

## Combining Ability Analysis for Yield and Its Attributing Traits over Environments in Tomato (*Solanum lycopersicum* L.)

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### Abstract

The nature of inheritance of days to first fruit set, days to first picking, plant height, number of primary branches per plant, fruit size, flesh thickness, number of fruits per plant, average fruit weight, fruit yield per plant and number of locules was studied from a 10 parent diallel cross of *Solanum lycopersicum* L. None of the parents exhibited desirable gca effects for all the traits in individual as well as in pooled over environments. However, overall ranking of genotypes revealed that the parents Arka Vikas, KS-227, Roma, DVRT-I and DARL-63 exhibited significant desirable gca effects for most of the traits.

**Keywords:** tomato, *Solanum lycopersicum* L., combining ability, yield, traits

### 1. Introduction

Tomato (*Solanum lycopersicum* L.,  $2n = 24$ ) a member of solanaceae family, is one of the most important vegetable crops both because of its special nutritive value and also due to its worldwide cultivation. Besides, fresh consumption, tomato ranks first among processed vegetables in the world given by Dhaliwal et al. (2000). In India, tomato is grown across all agro-ecological zones and occupies an area of about 865 thousand ha with an annual production of 16826 thousand metric tones Anonymous (2010-11). The average productivity is 19.50 mtha<sup>-1</sup> in the country as against 27.20 t ha<sup>-1</sup> in the world. 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 of desired traits. Combining ability studies provide useful information for the selection of suitable genotypes for an effective hybridization and at the same time elucidate the nature and magnitude of different types of gene action. The entire genetic variability observed in the analysis for each trait was partitioned into its components, i.e. general (GCA) and specific combining ability (SCA) by Sprague (1966). GCA effects were due to additive type of gene action and SCA effects were due to non-additive (dominant or epistatic) gene action. Several studies of combining ability for yield components are available in many species. Some researchers found the predominancy of GCA to be more important than that of SCA reported by Khan et al. (1991); Yaqoob et al. (1997), while others suggested that SCA was more important reported by Ortiz and Golmirzaie (2004), Biswas et al. (2005). The present investigation was carried out to analyze tomato cultivars to ascertain the relative performance regarding combining ability effects for yield and its components.

### 2. Materials and Methods

The basic materials consisted of ten diverse genotypes of Tomato (*Solanum lycopersicum* L.) viz., Arka Vikas, KS-227, VLT-32, DARL-63, DVRT-I, Local, Marglobe, Shalimar-II, Roma and Shalimar-I. These lines selected for the present study on the basis of genetic variability of various agronomic traits and maturity parameters. The distinguishing morphological features and pedigree record of the parents used in the present study is given as:

#### 2.1 Arka Vikas

It is a selection from American variety Tip Top and released from IIHR, Bangalore. Plants are semi-determinate in growth habit. Fruits are oblate, deep red in colour and each weighing 80 – 85 g with uniform ripening. It is

suitable for fresh market purpose. Yield potential is 350-400 q/ha in 105-110 days of crop duration.

### 2.2 KS-227

It is a mid early maturing variety, selection of Kaliyanpur, Kanpur. Plants are indeterminate; Fruits are medium in size, flattish, round, slightly furrowed, green stem end, smooth, semi-fleshy and high yielding. It is suitable for table purpose.

### 2.3 VLT-32

It is a selection of Vivekanand Parvati Krishi Anusandan Shala (VPKAS).

### 2.4 DARL-63

It is a selection from Pithoragarh Uttarakhand.

### 2.5 DVRT-1

This variety has been developed at IIVR (Indian Institute of Vegetable Research, Varanasi). Plants are indeterminate. Fruits are large, spherical, attractive red with 5-6 locules. It gives an average yield of 600q/ha.

### 2.6 Local

It is a local selection of Srinagar.

