Research Article **AJAR (2020), 5:80**

American Journal of Agricultural Research
(ISSN:2475-2002)

Combining Ability and Gene Action of Tomato Hybrids (*Lucopersicum Esculantum L.*) Genotypes in Azerbaijan

Gulare Huseynzade, Zeynal Akperov, Sabir Hasanov

Genetic Recources İnstitute, Azerbaijan National Academy of Sciences, 155 Azadlig Avenue, Baku Az1106, Azerbaijan

ABSTRACT

This work identifies the combining ability of 10 tomato (Lucopersicon esculantum) parents and 45 F1 hybrids obtained from 10 × 10 half diallel. The work aims to identify the parents with the best general combining ability (gca) and crosses with high specific combining ability (sca) for yield, quality and nature of gene action involved. The study was conducted within 2014 and 2017 at Absheron condition in Azerbaijan using randomized complete block design (RCBD) with three replications. The combined analysis of variance showed that variance for gca and sca was highly significant for all the traits studied. This indicates that both additive and non-additive gene actions were operating in the inheritance of these traits. Parental level of gca revealed that introduced genotype (Masalli variety-form) had highest (5843.87) effect followed by Belarusian variety 'Qarant' (1930.97) for fresh pod yield and other related traits. The highest sca for hybrids was exhibited by Masalli variety-form x Ilkin, 'Leyla x Masalli variety-form, 'Shahin' x Volqoqrad and Zorka x Shakar for yield and quality traits. This indicates the existence of immense potential for population improvement and heterosis breeding for enhancing productivity and qualities. The ratios of gca mean square to sca mean square were higher than unity for traits, indicating that additive gene action plays a predominant role in the inheritance of most of the traits.

Keywords: combining ability, gene action, hybrid, traits, parents, quality, yield.

***Correspondence to Author:**
Gulare Huseynzade
Genetic Recources İnstitute, Azerbaijan National Academy of Sciences, 155 Azadlig Avenue, Baku Az1106, Azerbaijan

How to cite this article:
Gulare Huseynzade, Zeynal Akperov, Sabir Hasanov. Combining Ability and Gene Action of Tomato Hybrids (Lucopersicum Esculantum L.) Genotypes in Azerbaijan. American Journal of Agricultural Research, 2020,5:80.

eSciPub LLC, Houston, TX USA.
Website: https://escipub.com/

INTRODUCTION

Plant breeders have extensively explored and utilized heterosis to boost yield levels in several cross-pollunated crops in the recent past. However, tomato being higly autogomous species, the scope for exploitation of hybrids vigour depends on the direction and magnitude of heterosis, ease with which hybrid seeds can be produced. The domestication and improvement of crops through breeding have been highly effective in consentrating allellic variation that confers useful characteristics for cultivation and consumption. (Osborn, T.C., Chad, K., Elaine, G. and Carl, J.B.) Cultivation of F_1 tomato hybrids in developed countries is primary reason of their higher productivity per unit area since they preferred over open pollinated varieties due to their higher yield and good quality. The genetic improvement of crop plants and exploitation of heterosis requires the selection of suitable parents and cross-combinations. Selection of the superior parents on the basis of varietal evaluation trials only is not a sound procedure, since these may not necessarily transmit their superior characters in hybrid combinations, but should be chosen on the basis of their combining ability. Combining ability has a prime importance in plant breeding since it provides information for the selection of parents and nature and magnitude of involued has a prime importance in plant breeding since it provides information for the selection of parents and nature and magnitude of involued gene action. The variance of general combining ability (GCA) includes additive and additive x additive portions, while specific combining ability (SCA) includes the non-additive genetic portion. Therefore, combining ability is important in the development of breeding procedures and it is of notable use in crop hybridization either to exploit heterosis or to combine the favorable fixable genes which may be used for selection programes. Combining ability of genotype is the ultimate factor determining future usefulness of the lines for hybrid development (Hallauer and Miranda, 1988). At the same time, it also elucidates the nature of gene actions involved in the inheritance of characters. General combining ability (gca) is attributed to additive gene effects and additive x additive epistasis and is theoretically fixable. On the other hand, specific combining ability (sca) attributable to non-additive gene action may be due to dominance or epistasis or both and is non-fixable. The presence of non-additive genetic variance is the primary justification for initiating the hybrid programme (Skoric et al., 2000; Pradhan et al., 2006; Anjum et al., 2009;).

