Electronic Journal of Plant Breeding, 9 (3) : 1157 - 1162 (Sep 2018) DOI: 10.5958/0975-928X.2018.00144.8
ISSN 0975-928X

Research Article

Combining ability analysis of indeterminate tomato F_1 hybrids suitable for polyhouse cultivation

G. Rajkumar[1], V. Premalakshmi[2], V. Thiruvengadam[3] and P. Irene vethamoni[4]
Department of Vegetable Crops, HC&RI, Tamil Nadu Agricultural University, Coimbatore-03.
[*]**E-Mail**: rajkumarjourney@gmail.com

(Received: 09Aug2018; Revised: 26 Sep 2018; Accepted: 01 Oct 2018)

Abstract
Ten parental lines were crossed in line x tester fashion comprising seven lines and three testers at Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2017-18. The developed 21 F_1s and their parents were evaluated under polyhouse condition in randomized block design with three replications. The estimate of variance of GCA, SCA and their ratio indicated the preponderance of non-additive gene action for most of the traits. Based on *gca* effects of parents, the lines IIHR 2042, Punjab Sartaj and EC 160885, and the tester EC 163605 were found to be the best general combiners for yield and attributing traits. The crosses Punjab Sartaj × EC 163605, IIHR 2042 × IIVR BT-10, Punjab Rakthak × EC 163611 and EC 160885 × EC 163611 were found to be good specific combiners for the growth, yield and quality attributing traits. Hence, these crosses of tomato can be recommended for commercial cultivation.

Key words
Tomato, Indeterminate, Line x Tester, Combining ability.

Introduction

Tomato (*Solanum lycopersicum* L.) is second most important fruit vegetable crop under cultivation after potato belonging to the family Solanaceae. It is gaining popularity among the consumers because of its higher content of antioxidants like vitamin C and lycopene. The choice of parents for hybridization needs to be based upon complete genetic information, the knowledge of heterosis and their combinations for the improvement of characters under consideration. The ultimate objective in any crop improvement programme is to identify the best parents and hybrids. Combining ability analysis is a common biometrical tool used in the breeding programme for testing the performance of parents in hybrid combinations. Line × Tester analysis is a useful tool for preliminary evaluation of genetic stock for use in hybridization programme with a view to identify good combiners, which may be used to build up a population with favorable and fixable genes for effective yield and quality improvement. Thus present investigation aimed to study the combining ability of indeterminate tomato for yield and quality traits.

Materials and Methods

The present investigation was conducted during year 2017-18 at Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The experimental material comprised of seven lines *viz.*, Punjab Rakthak, EC 249515, EC 163683, EC 160885, Punjab Sartaj, IIHR 2042 and EC 521038 and three indeterminate testers *viz.*, EC 163605, EC 163611 and IIVR BT-10 along with their 21 F_1 hybrids developed by crossing them in a line × tester mating design (Kempthorne, 1957) under polyhouse condition. The resultant 21 F_1's were evaluated along with their parents and standard check hybrid Savannah in randomized block design which were replicated thrice. The observations were recorded for fifteen traits *viz.*, plant height, days to 50 per cent flowering, number of flowers per truss, number of fruits per cluster, number of fruits per plant, individual fruit weight, yield per plant, harvest duration, number of locules per fruit, shelf life, total soluble solids, ascorbic acid and lycopene content. The data recorded were statistically analyzed using the method suggested by Panse and Sukhatme (1967).

Results and Discussion

The analysis of variance for combining ability (Table 1.) showed that the existence of significant variation for fifteen characters, indicating a wide range of variability among the genotypes. The variance due to SCA was higher than that of GCA for all the characters indicated that the importance of non-additive gene action of inheritance for all the traits. Similar results in tomato had been reported by Hannan *et al.* (2007), Saleem *et al.* (2011) and Kumar *et al.* (2013).

General combining ability refers to the average performance of parents in a series of cross combinations and it is attributable to additive (fixable) gene action. The estimates 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.