### 2.7 Marglobe

It is a selection from a cross between Marvel and Globe. It is an introduction, mid season variety. Plants are 70-80 cm tall, vigorous, erect and indeterminate growth habit. Leaves are large and broad with dense foliage. It has typically 4-5 flowers on truss, which bears 3 or 4 fruits. Fruits are nearly round, deep scarlet colour on ripening, 3-5 locules, juicy, mildly acidic, thick walled, smooth, solid and less seeded. Fruits have dark green shoulder. Diameter of ripe fruit is about 7.5 cm and weighing 100-150 g.

### 2.8 Shalimar-II

It is a selection from SKUAST (Sher-e-Kashmir University of Agricultural Science and Technology Kashmir). Plants are early maturing, indeterminate, dwarf and erect growing. Potato leaved plant with high yielding potential at the higher elevation. It yields about 200-210 q/ha.

### 2.9 Roma

It is an introduction from USA (EC-13513). Plants are determinate, semi-dwarf, bushy growth habit with luxuriant foliage cover. Fruits are borne in 4-5 clusters, pear shaped with thick pericarp, 7 cm long, 5 cm in girth, red in colour on ripening, free from green shoulder, bilocular, small seeded cavity, less seeded, medium, elliptical, good foliage cover and high TSS. This variety possesses good keeping quality, suitable for transportation and processing.

### 2.10 Shalimar-I

It is a selection from SKUAST (Sher-e-Kashmir University of Agricultural Science and Technology Kashmir). Plants are semi-determinate and fruit profusely. Fruits are red and round, appealing in colour. Fruits mature in about 100-110 days, yielding 200-210 q/ha.

Forty five  $F_1$  crosses were generated through 10 x 10 diallel mating design at Vegetable Experimental Farm, Division of Vegetable Science, SKUAST-K, Shalimar during the year 2010. The final experimental materials consisting of ten parents and forty five  $F_1$  crosses were evaluated during year 2011 at three locations. Vegetable Experimental Field, Division of Vegetable Science, SKUAST-K, Shalimar, Krishi Vigyan Kendra, Malangpora, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Baramulla. At each location, the experiment was laid out in completely randomized block design with three replications. The row to row and plant to plant spacing was maintained at 60 x 45 cm. Recommended package of practices were adopted to raise a healthy crop at all the locations. The observations were recorded on five randomly selected plants in each replication at all locations. The observations were recorded on the following characters: Days to first fruit set, days to first picking, plant height, number of primary branches per plant, fruit size, flesh thickness, number of fruits per plant, average fruit weight, fruit yield per plant and number of locules. The combining ability analysis over the environments was carried out as per the procedure carried out by Singh (1973b, 1979) for the data collected from half diallel (Parents and  $F_1$ 's) scheme. The data was derived from reference population, and the environments were random and contrasting. Therefore, both genotypes and locations (environments) were fixed and as such Method II and Model I was adopted for analysis. The analysis was based on the following statistical model:

$$X_{ijk} = \mu + g_i + g_j + S_{ij} + l_k + (gl)_{ik} + (gl)_{jk} + (sl)_{ijk} + \frac{1}{b\sum e_{ijk}}$$

Where,

$\mu$  = population mean,

$g_i$  = general combining effect of  $i^{\text{th}}$  parent,

$g_j$  = general combining effect of  $j^{\text{th}}$  parent,

$S_{ij}$  = specific combining ability effect of the cross between  $i^{\text{th}}$  and  $j^{\text{th}}$  parent,

$l_k$  = effect of  $k^{\text{th}}$  environment (location),

$(gl)_{ik}$  = interaction effect corresponding to  $g_i$  and  $l_k$ ,

$(gl)_{jk}$  = interaction effect corresponding to  $g_j$  and  $l_k$ ,

$(sl)_{ijk}$  = interaction effect corresponding to  $S_{ij}$  and  $l_k$ , and

$e_{ijk}$  = random error

### 3. Results and Discussion

Combining ability of a line indicates its potentiality in cross combination with other lines. Combining ability analysis helps in selection of parents for hybridization and also in selecting a proper breeding procedure. General combining ability (GCA) measures the average performance of a parent in various hybrid combinations.

