of a line in a series of cross combination and it is attributable to additive gene action. The estimate of gca effects provides a measure of general combining ability of each genotype, thus aids in selection of superior ones as parents for breeding programmes. Presented in table 2 for fruit yield per plant, the highest positive gca was observed in line PT-2009-02 (0.49) and highest negative gca effect was observed in S-06-1 (-0.32), line PT-19 and PT-09-06 were exhibited significant positive gca effect. Whereas, PT-41, PT-11, S-816, PT-20 and PT-1 were exhibited significant negative gca effect. Among different testers, the highest positive gca effect in Punjab Chhuhara and the highest negative in PT-3. Similar gca effect were reported by Veer *et al.* (2006), Saleem *et al.* (2009) and Garg *et al.* (2008).

Presented in Table 2 line S-816 exhibited highest significant negative (-8.98) and PT-2009-02 highest significant positive (15.21) gca effect for fruit weight. Tester Roma and Punjab Chhuhara exhibited highest significant positive gca effect and significant negative gca effect, respectively. For number of fruits per plant

among lines PT-09-06 exhibited highest significant positive gca effect and highest significant negative gca effect observed in gca effect. Whereas, PT-41, PT-19, S-816, PT-20, PT-1 and PT-12 were exhibited significant negative gca effects. Among testers highest positive gca effect was observed in Punjab Chhuhara and the highest negative gca effect in PT-3. Similar gca effects were reported by Veer *et al.* (2006), Puja *et al.* (2008), Garg *et al.* (2008) and Saleem *et al.* (2009).

Estimate of gca effects for fruit yield per hectare presented in Table 2, among lines, the highest significant positive gca effect was observed in PT-2009-02 (19.47) and the highest significant negative gca effect observed in S-06-1 (-12.67), line PT-19 and PT-09-06 exhibited positive significant gca effects and PT-41, PT-11, S-816, PT-20 and PT-1 were exhibited negative significant gca effects. For plant height, the highest positive gca effect was observed in line S-816 (18.38) and highest negative gca effect in PT-20 (-17.39). Among testers highest positive gca effect in Roma and highest negative gca effect recorded in Punjab Chhuhara. For days to first harvest and days to last harvest were exhibited highest significant negative gca effect in line PT-1 and highest significant positive gca effect in PT-20 and PT-41, respectively. Similar observation were recorded about days to first and last harvest by Saleem *et al.* (2009), Puja *et al.* (2008), Asati *et al.* (2007) and Lapushner *et al.* (1981).

The specific combining ability reveals the best cross combination among the genotype which can be useful for developing hybrids with high vigour for the traits. Results revealed that was no cross combinations consistently good for all the traits. However, some of the crosses exhibited significant sca effects for more than one character. Presented in Table 3 estimates of sca effects for seven characters for different cross combinations. Among F_1 hybrids for fruit yield per plant the highest positive value for sca effect was recorded in PT-19 \times Punjab Chhuhara (0.13) and the highest negative value recorded

Table 1: ANOVA for Combining Ability for yield and yield contributing traits in tomato

Source	Degree of freedom	Mean Sum of Squares						
		Fruit yield/plant (kg)	Fruit weight (g)	No. of fruits/plant	Fruit yield (t/ha)	Plant height (cm)	Days to first harvest	Days to last harvest
Replications	2	0	0.52	0.22	2.16	7.98	2.52	4.33
Crosses	29	0.23	266.63**	163.57**	364.28**	724.26**	21.59**	37.47**
Line effect	9	0.71	642.84**	427.85**	1133.77**	1140.18*	40.01	51.21
Tester effect	2	0.01	73.14	57.19	8.27	2671.72*	23.66	7.03
Line \times Tester effect	18	0.01	100.02**	43.25**	19.08**	299.91**	12.15**	33.98**
Error	58	0	0.75	0.77	0.98	53.24	2.79	8.4
Total	89	0.07	87.38	53.8	119.38	270.87	8.91	17.78

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

Table 2: Estimate of general combining ability (gca) effect of lines and testers for yield and yield contributing trait in tomato

