International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 318-324

Received: 01-07-2019
Accepted: 03-08-2019

Vishwanath AS
Department of Horticulture, College of Agriculture, Raichur, UAS, Raichur, Karnataka, India

Pampanna Y
Department of Horticulture, Head MARS, Raichur, UAS, Raichur, Karnataka, India

MG Patil
Department of Horticulture, Registrar, UAS, Raichur, Karnataka, India

RP Jaiprakash Narayan
Scientist (Horticulture), ICAR-KVK, Ballari (Hagari), UAS, Raichur, Karnataka, India

JM Nidagundi
Cotton Breeder and Head (AICCIP), MARS, Raichur, UAS, Raichur, Karnataka, India

Correspondence
Vishwanath AS
Department of Horticulture, College of Agriculture, Raichur, UAS, Raichur, Karnataka, India

Studies on combining ability for yield and yield attributes in tomato (*Solanum lycopersicum* L.)

Vishwanath AS, Pampanna Y, MG Patil, RP Jaiprakash Narayan and JM Nidagundi

Abstract
Six diverse lines of tomato were crossed in full diallel mating fashion (Including reciprocal) to study combining ability effects for yield and yield contributing traits. Nature and magnitude of general combining ability effects provide guideline in identifying the better parents and their utilization. Based on gca effects, parent P_6 and P_5 were found to be the best general combiner as they showed significant gca effects in desirable direction. The specific combining ability effects represents dominance and epistatic gene effects which can be used as an index to determine the usefulness of a particular cross combination for exploitation through heterosis breeding and hybridization programme. The Cross $P_5 \times P_6$ was found to be superior sca effect on the basis of yield and its attributing traits.

Keywords: General combining ability (gca), Specific combing ability (sca), diallel fashion, yield and yield attributing traits

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most popular vegetable crop belonging to Solanaceous family having chromosome number 2n=24. It is a tropical day neutral plant and is mainly self-pollinated but a certain percentage of cross-pollination also occurs. General combining ability is the performance of line as combination of solely crossing with other lines, whereas, sca is the performance of a hybrid resulted from the cross with other line (Singh and Chaudary, 1977) [16]. Greater the parental diversity there is chance of developing higher yielding breeding lines (Singh *et al.* 2012) [15]. Combining ability is a measurement of plant genotype ability in crossing to produce superior plants. Combining ability which is obtained from a cross between two parental lines can provide information regarding cross combinations for better heredity (Sujiprihati *et al.* 2008) [18]. The analysis of diallel crossing is needed to predict the additive and dominant effects from a certain population that can be used further to predict the genetic variability and heritability (Baihaki, 2000) [3].
Therefore, the present study was intended to evaluate the parents for their combining ability and to develop hybrids. Further, to evaluate the combining ability for yield and yield attributes in tomato F_1s.

Material and methods

The experiment was conducted at the Horticulture Garden, Main Agricultural Research Station (MARS), University of Agricultural Sciences, Raichur which is situated in the North-Eastern dry zone *i.e.*, Zone-II of region-I in Karnataka. The location corresponds to 16º15'N latitude and 77º21'E longitude at an altitude of 389 m above mean sea level (MSL). The climate of the experimental location is semi-arid and average annual rainfall is 660 mm.
Six genotypes (inbred lines) of tomato *viz.*, P_1, P_2, P_3, P_4, P_5 and P_6 were selected on the basis of contrasting morphological and quality characters. These six genotypes were crossed by following full diallel fashion (Including reciprocals), to obtain 30 F_1 crosses. The experiment was laid in Randomized Block Design (RBD) with two replications in open field. All the 30 F_1 hybrids along with their parents and standard check (Indam 13201) were raised during *Kharif* season, 2018.
The land was thoroughly ploughed during summer to make the soil cultivable. Raised beds of 1 m width, 10 m length and 15 cm height were made. 25 tonnes of FYM and 1,315.8 kg of 19:19:19 NPK per hectare was applied (To each bed 25 kg of FYM and 1.31 kg of 19:19:19

NPK applied as basal dose). Two laterals having inline drippers at 45 cm distance were stretched on each bed from one end to another end and mulching sheet was laid on the beds. Each genotype was accommodated in double row with 75 cm distance between row to row and 45 cm distance between plant to plant thus accommodating 30 plants in each bed. Five randomly selected plants in each cross under each replication were used for recording observations on plant height at 90 days after transplanting, number of branches per plant at 90 days after transplanting, leaf area at 90 days after transplanting, days to 50 per cent flowering, number of clusters per plant, number of flowers per cluster, number of fruits per cluster, days to first harvest, fruiting period, per cent fruit-set, number of fruits per plant, fruit length, fruit width, yield per plant, yield per plot and yield per hectare. The standard procedure was used to estimate the general and specific combining ability.