General combining ability estimates the mean performance of a parent relative to all its hybrid combinations and indicates additive genetic effects reported by Sprague (1966). The additive genetic effects give the direct measurement of the breeding value of a parent. However, the performance of a genotype based on GCA combined with *per se* performance is much more reliable.

Perusal of results on GCA effects indicated that none of the parents possessed significant and desirable general combining ability for all the traits simultaneously. However, different parents were found to reveal desirable general combining ability for different trait. For maturity traits, i.e., days to first fruit set and days to first picking Local, M.G, S-II and Roma showed significant negative GCA effects in almost all environments and pooled analysis. A. Vikas, Local, M.G, S-II and Roma were found desirable with respect to days to first fruit set; KS-227, Local, M.G, S-II and Roma for days to first picking. For plant height Local, M.G, S-II, Roma and S-I and for a number of primary branches per plant A. Vikas, DVRT-1, Local, S-II and Roma were found to be desirable combiners. For fruit size A. Vikas, M.G, S-II and Roma showed positive and significant GCA effects. VLT-32, DARL-63, DVRT-1 and S-I were found to be good combiners for flesh thickness; A. Vikas, KS-227, Local, M.G, S-II and Roma for a number of fruits per plant. For average fruit weight A. Vikas, KS-227, DARL-63, DVRT-1, Local and S-II depicted significant positive GCA effects. Desirable GCA effects were also depicted by A. Vikas, KS-227, M.G and S-II for fruit yield per plant and VLT-32 and DARL-63 for a number of locules fruit<sup>-1</sup>. In most of the cases, high general combining ability for the traits was associated with their high to average *per se* performance and poor general combining ability was associated with low *per se* performance. Overall performance of parents revealed that Local, M.G, S-II and Roma were desirable for most of the traits (maturity, yield and yield component traits). None of the parents exhibited superior general combining ability for all the traits simultaneously. Similar results have also been reported by Joshi et al. (2004), Hannan et al. (2007) and Dhaliwal et al. (2000). As none of the parents were a good combiner for all the traits simultaneously, the parents with desirable GCA for maximum traits could be selected for use in further breeding programmes. In case of self-pollinated species, like tomato, mass selection and progeny selection should be followed. Nandadevi et al. (2003) suggested that the genotypes which showed significant gca effect in desirable direction for various characters could be used in multiple crosses and segregating population obtained thereof, could be used for identifying and selecting segregants which are expected to recombine most of the favourable alleles distributed among the parents.

Rao et al. (2007) made it evident from their study that the fruit related traits were under the control of additive gene action and seed related traits are under non-additive gene action and suggested that breeding procedure of population improvement or some form of recurrent selection could be beneficial for improving the fruit quality.

Table 1. General combining ability effects for maturity and yield attributing traits in Tomato (*Solanum lycopersicum* L.)

