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Estimation of General and Specific Combining Abilities of Parents and Crosses in Tomato (*Lycopersicon esculantum* Mill.)

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ABSTRACT

Background: Tomato is commonly treated as “Protective Food” as it contain high amounts of several nutritive compounds especially carotenoids such as lycopene and â carotene (Provitamin A), flavonoids, phenolic acids and ascorbic acid and minerals like calcium, iron and phosphorus. Development of high yielding varieties, genetic improvement and best selection are the basic outcome of a superior breeding programme. Therefore, a study was conducted out to analyze the combining ability for yield and yield contributing traits of tomato genotypes.

Methods: This study analyzed the general combing ability (GCA) and specific combing ability (SCA) of tomato (*Lycopersicon esculantum* Mill.) including different breeding lines and landraces, which were grown during three seasons (March 2020, September 2020 and March 2021) with row to row and plant to plant spacing of 60 × 45 cm in randomized block designs (RBD) having three replications at the Agriculture research farm of Choudhary Chhotu Ram (PG) College, Muzaffarnagar U.P, India. Morpho-metric data were recorded on five competitive randomly selected plants in each line for sixteen traits.

Result: Number of fruit per plant and fruits yield was governed by non-additive gene action suggesting the advancement of the generation for selection to improve these traits. The parents floradade, arka meghali and EC-164563 were estimated to be best combiners for the inclusion in further breeding programs. The cross EC-620406 × EC-528360, a product of good combiners was best performing and can be used to obtain superior recombinants.

Key words: GCA, Genotype, Hybrid development, SCA, Selection.

INTRODUCTION

Tomato (*Lycopersicon esculantum* Mill.) is one of the most important fruit vegetable, which has achieved remarkable popularity during the last century and widely cultivated vegetable crops. Tomato being a moderate nutritional crop is considered as an important source of Vitamin A and C and minerals which play an important role as ingredients for table purpose, sambar preparation, chutney, pickles, ketchup, soup, juice pure *etc.* (Sekhar *et al.* 2010 and Helaly., 2021). Red colour of tomato is due to the presence of lycopene. Whereas, lycopene is valued for its anti-cancer property (Bose *et al.*, 2002). The choice of parents for use in a plant breeding programme is one of the most important decisions that a breeder makes (Borem and Miranda, 2005). There are several factors which increase the crop *i.e.*, mainly biotic and abiotic factors so that to overcome these problems, it is essential to improve the variety and genetic makeup of the genotypes by suitable genetic programme and appropriate methods of breeding. By the above problems, combining ability analysis plays an effective role or effective tool to solve these problems up to a greater extant. Identification of parents with good traits and studying its inheritance to the progeny in different cross combination is vital to characterize the nature and magnitude of gene effects in the expression of different traits. Diallel cross is prospective technique, because it provide comprehensive evaluation of hybrid combinations from inbred lines crosses (Chukwu *et al.*, 2016). Combining ability analysis gives an idea about the relative importance and magnitude of additive and non-additive types of gene action in the expression of the traits (Griffing, 1956). Determination of combining ability may inform gene action both additive and non-additive from GCA and SCA magnitudes that are essential for crop improvement (El-Gazzar *et al.*, 2013). Non additive effect are preferred for hybrid development, therefore SCA effect are more considered (Ruswandi *et al.* 2015). As a result, this study was conducted to identify the best parents on the basis of their general and specific combining ability for yield and yield contributing traits for quality improvement in tomato.

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MATERIALS AND METHODS

The experiment was conducted at Agriculture research farm of Choudhary Chhotu Ram (PG) College, Muzaffarnagar,

Uttar Pradesh on ten tomato genotypes for population development which are easily available and having importance of their characters. The genotypes are from two sources; nine genotypes (EC-620406, EC-163605, EC-165700, EC-631364, EC-164563, EC-521067, EC-528360, EC-145057and Floradade) are from National Bureau of Plant Genetic Resources (NBPGR) New Delhi and one genotype (Arka Meghali) from Indian Institute of Horticultural Research (IIHR) Bangalore. Forty five hybrid combinations were developed using half diallel cross from 10 inbred lines. All of the hybrids derived from inbred crosses were evaluated in randomized block design (RBD) under 3 replication. Crosses were made during first season (May 2020) and evaluation of F_1 was done in second season (December 2020) with specified spacing (65 cm × 45 cm). Prior to crop planting, seeds were treated with fungicide (Bavistin). All agronomic practices including weeding and fertilizer applications were performed as per the local recommendations.