Estimates of *gca* effects (Table 2.) indicated that the line Punjab Rakthak and EC 521038 recorded negative *gca* effects for days to 50 % flowering (-2.48 and -2.14) and number of locules per fruit (-0.31 and -0.28) and positive *gca* effect for number of fruits per plant (2.99) and ascorbic acid (1.40), lycopene (0.07) content respectively. The line EC 249515 showed positive and significant *gca* effects for total soluble solids (0.48) and lycopene (0.14) content. EC 160885 showed positive *gca* effects for plant height (30.23), individual fruit weight (12.94), ascorbic acid (6.37) and total soluble solids (0.58). The line Punjab Sartaj showed high *gca* effects for individual fruit weight (14.00), shelf life (9.79), harvest duration (9.40) and yield per plant (0.70). IIHR 2042 showed positive *gca* effects for plant height (37.21), individual fruit weight (8.01), shelf life (7.28), number of fruits per plant (6.71), harvest duration (5.83) and yield per plant (0.57). The tester EC 163605 showed positive *gca* effects for individual fruit weight (10.60), shelf life (9.86), harvest duration (4.83) and yield per plant (0.45). The tester EC 163611 made positive for number of fruits per plant (4.30) and negative gca effects for number of locules per fruit (-0.15). The tester IIVR BT-10 showed positive and significant *gca* effects for ascorbic acid (0.89) content and total soluble solids (0.26).

In this study, none of the parents was the best general combiner for all the traits, which corroborate with the findings of Srivastava *et al.* (1998), Dhaliwal *et al.* (2004) and Saleem *et al.* (2009). Thus the lines IIHR2042, Punjab Sartaj and EC 160885 and tester EC 163605 the most useful parent as these parents were found good general combiner for growth, yield and quality attributes. The parents having high *gca* effects would be useful since the *gca* effect is due to additive gene action and is fixable (Sprague and Tatum, 1942). Hence, these parents may also be recommended for exploitation in hybridization programme aimed at improving the yield components for which they were good general combiner. These results corroborated with the finding of Hannan *et al.* (2007) in tomato.

The specific combining ability reveals that the best cross combination among the genotypes 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.

In this study (Table 3.), the cross Punjab Sartaj × EC 163605 showed significant *sca* effects for seven traits *viz.*, number of fruits per plant (5.62), individual fruit weight (15.49), yield per plant (0.85), harvest duration (9.48), number of locules per fruit (-0.41), shelf life (5.54) and ascorbic acid (2.42). The cross EC 249515 × EC 163611 possessed significant *sca* effects for six traits *viz.*, individual fruit weight (8.52), yield per plant (0.32), shelf life (15.66), total soluble solids (1.05) and ascorbic acid (3.16). Likewise, the cross IIHR 2042 × IIVR BT-10 identified as good specific combiners for four traits *viz.*, individual fruit weight (13.79), yield per plant (0.91), harvest duration (8.88) and shelf life (14.18) followed by Punjab Rakthak × EC 163611 and EC 163683 × IIVR BT-10. Remaining all other crosses had significant *sca* effects except EC 163683 × EC 163605, EC 163683 × EC 163611 and EC 160885 × EC 163605.

Amarnath and Subrahmanyam (1992), suggested that the crosses with high *sca* effects could be much useful if they were accompanied by high *gca* effects of parents involved. In the present study, the parents involving the crosses Punjab Sartaj × EC 163605 (individual fruit weight, yield per palnt and harvest duration) for the respective traits had high *gca* effects and produced high *sca* effects. Manifestation of high *sca* effects by crosses where both the parents were good general combiners might be attributed to additive × additive gene action (Agarwal *et al.*, 2014).

The crosses having one parent with high *gca* effects and other parent with low *gca* effects are expected to throw desirable transgressive segregates if the additive genetic system present in high combiner and complementary epistatic effects act in same direction (Iqbal and Khan, 2003). The situation was well reflected in promising cross combinations having parents with high × low and low × high *gca* effects also produced significant *sca* effects as observed in the EC 160885 × EC 163611 (plant height), IIHR 2042 × IIVR BT-10 (yield per plant), EC 160885 × EC 163611 (number of locules per fruit and ascorbic acid) and EC 249515 × EC 163605 (lycopene content). These hybrids are the product of high x low and low x high *gca* suggesting additive x dominant and dominant x additive type of gene interaction and hence could be used in heterosis breeding (Sundharaiya *et al.*, 2018).