The mean sum of squares due to gca and sca and their variance ratio are indicator of the nature of gene action (Patel, 2004). In other words, relatively larger gca/sca variance ratio demonstrates importance of additive genetic effects and a lower ratio indicates predominance of dominance and/or epistatic gene effects (Fasahat P, 2016; Rai, N, Syamal, M.M and Joshi, A.K. 1996). High sca effects resulting from crosses where both parents are good general combiners (good gca × good gca) may be ascribed to additive × additive gene action. (Singh, P.K., Singh, B et al., 2016) The high sca effects derived from crosses including good × poor general combiner parents (Angadi, A., Dharmatti, P.R. and Angadi, P. K. 2012.) may be attributed to favorable additive effects of the good general combiner parent and epistatic effects of poor general combiner, which fulfills the favorable plant attribute. High SCA effects manifested by low × low crosses (May 2012). may be due to dominance × dominance type of non-allelic gene interaction produced over dominance, thus being non-fixable (Vasal SK, Cordova H, Pandey S, Srinivan G.1986). The diallel mating design is the most important for gca and sca. Despite the long history of tomato production and its importance in Azerbaijan, the research work done. although, such genetic studies have been made in various crops, including pepper, in various parts of the world, little or no effort has been made on tomato under Azerbaijan condition to exploit the existing potential . In this study, therefore, an attempt was made to generate information on six introduced and four released cultivars of tomato crossed in half-diallel fashion with the following objective:1. To identify promising parents with better gca effects and single cross hybrids of tomato with promising sca effects.2. To investigate the type of gene actions involved in traits for hybridization.

MATERIALS AND METHODS

Description of the study areas

The field experiment of F1 crosses with the parental materials was conducted at Absheron condi-tion that represent major tomato growing areas in the Azerbaijan for two cropping seasons in 2014 to 2017.

Experimental materials

The experimental materials consist of 10 parents (two introduced genotypes from Belarus Research Center and two from Russia. The local parental materi-als were collected from Scientific Research Vegetable Institute (Table 1).

Treatments, experimental design and field management

The experiment consisted of 45 F1s and 10 parents with a total of 55 genotypes. The experiment was laid out using RCBD with three replications. Field planting was done using plant spacing of 70 x 30 cm between rows and plants, respec-tively. Each plot had 2 rows and 10 plants per row. The total plot area was 1.4 x 3.0 m = 4.2 m2.

Table 1. Tomato (*Lucopersicon esculantum* Mill) parental materials used for study in 2014 to 2017, Azerbaijan

1	Shahin	Azerbaijan	P1
2	Qarant	Belorus	P2
3	Zafar	Azerbaijan	P3
4	Utro	Russia	P4
5	Zorka	Belorus	P5
6	Volqoqrad	Russia	P6
7	Masalli variety-form	Azerbaijan	P7
8	Azerbaijan	Azerbaijan	P8
9	Shakar	Azerbaijan	P9
10	Ilkin	Azerbaijan	P10

Statistical analysis

The combining ability analysis of the parents and crosses

The combining ability analysis was carried out by using method 2 and model I (fixed effect model) of Griffing (1956) using SAS software (SAS 9.2 version). The mathematical model underlying this analysis was assumed as follows

$$Xij = \mu + gi + gj + Sij + \frac{1}{bc} \sum_k \sum_1 eijk$$

where, Xij = Mean of ijth genotypes over K block; μ = population mean; gi = general combining ability effect of the i^{th} parent; gj =General combining ability effect of the jth parent; Sij = Specific

combining ability effect of the ij^{th} combination such that Sij = Sji; eijk =The environmental effect pertaining to ij^{th} parent in the k^{th} replication; i, j = 1, 2 ………., p (number of parents); k = 1, 2

………., b (number of replication).

General (gi) and specific combining ability (Sij) effects

The following effects were obtained:

(i) General combining ability (GCA) effect of the i^{th} parent

gi = (Xi + Xij – 2 X.,/P) P+2

(ii) Specific combining ability (SCA) effect of ij^{th} cross.