The combining ability analysis was carried out by the procedure given by Griffing (1956). Method-2 and Model-1 was adopted for the present study. Method-2 includes P inbreds (parents) and P (P-1)/2 F_1s, in all P (P+1)/2 different genotypes which form a set of treatments. Model-1 is also known as fixed effect model in which inference drawn are applicable only to the lines (treatments) involved in the experiment and not beyond these errors. The statistical model for combining ability analysis under Model 1 is:

$$Y_{ijk} = \mu + g_i + g_j + S_{ij} + \frac{1}{b}\sum_i \sum_j e.ijk$$

For i, j = 1, 2,….., P (number of parents);

K = 1, 2,….., b (number of replications),

Where,

μ = Population mean.

g_i = General combining ability effect of i^{th} parent.

g_j = General combining ability of j^{th} parent.

S_{ij} = Specific combining activity effect of ij^{th} combination.

Such that $S_{ij} = S_{ji}$

E_{ijk} = The environmental effect pertaining to ijk^{th} observation.

The restrictions imposed on the model are:

$$\sum_i gi = o \text{ and } \sum_j Sij + Sii = o \text{ for each}$$

Estimation of the general combining ability and specific combining ability effects

The following formulae were adopted to determine the G.C.A. and S.C.A.:

General combining ability (GCA effects of i^{th} parent was calculated as:

$$\hat{g}_i = \frac{1}{p+2}(Y_{io} + Y_{oi} - \frac{2}{p} Y_{oo})$$

Specific combining ability (SCA effects of ij^{th} cross was calculated as:

$$S_{ij} = \frac{1}{p+2}(Y_{io} + Y_{oi} + Y_{jo} + Y_{oj}) + \frac{2}{(p+1)(p+2)} Y_{oo}$$

All of analyses in this research were computed using INDOSTAT statistical package.

RESULTS AND DISCUSSION

The analysis of variance for yield and yield components presented in Table 1 which revealed that significant differences ($p \leq 0.05$) among the tested genotypes for all measured traits and also for GCA and SCA. The significant general and specific combining ability indicated that the importance of both additive and non-additive gene actions in the expression of these characters.

The mean performance of parents and crosses are important criteria for genotypic evaluation; however, the parents with high mean value may not transmit this characteristic to their hybrids. These parental and hybrid abilities are estimated in terms of GCA and SCA effects. The mean performances of parents and crosses are furnished in the Table 2 and Table 3, respectively.

Among the parents Floradade had maximum significant value of total yield/plant (686.78g), while EC-620406 showed the highest significant value of number of primary branches/plant (0.96). EC-521067 recorded the highest significant value of plant height (12.86 cm) and EC-620406 attained negative significant relation for plant height (-8.23 cm). The parents were characterized for their ability to transmit desirable genes to their progenies based on the significance of general combining ability effect in the appropriate direction and the result is presented in the Table 2. For total yield per plant the genotype Floradade, Arka Meghali and EC-528360 were good combiners. Similar results were reported by Geleta and Labuschagne, 2006, Saleem *et al.*, 2009, Kumar *et al.* (2020) and Liu *et al.* (2021) in the genetic analysis of tomato genotypes.

The best combination from the parent's combination shows that the compatibility of these parents is good which can be measure by the calculating the SCA effects of the combination. The crosses show significant (Table 3) variations among them for the traits studied. Out of 45 crosses studied, SCA ranged from 0.05 (EC-165700 × Floradade) to 3.47 (EC-165700 × EC-145057) which had positive significant effects of SCA for days to first flowering. For days to 50% fruiting SCA ranged from 0.50 (Floradade × Arka Meghali) to 5.66 (EC-165700 × Floradade) which showed significant positive SCA effects for this trait. The most favorable hybrid among the all is obtained from the cross (EC-165700 × EC-145057) for primary branches/plant having the value 3.11 which show the relation with the result of Alsaon *et al.* (2021). The crosses ranged for highest total yield per plant from-829.73 (EC-521067 × Floradade) to 857.57 (EC-165700 × EC-164563) and ascorbic acid (mg/100 g) ranged from -12.61 (EC-620406 × EC-164563) to 15.67 (EC-165700 × EC-164563) which showed positive and significant SCA. When the mean performance of fruit yield per plant with significant specific combining ability effects was taken as criteria for the selection of elite cross, the crosses in order as EC-165700 × Floradade, Floradade ×

Table 1: Analysis of variance for combing ability of different characters.