| Parents                | Days to first fruit set |                |                |          | Days to first picking |                |                |          | Plant height (cm) |                |                |          |
|------------------------|-------------------------|----------------|----------------|----------|-----------------------|----------------|----------------|----------|-------------------|----------------|----------------|----------|
|                        | E <sub>1</sub>          | E <sub>2</sub> | E <sub>3</sub> | Pooled   | E <sub>1</sub>        | E <sub>2</sub> | E <sub>3</sub> | Pooled   | E <sub>1</sub>    | E <sub>2</sub> | E <sub>3</sub> | Pooled   |
| Arka Vikas             | -1.253**                | -1.183**       | -1.113**       | -1.183** | 1.644**               | 2.189**        | 1.974**        | 1.936**  | -5.708**          | -6.732**       | -5.370**       | -5.937** |
| KS-227                 | 0.313**                 | 0.389**        | 0.142**        | 0.281**  | -0.239*               | 0.094          | -0.031         | -0.059** | -4.986**          | -4.332**       | -5.592**       | -4.970** |
| VLT-32                 | 0.086*                  | 0.378**        | 0.181*         | 0.202**  | 0.339**               | 1.122**        | 0.613**        | 0.691**  | -1.697**          | -0.343*        | -0.217         | -0.752** |
| DARL-63                | 2.019**                 | 1.928**        | 1.987**        | 1.978*   | 0.583**               | 0.378**        | 0.741**        | 0.567**  | -0.269*           | -0.421**       | -0.556**       | -0.415** |
| DVRT-1                 | -0.376**                | 0.294**        | 0.509**        | 0.142**  | -0.156                | -0.161         | 0.330**        | 0.004**  | -2.347**          | -2.318**       | -3.253**       | -2.639** |
| Local                  | -0.920**                | -1.050**       | -0.858**       | -0.943** | -0.883**              | -0.344**       | -0.192         | -0.473** | 1.992**           | 2.157**        | 1.449**        | 1.867**  |
| Marglobe               | -0.353**                | -0.539**       | -0.330**       | -0.407** | -0.106                | -1.178**       | -1.081**       | -0.788** | 4.048**           | 4.602**        | 5.363**        | 4.671*   |
| Shalimar-II            | -0.959**                | -1.100**       | -1.180**       | -1.079** | -1.217**              | -1.289**       | -1.131**       | -1.212** | 2.903**           | 2.879**        | 2.974**        | 2.919*   |
| Roma                   | -0.214**                | -0.378**       | -0.297**       | -0.296** | -0.133                | -0.522**       | -0.737**       | -0.464** | 3.626**           | 2.352**        | 3.102**        | 3.026**  |
| Shalimar-I             | 1.658**                 | 1.261**        | 0.959**        | 1.293*   | 0.167                 | -0.289*        | -0.487**       | -0.204   | 2.437**           | 2.154**        | 2.099**        | 2.229**  |
| SE± (g)                | 0.04                    | 0.07           | 0.04           | 0.05     | 0.11                  | 0.12           | 0.12           | 0.12     | 0.13              | 0.16           | 0.15           | 0.15     |
| SE±(g-g <sub>i</sub> ) | 0.06                    | 0.11           | 0.06           | 0.08     | 0.16                  | 0.18           | 0.17           | 0.17     | 0.19              | 0.24           | 0.23           | 0.22     |

\*, \*\* Significant at 5 and 1 per cent levels, respectively

Table 2. General combining ability effects for maturity and yield attributing traits in Tomato (*Solanum lycopersicum* L.)

