ANALYSIS OF COMBINING ABILITY TO RECOGNIZE SUPERIOR F₁ HYBRIDS IN TOMATO (LYCOPERSICUM ESCULENTUM L.) FOR YIELD AND ITS CONTRIBUTING TRAITS

CHANDAN KUMAR AND S. P. SINGH*
Central Arid Zone Research Institute, KVK, Pali-Marwar - 306 401 (Rajasthan), INDIA
*Department of Horticulture, Institute of Agriculture Science, BHU, Varanasi - 221 005, INDIA
e-mail: chandankumarveg.sc@gmail.com

INTRODUCTION
Tomato (Lycopersicum esculentum L.) is one of the most important vegetable crops grown throughout the world because of its wider adaptability, high yielding potential and suitability for variety of uses in fresh as well as processed food industries (Meena and Bahadur, 2014). Efforts are being made to increase its productivity by developing superior varieties. Plant breeders have extensively explored and utilized heterosis to boost yield levels in several cross-pollinated crops in the recent past. It belongs to the large and diverse Solanaceae family also called Nightshades which includes more than three thousand species (Kumar and Singh, 2016).

Identification and selection of flexible parental lines are required to be used in any hybridisation programme to produce genetically modified and potentially rewarding germplasm by assembling fixable gene effects more or less in a homozygous line. Information pertaining to different types of gene action, relative magnitude of genetic variance, and combining ability estimates are important and vital parameters to mould the genetic makeup of tomato crop. This important information could prove an essential strategy to tomato breeders in the screening of better parental combinations for further enhancement (Pedapati et al., 2013). Exploitation of heterosis is primarily dependent on the screening and selection of available germplasm that could be produced by better combinations of important agronomic characters (Hannan et al., 2007). Although many commercial cultivars have high agronomic performances, they perform poorly because of some genetic hindrances in diverse cross combinations. Thus crossing in a diallel fashion is the only specific and flourishing approach of measurement for the identification and selection of superior genetically recombined material. Information about magnitude of general combining ability (GCA) in parents and specific combining ability (SCA) in F₁’s crosses is imperative for crop improvement programmes (Sprague and Tatum, 1942). GCA reveals the existence of additive gene effects while SCA reveals non-additive gene effects. Information about GCA effects are beneficial while choosing best combiner parents and SCA effects information reveal best cross combinations for further judgement. Judicious application of information relevant to standard heterosis and SCA are fruitful for selecting best hybrids for desired traits. Considering this, the present investigation was undertaken to generate information on nature of combining ability in eight parental lines of tomato to assess the pre-potency of parents in hybrid combination develop by diallel matting design.

MATERIALS AND METHODS
The present study was conducted at Horticulture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.), India during Rabi season of 2012 and 2013. The soil of experimental field was alluvial type of soil with average fertility level and pH in the range of 6.6 to 7.4. The experimental materials was procured from Indian Institute of Vegetable Research, Varanasi (India) followed by selfing for maintenance. Eight genetically diverse lines (Arka
Meghali, Pant T-3, Punjab Chhuhara, H-88-78-1, Arka Alok, Azad T-5, H-24 (Hisar Anmol), Sel-7 (Hisar Arun)) were crossed in diallel mating design during rabi 2012. The resultant 28 F₁'s were evaluated along with their parents during rabi 2013 in randomized block design which was replicated thrice. Each entry was grown in one row of 10 plants in each by adopting inter row spacing of 60 cm and intra row spacing of 45 cm. The observations were recorded on five randomly selected plants for viz., number of flowers per cluster, days to first harvest, fruit diameter (cm), fruit length (cm), average fruit weight (g), number of fruit per plant, plant height at final harvest (cm), number of seeds per fruit and fruit yield per plant (kg/plant).

Combining ability analysis was carried out according to Singh and Chaudhary (1979) based on Griffing's (1956) fixed effect model using the following formula:

\[ X_{ik} = \mu + g_i + g_j + S_{ij} + e_{ik} \]

Where, \( \mu \) = General mean, \( g_i \) = gca effect of \( i \)th line, \( i = 1, 2, \ldots \) (Number of lines), \( g_j \) = gca effect of \( j \)th tester, \( j = 1, 2, \ldots \) (Number of testers), \( S_{ij} \) = sca effect of the \( ij \)th combination, \( e_{ik} \) = Error associated with the observation, \( k = 1, 2, \ldots \) (Number of replications).

**RESULTS AND DISCUSSION**

Analysis of variance (Table 1) for combining ability revealed that the variance due to genotypes effect was highly significant (@P ≤ 0.01) for all characters. Significant mean squares for GCA and SCA indicated joint role of additive, non-additive and maternal effects for the expression of all traits. The predictability ratio of GCA/SCA variance was less than 1 for number of flowers per cluster, days to first harvest, number of seeds per fruit and fruit yield per plant showing preponderance of non-additive gene effects while it was more than 1 for fruit diameter, fruit length, average fruit weight, number of fruit per plant and plant height indicating predominance of additive gene effect.