Sourced of variation	df	DFF	DF50 %	D-F50 %-	No PB/p	No2 PB/p	PlH	Fdi	FL	AFW	No F|p	No C/p	TY/p	Pc Thk	TSS	A.A	T.A.
GCA	9	3.50**	3.83**	8.51**	3.38**	2.55**	433.30**	149.88**	179.76**	453.4**	686.4**	0.47**	885226.5**	2.23**	0.19**	765.7**	0.017**
SCA	45	3.74**	2.19**	5.85**	1.48**	1.32**	86.46**	35.15**	45.53**	109.3**	156.3**	0.54**	175189.5**	0.17*	0.14**	168.9**	0.004**
Error	108	0.43	0.48	0.92	0.28	0.23	4.07	5.44	1.66	3.55	2.69	0.10	971.29	0.06	0.03	2.22	0.0002
Var due to GCA		0.26	0.28	0.63	0.26	0.19	35.77	12.04	14.84	37.49	56.98	0.03	73687.91	0.18	0.01	63.63	0.0014
Var due to SCA		3.32	1.72	4.92	1.20	1.09	82.39	29.71	43.87	105.82	153.65	0.44	174218.23	0.11	0.11	166.68	0.0040
GCA/SCA ratio		0.08	0.16	0.13	0.22	0.18	0.43	0.41	0.34	0.35	0.37	0.07	0.42	1.64	0.12	0.38	0.3486

*, ** Significant at 5% and 1% level, respectively, DFF- Days to first flowering, DF50%- Days to 50% flowering, D-F50%- Days to 50% fruiting, NoPB/p- Number of primary , No2PB/p- Number of primary branches per plant branches per plant, PlH- Plant height, Fdi- Fruit diameter, FL- Fruit length, AFW- Avg. fruit Wt. (gm), No F|p -Number of fruit per plant, NoC/p- Number of cluster per plant, TY/p-total yield per plant, PcThk- Pericarp thickness, TSS- Total soluble solid, AA- Ascorbic acid (mg/100 g) and TA- Titratble acidity (%).

Table 2: General combining ability effects of parents for different characters.

Parents	DFF	DF50 %	D-F50 %-	No PB/p	No2 PB/p	PlH	Fdi	FL	AFW	No F|p	NoC/p	TY/p	Pc Thk	TSS	A.A	T.A.
EC-620406	0.23	0.93**	-1.73**	0.96**	0.43**	-8.23**	7.14**	6.45**	7.14**	-7.88**	-0.16	-43.13**	0.20**	-0.06	-11.11**	-0.02**
EC-163605	0.12	0.02	-0.68*	0.32*	0.66**	2.30**	-4.91**	-4.19**	-10.78**	14.12**	0.34**	-184.58**	-0.71**	-0.10*	-17.62**	0.06**
EC-165700	-0.97**	-1.18**	0.66*	0.32*	0.10	-4.06**	0.16	-1.68**	-4.80**	-1.82**	-0.10	-192.26**	-0.52**	-0.03	2.32**	-0.02**
EC-164563	-0.22	-0.29	0.96**	0.40**	-0.12	-4.45**	2.20**	-2.22**	5.07**	-2.57**	-0.10	55.82**	0.17**	-0.01	4.49**	-0.04**
EC-631364	0.84**	0.41*	0.21	-0.82**	-0.84**	2.69**	-1.30*	6.75**	4.15**	-8.27**	-0.21*	-115.63**	0.60**	0.01	-0.20	-0.02**
EC-521067	0.12	0.04	0.93**	-0.32*	0.27*	12.86**	-3.91**	2.09**	-2.80**	-7.63**	-0.13	-253.46**	0.56**	-0.06	3.79**	-0.03**
EC-528360	0.03	-0.04	-0.34	-0.52**	-0.32*	1.58**	-1.40*	-1.85**	-3.56**	-0.88	0.09	-103.38**	-0.22**	-0.19**	3.11**	-0.02**
EC-145057	-0.80**	-0.46*	-0.01	-0.27	0.07	-1.70**	-1.97**	-3.31**	-3.19**	1.71**	-0.04	-16.53	-0.18**	0.02	7.17**	-0.01
Floradade	0.28	0.29	0.52*	-0.29*	-0.54**	-4.81**	1.09	-1.88**	8.73**	10.21**	-0.04	686.78**	0.22**	0.22**	2.19**	0.06**
Arka meghali	0.37*	0.27	-0.51	0.23	0.29*	3.83**	2.90**	-0.17	0.04	3.01**	0.34**	166.37**	-0.13*	0.19**	5.86**	0.03**
SE GCA (j)	0.18	0.19	0.26	0.15	0.13	0.55	0.64	0.35	0.52	0.45	0.09	8.54	0.06	0.04	0.41	0.00