The *sca* effects of hybrids have been attributed to the combination of positive favourable genes from different parents or might be due to the presence of linkage in repulsion phase (Sarsar *et al.*, 1986).

Hence, selection of hybrids based on *sca* effects would excel in their heterotic effect.

It can be concluded that under polyhouse condition, the parents IIHR 2042, Punjab Sartaj, EC 160885 and EC 163605 can be utilized in multiple crossing programmes. The crosses, Punjab Sartaj × EC 163605, IIHR 2042 × IIVR BT-10 and Punjab Rakthak × EC 163611 had good *sca* effects for most of the traits including yield per plant. For indeterminate growth habit, the cross EC 160885 × EC 163611 had good *sca* effects. The selected parents having better performance can be crossed in the suitable combinations. The crosses which showed high specific combining ability can be utilized in heterosis breeding.

Reference

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

Amarnath, S., and Subrahmanyam, G. (1992). Combining ability for seedling traits in chewing tobacco (*Nicotiana tobacum*). *Annals of Agricultural Research*, ***13*(4)**, 330-334.

Hannan, M., Ahmed, M., Roy, U., Razvy, M., Haydar, A., Rahman, M., Islam, M., 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 J. Sci. Res*, ***2*(3-4)**, 128-131.

Iqbal, M. Z., and Khan, S. A. (2003). Line x Tester analysis in true seed of potato (*Solanum tubersum* spp *tubersum*). *Online J. Bio. Sci*, ***3*(7)**, 674-680.

Kempthorne, O. (1957). *An introduction to genetic statistics*: John Wiley And Sons, Inc.; New York.

Kumar, R., Srivastava, K., Singh, N. P., Vasistha, N., Singh, R., and Singh, M. (2013b). Combining ability analysis for yield and quality traits in tomato (*Solanum lycopersicum* L.). *Journal of Agricultural Science*, ***5*(2)**, 213.

Panse, V., and Sukhatme, P. (1967). Statistical Methods Agricultural Workers, published by Indian Council of Agricultural Research. *New Delhi (India)*.

Saleem, M. Y., Asghar, M., Haq, M. A., Rafique, T., Kamran, A., and Khan, A. (2009). Genetic analysis to identify suitable parents for hybrid seed production in tomato (*Lycopersicon esculentum* Mill.). *Pak. J. Bot*, ***41*(3)**, 1107-1116.

Sarsar, S., Patil, R., and Bhatade, S. (1986). Heterosis and combining ability in upland cotton. *Indian Journal of Agricultural Sciences (India)*.

Sundharaiya, K., Karuthamani, M., and Sathish, G. (2018). Estimate of Heterosis and Per Se Performance of Tomato F1 Hybrids for Leaf Curl Virus Resistance.

Electronic Journal of Plant Breeding, 9 (3) : 1157 - 1162 (Sep 2018) DOI: 10.5958/0975-928X.2018.00144.8
ISSN 0975-928X

Table 1. Analysis of variance for general and specific combining ability in tomato

Source (df)	Replication (1)	Hybrids (20)	Lines (6)	Testers (2)	Line x Tester (12)	Error (20)	σ^2 gca	σ^2 sca	σ^2 gca /σ^2 sca
Plant height	2486.025	7908.043**	4514.583**	6366.958	9861.620**	585.335	-76.311	4638.14	-0.016
Days to 50 % flowering	17.357	29.657**	25.691**	72	24.583**	4.357	0.198	10.113	0.02
Number of flowers/truss	1.68	2.409**	2.339**	1.069	2.667**	0.992	-0.01	0.837	-0.012
Number of fruits/cluster	2.287	0.868**	0.527**	1.772	0.888**	0.287	0	0.3	0
Number of fruits/plant	29.837	81.900**	111.734**	318.052	27.625**	5.52	2.12	11.052	0.192
Individual fruit weight	49.313	571.661**	823.304**	1564.917	280.297**	12.136	11.381	134.08	0.085
Yield per plant	0.104	0.999**	1.263**	2.784	0.570**	0.025	0.016	0.272	0.059
Harvest duration	78.201	137.295**	198.444**	352.639	70.831**	18.029	2.596	26.4	0.098
Number of locules per fruit	0.155	0.324**	0.353**	0.315	0.310**	0.044	0	0.133	0
Shelf life	63.493	710.880**	273.164**	1509.661	796.608**	12.756	-3.348	391.926	-0.009
Total soluble solids	0.639	1.374**	1.069**	1.601	1.488**	0.148	-0.004	0.669	-0.006
Ascorbic acid	2.803	30.868**	65.743**	12.96	16.415**	0.767	0.564	7.824	0.072
Lycopene content	0.002	0.037**	0.038**	0.004	0.043**	0.001	0	0.021	0