Mean sum of square due to parent were highly significant for all traits indicating genetic diversity among the parent (GCA) except number of flowers per cluster and days to first harvest, thus highest contribution by these characters towards combining ability. Whereas, variance due to hybrids (SCA) were also highly significant for all the characters and suggested manifestation of parental genetic variability in their crosses or possibility of better selection of cross combinations among 28 F₁ hybrids for these traits. The details of combining ability analysis of 8 parents and their 28 crosses are being furnished as under.

**Number of flowers per cluster**

Among 8 parents (Table 2) none of the parents recorded significant gca effects, 13 cross hybrids (Table 3) recorded significant sca effects and remaining 15 crosses were observed to be deviated from significance level. The cross Punjab Chhuhara x H-24 (1.512) had recorded highest positive significant value followed by the crosses Pant T-3 x H-88-78-1 (1.228) and Arka Meghali x H-88-78-1 (1.212). Hannan et al. (2007) and Kumar et al. (2013) they also reported significant variation due to SCA, that indicated the importance of non-additive types of gene action of inheritance for this traits.

**Days to first harvest**

Table 1: Analysis of variance for combining ability

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f</th>
<th>Number of flowers per cluster</th>
<th>Days to first harvest</th>
<th>Fruit diameter (cm)</th>
<th>Fruit length (cm)</th>
<th>Average fruit weight (g)</th>
<th>Number of fruits per plant (cm)</th>
<th>Plant height at final harvest (cm)</th>
<th>Number of seeds per fruit</th>
<th>Yield per plant (Kg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCA</td>
<td>7</td>
<td>0.944**</td>
<td>6.86</td>
<td>1.141**</td>
<td>0.907**</td>
<td>701.56**</td>
<td>310.61**</td>
<td>609.83**</td>
<td>465.07**</td>
<td>1.09**</td>
</tr>
<tr>
<td>SCA</td>
<td>28</td>
<td>2.511**</td>
<td>16.98**</td>
<td>0.473**</td>
<td>0.388**</td>
<td>135.98**</td>
<td>78.16**</td>
<td>120.32**</td>
<td>649.84**</td>
<td>1.11**</td>
</tr>
<tr>
<td>Error</td>
<td>700</td>
<td>0.372</td>
<td>0.4</td>
<td>2.41</td>
<td>2.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gca/sca ratio</td>
<td></td>
<td>0.38</td>
<td>0.4</td>
<td>2.41</td>
<td>2.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.99</td>
</tr>
</tbody>
</table>

* **significant at 5% and 1% level, respectively

Table 2: General combining ability effects for parents

<table>
<thead>
<tr>
<th>S.No</th>
<th>Parents</th>
<th>Number of flowers per cluster</th>
<th>Days to first harvest</th>
<th>Fruit diameter (cm)</th>
<th>Fruit length (cm)</th>
<th>Average fruit weight (g)</th>
<th>Number of fruits per plant</th>
<th>Plant height at final harvest (cm)</th>
<th>Number of seeds per fruit</th>
<th>Yield per plant (Kg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P1 (Arka Meghali)</td>
<td>0.285</td>
<td>-0.756</td>
<td>-0.029</td>
<td>0.281**</td>
<td>3.758**</td>
<td>-2.135**</td>
<td>0.722</td>
<td>1.327</td>
<td>0.207**</td>
</tr>
<tr>
<td>2</td>
<td>P2 (Pant T-3)</td>
<td>0.076</td>
<td>-0.023</td>
<td>0.103</td>
<td>-0.096</td>
<td>-8.758**</td>
<td>2.728**</td>
<td>-0.876</td>
<td>-4.173**</td>
<td>-0.249**</td>
</tr>
<tr>
<td>3</td>
<td>P3 (Punjab Chhuhara)</td>
<td>0.165</td>
<td>0.375</td>
<td>-0.350**</td>
<td>0.241**</td>
<td>0.462</td>
<td>-0.701</td>
<td>3.081**</td>
<td>1.282</td>
<td>0.042</td>
</tr>
<tr>
<td>4</td>
<td>P4 (Arka Alok)</td>
<td>-0.276</td>
<td>-0.474</td>
<td>0.233**</td>
<td>-0.032</td>
<td>-1.201</td>
<td>-0.872</td>
<td>0.614</td>
<td>3.337**</td>
<td>0.222**</td>
</tr>
<tr>
<td>5</td>
<td>P5 (H-88-78-1)</td>
<td>0.004</td>
<td>0.310</td>
<td>-0.176**</td>
<td>-0.161</td>
<td>-2.564**</td>
<td>-0.601</td>
<td>1.532</td>
<td>5.73**</td>
<td>-0.292**</td>
</tr>
<tr>
<td>6</td>
<td>P6 (Azad T-5)</td>
<td>-0.131</td>
<td>0.496</td>
<td>-0.003</td>
<td>-0.109</td>
<td>8.011**</td>
<td>-4.724**</td>
<td>1.936</td>
<td>3.817**</td>
<td>0.081</td>
</tr>
<tr>
<td>7</td>
<td>P7 (Hisar Anmol)</td>
<td>0.437</td>
<td>0.217**</td>
<td>-0.159</td>
<td>0.611</td>
<td>0.263</td>
<td>2.200</td>
<td>-3.738**</td>
<td>-0.062</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>P8 (Hisar Arun)</td>
<td>-0.112</td>
<td>-0.364</td>
<td>0.003</td>
<td>0.036</td>
<td>-0.318</td>
<td>6.040**</td>
<td>-10.962</td>
<td>3.885**</td>
<td>0.051</td>
</tr>
<tr>
<td></td>
<td>SE (g)</td>
<td>0.104</td>
<td>0.347</td>
<td>0.055</td>
<td>0.062</td>
<td>0.638</td>
<td>0.569</td>
<td>0.770</td>
<td>0.622</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>SE (g-g)</td>
<td>0.157</td>
<td>0.524</td>
<td>0.084</td>
<td>0.094</td>
<td>0.965</td>
<td>0.860</td>
<td>1.164</td>
<td>0.940</td>
<td>0.053</td>
</tr>
<tr>
<td></td>
<td>SE (g-g-g)</td>
<td>0.334</td>
<td>1.115</td>
<td>0.177</td>
<td>0.199</td>
<td>2.051</td>
<td>1.829</td>
<td>2.475</td>
<td>1.999</td>
<td>0.112</td>
</tr>
</tbody>
</table>