Sij = [Xij – (Xi. + Xij + Xj. + Xjj) P+2 + 2X .. /(P+1) (P+2)] General (gi) and specific combining ability (Sij) effects

Table 2. ANOVA for general and specific combining ability of tomato (*Lucopersicon esculantum* MIIL.) genotypes studied in 2014 and 2016, Absheron condition

SOV	DF	PH	BN	FL	FD	FN	Tic	SN	Yld	DW
Gen	54	424.33**	3.88**	1623.43**	1625.57**	47.39**	0.43**	2154.30**	132177228**	**4351578****
GCA	9	843.075**	6.11**	4938.53**	195.56**	1954.27**	1.15**	4980.12**	188670890**	**2377539****
SCA	45	345.306**	3.57**	1053.24**	18.42**	1627.41**	0.30**	1717.00**	136369869**	**4829197****
Error	660	67.44	0.42	169.35	65.66	2.60	0.05	140.11	14721085	**609121**
GCA/SCA	-	2.38	1.71	4.69	10.62	1.14	3.83	2.92	1.49	**0.49**
CV		**15.13**	**11.83**	**31.27**	**9.02**	**11.81**	**15.85**	**15.66**	**34.06**	**33.84**

*Significant at 5% probability; **=Significant at 1% probability. DF=degrees of freedom; PH=plant height(cm); BN=branch number per plant; FL=average fruit length (mm); FD=average fruit diameter(mm); FN=Fruit number per plant; SN=seed number per fruit; TIC=fruit flesh thickness (mm); Yld=fresh fruit yield (kg ha-1); and Dw =fruit/pod dry weight (kg ha)

Table 3. Estimation of general combining ability effects of 10 parents of tomato (*Lucopersicon esculantum* Mill.) genotypes studied at Absheron condition, 2014 and 2017, Azerbaijan.

Parent	PH	BN	SD	FL	FD	FN	SN	Tic	Yld	DW
Shahin	1.47**	0.16*	-0.01	-1.83*	-0.09	0.62	5.87**	-0.03	-140.58	**-0.75**
Qarant	0.33	-0.01	-0.18*	-2.68**	2.32**	-4.25*	8.78**	0.11**	930.97*	**92.24**
Zafar	-1.29	0.13	-0.09	-2.50**	-1.38**	6.07**	-5.49**	-0.12**	-1344.28**	**-126.86**
Shahin	3.65**	0.26**	0.37**	2.60**	0.27	-2.25	-1.34	-0.003	-446.54	**-64.41**
Zorka	0.63	0.07	-0.02	1.98*	0.09	-1.51	-3.99**	0.04	213.81	**16.94**
Volqoqrad	-2.11**	-0.16*	-0.05*	-3.21**	-0.74**	2.79	-5.92**	-0.07*	-344.84	**-43.80**
Masalli variety-f.	-3.13**	-0.05	0.13	9.44**	0.71**	0.97	-0.90	0.07*	1943.87**	**202.41***
Azerbaijan	-1.06	0.04	0.10	4.56**	-0.19	1.04	-2.64*	0.06*	525.66	**139.16**
Shakar	0.05	-0.39**	-0.21**	1.30	0.18	-4.33**	4.69**	0.03	84.54	**-111.09**
Ilkin	**0.55**	**-0.06**	**-0.06**	**-8.99****	**-1.12****	**1.85**	**0.84**	**-0.09****	**-1322.61****	**-63.83**

*Significant at 5% probability; **=Significant at 1% probability. PH=plant height(cm); BN=branch number per plant; SD= stem diameter(cm); FL= average fruit length (mm); FD= average fruit diameter(mm); FN= Fruit number per plant; SN= Seed number per fruit; TIC= fruit flesh thickness (mm); Yld=fresh fruit yield (kg ha-1); and Dw = fruit/pod dry weight (kg ha-1).

Table 4. Estimation of specific combining ability effects of crosses for 11 traits in tomato hybrids at Absheron condition in 2014 and 2017, Azerbaijan.