Results and discussion

Nature and magnitude of combining ability effects provide guidelines for identifying parents and their utilization in hybridization programme. Normally SCA effects do not contribute much to the improvements of self-pollinated crops. The estimates of general combining ability (gca) effects of parents for various characters are presented in Table 1. The specific combining ability (sca) effects of each crosses estimated for various characters are presented in Table 2 to 5.

Table 1: Estimation of GCA effects of parents for various characters in tomato

Parents	Plant height (cm)	Number of branches/ plant	Leaf area (cm^2)	Days to 50 per cent flowering	Number of clusters / plant	Number of flowers/ cluster	Number of fruits/ cluster	Days to first harvest
P_1	-0.441	-0.450*	-1.550	0.875**	-0.441	-0.173	-0.153	0.083
P_2	-2.570**	-0.618**	-4.750**	1.167**	-1.713**	-0.376*	-0.134	1.583**
P_3	-0.760	0.340	2.859**	0.563	-0.211	0.014	-0.055	-0.083
P_4	1.106	0.003	-5.220**	1.250**	-0.571	-0.166	-0.017	-0.083
P_5	1.205	0.199	5.459**	-1.292**	1.429**	0.268	0.037	-0.292
P_6	1.460	0.528**	3.215**	-2.000**	1.508**	0.433**	0.321**	-1.208**
G_i-G_j @ 5%	3.745	0.715	3.835	0.693	1.251	0.565	0.376	0.818
G_i-G_j @ 1%	5.875	1.122	6.016	1.086	1.962	0.886	0.590	1.283

Parents	Fruiting period (days)	Per cent fruit-set	Number of fruits/ plant	Fruit length (cm)	Fruit width (cm)	Yield per plant (Kg)	Yield per plot (Kg)	Yield per hectare (t)
P_1	-0.042	-0.117	-1.493**	-0.115*	-0.241*	-0.047	-0.867	-0.867
P_2	-1.792**	-5.698**	-3.297**	-0.038	-0.149	-0.231**	-6.905**	-6.905**
P_3	0.083	0.311	0.811*	-0.140**	0.258*	0.046	1.483	1.483
P_4	0.292	-0.732	0.249	-0.289**	0.008	-0.015	-0.529	-0.529
P_5	-0.042	2.391	1.707**	0.245**	0.231*	0.118*	3.031	3.031
P_6	1.500**	3.845**	2.024**	0.338**	-0.107	0.130*	3.786*	3.786*
G_i-G_j @ 5%	1.569	5.421	1.241	0.180	0.386	0.226	7.192	7.192
G_i-G_j @ 1%	2.461	8.504	1.946	0.282	0.606	0.354	11.282	11.282

* Significance at 5% and ** Significance at 1% level

Table 2: Estimation of SCA effects of crosses on plant height, number of branches per plant, leaf area and days to 50 per cent flowering in tomato