Notes: DFF- Days to first flowering, DF50%- Days to 50% flowering, D-F50%- Days to 50% fruiting, NoPB/p- Number of primary , No2PB/p- Number of primary branches per plant branches per plant, PlH- Plant height, Fdi- Fruit diameter, FL- Fruit length, AFW- Avg. fruit Wt. (gm), No F|p- Number of fruit per plant, NoC/p- Number of cluster per plant, TY/p- Total yield per plant, PcThk- Pericarp thickness, TSS- Total soluble solid, AA- Ascorbic acid (mg/100 g) and TA- Titratble acidity (%).

Table 3: Specific combining ability effects of crosses for different characters.

Cross combinations	DFF	DF50 %	D-F50 %-	No PB/p	No2 PB/p	PIH	Fdi	FL	AFW	No F|p	NoC/p	TY/p	Pc Thk	TSS	A.A	T.A.
EC-620406 × EC-163605	-2.31 **	-1.96 **	4.25 **	0.56 **	-1.22 **	-1.38	2.78 **	17.37 **	12.49 **	-19.11 **	-0.21	24.36 *	0.74 **	0.05	5.04 **	0.000
EC-620406 × EC-165700	-1.22 **	-0.77 **	-2.75 **	-0.44 *	1.67 **	8.98 **	7.60 **	4.14 **	-5.25 **	-1.83 **	0.24 *	-197.83 **	0.47 **	-0.15 *	-4.97 **	-0.02 **
EC-620406 × EC-164563	1.36 **	1.34 **	-2.72 **	1.14 **	0.22	0.04	2.07 *	-4.70 **	-12.74 **	14.58 **	-0.10	119.79 **	-0.45 **	0.08	-12.61 **	0.07 **
EC-620406 × EC-631364	1.30 **	0.65 *	-2.97 **	0.70 **	0.94 **	2.56 **	3.36 **	-6.03 **	-16.95 **	-3.39 **	-0.98 **	-500.09 **	-0.42 **	-0.03	-1.06	-0.010
EC-620406 × EC-521067	-0.31	-0.32	-3.03 **	0.53 **	1.83 **	-1.94 **	1.28	4.39 **	1.84 **	16.31 **	0.60 **	592.90 **	-0.38 **	0.18 **	4.13 **	0.06 **
EC-620406 × EC-528360	2.44 **	1.76 **	-2.42 **	-0.28	0.08	-4.33 **	-6.69 **	-8.24 **	9.58 **	10.22 **	1.38 **	725.22 **	0.52 **	0.42 **	3.93 **	-0.03 **
EC-620406 × EC-145057	-1.72 **	-0.49	-0.75 *	1.81 **	-1.31 **	2.29 **	9.27 **	-5.63 **	3.22 **	-3.36 **	0.52 **	-180.85 **	0.04	-0.20 **	1.14 *	0.07 **