Cross	PH	BN	SD	FL	FD	FN	SN	Tic	Yld	DW
1x2	7.36**	-0.11	0.10	4.19	0.01	-0.79	0.79	0.16	588.43	**269.41**
1x3	-0.51	0.14	-0.23	-3.36	-0.06	-9.26	-0.71	0.02	-580.77	**-78.69**
1x4	6.38*	0.85**	-0.03	-	0.92	1.00	3.89	0.12	-2293.44	**-452.42**
1x5	0.25	-0.84**	-0.99**	-0.24	0.40	-7.00	-0.03	-0.25**	-1416.88	**4.01**
1x6	-3.11	0.30	-0.07	10.57**	-0.82	8.35	-3.86	-0.07	3699.42*	**587.50****
1x7	0.28	-0.07	0.53*	-3.54	0.34	-0.55	1.74	-0.09	767.63	**167.66***
1x8	2.29	0.12	0.15	2.76	-0.42	0.58	2.60	-0.10	-275.18	**98.70**
1x9	-1.64	-0.10	0.36	9.24**	-0.11	10.33*	-1.18	0.07	576.34	**-261.88**
1x10	- 2.81	0.92*	0.07	-6.03	-1.73*	-10.11	7.27	-0.02	-2869.98	**-829.70***
2x3	-	-0.23	-0.16	-1.85	-2.05**	-8.52	-15.08**	-0.12	-3904.83	**-569.64***
2x4	-2.42	-0.37	-0.49*	-5.42*	-1.30**	-1.31	5.25	-0.28**	-	**-390.84**
2x5	0.56	0.41	0.02	-1.49	-0.31*	5.46	13.27**	0.08	-104.96**	**-367.60**
2x6	12.22*	0.36	0.25	5.89*	1.28**	1.57	13.98**	0.13	1922.17	**150.17**
2x7	1.47	0.67**	0.10	12.63**	1.78**	7.28	-3.21	-0.15	6043.56*	**866.80****
2x8	-2.59	0.53*	0.43	-0.09	0.62	7.41	2.19	0.08	1636.27	**279.17**
2x9	-0.54	-0.59*	0.02	-8.51**	-1.69**	-3.56	-11.11**	0.07	-548.43	**-24.63**
2x10	0.48	0.69	-0.11	0.38	1.78*	-8.25	11.67*	-0.16	-431.20	**421.67**
3x4	1.62	0.64**	0.35	-0.97	0.01	13.32**	8.76*	-0.12	1828.02	**309.09**
3x5	0.36	0.04	0.51*	-6.52**	-0.46	14.42**	2.72	-0.06	1372.92	**840.97****
3x6	-0.58	-0.28	0.40	-0.82	0.06	9.92*	0.32	-0.13	1154.61	**201.77**
3x7	1.40	-0.20	0.16	13.89**	0.28	1.44	-5.68	0.30**	-1544.68	**-22.82**
3x8	5.26	-0.64**	-1.40**	-3.34	-0.07	-7.66	-15.22**	-0.04	100.34	**-467.08**
3x9	2.19	0.12	0.04	0.75**	0.14	-0.51	7.20*	-0.05	-151.58	**-137.65**
3x10	12.24*	1.23**	9.12	10.72**	-3.22	16.46*	-1.11	-0.07	390.55	**257.72**
4x5	2.60	-0.27	0.29	2.54	0.14	-9.99	11.17**	0.05	-982.13	**-397.29**
4x6	-4.12	0.15	0.03	4.59	0.22	5.53	-0.51	0.20*	1709.96	**254.76**
4x7	3.18	-0.08	0.24	1.15	0.72	0.68	-3.09	0.08	1591.78	**239.02**
4x8	-0.72	-0.16	0.30	8.35**	-0.86	-6.80	-4.93	-0.05	436.83	**344.31**
4x9	-0.07	0.30	0.34	-1.73	0.61	4.58	-2.21	-0.02	3125.27*	**636.91****
4x10	3.18	0.88*	0.55	-4.80**	0.41	-1.53	-11.67*	0.04	1877.04	**369.58**
5x6	-2.40	0.05	-0.12	-2.81	-0.35	-4.95	-2.46	-0.09	-	**-621.52****
5x7	-0.31	0.15	0.12	4.24	-1.21**	-3.92	-6.57	-0.06	-1338.54	**-344.60**
5x8	-0.92	0.09	0.12	3.52	0.99*	5.47	-6.92*	0.10	1465.31	**315.77**
5x9	4.39	0.51*	0.03	2.67	1.53**	3.92	1.74	0.22*	3457.44*	**524.88***
5x10	4.31	-0.42	0.055	-4.80	-1.31	-15.56	-15.65**	-0.19	-2637.35	**-222.65**
6x7	-4.06	-0.49*	-0.24	-3.41	-0.85	-13.72**	-9.86**	-0.04	-	**-1157.54****
6x8	0.51	-0.29	0.29	-8.99**	0.85	2.48	11.40**	0.18	1294.12	**309.10**
6x9	0.08	-5.67	0.24	-13.84**	-1.93**	-4.76	-25.69**	-0.18	-2076.14	**224.82**
6x10	-0.34	-9.37**	-0.62	-13.21**	-2.44**	-2.28	2.91	-0.32*	-	**-1022.91****
7x8	0.30	-4.24**	-0.16	1.95	-1.33	-8.97	-6.72	-0.04	-1202.24	**-7.19**
7x9	-5.21*	0.94	0.13	4.74	1.41**	-8.00	9.71**	0.04	-648.41	**-491.32***
7x10	5.33	4.97*	0.94*	20.80**	0.23	52.36**	-5.41	0.05	13410.28	**2679.56****
8x9	0.12	-0.35	-0.23	-5.27	0.70	3.98	14.82**	-0.08	-1582.77	**-336.51**
8x10	5.63	6.00**	0.15	6.40	-0.11	7.29	-24.47**	0.12	-69.11	**-50.33**
9x10	**13.28***	**14.36***	**-0.39**	**7.07**	**0.25**	**-8.38**	**15.18****	**0.02**	**1935.06**	**-262.20***