Crosses	Plant height (cm)	Number of branches/ plant	Leaf area (cm^2)	Days to 50 per cent flowering
$P_1 \times P_2$	-3.021	0.993	-10.992**	0.563
$P_1 \times P_3$	-3.843	-1.257	-2.483	1.000
$P_1 \times P_4$	3.139	0.574	-1.978	-1.750*
$P_1 \times P_5$	2.674	0.918	12.423**	-3.688**
$P_1 \times P_6$	-2.377	0.112	-11.388**	-4.375**
$P_2 \times P_1$	-5.077	-3.945**	-2.209	-0.563
$P_2 \times P_3$	7.454*	1.587*	10.421**	-3.313**
$P_2 \times P_4$	5.939	-0.070	5.953**	1.750*
$P_2 \times P_5$	-4.386	0.024	-15.709**	2.563**
$P_2 \times P_6$	-4.818	-0.063	0.174	1.125
$P_3 \times P_1$	-0.295	1.680*	6.566**	-2.313**
$P_3 \times P_2$	5.917*	1.774*	-6.286**	2.000**
$P_3 \times P_4$	-1.201	-0.188	-1.044	2.938**
$P_3 \times P_5$	-1.802	-0.245	-9.941**	1.250
$P_3 \times P_6$	-2.817	-0.351	-9.664**	0.958*
$P_4 \times P_1$	-5.938*	-1.161*	-1.414	-0.083
$P_4 \times P_2$	2.728	0.456	3.328	1.333**
$P_4 \times P_3$	-1.339	0.568	-0.893	2.083**
$P_4 \times P_5$	-6.975**	-1.528**	-16.587**	4.375**
$P_4 \times P_6$	3.442	1.593**	2.601	-1.167*
$P_5 \times P_1$	-0.464	-0.403	-6.051*	-1.208**
$P_5 \times P_2$	4.790*	0.101	-0.15	3.292**
$P_5 \times P_3$	-0.539	-0.911*	4.068	0.083
$P_5 \times P_4$	-5.239*	-1.290**	7.505**	4.042**
$P_5 \times P_6$	5.718**	1.260**	-5.205*	3.313**
$P_6 \times P_1$	1.232	1.206*	13.893**	0.250

$P_6 \times P_2$	0.277	0.851	7.509**	1.458**
$P_6 \times P_3$	-1.570	-0.307	-0.921	1.250**
$P_6 \times P_4$	-2.525	-1.686**	-6.189*	-0.792
$P_6 \times P_5$	6.262*	1.718**	-0.364	-1.250**
Sij C.D. @ 5%	4.600	0.880	4.710	0.851
Sij C.D. @ 1%	6.384	1.219	6.538	1.181
Sij-Sik C.D. @ 5%	6.988	1.334	7.156	1.292
Sij-Sik C.D. @ 1%	9.698	1.852	9.932	1.793

* Significance at 5% level, **Significance at 1% level.

Table 3: Estimation of SCA effects of crosses on number of clusters per plant, number of flowers per cluster, number of fruits per cluster and days to first harvest in tomato

Crosses	Number of clusters/ plant	Number of flowers/ cluster	Number of fruits/ cluster	Days to first harvest
$P_1 \times P_2$	-4.116**	-6.043	-2.500	1.214
$P_1 \times P_3$	-1.479	-3.612	-4.406	0.902
$P_1 \times P_4$	-1.613	-4.893	2.094	1.527*
$P_1 \times P_5$	0.653	4.488	-2.481	-0.473
$P_1 \times P_6$	2.325*	-0.125	-0.201	-1.348
$P_2 \times P_1$	-0.360	-3.337	-5.144	2.527**
$P_2 \times P_3$	0.056	-1.268	2.106	-2.848**
$P_2 \times P_4$	0.371	0.213	0.731	-0.348
$P_2 \times P_5$	-1.656	-5.030	0.681	-0.223
$P_2 \times P_6$	-0.856	-2.137	-2.000	2.339**
$P_3 \times P_1$	0.859	3.895*	13.425**	-3.661**
$P_3 \times P_2$	0.581	5.601*	5.125	0.464
$P_3 \times P_4$	-1.225	-4.037	-2.625	-3.036**
$P_3 \times P_5$	-2.083	-7.530	-4.375	-2.911**
$P_3 \times P_6$	-0.838	-1.149	-2.850	2.589**
$P_4 \times P_1$	-0.297	-0.187	-0.254	1.250*
$P_4 \times P_2$	-1.114	-0.435	-0.178	-3.083**
$P_4 \times P_3$	-0.789	-0.240	-0.201	-1.083*
$P_4 \times P_5$	-3.364**	-1.154**	-0.280	2.625**
$P_4 \times P_6$	-0.443	0.104	0.019	0.292
$P_5 \times P_1$	-0.301	-0.399	0.436	-0.833
$P_5 \times P_2$	0.384	0.541	0.658*	1.917**
$P_5 \times P_3$	0.257	0.342	-0.019	-1.625*
$P_5 \times P_4$	-2.245**	-0.865*	-0.842*	0.292
$P_5 \times P_6$	2.159**	4.695**	4.619**	0.583
$P_6 \times P_1$	0.807	0.383	0.107	0.042
$P_6 \times P_2$	1.303	0.659	-0.096	0.958
$P_6 \times P_3$	0.542	-0.111	-0.398	-0.458
$P_6 \times P_4$	-1.062	-0.543	-0.114	-2.292**
$P_6 \times P_5$	1.888*	0.445*	0.877*	-1.833*
C.D. Sij @ 5%	1.536	0.693	0.462	1.004
C.D. Sij @ 1%	2.132	0.962	0.641	1.394
C.D. Sij-Sik @ 5%	2.333	1.053	0.702	1.526
C.D. Sij-Sik @ 1%	3.238	1.462	0.974	2.117