Electronic Journal of Plant Breeding, 9 (3) : 1157 - 1162 (Sep 2018) DOI: 10.5958/0975-928X.2018.00144.8
ISSN 0975-928X

Table 2. Estimates of general combining ability (GCA) effects of parents (lines and testers) in tomato

Line / testers	L_1 Punjab Rakthak	L_2 EC249515	L_3 EC 163683	L_4 EC 160885	L_5 Punjab Sartaj	L_6 IIHR2042	L_7 EC 521038	T_1 EC 163605	T_2 EC 163611	T_3 IIVR BT-10
Plant height	-19.6	11.09	-20.64	30.23 **	-35.73 **	37.21 **	-2.55	-24.60 **	13.22	11.38
Days to 50 % flowering	-2.48 **	1.02	-0.14	1.86 *	3.02 **	-1.14	-2.14 *	-2.57 **	0.86	1.71 **
Number of flowers/truss	0.32	-0.73	0.02	-0.48	0.8	0.68	-0.6	0.29	-0.03	-0.26
Number of fruits/cluster	0.2	0	0.08	-0.05	0.3	0.08	-0.62 *	0.29	0.11	-0.40 *
Number of fruits/plant	2.99 **	1.47	-1.39	-6.10 **	0.36	6.71 **	-4.05 **	0.83	4.30 **	-5.13 **
Individual fruit weight	-4.82 **	-3.76 *	-10.92 **	12.94 **	14.00 **	8.01 **	-15.46 **	10.60 **	-10.55 **	-0.05
Yield per plant	-0.23 **	-0.33 **	-0.32 **	0.04	0.70 **	0.57 **	-0.42 **	0.45 **	-0.44 **	-0.02
Harvest duration	-1.83	-5.23 **	-3.5	0.99	9.40 **	5.83 **	-5.66 **	4.83 **	-5.18 **	0.35
Number of locules per fruit	-0.31 **	0.40 **	0.07	0.11	0.02	-0.01	-0.28 **	0.15 *	-0.15 *	0
Shelf life	-5.91 **	-3.61 *	1.11	0.02	9.79 **	7.28 **	-8.67 **	9.86 **	-10.84 **	0.98
Total soluble solids	-0.50 **	0.48 **	-0.27	0.58 **	0.14	-0.40 *	-0.03	-0.38 **	0.12	0.26 *
Ascorbic acid	-0.65	0.02	-2.80 **	6.37 **	-3.82 **	-0.51	1.40 **	-1.02 **	0.14	0.89 **
Lycopene content	-0.05 **	0.14 **	-0.09 **	0.01	-0.01	-0.05 **	0.07 **	-0.02 *	0.01	0.01

Electronic Journal of Plant Breeding, 9 (3) : 1157 - 1162 (Sep 2018) DOI: 10.5958/0975-928X.2018.00144.8
ISSN 0975-928X

Table 3. Estimates of specific combining ability (SCA) effects of crosses for 15 characters in tomato