*Significant at 5% probability; **Significant at 1%probability. PH=plant height(cm); BN= branch number per plant; SD= stem diameter(cm); FL= average fruit length (mm); FD= average fruit diameter(mm); FN= fruit number per plant; SN= Seed number per fruit; TIC= fruit flesh thickness (mm); Yld=fresh fruit yield (kg ha-1); and Dw = fruit/pod dry weight(kg ha-1).

RESULTS AND DISCUSSION

ANOVA of general combining ability (gca) and specific combining ability (sca)

Combining ability analysis revealed highly significant (P ⩽ 0.01) effects of gca and sca for all traits considered. (Table 2). The result indicated that the magnitude of mean squares for gca was higher than the mean squares of sca, suggesting that additive gene effects were more important than non-additive gene effects for these traits. This is in agreement with Nsabiyera et al. (2013) and Geleta and Labuschagne (2006) who indicated that gca effects were higher than sca effects on seven tomato parents

General combining ability study (gca)

The estimates of gca effects of the parents presented in Table 3 indicated significant desirable and undesirable effects depending on the trait under consideration. The analysis revealed that among the introduced genotypes, except parents 6 (Volqoqrad) and 10 (Ilkin), the rest exhibited significant and positive GCA effects in most of the cases including fresh fruit yield and dry weight. Whereas, genotypes Volqoqrad and Ilkin showed undesirable gca in almost all growth and yield traits. The Belarusian genotype 'Qarant' showed significant positive gca effects in the desired di-rection for fruit diameter, seed number per fruit, fruit thickness and fresh fruit yield, whereas other Belarusian genotypes had undesirable gca effects in most of the traits considered (Table 3). The gca effects for fruit length were highly significantly positive (9.44) for Masalli variety -form fol-lowed by 4.56 for Azerbaijan. In contrary, the lowest gca for fruit length (-8.99) was recorded by Ilkin. Similarly, fruit diameter has both positive and negative gca values with the highest highly significant gca (2.32) recorded for parent Qarant, whereas the lowest negative value (-1.38) was recorded for parent Zafar. Fruit number per plant had highly significant positive gca (5.07) for Qarant and negative gca (-4.33) values for Ilkin (2679.56), Qarant x Masalli variety-form (978.80) and Zafar x Zorka (940.77) parents Zafar and Shakar, respectively. Fresh fruit (pod) yield had positive gca value (1843.87) recorded by parent Masalli variety -form followed by (930.97) parent Qarant and that of highly significant negative gca (-1344.28) followed (- 1322.61) by parents Zafar and Ilkin, respectively. In most cases, the gca for fruit dry weight was non-significant except that recorded by parent Masalli variety-form (202. 41) (Table 4). Consistent result was reported by in that out of 10 parental tomatoes evaluated, four were found to be good general combiners for fruit yield and other related traits. (Nsabiyera et al. 2013) reported the existence of gca and sca effects on hot pepper traits. In support of the current result, additive and non- additive gene actions were reported for most agro-morphological and quality traits on tomato (Saeed, A. S. C.; A. A. Khan et al.,2008; Saidi, M.; S. D. Warade and T. Prabu (2008). Parents with significant negative gca ef-fects are considered desirable and should be selected in a breeding program for traits that need reduced expression in the progeny including days to flowering and fruit maturity, pedicel length and disease incidence. In such cases, parents 6 (Volqoqrad) and 10 (Ilkin) could be selected. In contrast, parents with significant positive gca effects were considered desirable for traits that re-quire increased expression in the progeny. Thus, among released Azerbaijan tomato varieties, Shahin and Utro were selected as parents for plant height, canopy width and primary branch number per plant. Qarant variety is best combiner for fruit diameter, seed number per fruit, peri-carp thickness and fresh fruit yield. Thus, the result indicated that there were introduced and lo-cal tomato genotypes which were considered to be the best general combiners for growth, yield and quality