EC-620406 × floradade	1.19 **	0.76 **	0.72 *	-1.16 **	-0.36 *	-3.60 **	-7.37 **	-7.55 **	0.93	5.14 **	0.18	183.73 **	-0.38 **	-0.15 *	-5.24 **	-0.02 **
EC-620406 × Arka meghali	2.78 **	1.45 **	-1.59 **	0.64 **	2.14 **	3.76 **	-2.42 **	-8.69 **	-1.55 *	-9.67 **	-0.21	-105.31 **	-0.43 **	-0.13 *	3.64 **	-0.05 **
EC-163605 × EC-165700	1.89 **	2.15 **	-1.47 **	0.53 **	-1.22 **	7.45 **	0.30	-5.13 **	-1.03	12.17 **	1.40 **	205.39 **	-0.06	-0.12	-5.29 **	0.09 **
EC-163605 × EC-164563	-1.53 **	-0.07	-0.78 *	-1.22 **	1.00 **	11.17 **	-9.90 **	-1.45 **	-15.90 **	13.25 **	-0.26 *	-326.53 **	-0.28 **	0.08	8.65 **	-0.05 **
EC-163605 × EC-631364	3.08 **	1.90 **	-1.70 **	1.34 **	-0.61 **	-0.96	0.92	-6.75 **	11.64 **	-5.06 **	1.18 **	625.07 **	-0.76 **	-0.16 **	2.31 **	-0.05 **
EC-163605 × EC-521067	0.80 **	0.26	-0.75 *	-0.16	0.28	-11.46 **	5.69 **	4.98 **	-0.34	9.64 **	-0.90 **	286.71 **	-0.68 **	0.13 *	-11.56 **	0.05 **
EC-163605 × EC-528360	-1.45 **	-1.32 **	-0.81 *	1.36 **	1.19 **	-5.52 **	9.81 **	13.75 **	6.07 **	-17.11 **	-0.46 **	77.44 **	0.14	0.38 **	-2.47 **	-0.07 **
EC-163605 × EC-145057	-1.61 **	-2.57 **	-0.81 *	-0.55 **	-0.19	-5.24 **	-5.26 **	-4.19 **	7.54 **	-12.69 **	-0.98 **	66.60 **	0.12	0.05	8.03 **	-0.09 **
EC-163605 × Floradade	-0.36	0.34	-0.67	-0.19	-1.25 **	-4.13 **	-2.48 **	-8.16 **	-12.06 **	3.14 **	-0.32 **	-412.71 **	0.01	-0.37 **	-10.54 **	-0.02 **
EC-163605 × Arka meghali	0.55 *	0.04	-0.97 **	-0.05	1.58 **	-0.10	3.87 **	-7.44 **	-9.86 **	6.67 **	0.63 **	-526.61 **	-0.04	-0.12 *	-3.47 **	-0.06 **
EC-165700 × EC-164563	-0.11	0.45	-0.78 *	-1.89 **	-0.78 **	-5.46 **	-8.56 **	8.69 **	6.43 **	13.86 **	0.18	857.57 **	-0.05	0.27 **	15.67 **	0.01 **

Table 3: Continue...

Table 3: Continue...

