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Combining Ability Studies for Fruit Yield and Quality Traits in Tomato (*Solanum lycopersicum* L.)

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ABSTRACT

The present investigation was undertaken to study the combining ability of parents and crosses for fruit yield and quality components in tomato using 45 hybrids involving 10 lines in half diallel design. The present study revealed that none of the parent was good general combiner for all the traits as combining ability effects were not consistent for yield and its components. Five parents viz., C-13-1-2-1, IIHR-2199, D-12-1-6-1, IIHR-2201 and Arka Sourabh were good general combiners for yield per plant as they have shown significant gca effect in positive direction. The crosses, D-12-1-6-1 × D-6-1-9-6-1, Arka Sourabh × C-13-1-2-1, Arka Sourabh × D-6-1-9-6-1 and Arka Sourabh × C-13-1-2-1 are best specific combiner for average fruit weight, number of fruits per cluster, number of clusters per plant and yield per plant respectively. These are the combinations of parents with positive × positive gca effects. Among these crosses Arka Sourbah is common parent. This indicates presence of additive × additive type of gene action in the expression of these characters.

Key words: *General combining ability, Specific combining ability, Additive gene action.*

INTRODUCTION

Tomato (Family : Solanaceae L.,) and is one of the most remunerable and widely grown vegetables in the world. The entire genetic variability observed in the analysis for each trait was partitioned into its components, (GCA) and (SCA) as defined by Sprague[15] and reciprocal effects as sketched by Griffing[6]. They stated that GCA effects were due to additive type of gene action and SCA effects were due to non additive gene action. Information on the relative importance of general combining ability (GCA) and specific combining ability (SCA) is pertinent in any breeding programme for selection of the suitable parents for development of F1 hybrids. 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 on the basis of average performance of the lines involved[16].

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The higher side of SCA directs the importance of the magnitude of non- additive gene effects to the total genetic variance[5] Combining ability is an effective tool, which gives useful genetic information for the choice of parents in terms of performance of their hybrids[4].

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[1]. 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 half diallel analyses are commonly used for the analysis of combining ability. It helps to evaluate relatively more number of germplasm lines. It clearly guides breeder about choice of hybrids development or advance generation selection programmes to realize promising improved genotypes in homozygous condition. The objective of the present investigation was to estimate GCA and SCA effects of parents for desirable horticultural traits and to identify hybrid combinations in tomato for commercial use with desirable quality attributes.

MATERIAL AND METHODS

The present investigation was carried out at vegetable block, College of Horticulture, UHS Campus, GKVK, Bengaluru. The experimental site is located at an altitude of 930 meters above mean sea level (MSL) and 13^0 N latitude and 77.37^0 E longitude in the Eastern Dry Zone of Karnataka (Zone-5). The soil of the experimental area was red sandy loam (Alfisol) with an uniform fertility having soil pH range 6 to 7.3. The material for the present study comprised a total of 10 genotypes which were procured from Indian Institute of Vegetable Research (IIVR), Varanasi, Uttara Pradesh, Indian Institute of Horticultural Research (IIHR), Hessarghatta, Bengaluru and University of Agricultural Sciences, GKVK, Bengaluru.

The experimental material for the present study consists of 45 crosses (F1s) developed through half diallel mating design involving 10 genotypes. The 45 crosses combination with parents. The genotypes and hybrids were evaluated in Randomized Block Design with three replication, at the field of Vegetable Science unit of College of Horticulture, GKVK Campus, Bengaluru, (Karnataka) during 2013-14. Thirty days old seedlings were transplanted in a spacing 60 × 45 cmrow to row and plant to plant, respectively. Five plants were sampled at random in each genotype and observations were recorded on yield & quality attributes. The Total soluble solid of the selected samples was determined with hand refract meter.

Data were recorded from five randomly selected plants excluding the border plants. Observations were recorded for average fruit weight (g), total fruit yield (kg/plant), number of locules per fruit, total soluble solids (^{o}Brix).