| Parents                | Number of primary branches plant <sup>-1</sup> |                |                |          | Fruit size (cm <sup>2</sup> ) |                |                |          | Flesh thickness (mm) |                |                |          |
|------------------------|------------------------------------------------|----------------|----------------|----------|-------------------------------|----------------|----------------|----------|----------------------|----------------|----------------|----------|
|                        | E <sub>1</sub>                                 | E <sub>2</sub> | E <sub>3</sub> | Pooled   | E <sub>1</sub>                | E <sub>2</sub> | E <sub>3</sub> | Pooled   | E <sub>1</sub>       | E <sub>2</sub> | E <sub>3</sub> | Pooled   |
| Arka Vikas             | 0.441**                                        | 0.354**        | 0.455**        | 0.416**  | 2.355**                       | 2.351**        | 2.089**        | 2.264**  | -0.278**             | -0.194**       | -0.108**       | -0.194** |
| KS-227                 | -0.337**                                       | -0.334**       | -0.356**       | -0.343** | -0.225**                      | -0.279**       | -0.197**       | -0.234** | -0.084**             | -0.011         | -0.113**       | -0.070** |
| VLT-32                 | 0.052**                                        | 0.077*         | -0.106**       | 0.008**  | -1.588**                      | -1.201**       | -1.600**       | -1.462** | 0.077*               | 0.195**        | 0.287**        | 0.185*   |
| DARL-63                | -0.426**                                       | -0.496**       | -0.362**       | -0.427*  | -1.115**                      | -1.012**       | -0.939**       | -1.022** | 0.211**              | 0.251**        | 0.270**        | 0.244**  |
| DVRT-1                 | 0.080*                                         | 0.210**        | 0.155**        | 0.147**  | -1.370**                      | -1.199**       | -1.009**       | -1.192** | 0.352**              | 0.134**        | 0.176**        | 0.221*   |
| Local                  | 0.097**                                        | 0.099**        | 0.149**        | 0.115**  | -0.830**                      | -0.494**       | -0.283**       | -0.535** | -0.134**             | -0.088**       | -0.080*        | -0.100** |
| Marglobe               | 0.036                                          | 0.077*         | -0.006         | 0.036**  | 0.878**                       | 1.376**        | 0.936**        | 1.064**  | -0.148**             | -0.280**       | -0.241**       | -0.223** |
| Shalimar-II            | 0.324**                                        | 0.193**        | 0.127**        | 0.215**  | 1.107**                       | 1.021**        | 1.625**        | 1.251**  | -0.306**             | -0.183**       | -0.358**       | -0.281** |
| Roma                   | 0.147**                                        | 0.104**        | 0.127**        | 0.127**  | 0.885**                       | 0.536**        | 0.427**        | 0.615**  | 0.016                | -0.105**       | 0.119**        | -0.069** |
| Shalimar-I             | -0.414**                                       | -0.284**       | -0.184**       | -0.295** | -0.097**                      | -1.099**       | -1.050**       | -0.749*  | 0.294**              | 0.281**        | 0.287**        | 0.287**  |
| SE± (g)                | 0.03                                           | 0.03           | 0.02           | 0.03     | 0.05                          | 0.05           | 0.06           | 0.05     | 0.03                 | 0.03           | 0.04           | 0.03     |
| SE±(g-g <sub>i</sub> ) | 0.05                                           | 0.05           | 0.04           | 0.05     | 0.07                          | 0.08           | 0.08           | 0.08     | 0.05                 | 0.05           | 0.06           | 0.05     |

\*, \*\* Significant at 5 and 1 per cent levels, respectively

Table 3. General combining ability effects for maturity and yield attributing traits in Tomato (*Solanum lycopersicum* L.)