* Significance at 5% level, **Significance at 1% level

Table 4: Estimation of SCA effects of crosses on fruiting period, per cent fruit-set, number of fruits per plant and fruit length in tomato

Crosses	Fruiting period (days)	Per cent fruit-set	Number of fruits/ plant	Fruit length (cm)
$P_1 \times P_2$	-1.705	-10.053*	-7.034**	0.088
$P_1 \times P_3$	-0.705	-3.561	1.235	-6.850**
$P_1 \times P_4$	-1.705	0.939	2.235*	-9.894**
$P_1 \times P_5$	-0.018	5.892	-2.465**	3.356*
$P_1 \times P_6$	1.420	3.952*	1.472	8.950**
$P_2 \times P_1$	-2.268	-7.203	-4.24**	4.163*
$P_2 \times P_3$	3.732**	0.992	2.310*	-6.231**
$P_2 \times P_4$	-1.080	2.159	1.035	-6.181**
$P_2 \times P_5$	-1.143	-3.726	-3.053**	-1.638
$P_2 \times P_6$	-1.268	0.164	-1.971*	0.031
$P_3 \times P_1$	2.920*	3.401	3.154**	2.181
$P_3 \times P_2$	-0.143	-1.163	2.566*	-2.375
$P_3 \times P_4$	-0.458	-2.634	-2.096*	2.838
$P_3 \times P_5$	2.857*	-4.349	-3.734	-5.419**
$P_3 \times P_6$	-1.955	-0.176	-2.059**	-1.069
$P_4 \times P_1$	-0.750	-1.604	-0.540*	-0.040
$P_4 \times P_2$	2.875**	-3.95	-1.474	-0.512**

$P_4 \times P_3$	0.917	-1.252	-1.786*	-0.313**
$P_4 \times P_5$	-2.250*	-9.585**	-5.694**	-0.405**
$P_4 \times P_6$	-0.542	0.308	0.714	-0.203
$P_5 \times P_1$	1.125	-1.755	-1.469	-0.175
$P_5 \times P_2$	-1.583	0.858	2.643**	-0.341**
$P_5 \times P_3$	0.250	1.966	1.735*	0.348**
$P_5 \times P_4$	0.208	-6.899*	-4.457**	-0.236*
$P_5 \times P_6$	3.920**	1.931*	3.710**	0.424**
$P_6 \times P_1$	0.375	2.299*	1.626*	0.250*
$P_6 \times P_2$	-1.417	4.217**	2.060*	0.169
$P_6 \times P_3$	0.917	-2.757	-0.611	0.192
$P_6 \times P_4$	3.125**	-3.999	-1.528*	0.056
$P_6 \times P_5$	1.958*	3.31	2.014*	-0.543**
Sij C.D. @ 5%	1.927	6.658	1.524	0.221
Sij C.D. @ 1%	2.675	9.241	2.115	0.306
Sij-Sik C.D. @ 5%	2.928	10.115	2.315	0.335
Sij-Sik C.D. @ 1%	4.063	14.039	3.213	0.466

* Significance at 5% level, **Significance at 1% level

Table 5: Estimation of SCA effects of crosses on fruit width, yield per plant, yield per plot and yield per hectare in tomato