RESULTS AND DISCUSSION

Analysis of variance for general combining ability (gca) and specific combining ability (sca) for10 characters were computed and presented in Table 1.Mean sum of square due to general combining ability (gca) exhibited positive significance for all the parameters. Mean sum of square due to specific combining ability (sca) exhibited positive significance for all the listed parameters.

Variances for GCA, SCA and GCA/SCA ratio, additive and dominance variance for 10 characters were computed and presented in Table 2.The magnitude of SCA variance is more than GCA variance for all the characters except for average fruit weight. This reveals predominance of additive and non additive gene effects in governing expression of all these characters[11]. Further, it is supported by additive variance (Va) and dominance variances (Vd) Table 3. Additive variance is more than dominance variance for average fruit weight, number of locules per fruit, yield per plant; this indicates that predominance of additive gene actions in these characters and can be improved through selection process. Dominance variance is more

than additive variance for pericarp thickness, number of flowers per cluster, number of fruits per cluster, number of clusters per plant, yield per hectare, TSS, ascorbic acid[9]. This indicates predominance of non additive gene action in these characters and can be improved by heterosis breeding. Similar results were also found by Jyothi[8] and Jaiprakashnarayan[7].

General combining ability (gca)

From the studies on gca effects and their relative performance, it may be said that, all the desirable characters are not present in any single parent. However, five parents *viz.,* C-13-1-2-1, IIHR-2199, D-12-1-6-1, IIHR-2201 and Arka Sourabh were good general combiners for yield per plant as they have shown significant gca effect in positive direction Table 4.

The parent D-6-1-9-6-1 is good general combiner for average fruit weight and number of clusters per plant. D-12-1-6-1 is good general combiner for average fruit weight, number of locules per fruit and yield per hectare. C-13-1-2-1 is good general combiner for average fruit weight, pericarp thickness, number of flowers per cluster, number of fruits per cluster, number of clusters per plant, yield per plant, yield per hectare, TSS and ascorbic acid

IIHR-2199 showed good general combiner for pericarp thickness, number of fruits per cluster, number of clusters per plant, yield per plant and yield per hectare. Parent IIHR-2201 exhibited positive significant gca effect for average fruit weight, number of fruits per cluster, number of clusters per plant, yield per plant and yield per hectare.

Arka Sourabh has shown significant positive gca effect for number of flowers per cluster, number of fruits per cluster and yield per plant. Megha has shown significant positive gca effect for number of flowers per cluster. Arka Ashish has shown significant positive gca effect for number of locules per fruit and number of flowers per cluster, Arka Ahuti has shown significant positive gca effect for fruit firmness and titrable acidity. PKM-1 is good general combiner for number of locules per fruit and ascorbic acid. Similar findings were done by Jyothi[8], Bharathkumar[3], Jaiprakashnarayan[7] and Premalakshmi *et al*.,[12]

Specific combining ability (sca)

The SCA effects were presented in Table 5. The crosses, D-12-1-6-1 × D-6-1-9-6-1, Arka Sourabh × C-13-1-2-1, Arka Sourabh × D-6-1-9-6-1 and Arka Sourabh × C-13-1-2-1 have exhibited highest sca effect for average fruit weight, number of fruits per cluster, number of clusters per plant and yield per plant respectively. These are the combinations of parents with positive × positive gca effects. Among these crosses Arka Sourbah is common parent. This indicates presence of additive × additive type of gene action in the expression of these characters.

Arka Ahuti × D-12-1-6-1 exhibited highest sca effect for number of fruits per plant. Crosses like, IIHR-2199 × D-12-1-6-1, Arka Ahuti × IIHR-2201, IIHR-2199 × C-13-1-2-1 have shown highest sca effect for number of locules per fruit, number of flowers per cluster and ascorbic acid involving parents negative × positive gca effects. This revealed involvement of additive and non additive type of gene action in the expression of these characters.