	Fruit yield/ plant (kg)	Fruit weight (g)	No. of fruits/plant	Fruit yield (t/ha)	Plant height (cm)	Days to first harvest	Days to last harvest
Lines							
PT-41	-0.21**	-3.03**	-4.51**	-8.27**	7.35*	0.15	3.43**
S-06-1	-0.32**	-4.77**	-6.85**	-12.67**	0.59	2.15**	0.82
PT-2009-02	0.49**	15.21**	1.78**	19.47**	10.61**	-0.68	0.63
PT-11	-0.05**	-7.69**	5.48**	-1.87**	5.86	-3.22**	1.01
PT-19	0.24**	11.94**	-2.22**	9.47**	-14.20**	2.03*	-0.19
S-816	-0.29**	-8.98**	-1.99**	-11.60**	18.38**	0.06	0.28
PT-20	-0.03**	5.66**	-4.86**	-1.20**	-17.39**	2.29**	-0.07
PT-09-06	0.37**	-5.13**	16.96**	14.80**	0.83	1.49	-1.36
PT-1	-0.22**	-5.73**	-2.04**	-8.80**	-2.56	-3.53**	-5.82**
PT-12	0.02	2.51**	-1.75**	0.67	-9.47**	-0.74	1.27
Testers							
PT-3	-0.01*	0.71**	-1.05**	-0.48*	-2.01	-1.02*	0.56
Roma	0.01**	1.08**	-0.51**	0.56**	10.28**	0.62	-0.22
Punjab Chhuhara	0	-1.79**	1.56**	-0.08	-8.27**	0.39	-0.34

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

Table 3: Estimate of specific combining ability (sca) effects for yield and yield contributing traits in tomato

Crosses	Fruit yield/plant (kg)	Fruit weight (g)	No. of fruits/ plant	Fruit yield (t/ha)	Plant height (cm)	Days to first harvest	Days to last harvest
PT-41 x PT-3	0.03	3.20**	-1.10	1.14	6.34	0.31	-0.87
PT-41 x Roma	0.06**	-2.74**	4.23**	2.51**	13.58**	1.77	2
PT x Punjab Chhuhara	-0.09**	-0.45	-3.14**	-3.65**	-19.92**	-2.08	-1.14
S-06-1 x PT-3	0.03	-3.73**	3.82**	1.15	7.34	-1.21	0.03
S-06-1 x Roma	-0.04*	1.04	-1.73**	-1.49*	-3.30	-0.18	-2.27
S-06-1 x Punjab Chhuhara	0.01	2.69**	-2.10**	0.35	-4.04	1.39	2.25
PT-2009-02 x PT-3	0.01	5.18**	-2.67**	0.62	-3.05	0.2	-1.28
PT-2009-02 x Roma	0.06**	5.21**	-2.14**	2.37**	0.91	1.43	-1.51
PT-2009-02 x Punjab Chhuhara	-0.07**	-10.39**	4.81**	-2.99**	2.14	-1.63	2.79
PT-11 x PT-3	-0.02	-1.81**	0.97	-0.85	-11.98*	-0.40	-5.79**
PT-11 x Roma	-0.01	-3.21**	3.40**	-0.29	9.08	1.38	4.64*
PT-11 x Punjab Chhuhara	0.03	5.02**	-4.37**	1.14	2.89	-0.98	1.15
PT-19 x PT-3	-0.08**	-2.47**	-0.30	-3.39**	-3.62	-2.35	0.68
PT-19 x Roma	-0.04*	-6.96**	3.28**	-1.63*	2.87	-0.57	1.55
PT-19 x Punjab Chhuhara	0.13**	9.43**	-2.98**	5.01**	0.75	2.92*	-2.23
S-816 x PT-3	0.01	-0.86	0.59	0.48	3.71	-0.19	0.92
S-816 x Roma	0.01	4.25**	-3.73**	0.24	-12.82*	1.25	0.52
S-816 x Punjab Chhuhara	-0.02	-3.39**	3.14**	-0.72	9.11	-1.06	-1.44
PT-20 x PT-3	0	-1.14	0.77	0.08	1.07	3.02*	4.71*
PT-20 x Roma	-0.04**	3.86**	-2.86**	-1.76*	-9.52	-0.82	-0.41
PT-20 x Punjab Chhuhara	0.04*	-2.73**	2.09**	1.68*	8.45	-2.20	-4.31*
PT-09-06 x PT-3	0.08**	1.66*	-0.36	3.28**	10.87*	-0.23	2.78
PT-09-06 x Roma	-0.02	0.67	-2.17**	-0.56	-7.82	-1.98	0.33
PT-09-06 x Punjab Chhuhara	-0.06**	-2.33**	2.54**	-2.72**	-3.05	2.2	-3.11
PT-1 x PT-3	-0.01	6.97**	-5.55**	-0.32	-4.97	-1.00	1.08
PT-1 x Roma	-0.01	-3.78**	2.11**	-0.56	-2.25	-1.37	-1.60
PT-1 x Punjab Chhuhara	0.02	-3.20**	3.45**	0.88	7.22	2.37	0.52
PT-12 x PT-3	-0.05**	-7.00**	3.83**	-2.19**	-5.71	1.85	-2.26
PT-12 x Roma	0.03	1.66*	-0.38	1.17	9.27	-0.92	-3.25
PT-12 x Punjab Chhuhara	0.02	5.35**	-3.45**	1.02	-3.56	-0.92	5.51**