Estimates of specific combining ability effects of crosses

The current result revealed that highly significant sca values were recorded both positively and negatively by hybrids in traits measured. Out of 45 crosses, only 10 for fresh and 14 for dry weight showed significant sca effects, and among these, only 5 for fresh fruit yield and 7 for dry weight showed desirable (positive) sca effects. The cross combinations of Shahin x Volqoqrad, Qarant x Masalli variety form, Shahin x Shakar, Zorka x Masalli variety from and Masalli variety-from x Ilkin were the top desirable crosses for fresh pod yield and dry weight as well (Table 4). The result also indicated that the highest desirable sca value (11410.58) for fruit yield was recorded by crosses between introduced genotypes (Masalli variety-form x Ilkin) followed by sca value (8073.76) obtained by cross made by Azerbaijanian and introduced genotypes (Qarant x Masalli variety -form). This indicates that there are potentials for the production of hybrids from Azerbaijan local tomato genotypes. Besides the above listed crosses, sca value for dry weight was highly significant for cross Zafar x Zorka. The best three top crosses for dry weight include Masalli vari-ety–form x Ilkin (2559.56), Qarant x Masalli variety-form (978.00) and Zafar x Zorka (947.07). (Ta-ble 4). Furthermore, the result revealed that the parent genotype Masalli variety-form has positive significant gca, whereas Ilkin has highly significant negative gca effects for yield and other relat-ed traits. Sca effect is highly significant in desirable direction. This indicates the strong contribu-tion of additive gene effect of Masalli variety-form for the cross and hence should be selected as best combiner for hybrid production in improving yield in tomato production. Statistically signifi-cant positive or negative sca effects for fruit yield and other traits showed that the crosses per-formed better or poorer than what would be expected from the gca effects of their respective par-ents (Table 4). Parents with various gca effects are combined to produce crosses varying in sca effects. This result is consistent with the findings reported by some researchers (Lohithaswa et al., 2000; Marchesan et al., 2009).

In the case of fruit quality traits such as fruit length and width, some of the hybrids with highly significant and positive SCA effects include Shahin x Volqoqrad, Qarant x Volqoqrad, Qarant x Masalli variety-form x AVPP0105, Zafar x Ilkin, Utro x Azerbaijan, for fruit length; Qarant x Volqoqrad, Qarant x Masalli variety-form, Zorka x Azerbaijan, Zorka x Shakar and Masall; variety-form x Shakar for fruit width. Fruit number per plant had significant positive SCA effects in cross-es, such as Shahin x Shakar, Zafar x Zorka, Zafar x Ilkin and Masalli-variety form x Ilkin. In most cases, the result indicated that, SCA effects of fruit length, width and fruit number had much more related effects with that of fruit yield (Table 4). observed and reported almost similar finding (Hannan, M.M, Ahmed, M.B, Raj, U.K, Razvy, M.A, Rahman, M.A, Islam, M.A and Islam, R. 2007a.).