In general crosses involving positive × positive combination, genetic interaction might be of additive × additive type. The category of positive × positive gca effects played an important role in the expression of favourable and significant sca effects. Thus, choice of parents based on combining ability is a sound proposition[14]. The combination of poor × poor gca effect due to non additive gene interaction and non fixable genetic components[13].

The top selected cross combination involved both parents with positive × positive gca effect indicating improvement of more additive gene effect in their heterotic performance. Thus, they may be further improved upon through conventional selections methods like pedigree or recurrent selection. Similar results were noticed by Jyothi[8], Bharatkumar[3] and Jaiprakashnarayan[7].

Table 1: Analysis of variance for various traits in 10 × 10 half diallel set of cross during *kharif* 2013 in tomato

Source of variation	Df	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Number of flowers cluster^{-1}	Number of fruits cluster^{-1}	Number of fruits plant^{-1}	Yield plant^{-1} (kg)	Yield hectare^{-1} (t)	Total Soluble Solids (^{o}Brix)	Ascorbic acid (mg/100g)
Replicates	1	0.05	0.27	0.05	0.06	0.02	151.09*	0.00	0.041	0.02	0.006
Treatments	54	474.48**	2.49**	1.01 **	0.31**	0.24**	253.22**	0.75**	361.66 **	0.24**	0.011 *
Parents	9	546.03**	4.68**	0.30	0.12*	0.32**	123.56**	0.40**	155.99**	0.32**	0.008
Crosses	44	460.74**	2.10**	1.11 **	0.36**	0.22**	283.57**	0.82**	402.63**	0.22**	0.01 *
Parent V/S. Crosses	1	435.30**	0.03	2.55 *	0.07	0.09	84.62	1.07**	409.77**	0.09	0.02
Error	54	9.65	0.24	0.25	0.04	0.08	29.63	0.045	27.09	0.08	0.006
Total	109	239.85	1.36	0.62	0.18	0.15	151.09*	0.001	0.04	0.15	0.006

*Significant @ P = 0.05, **Significant @ P = 0.01

Table 2: Analysis of variance for combining ability for various tomato parameters in 10 × 10 half diallel set of cross during *kharif* 2013

Source of variation	Df	Average fruit weight (g)	Number of loculesfruit^{-1}	Pericarp thickness (mm)	Number of flowers cluster^{-1}	Number of fruits cluster^{-1}	Number of fruits plant^{-1}	Yield plant^{-1} (kg)	Yield hectare^{-1} (t)	Total Soluble Solids (^{o}Brix)	Ascorbic acid (mg/100g)
GCA	9	1131**	4.07**	1.06**	0.38**	0.24**	400.79**	1.19**	557.53**	0.27*	35.32**
SCA	45	58.42**	0.68**	0.64**	0.11**	0.09**	71.77**	0.211**	105.48**	0.45**	38.17**
Error	54	4.83	0.12	0.17	0.020	0.04	14.81	0.022	13.54	0.11	6.04

*Significant @ P = 0.05, **Significant @ P = 0.01

Table 3: Variance due to general and specific combining ability effects for various characters in tomato during *kharif* 2013

Source of variation	Average fruit weight (g)	Number of loculesfruit^{-1}	Pericarp thickness (mm)	Number of flowers cluster^{-1}	Number of fruits cluster^{-1}	Number of fruits plant^{-1}	Yield plant^{-1} (kg)	Yield hectare^{-1} (t)	Total Soluble Solids (^{o}Brix)	Ascorbic acid (mg/100g)
GCA Variance	93.87	0.33	0.07	0.03	0.02	32.17	0.09	45.33	0.01	2.44
SCA Variance	53.60	0.565	0.47	0.09	0.06	56.96	0.19	91.94	0.34	32.12
GCA/SCA Ratio	1.75	0.58	0.16	0.32	0.29	0.56	0.52	0.49	0.04	0.08
VA	203.52	0.63	0.17	0.08	0.041	81.60	0.23	109.26	0.04	7.75
VD	48.85	0.56	0.50	0.09	0.062	54.18	0.18	89.91	0.36	26.53