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

in PT-41 × Punjab Chhuhara (-0.09). Significant positive sca effect was observed in cross combinations, PT-09-06 × PT-3, PT-2009-02 × Roma and PT-20 × Punjab Chhuhara whereas, significant negative sca effect was observed in PT-19 × PT-3, S-06-1 × Roma, PT-19 × Roma, PT-20 × Roma, PT-2009-02 × Punjab Chhuhara and PT-09-06 × Punjab Chhuhara. Estimate of gca for fruit weight was recorded highest positive value in PT-19 × Punjab Chhuhara (9.42) and highest negative value was recorded in PT-12 × PT-3 (-7.00). Significant positive sca effects were observed in cross combination PT-41 × PT-3, PT-2009-02 × PT-3, PT-09-06 × PT-3, PT-1 × PT-3, PT-2009-02 × Roma, PT-20 × Roma, PT-12 × Roma, S-06-1 × Punjab Chhuhara, PT-11 × Chhuhara and PT-12 × Punjab Chhuhara. Whereas, significant negative sca effect were recorded in S-06-1 × PT-3, PT-19 × PT-3, PT-12 × PT-3, PT-41 × Roma, PT-11 × Roma, PT-19 × Roma, PT-2009-02 × Punjab Chhuhara, S-816 × Punjab Chhuhara, PT-20 × Punjab Chhuhara, PT-09-06 × Punjab Chhuhara and PT-1 × Punjab Chhuhara. The sca effect for number of fruits per plant was recorded highest significant positive value in PT-41 × Roma (4.23) and highest significant negative value in PT-1 × PT-3 (-5.55). Estimate of gca for fruit yield per hectare were recorded highest significant positive value in PT-19 × Punjab Chhuhara (5.01) and highest significant negative value in PT-41 × Punjab Chhuhara (-3.65). Similar sca effects were also reported by Veer *et al.* (2006), Asati *et al.* (2007) and Puja *et al.* (2008). The sca effect for plant height were exhibited highest positive value in cross combination PT-41 × Roma (13.58) and highest negative value in PT-41 × Punjab Chhuhara (-19.92). Days to first harvest sca effect exhibited highest significant in PT-20 × PT-3 whereas, highest negative value in PT-19 × PT-3. The sca effect for days to last harvest were exhibited highest significant positive value in PT-12 × Punjab Chhuhara (5.50) and highest significant negative value in PT-11 × PT-3 (-5.79).

CONCLUSION

In conclusion, the present investigation suggests that study resulted into identification of lines PT-2009-02 and S-816 as good general combiners for overall characters. Among testers, PT-3 and Roma were identified as good general combiners for overall characters. Hence, these can be utilised in commercial breeding programme as good donors for yield and yield contributing traits. Two hybrids PT-19 × Punjab Chhuhara and PT-41 × Punjab Chhuhara were showed most promising for yield and other related traits.

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