Moreover, the result showed that the ratios of gca to sca mean squares were greater than that for all traits, except fruit dry weight indicating the influence of additive gene actions in the inher-itance of the characters (Table 4). This is again in line with most of the previous findings, sug-gesting that additive variance (gca) might have played more significant roles in the expression of both plant height and fruit length with contrasting result in other traits (Reif et al., 2007; Fekadu et al., 2009). Similarly, Geleta and Labuschagne (2006) reported that the magnitude of mean squares for gca was higher than that of sca in traits studied in introduced and Azerbaijanian to-mato genotypes

Conclusion

Estimates of gca effects of the parents showed that individually, parents contributed to specific traits. However, parents such as Qarant (Belarus) and Masalli variety-form (Azerbaijan) showed desirable gca effects for fresh fruit yield and fruit dry weight and could be used in the breeding program for the development of hybrids. Moreover, cross combinations with desirable sca effects included Shahin x Volqoqrad, Qarant x Masalli variety- form, Shahin x Shakar, Zorka x Shakar and Masalli variety-form x Ilkin, while the best three top crosses for dry weight included Masalli variety form x Ilkin, Qarant x

Masalli variety form and Zafar x Zorka. These crosses can be used to produce desirable hybrids and hence could be recommended for improvement of yield, and other related traits in tomato production. Moreover, the significant gca and sca mean squares in-dicated the role of additive and non-additive gene action governing the expression of most traits. Further, the result indicated that the magnitude of mean squares for gca was higher than the mean squares of sca, suggesting that additive gene effects were more important than dominant gene effects for these traits (Singh et al., 2009; 2010; 2011).

REFERENCES

1. Acquaah G (2007). Principles of Plant Genetics and Breeding. Blackwell Publishing Ltd., USA.
2. Angadi, A., Dharmatti, P.R. and Angadi, P. K. 2012. Combining ability studies for productivity related traits in tomato (Lycopersicon esculentum Mill.). Asian J. Horti., 7(1): 118-122.
3. Anjum Ara, Raj, N, Nazzer, A and Khan, S.H. 2009. Genetic variability and selection parameters for yield and quality attributes in Tomato. Indian Journal of Horticulture. 66 (1): 73-78.
4. Dey SS, Singh N, Bhaatia R, Parkash C, Chandel C (2014). Genetic combining ability and heterosis for im-portant vitamins and antioxidant pigments in cauliflower (Brassica oleracea var. botrytis L.). Euphytica 195(2):169-181.
5. Fasahat P, Rajabi A, Rad JM, Derera J (2016). Principles and Utilization of Combining Ability in Plant Breed-ing. Biometrics and Biostatistics International Journal 4(1):1- 25.
6. Fekadu M, Singh H, Lemma D, Chemeda F, Sigvald R (2009). Combining Ability and Gene Action in Crosses among Asian and Ethiopian Genotypes of Hot Pepper (Capsicum annuum L.). East African Journal of Sciences 3(2):153-160.
7. Geleta LF, Labuschagne MT (2006). Estimates of combining ability for agronomic traits in pepper (Capsicum annuum L.). South African Journal of Plant and Soil 23(2):73-77.
8. Griffing B (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Australian Journal of Biological Sciences 9:463-493.
9. Gogula KR (2015). Development of Hybrids and Their Stability in Chilli (Capsicum annuum L.) PhD. Disserta-tion, Department of Vegetable Science, Horticultural College and Research Institute, Dr. Y. S. R. Horticultural University.
10. Hallauer AR, Miranda JB (1988). Quantitative Genetics in Maize Breeding. 2nded. Iowa State University Press, Iowa, Ames. USA.
11. Kaya Y, Atakisi IK (2004). Combining Ability Analysis of Some Yield Characters of Sunflower (Helianthus an-nuus L.). Helia 27(41):75-84.
12. Kumar P, Singh G, Singh YP, Abhishek D, Nagar SS (2015). Study of combining ability analysis in half diallel crosses of spring wheat (Triticum aestivum L.). International Journal of Advanced Research 3(9):1363-1370.
13. Lohithaswa HC, Kulkarni RS, Manjunath A (2000). Combining ability analysis for fruit yield, capsaicin and oth-er quantitative traits in chillies (Capsicum annum L.) over environments. Indian Journal of Genetics and Plant Breeding 60:511- 518.
14. Marchesan CB, Melo AMT, Paterniani MEAGZ (2009). Combining ability in sweet pepper for resistance to powdery mildew. Horticultura Brasileira 27(2):189-195.
15. Hannan, M.M, Ahmed, M.B, Raj, U.K, Razvy, M.A, Rahman, M.A, Islam, M.A and Islam, R. 2007a. Heterosis, combining ability and genetics for Brix %, days to first fruit ripening and yield in tomato (Lycopersicon escu-lentum Mill.). Middle : East J. of Scientific Res. 2(3-4): 128-131.
16. May AMP, Nájera GC, Suárez JMT, Elos MM, Cortés JOM, Gutiérrez AP, Moreno LL (2010). Combining ability and heterotic effects in sweet pepper populations (Capsicum annuum L.). Revista Fitotecnia Mexicana 33(4):353-360
17. Nsabiyera V, Ochwo-Ssemakula M, Sseruwagi P, Ojiewo Ch, Gibson P (2013). Combining Ability for Field Resistance to Disease, Fruit Yield and Yield Factors among Hot Pepper (Capsicum annuum L.) Genotypes in Uganda. International Journal of Plant Breeding 7(1):12-21
18. Osborn, T.C., Chad, K., Elaine, G. and Carl, J.B. (2007) Insight and Innovations from Wide Crosses: Ex-amples from Canola and Tomato. Crop Science Society of America, Madison.
19. Vasal SK, Cordova H, Pandey S, Srinivan G (1986). Tropical maize and heterosis.