| Parents                | Number of fruits plant <sup>-1</sup> |                |                |          | Av. fruit weight |                |                |          | Fruit yield plant <sup>-1</sup> |                |                |          |
|------------------------|--------------------------------------|----------------|----------------|----------|------------------|----------------|----------------|----------|---------------------------------|----------------|----------------|----------|
|                        | E <sub>1</sub>                       | E <sub>2</sub> | E <sub>3</sub> | Pooled   | E <sub>1</sub>   | E <sub>2</sub> | E <sub>3</sub> | Pooled   | E <sub>1</sub>                  | E <sub>2</sub> | E <sub>3</sub> | Pooled   |
| Arka Vikas             | 0.548**                              | 0.397**        | 0.276**        | 0.407**  | 1.621**          | 0.724**        | 0.608**        | 0.984**  | 0.045**                         | 0.015**        | 0.010*         | 0.024**  |
| KS-227                 | 0.648**                              | 0.958**        | 1.032**        | 0.879**  | 1.449**          | 0.333**        | 0.177**        | 0.653**  | 0.018                           | 0.013*         | 0.018**        | 0.016**  |
| VLT-32                 | -0.129*                              | -0.289**       | -0.599**       | -0.339   | -2.106**         | 1.968**        | 2.197**        | 0.686**  | -0.044**                        | -0.038**       | -0.042**       | -0.041*  |
| DARL-63                | -0.641**                             | -0.253**       | -0.329**       | -0.407** | 1.160**          | 0.368**        | 0.720**        | 0.749**  | -0.067**                        | -0.044**       | -0.023**       | -0.045** |
| DVRT-1                 | -1.991**                             | -2.073**       | -1.671**       | -1.912** | 1.483**          | 1.013**        | 1.275**        | 1.257**  | -0.049**                        | -0.062**       | -0.023**       | -0.045** |
| Local                  | 0.359**                              | 0.641**        | 0.593**        | 0.531**  | 0.809**          | 0.441**        | 0.514**        | 0.588**  | 0.016                           | 0.048**        | 0.064**        | 0.042    |
| Marglobe               | 1.548**                              | 1.286**        | 1.337**        | 1.39**   | 1.271**          | 1.463**        | 0.886**        | 1.207    | 0.075**                         | 0.065**        | 0.064**        | 0.068**  |
| Shalimar-II            | 1.287**                              | 1.308**        | 1.171**        | 1.255**  | 0.120*           | 0.178*         | 0.336**        | 0.221**  | 0.081**                         | 0.099**        | 0.079**        | 0.086*   |
| Roma                   | 0.426**                              | 0.352**        | 0.359**        | 0.379**  | -1.317**         | -1.900**       | -1.992**       | -1.735** | 0.070**                         | 0.026**        | 0.007          | 0.035**  |
| Shalimar-I             | -2.057**                             | -2.326**       | -2.168**       | -2.184** | -4.490**         | -4.589**       | -4.753**       | -4.611** | -0.146**                        | -0.121**       | -0.153**       | -0.140*  |
| SE± (g)                | 0.05                                 | 0.05           | 0.05           | 0.05     | 0.05             | 0.07           | 0.06           | 0.06     | 0.01                            | 0.005          | 0.004          | 0.006    |
| SE±(g-g <sub>i</sub> ) | 0.08                                 | 0.08           | 0.08           | 0.08     | 0.07             | 0.10           | 0.22           | 0.10     | 0.02                            | 0.008          | 0.006          | 0.01     |

\*, \*\* Significant at 5 and 1 per cent levels, respectively

Table 4. General combining ability effects for maturity and yield attributing traits in Tomato (*Solanum lycopersicum* L.)

| Parents                              | Locule number  |                |                |             |
|--------------------------------------|----------------|----------------|----------------|-------------|
|                                      | E <sub>1</sub> | E <sub>2</sub> | E <sub>3</sub> | Pooled      |
| Arka Vikas                           | -0.247**       | -0.191**       | -0.289**       | -0.243**    |
| KS-227                               | 0.142**        | 0.081*         | 0.050          | 0.091**     |
| VLT-32                               | 0.203**        | 0.292**        | 0.206**        | 0.233**     |
| DARL-63                              | 0.175**        | 0.209**        | 0.333**        | 0.238**     |
| DVRT-1                               | -0.114**       | -0.086**       | -0.106**       | -0.101**    |
| Local                                | 0.167**        | 0.048          | 0.150**        | 0.122       |
| Marglobe                             | 0.108**        | 0.076*         | 0.044          | 0.077**     |
| Shalimar-II                          | 0.036          | 0.042          | 0.061*         | 0.046**     |
| Roma                                 | -0.425**       | -0.436**       | -0.372**       | -0.411**    |
| Shalimar-I                           | -0.044         | -0.036         | -0.078*        | -0.052**    |
| SE± (g)                              | <b>0.03</b>    | <b>0.03</b>    | <b>0.03</b>    | <b>0.03</b> |
| SE±(g <sub>r</sub> -g <sub>j</sub> ) | <b>0.04</b>    | <b>0.05</b>    | <b>0.04</b>    | <b>0.04</b> |

\*, \*\* Significant at 5 and 1 per cent levels, respectively

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