Crosses	Fruit width (cm)	Yield per plant (kg)	Yield per plot (kg)	Yield per hectare (t)
$P_1 \times P_2$	0.017	-5.192*	-16.543*	-16.543*
$P_1 \times P_3$	13.104**	-0.098	-0.361	-0.361
$P_1 \times P_4$	0.773	0.439	2.024	2.024
$P_1 \times P_5$	6.423	2.121	6.593	6.593
$P_1 \times P_6$	-4.214	0.065	0.218	0.218
$P_2 \times P_1$	-7.477	-1.292	-4.894	-4.894
$P_2 \times P_3$	1.842	1.146*	3.206	3.206
$P_2 \times P_4$	1.342*	0.577	0.960	0.960
$P_2 \times P_5$	-0.096	-2.067	-6.766	-6.766
$P_2 \times P_6$	-2.721	-1.311	-3.082	-3.082
$P_3 \times P_1$	-0.971	0.871	2.886	2.886
$P_3 \times P_2$	2.642	1.027	3.616	3.616
$P_3 \times P_4$	-6.152	-1.942	-3.659	-3.659
$P_3 \times P_5$	2.161*	-2.686	-6.744	-6.744
$P_3 \times P_6$	-6.439	0.196	-2.810	-2.810
$P_4 \times P_1$	-0.288	-0.035	-1.435	-1.435
$P_4 \times P_2$	-0.043	-0.150	-4.884	-4.884
$P_4 \times P_3$	0.022	-0.146	-4.679	-4.679
$P_4 \times P_5$	-0.221	-0.459**	-12.274**	-12.274**
$P_4 \times P_6$	0.310	-0.032	-0.612	-0.612
$P_5 \times P_1$	0.232	-0.107	-2.906	-2.906
$P_5 \times P_2$	-0.062	0.058	2.029	2.029
$P_5 \times P_3$	0.075	0.122	2.434	2.434
$P_5 \times P_4$	-0.382	-0.243	-6.546	-6.546
$P_5 \times P_6$	-0.335	2.027*	6.477*	6.477*
$P_6 \times P_1$	-0.320	0.042	1.978	1.978
$P_6 \times P_2$	-0.539*	0.034	2.055*	2.055*
$P_6 \times P_3$	-0.382	-0.106	-2.343	-2.343
$P_6 \times P_4$	0.496*	-0.264	-7.467	-7.467
$P_6 \times P_5$	0.213	0.228	3.653	3.653
Sij C.D. @ 5%	0.474	0.277	8.833	8.833
Sij C.D. @ 1%	0.658	0.385	12.26	12.26
Sij-Sik C.D. @ 5%	0.720	0.421	13.418	13.418
Sij-Sik C.D. @ 1%	1.000	0.585	18.624	18.624

* Significance at 5% level, **Significance at 1% level

Plant height (cm)

For plant height, none of the parent showed significant positive gca effects for plant height. On the other hand, parent *viz*., P_2 (-2.570) was found to be poor general combiner as it showed negative and high significant gca effect. The crosses $P_2 \times P_3$ (7.454), $P_6 \times P_5$ (6.262) and $P_5 \times P_6$ (5.718) exhibited positive significant sca effect for plant height.

Taller plant is considered to be desirable because it leads to more number of branches per plant and ultimately result in increased productivity but dwarf plant is not desirable due to decrease in the productivity with decrease in number of branches per plant. These results are in line with the reports from Shende *et al*. (2010) [14] and Yadav *et al*. (2013) [20].

Number of branches per plant

The significant positive gca effect for number of branches per plant was exhibited by parent P_6 (0.528) which is considered as good general combiner. The crosses $P_6 \times P_5$ (1.718), $P_4 \times P_6$ (1.593) and $P_5 \times P_6$ (1.260) were found to be good specific combiners as they showed highly significant positive sca effect.

Number of branches per plant is also an important character which indirectly contributes to the total yield. Considerable genetic variation was observed for number of branches per plant. These results are in accordance with the findings of Vilas *et al*. (2015) [19] and Savale and Patel (2017) [11].

Leaf area (cm^2)

The gca effects of parents for leaf area ranged from -5.220 (P_4) to 5.459 (P_5). Three parents P_5 (5.459), P_6 (3.215) and P_3 (2.859) had positive significant gca effect, thus, can be considered as good general combiners for this trait. The sca effect for leaf area ranged from -16.587 ($P_4 \times P_5$) to 13.893 ($P_6 \times P_1$). The crosses $P_6 \times P_1$ (13.893), $P_1 \times P_5$ (12.423) and $P_2 \times P_3$ (10.421) were found to be good specific combiners for leaf area has they showed highly significant positive sca effect.