CIMMYT research high-lights, Mexico, DF, CIMMYT

20. Navhale VC, Dalvi VV, Wakode MM, Sawant AV, Dhekale JS (2014). Combining ability analysis in chilli (Cap-sicum annum L.). Electronic Journal of Plant Breeding 5(3):340-4.
21. Pradhan SK, Boss LK, Meher J (2006). Studies on gene action and combining ability analysis in Basmati rice. Journal of Central European Agriculture 7(2):267-272.
22. Saeed, A. S. C.; A. A. Khan; B. Sadia and L. A. Khan (2008). Analysis of combining ability for yield, yield components and quality characters in tomato (Lycopersicon esculentum Mill). J. Agric. Res., 46 (4): 325 – 332.
23. Saidi, M.; S. D. Warade and T. Prabu (2008). Combining ability estimates for yield and its contributing traits in tomato (Lycopersicon esculentum). Int. J. Agric. Biol. 10 (2):238-240
24. Patil MY (2012). Heterosis and Combining ability studies in Chilli (Capsicum annuum L.), MSc. Thesis. Department of Botany College of Agriculture, Dapoli, India.
25. Shiferaw M, Alemayehu Ch (2014). Assessment of Hot Pepper (Capsicum species) Dis-eases in Southern Ethiopia. International Journal of Science and Research 3(3):91-95.
26. Singh, A.K. 2009. Genetic variability, heritability and genetic advance studies in tomato under cold drip region of Ladakh. Indian Journal of Horticulture, 66(3): 400-403.
27. Singh, B, Kaul, S, Kumar, D and Kumar, V. 2010. Combining ability for yield and its con-tributing characters in tomato. Indian Journal of Horticulture,67(1): 50-55.
28. Singh, A.K and Asati, B.S. 2011. Combining ability and heterosis studies in tomato un-der bacterial wilt condition. Bangladesh J. Agril. Res. 36(2): 313-318.
29. Sivaprasad, K. 2008. GeneticSkoric D, Jocic S, Molnar I (2000). General (GCA) and Spe-cific (SCA) combining abilities in sunflower. In: Proc. of the 15th International Sunflower Conference. Toulouse, France, June 12-15.
30. Reif JC, Gumpert FM, Fischer S, Melchinger AE (2007). Impact of inter- population di-vergence on additive and dominance variance in hybrid populations. Genetics 176:1931-1934.
31. Rai, N, Syamal, M.M and Joshi, A.K. 1996. Combining ability and gene action studies for number of locule in tomato (Lycopersicon esculentum Mill.).Vegetable Science. 23(2): 156-161.
32. Vasal SK, Cordova H, Pandey S, Srinivan G (1986). Tropical maize and heterosis. CIMMYT re-search highlights, Mexico, DF, CIMMYT.