*Significant @ P = 0.05, **Significant @ P = 0.01

Table 4: Estimates of gca effects of various tomato parameters in 10 x 10 half diallel set of crosses during *kharif*2013

Parents	Average fruit weight (g)	Number ofloculesfruit^{-1}	Pericarp thickness (mm)	Number of flowers cluster^{-1}	Number of fruits cluster^{-1}	Number of fruits plant^{-1}	Yield plant^{-1} (kg)	Yield hectare^{-1} (t)	Total Soluble Solids (^{o}Brix)	Ascorbic acid (mg/100g)
D-6-1-9-6-1	8.12**	-0.19	-0.25 *	-0.07	-0.04	0.65	0.04	0.77	0.001	-0.32
D-12-1-6-1	15.74**	0.89**	0.01	0.00	0.01	-4.18 **	0.26 **	5.56 **	-0.13	-0.04
C-13-1-2-1	9.22**	-0.35**	0.33**	0.14**	0.14**	1.93	0.35 **	7.73 **	0.26 **	2.11**
IIHR-2199	-0.52	-0.28**	0.32**	0.05	0.09	8.40 **	0.35 **	7.77 **	-0.25 **	-1.21
IIHR-2201	5.23**	-0.38**	0.18	0.07	0.15**	6.80 **	0.22 **	4.74 **	0.06	0.93
ArkaSourabh	0.50	0.19	-0.09	0.16**	0.11*	1.50	0.10 *	2.00	0.15	0.06
Megha	-11.88**	-0.52**	-0.16	0.13**	-0.16**	2.08	-0.26 **	-5.86 **	0.06	-1.50 *
Arka Ashish	-10.54**	0.77**	-0.53**	0.08*	-0.09	-8.52 **	-0.47 **	-9.43 **	-0.10	-3.07 **
ArkaAhuti	-3.27**	-0.76**	0.38**	-0.13**	0.06	0.45	-0.12 *	-2.84 **	-0.10	0.23
PKM-1	-12.60**	0.64**	-0.20	-0.43**	-0.27**	-9.10 **	-0.46 **	-10.43 **	0.05	2.79 **
SEm±	0.60	0.09	0.11	0.04	0.05	1.05	0.04	1.00	0.09	0.67
CD @ 5 %	1.36	0.21	0.25	0.09	0.12	2.38	0.09	2.28	0.21	1.52

*Significant @ P = 0.05, **Significant @ P = 0.01

Table 5: Estimates of sca effects for various tomato growth parameters in 10 x 10 half diallel set of crosses/hybrids during *kharif* 2013