CHANDAN KUMAR AND S. P. SINGH
Early harvesting was desirable and preferable over late harvesting; data presented in Table 2 for days to first harvest and Table 3 for days to cluster harvest. Only Punjab Chhuhara (3.081) parent was observed the highest significant positive value for gca effect. The negative sca effect, the highest significant positive value for sca effect was recorded in Azad T-5 x Sel-7 (15.078) followed by the crosses Arka Meghali x Punjab Chhuhara (9.137) and Arka Meghali x Arka Alok (7.610). Similar results with respect to gca and sca effects were obtained by Asati et al. (2013) and Saleem et al. (2007).

Fruit diameter (cm)

The highest significant positive gca effect was observed in Arka Alok (0.233) and sca effects ranged between -0.363 (Punjab Chhuhara x Azad T-5) to 0.650 (H-88-78-1 x H-24). Seven out of 28 crosses recorded significant to this trait in which five are positive or desirable direction and two crosses are negative or undesirable direction. Mondal et al. (2009) and Saleem et al. (2013) also reported that involvement of both additive and non additive gene action was operative for the control of equatorial diameter of fruit.

Fruit length (cm)

Among parents, (Table 2) Arka Meghali (0.281) and Punjab Chhuhara (0.241) exhibited significant positive gca effects. Among cross combinations, (Table 3) highest significant positive sca effect recorded in the cross Arka Meghali x Arka Alok (0.566) followed by Punjab Chhuhara x Sel-7 (0.476) and Arka Meghali x Sel-7 (0.403). The results with respect to gca and sca effects are similar to the finding of Saleem et al. (2013).

Average fruit wt. (Kg.)

Among parents, Azad T-5 (8.011) exhibited highly significant positive gca effects followed by Arka Meghali (3.758). Among F1 hybrids, 13 out of 28 crosses showed significant positive and negative sca effect, the highest significant positive value for sca effect was recorded in Azad T-5 x Sel-7 (15.078) followed by the crosses Arka Meghali x Punjab Chhuhara (9.137) and Arka Meghali x Arka Alok (7.610). Similar results with respect to gca and sca effects were obtained by Asati et al. (2007) and Saleem et al. (2013).

Number of fruits per plant

The highly significant positive gca effects for this trait was recorded in Sel-7 (6.040) and Pant T-3 (2.728) parents which is desirable. Among F1 hybrids, (Table 3) the highest significant positive value for sca effect was recorded in H-24 x Sel-7 (8.823) followed by Punjab Chhuhara x Sel-7 (7.137), Pant T-3 x Azad T-5 (6.346) and Pant T-3 x Sel-7 (6.262).

Plant height at final harvest (cm)

Only Punjab Chhuhara (3.081) parent was observed the highest significant positive value for this trait.

ACKNOWLEDGMENT

I proffer my sincere thanks to Indian Institute of Vegetable
Research (IIVR), Varanasi for provide me genetically diverse lines and U.G.C. for providing fellowship (R/Dev./2012-13/ 3729) during course of investigation.

REFERENCES