Crosses	Plant height	Days to 50 % flowering	Number of flowers per truss	Number of fruits per cluster	Number of fruits per plant	Individual fruit weight	Yield per plant	Harvest Duration	Number of locules per fruit	Shelf life	Total soluble solids	Ascorbic acid	Lycopene content
$L_1 \times T_1$	50.05 **	0.4	-0.67	-0.57	-2.53	-9.85 **	-0.33 **	-1.1	-0.07	-23.91 **	0.52	2.03 **	-0.06 **
$L_1 \times T_2$	-107.01 **	-0.02	0.35	-0.24	2.92	8.61 **	0.40 **	4.48	-0.19	40.89 **	-0.41	-3.10 **	-0.07 **
$L_1 \times T_3$	56.96 **	-0.38	0.33	0.81 *	-0.4	1.24	-0.08	-3.38	0.27	-16.98 **	-0.11	1.06	0.13 **
$L_2 \times T_1$	-4.79	-0.1	1.23	0.38	1.32	-2.45	0.11	-1.73	-0.13	-1.77	-0.74 *	-2.69 **	0.29 **
$L_2 \times T_2$	-79.74 **	-3.52 *	0.45	0.31	1.01	8.52 **	0.32 **	6.08	0.42 *	15.66 **	1.05 **	3.16 **	-0.03
$L_2 \times T_3$	84.54 **	3.62 *	-1.67 *	-0.69	-2.32	-6.07 *	-0.43 **	-4.35	-0.29	-13.89 **	-0.31	-0.47	-0.27 **
$L_3 \times T_1$	-43.65 *	1.07	-0.92	-0.15	1.48	0.24	-0.23	-2.96	-0.25	4.49	0.04	-0.74	-0.08 **
$L_3 \times T_2$	33.34	-1.86	0.55	-0.43	-5.54 **	-4.57	0.23	2.6	0.46 **	-12.70 **	-0.5	-0.29	0.03
$L_3 \times T_3$	10.31	0.79	0.38	0.58	4.06 *	4.33	-0.01	0.36	-0.21	8.21 **	0.46	1.03	0.05 **
$L_4 \times T_1$	-60.47 **	-0.43	-0.32	0.68	0.27	1.74	0.21	1.75	0.47 **	-3.84	-0.38	-1.03	-0.02
$L_4 \times T_2$	107.12 **	-4.36 **	1.3	0.31	2.49	-13.96 **	0	-0.44	-0.55 **	-7.74 **	0.31	3.97 **	0.04 *
$L_4 \times T_3$	-46.65 *	4.79 **	-0.97	-0.99 *	-2.76	12.23 **	-0.21	-1.31	0.07	11.58 **	0.06	-2.94 **	-0.02
$L_5 \times T_1$	17.19	0.4	0.94	0.43	5.62 **	15.49 **	0.85 **	9.48 **	-0.41 *	5.54 *	-0.96 **	2.42 **	-0.02
$L_5 \times T_2$	42.68 *	3.48 *	-1.39	0.06	-3.36	0.78	-0.49 **	-5.6	-0.11	-15.76 **	0.64 *	-1.12	0.08 **
$L_5 \times T_3$	-59.86 **	-3.88 *	0.44	-0.49	-2.25	-16.26 **	-0.36 **	-3.89	0.52 **	10.22 **	0.32	-1.30 *	-0.06 **
$L_6 \times T_1$	9.79	-0.43	0.46	-0.65	-3.27	-3.87	-0.24 *	-0.97	0.28	3.26	1.34 **	2.73 **	0.03
$L_6 \times T_2$	10.59	1.14	-1.37	-0.13	2.12	-9.91 **	-0.67 **	-7.91 *	0.02	-17.44 **	-1.50 **	-3.19 **	-0.03
$L_6 \times T_3$	-20.37	-0.71	0.91	0.78	1.15	13.79 **	0.91 **	8.88 **	-0.3	14.18 **	0.16	0.45	0
$L_7 \times T_1$	31.89	-0.93	-0.71	-0.1	-2.88	-1.29	-0.38 **	-4.47	0.11	16.23 **	0.18	-2.72 **	-0.14 **
$L_7 \times T_2$	-6.97	5.14 **	0.11	0.12	0.36	10.54 **	0.2	0.78	-0.05	-2.92	0.4	0.56	-0.02
$L_7 \times T_3$	-24.92	-4.21 **	0.59	-0.02	2.52	-9.25 **	0.18	3.68	-0.06	-13.31 **	-0.59 *	2.17 **	0.16 **