EC-165700 × EC-631364	-3.17 **	-2.24 **	-1.36 **	-0.33	0.94 **	-2.94 **	-0.09	3.18 **	-15.11 **	8.22 **	0.63 **	-252.97 **	-0.43 **	-0.01	8.29 **	0.03 **
EC-165700 × EC-521067	-0.45	-0.88 **	2.58 **	-0.16	-0.50 **	-19.77 **	-0.26	-2.54 **	-1.16	0.92	0.21	-100.24 **	-0.30 **	-0.15 *	6.60 **	0.02 **
EC-165700 × EC-528360	3.30 **	1.87 **	-3.14 **	-1.97 **	-0.92 **	-8.49 **	6.25 **	1.03 *	12.90 **	-2.83 **	0.32 **	253.79 **	-0.01	0.28 **	10.05 **	0.01 *
EC-165700 × EC-145057	3.47 **	2.95 **	-0.47	3.11 **	2.03 **	2.79 **	6.71 **	1.25 **	5.21 **	0.25	0.46 **	51.91 **	0.03	-0.15 *	4.88 **	0.000
EC-165700 × Floradade	0.05	-0.13	5.66 **	-0.86 **	-0.03	-0.10	6.84 **	-0.51	-2.57 **	-13.92 **	-0.87 **	-546.52 **	-0.28 **	-0.27 **	4.32 **	-0.03 **
EC-165700 × Arka meghali	-1.70 **	-1.43 **	-0.64	0.95 **	2.14 **	3.26 **	-1.18	0.29	-0.45	-1.72 **	-0.93 **	-150.02 **	-0.10	-0.11	8.41 **	-0.05 **
EC-164563 × EC-631364	1.75 **	1.54 **	2.66 **	1.25 **	0.17	-9.88 **	3.60 **	-10.78 **	5.11 **	-9.69 **	1.29 **	-249.10 **	0.26 **	-0.24 **	0.44	-0.03 **
EC-164563 × EC-521067	0.47	0.57 *	-0.72 *	-0.25	0.06	-5.38 **	1.42	-1.61 **	3.94 **	-1.67 **	-0.12	87.25 **	0.09	-0.42 **	7.30 **	0.04 **
EC-164563 × EC-528360	-2.11 **	-1.35 **	-2.11 **	-0.39 *	0.31	-11.44 **	13.64 **	-0.24	9.08 **	-17.08 **	0.32 **	-316.51 **	0.15	0.04	5.58 **	0.06 **
EC-164563 × EC-145057	1.72 **	1.07 **	5.22 **	0.03	0.92 **	9.51 **	6.68 **	-4.93 **	-3.62 **	1.33 *	-0.87 **	16.57	0.13	-0.08	7.43 **	0.09 **
EC-164563 × Floradade	-2.03 **	-2.02 **	-3.31 **	1.06 **	0.53 **	9.62 **	-0.03	-1.68 **	-11.81 **	13.50 **	0.79 **	29.83 **	-0.35 **	-0.28 **	12.70 **	-0.10 **
EC-164563 × Arka meghali	0.22	-0.66 *	-1.28 **	0.20	-0.64 **	5.31 **	-8.72 **	-2.56 **	9.08 **	3.36 **	-0.26 *	592.14 **	0.16	-0.12 *	7.60 **	-0.04 **
EC-631364 × EC-521067	-3.92 **	-3.13 **	-0.97 **	-2.03 **	-1.56 **	-13.19 **	-2.17 *	3.44 **	9.15 **	0.36	0.99 **	305.30 **	-0.24 **	-0.02	1.63 **	0.000
EC-631364 × EC-528360	-0.17	-0.05	1.64 **	-0.50 *	0.03	4.09 **	-4.68 **	1.40 **	-4.09 **	17.28 **	-0.57 **	392.00 **	0.27 **	0.07	6.56 **	0.02 **
EC-631364 × EC-145057	-0.67 **	-0.96 **	-0.36	0.92 **	0.64 **	-2.63 **	-2.63 **	6.40 **	7.46 **	-8.31 **	-0.10	-106.38 **	0.56 **	-0.05	1.25 *	-0.02 **
EC-631364 × Floradade	1.58 **	1.29 **	-0.89 *	0.28	0.92 **	3.48 **	-7.18 **	-0.58	-15.39 **	7.86 **	-0.43 **	-235.38 **	0.85 **	-0.48 **	7.44 **	-0.06 **
EC-631364 × Arka meghali	2.83 **	1.32 **	1.14 **	2.09 **	0.08	1.51 *	6.24 **	-4.28 **	3.94 **	-6.61 **	-0.82 **	28.25 *	0.20 *	-0.15 *	8.10 **	-0.03 **
EC-521067 × EC-528360	0.55 *	-0.02	1.91 **	0.34	-0.75 **	13.26 **	-0.54	0.35	-2.39 **	-13.03 **	-0.32 **	-284.35 **	0.73 **	-0.24 **	7.96 **	-0.03 **
EC-521067 × EC-145057	-1.28 **	-0.60 *	1.91 **	0.42 *	-0.14	-2.46 **	-2.74 **	-0.55	-7.25 **	-7.61 **	-0.18	-196.80 **	0.41 **	-0.20 **	-0.27	0.01 *

Table 3: Continue...

Table 3: Continue...