Days to 50 per cent flowering

The general combining ability effects for days to 50 per cent flowering varied from -2.000 (P_6) to 1.250 (P_4). Parents P_6 (-2.000), and P_5 (-1.292) have significant negative general combining ability effects and considered as good combiners for this trait. The crosses $P_1 \times P_6$ (-4.375), $P_2 \times P_3$ (-3.313) and $P_3 \times P_1$ (-2.313) recorded good specific combiners for days to 50 per cent flowering as they showed highly negative significant sca effect in desirable direction for days to 50 per cent flowering.

Earliness is one of the major considerations taken into account to select a particular parent/cross for cultivation as it fetch premium price in the market for being early flowering and early harvest. Therefore, days to 50 per cent flowering is considered as an important indicator to earliness. These results are in line with the reports from Shende *et al*. (2010) [14], Shankar *et al*. (2013) [12] and Mali *et al*. (2014) [8].

Number of clusters per plant

The significant positive gca effects for number of clusters per plant exhibited by parents P_6 (1.508) and P_5 (1.429), thus these parents are considered as good general combiners. The crosses $P_1 \times P_6$ (2.325), $P_5 \times P_6$ (2.159) and $P_6 \times P_5$ (1.888) found to be good specific combiners as they showed highly significant positive sca effect.

More fruiting clusters per plant directly contribute to the higher yield, with increase in the fruit-set percentage and *vice-versa*. The results obtained are in accordance with the findings of Vilas *et al*. (2015) [19] and Kumar and Gowda (2016) [7].

Number of flowers per cluster

The highly significant and positive GCA effect for number of flowers per cluster (0.433) was recorded by the parent P_6. The crosses $P_3 \times P_2$ (5.601), $P_5 \times P_6$ (4.695) and $P_3 \times P_1$ (3.895) were found to be good specific combiners for number of flowers per cluster as they showed highly significant positive sca effect.

Higher the number of flowers per cluster indicates the higher fruit-set, which leads to increase in the fruit yield. These results are similar to the findings of Sharma and Sharma (2010) [13] and Shende *et al*. (2010) [14].

Number of fruits per cluster

With regards to number of fruits per cluster only one parent P_6 (0.321) as shown significant positive gca effects which is considered to be good general combiner as it showed positive and significant gca effect. The crosses $P_3 \times P_1$ (13.425) and $P_5 \times P_6$ (4.619) showed highly positive and significant sca effect.

Number of fruits per cluster indicates the number of fruits per plant, which leads to increase in the fruit yield per plant. The results obtained are in accordance with the findings of Vilas *et al*. (2015) [19] and Panchal *et al*. (2016) [9].

Days to first harvest

The negatively significant gca effect for days to first harvest (-1.208) was recorded by the parent P_6 which will be regarded as good general combiner as it showed negative and significant gca effect. On the basis of specific combining ability effects, crosses $P_3 \times P_1$ (-3.661), $P_4 \times P_2$ (-3.083) and $P_6 \times P_4$ (-2.292) were found to be good specific combiners for days to first harvest as they showed highly significant negative sca effect which is desirable for days to first harvest.

Days to first fruit harvest is a measure of earliness, as early picking gives better returns and also widen the fruiting period of the plant. Hence, gca and sca in negative direction is desirable for days to first harvest. The present studies are in agreement with findings of Shankar *et al*. (2013) [12] and Kumar *et al*. (2018) [6].

Fruting period (days)

Out of six parents, one parent *viz.*, P_6 showed positive significant gca effect (1.500) and thus consider as good combiner for fruiting period. On the basis of specific combining ability effects, crosses $P_5 \times P_6$ (3.920), $P_2 \times P_3$ (3.732) and $P_6 \times P_4$ (3.125) were found to be best for fruiting period as they showed highly significant positive sca effect.

Longer fruiting period ensures the continuous supply of produce and good price for tomato over a longer period. It also keeps a balance between the demand and supply, thereby avoiding glut in the market and fall in prices. Similar results on fruiting period have been reported by Singh *et al*. (2010) [17] and Dishri *et al*. (2017) [4].

Per cent fruit-set

The significant positive gca effects (3.845) exhibited by parent P_6 thus this parent is consider as good general combiner. Out of 30 combinations, four crosses $P_6 \times P_2$ (4.217), $P_1 \times P_6$ (3.952), $P_6 \times P_1$ (2.299) and $P_5 \times P_6$ (1.931) exhibited positive significant sca effects at higher level for the character per cent fruit-set.