Sl. No.	Crosses/hybrids	Average fruit weight (g)	Number of loculesfruit^{-1}	Pericarp thickness (mm)	Number of flowers cluster^{-1}	Number of fruits cluster^{-1}	Number of fruits plant^{-1}	Yieldplant^{-1} (kg)	Yield hectare^{-1} (t)	Total Soluble Solids (^{o}Brix)	Ascorbic acid (mg/100g)
1	D-12-1-6-1 × D-6-1-9-	18.15**	0.39	-1.42**	0.01	0.21	-8.64*	-0.28 *	-6.06	0.59	-6.284 **
2	C-13-1-2-1 × D-6-1-9-	3.20	-0.28	-0.75	0.03	-0.19	-2.55	0.29 *	6.66	-0.01	0.72
3	C-13-1-2-1 × D-12-1-6-	12.63 **	-0.26	0.41	0.06	-0.003	-3.82	0.08	1.88	-0.30	2.03
4	IIHR-2199 × D-6-1-9-6-	-5.10 *	-0.75 *	0.44	-0.20	-0.03	2.98	0.18	4.12	-0.07	2.03
5	IIHR-2199 × D-12-1-6-	3.49	2.48**	-1.21**	0.32*	-0.05	-12.90	-0.43 **	-9.43**	-2.63**	1.00
6	IIHR-2199 × C-13-1-2-	4.31 *	-0.09	0.34	0.03	-0.23	4.50	0.24	5.49	-0.13	13.50**
7	IIHR-2201 × D-6-1-9-6-	4.09 *	0.75 *	0.29	-0.26	-0.09	-12.15	-0.68 **	-14.86 ***	-0.44	9.25**
8	IIHR-2201 × D-12-1-6-	-1.51	-1.32**	0.36	0.35 *	-0.11	6.08	0.32 *	7.30 *	-0.63	9.21**
9	IIHR-2201 × C-13-1-2-	0.39	0.21	1.04**	0.27 *	0.03	1.39	0.40 **	9.01 *	-0.82 *	3.61
10	IIHR-2201 × IIHR-2199	-0.90	-0.76 *	0.55	0.27 *	-0.22	6.12	0.19	4.28	0.58	4.33
11	ArkaSourabh× D-6-1-9-	17.90**	0.19	2.18**	0.36 **	0.23	5.28	0.53 **	11.79 **	0.34	4.27
12	ArkaSourabh× D-12-1-	-11.02	-0.69 *	0.94 *	0.37 **	0.16	-7.59 *	-0.60 **	-13.26**	-0.35	-1.22
13	ArkaSourabh× C-13-1-	8.80**	0.65*	-0.78 *	0.46**	0.63**	18.08 **	1.26 **	28.13 ***	-0.69 *	-7.64**
14	ArkaSourabh× IIHR-	16.47 **	-0.32	-0.30	0.33*	0.42 *	7.23 *	0.66 **	14.78**	0.21	2.60
15	ArkaSourabh× IIHR-	-2.65	0.08	-0.46	0.23	-0.27	4.32	-0.12	-2.55	0.09	-6.25**
16	Megha× D-6-1-9-6-1	-3.78	-0.41	-0.50	0.01	-0.24	9.25 *	0.54 **	11.93 **	-0.10	-4.15
17	Megha× D-12-1-6-1	-5.34 *	-1.08**	-0.39	0.02	0.07	2.42	-0.22	-4.72	0.57	-8.74**
18	Megha× C-13-1-2-1	3.52	0.15	-0.84*	0.11	-0.11	-4.29	-0.42 **	-9.20**	0.30	-4.02
19	Megha× IIHR-2199	-10.97**	-0.61	-0.82 *	0.07	0.28	14.94 **	-0.11	-2.33	-0.18	0.39
20	Megha× IIHR-2201	-7.72 **	-0.31	-0.30	-0.29*	0.04	13.53 **	0.61 **	13.73**	-0.01	4.33
21	Megha×ArkaSourabh	-0.45	0.22	0.29	-0.02	-0.07	-0.50	-0.15	-3.16	0.03	-2.98
22	Arka Ashish × D-6-1-9-	-9.46**	-0.90**	0.27	-0.08	0.19	-4.81	0.00	-1.03	-0.24	-3.88
23	Arka Ashish × D-12-1-	-2.47	0.53	0.34	0.10	0.09	1.53	0.27	4.89	0.84*	-2.33
24	Arka Ashish × C-13-1-	-2.05	-0.54	0.45	-0.13	0.25	-2.18	-0.23	-6.18	-0.10	-9.04**