EC-521067 × Floradade	-1.03 **	-1.02 **	1.39 **	0.78 **	-0.86 **	13.65 **	-2.45 **	-5.85 **	-9.82 **	-13.78 **	-0.51 **	-829.73 **	0.03	-0.23 **	14.85 **	-0.02 **
EC-521067 × Arka meghali	-1.78 **	-1.32 **	-0.92 **	-1.08 **	-1.03 **	-9.33 **	-5.70 **	-1.97 **	-1.90 **	2.08 **	0.43 **	-94.97 **	0.24 **	-0.16 **	11.70 **	-0.05 **
EC-528360 × EC-145057	-0.53 *	0.15	-0.47	0.28	0.44 *	1.15	-6.19 **	-0.51	-4.08 **	5.97 **	0.27 *	-94.10 **	-0.35 **	-0.15 **	1.74 **	0.010
EC-528360 × Floradade	1.72 **	1.07 **	0.00	-0.36	0.06	6.92 **	-4.62 **	-1.31 **	-16.87 **	-1.53 *	-0.07	-754.41 **	-0.70 **	-0.36 **	8.63 **	-0.04 **
EC-528360 × Arka meghali	-2.36 **	-1.57 **	3.69 **	-0.22	-0.78 **	-8.05 **	4.32 **	-3.02 **	-2.04 **	-0.33	-0.46 **	-115.20 **	-0.28 **	-0.36 **	7.80 **	-0.02 **
EC-145057 × Floradade	0.89 **	0.15	-1.67 **	-1.28 **	-1.33 **	-27.80 **	0.98	1.59 **	-4.63 **	21.56 **	1.40 **	570.33 **	-0.48 **	-0.13 *	9.70 **	-0.05 **
EC-145057 × Arka meghali	1.80 **	1.84 **	2.36 **	-0.14	-0.50 **	-6.44 **	4.16 **	-1.04 *	-2.42 **	26.75 **	0.68 **	565.87 **	-0.37 **	-0.20 **	7.30 **	-0.02 **
Floradade × Arka meghali	-1.61 **	0.09	0.50	0.89 **	0.44 *	3.34 **	2.38 **	-0.84	-5.96 **	19.92 **	1.02 **	639.54 **	0.26 **	-0.49 **	13.30 **	-0.05 **
SE (sij)	0.60	0.64	0.89	0.49	0.44	1.86	2.15	1.19	1.73	1.51	0.30	28.71	0.22	0.15	1.37	0.012
SE (sij-sik)	0.24	0.25	0.36	0.20	0.18	0.75	0.86	0.48	0.70	0.61	0.12	11.51	0.09	0.06	0.55	0.005

Notes: DFF- Days to first flowering, DF50%- Days to 50% flowering, D-F50%- Days to 50% fruiting, NoPB/p- Number of primary , No2PB/p- Number of primary branches per plant branches per plant, PH- Plant height, Fdi- Fruit diameter, FL- Fruit length, AFW- Avg. fruit Wt. (gm), No F|p- Number of fruit per plant, NoC/p- Number of cluster per plant, TY/p- Total yield per plant, PcThk- Pericarp thickness, TSS- Total soluble solid, AA- Ascorbic acid (mg/100 g) and TA- Titratble acidity (%).

Arka Meghali, EC-164563 × EC-145057, EC-620406 × Floradade and EC-165700× EC-164563 could be selected. The foregoing results of combining ability effects suggested that both additive and non-additive gene effects were important in controlling the expression of all the studied characters. The calculated specific combining ability effects exhibited higher values than those of general combining ability for most of the studied characters. Therefore, F_1 hybrids may perform better, in one or more aspects, than either of their parents or commercial cultivars. Such results support the study of El-Gabry *et al.,* (2014) for pericarp thickness, total soluble solids, fruit weight and total yield and also the study of Saleem *et al.* (2009), Barragan *et al.* (2020) and Soresa *et al.* (2021).

CONCLUSION

Thus, from the present study fruit yield per plant in tomato showed the preponderance of non-additive gene action suggesting that selection for these traits should be carried out in the later generations of the recombinants. The parents Floradade, Arka Meghali and EC-164563 were estimated to be best combiners to be used as parent in various breeding programs. The cross EC-620406 × EC-528360, a product of good combiners was best performing and can be used to obtain superior recombinants. Based on the present investigation, both general combing ability and specific combing ability is higher for fruit diameter which is ultimate source of final yield. So that with the application of GCA and SCA one can easily select the genotype and further utilize the selected genotype for the development of the hybrid for better yield and production which are the main raw material for the economic growth.

Conflict of interest: None.

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