As tomato is a self-pollinated crop, thus contains hermoprodite flower which in turn leads to more fruit-set. Higher the fruit-set percentage leads to more fruit yield and *vice-versa*. Fruit-set also depends on the parental character and source availability. The results are in the accordance with the findings of Ahmed *et al*. (2009) [1] and Shankar *et al*. (2013) [12].

Number of fruits per plant

Parents P_6 (2.024), P_5 (1.707) and P_3 (0.811) has highly positive significant gca effect, thus consider good general combiners. Out of 30 crosses, three cross combinations $P_5 \times P_6$ (3.710), $P_3 \times P_1$ (3.154) and $P_5 \times P_2$ (2.643) exhibited highly positive significant sca effects for number of fruits per plant.

Number of fruits per plant is the most important component trait, which is directly related with higher fruit yield per plant. The results obtained are in accordance with the findings of Katkar *et al*. (2012) [5] and Mali *et al*. (2014) [8].

Fruit length (cm)

The parents P_6 (0.338) and P_5 (0.245) showed general combining ability effect in positive direction and considered as good general combiner for fruit length. The top three crosses $P_1 \times P_6$ (8.950), $P_2 \times P_1$ (4.163) and $P_1 \times P_5$ (3.356) exhibited positive significant sca effects at higher level.

Fruit length has been considered as an important direct contributing trait to yield in tomato with respect to quantitative character by increasing the size of the fruit. The results are in the accordance with the findings of Yadav *et al*. (2013) [20] and Shankar *et al*. (2013) [12].

Fruit width (cm)

Two parents *viz.,* P_3 (0.258) and P_5 (0.231) as showed good general combining ability effect in positive direction and regarded as good general combiner for fruit width. The top three crosses $P_1 \times P_3$ (13.104), $P_3 \times P_5$ (2.161) and $P_2 \times P_4$ (1.342) exhibited positive significant sca effects for fruit width at higher level.

Fruit width has been considered as an important direct contributing trait to yield in tomato with respect to quantitative character by increasing the size of the fruit. The results are in the accordance with the findings of Yadav *et al*. (2013) [20] and Shankar *et al*. (2013) [12].

Yield per plant (kg)

Out of six parents, two parents *viz*., P_6 (0.13) and P_5 (0.118) showed gca effect in positive direction, which is found to be goof general combiner for this trait. Out of 30 crosses, two cross combinations *viz*., $P_5 \times P_6$ (2.027) and $P_2 \times P_3$ (1.146) exhibited positive significant sca effects, for yield per plant.

The ultimate goal of any breeding programme is to target and achieve higher yield. This is also the key factor in adoption or rejection of parent/crosses for breeding programme. Similar results on yield per plant have been reported by Katkar *et al*. (2012) [5] and Mali *et al*. (2014) [8].

Yield per plot (kg)

Parent P_6 expressed positively significant gca effect (3.786). Thus it is the highest general combiner for yield per plot. Out of 30 crosses, two crosses $P_5 \times P_6$ (6.477) and $P_6 \times P_2$ (2.055) exhibited positive significant sca effects, for yield per plot.

Positive response of the yield and yield contributing characters ultimately leads to increase in the fruit yield per plant, which in turn increases the plot yield. The results obtained are in accordance with the findings of Renuka *et al*. (2015) [10] and Aminu and Mala (2015) [2].

Yield per hectare (t)

For fruit yield per hectare, only one parent P_6 as showed gca effect in positive direction (3.786). Thus it is the highest general combiner for yield per hectare. Out of 30 crosses, two cross combinations $P_5 \times P_6$ (6.477) and $P_6 \times P_2$ (2.055) exhibited positive significant sca effects, for yield per hectare.

Ultimately with increase in yield per plot of a particular parent/cross leads to the higher yield per hectare, which is desirable in selecting the best parent/cross combination for its higher yield per hectare and *vice-versa*. The present studies are in agreement with findings of Yadav *et al*. (2013) [20] and Renuka *et al*. (2015) [10] in tomato crop.

Conclusion

Studies indicated that parents P_5 and P_6 are good general combiners for yield and its component traits and these parents may be utilized in future hybridization programmes for getting superior and high yielding hybrids or transgressive segregants in the segregating generations. The cross $P_5 \times P_6$ was found to be promising for most of the yield and yield contributing traits, hence this hybrid may be advanced for trials and further segregating studies.

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