*Significant @ P = 0.05, **Significant @ P = 0.01

Sl. No.	Crosses/hybrids	Average fruit weight (g)	Number of loculesfruit^{-1}	Pericarp thickness (mm)	Number of flowers cluster^{-1}	Number of fruits cluster^{-1}	Number of fruits plant^{-1}	Yield plant^{-1} (kg)	Yield hectare^{-1} (t)	Total Soluble Solids (^{o}Brix)	Ascorbic acid (mg/100g)
25	Arka Ashish × IIHR-2199	-1.32	0.695 *	0.06	0.12	-0.05	-7.96 *	-0.39**	-9.68 **	0.14	-4.26
26	Arka Ashish × IIHR-2201	5.72 **	-0.01	0.64	-0.01	0.00	9.04 *	0.23	3.88	0.47	-1.39
27	Arka Ashish ×ArkaSourabh	-2.16	-0.47	-0.24	-0.35*	0.04	-5.65	-0.29 *	-7.53 *	-0.34	1.51
28	Arka Ashish ×Megha	12.02 **	0.04	0.52	-0.26	-0.43 *	-4.74	0.17	2.64	-0.21	-0.21
29	ArkaAhuti× D-6-1-9-6-1	-5.01 *	0.04	0.62	0.10	0.03	-3.18	-0.23	-4.96	0.18	-5.97 *
30	ArkaAhuti× D-12-1-6-1	2.02	-0.54	0.87 *	0.04	-0.18	10.86 **	1.03**	23.01	0.55	-0.99
31	ArkaAhuti× C-13-1-2-1	-1.99	0.50	0.06	-0.09	0.18	-7.35 *	-0.44	-9.622**	0.87**	-3.88
32	ArkaAhuti× IIHR-2199	2.75	-0.07	0.76 *	0.00	0.16	9.912**	0.61 **	13.72**	1.07 **	4.78 *
33	ArkaAhuti× IIHR-2201	4.04	0.43	0.63	0.53**	0.30	5.31	0.71 **	15.92**	0.58	5.05 *
34	ArkaAhuti×ArkaSourabh	0.07	-0.44	-0.83 *	-0.72 **	-0.13	1.23	-0.30 *	-6.48	0.34	2.25
35	ArkaAhuti×Megha	3.96	0.27	1.60 **	-0.05	0.13	-4.85	-0.38	-8.30*	0.29	-3.79
36	ArkaAhuti×Arka Ashish	2.08	-0.92 **	-0.35	-0.12	0.10	1.80	-0.09	-3.09	-1.72**	4.87*
37	PKM-1 × D-6-1-9-6-1	-4.57 *	0.04	0.03	0.28 *	-0.04	-5.03	-0.25	-5.58	-0.52	3.52
38	PKM-1 × D-12-1-6-1	-5.09 *	-1.54 **	0.23	-0.34 *	0.32	4.70	0.04	0.94	0.04	-4.95 *
39	PKM-1 × C-13-1-2-1	0.81	-0.71 *	0.41	-0.31 *	-0.37 *	4.09	-0.28 *	-6.02	0.42	3.25
40	PKM-1 × IIHR-2199	-4.12 *	1.13**	-0.23	-0.80 **	-0.81 ***	-12.28 **	-0.15	-3.28	-0.24	1.38
41	PKM-1 × IIHR-2201	-4.77 *	1.03 **	-0.10	-0.82 **	-0.62 **	-10.89**	-0.38	-8.32 *	-0.47	0.26
42	PKM-1 ×ArkaSourabh	0.35	0.56	0.22	0.17	0.22	1.62	0.03	0.64	0.24	-3.40
43	PKM-1 ×Megha	4.05	1.27 **	-0.11	0.39 **	0.44 *	-3.67	0.14	3.38	-0.14	-3.47
44	PKM-1 ×Arka Ashish	1.86	-0.32	0.38	0.44 **	0.07	4.64	0.30 *	5.58	0.23	-0.98
45	PKM-1 ×ArkaAhuti	2.18	1.31 **	-1.63 **	-0.09	0.23	-7.23 *	-0.32 *	-7.08 *	-0.22	-5.42 *
	SEm±	2.02	0.32	0.38	0.13	0.18	3.55	0.14	3.39	0.31	2.26
	CD @ 5%	4.08	0.64	0.76	0.27	0.36	7.14	0.28	6.83	0.63	4.56

*Significant @ P = 0.05, **Significant @ P = 0.01

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