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Assessment of combining ability using Line × tester analysis over environments in tomato (*Solanum lycopersicum* L.)

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Abstract
The experimental materials consisted of 65 entries comprising 48 hybrids, 4 female lines and 12 testers along with one standard check (Arka Rakshak) were evaluated in a Randomized Complete Block Design with three replications under three environments during *kharif-rabi* season of the year 2016-17 at the Main Vegetables Research Station, Anand Agricultural University, Anand to estimate the combining ability effects and gene action for fruit yield, yield components and fruit quality traits in tomato. The source of variation due to lines × testers was significant for all the characters reflected importance of non-additive gene action in the inheritance of most of the characters. The parents DVRT 2, H 24, TBK 00113 and ATL 11-05 displayed high gca effect for fruit yield per plant and some desirable traits like number of fruits per plant and fruit weight. These parents possessed high concentration of favourable genes for more number of traits and would be utilized in multiple crossing programmes. Out of 48 hybrids studied, 22 exhibited significant positive sca effects for fruit yield per plant on pooled basis. The top five hybrids on the basis of significant positive sca effects for fruit yield per plant were H 24 × DARL 66, H 24 × SL 120, AT 3 × VTG 93, AT 3 × Feb 4 and DVRT 2 × NTL 14-71. Combining ability analysis provides specific information on selection of better parents and cross combinations for their further use in hybrid breeding programme.

Keywords: Combining ability, Line × Tester analysis, environments, tomato

Introduction

Tomato (*Solanum lycopersicum* L., 2n = 2x = 24) is one of the most widely grown vegetable crop in both tropics and sub tropics of the world. It belongs to the family Solanaceae and ranks second in importance among vegetables. The center of origin of tomato believed to be the tropical America from Peruvian and Mexican regions (Thompson and Kelly, 1957) [30]. Tomato originated in wild form in Ecuador, Peru and Bolivia of South America (center of diversity of wild tomato). In India, it was introduced by English traders of the East India Company in 1822 (Kalloo, 1988) [15].

Tomato ranks third in priority after potato and onion in India but ranks second after potato in the world. India ranks second in the area and production of tomato in the world. The area, production and productivity of tomato in India during 2016-17 were 7.97 lakh hectares, 207.08 lakh tonnes and 26.0 tonnes per hectare, respectively. Odisha, Madhya Pradesh, Karnataka, West Bengal, Andhra Pradesh, Telangana, Chhattisgarh, Bihar, Gujarat and Maharashtra were the main tomato growing states in India (NHB, 2017) [21].

Tomato also ranks first in the list of processed vegetables in the world as number of products are prepared from tomato *viz*., ketchup, paste, soup etc. Tomato is consumed in diverse ways, including raw, as an ingredient in many dishes of cooked vegetables, sauces, salads and drinks. Tomato cultivation has become increasingly popular since the mid-nineteenth century because of its varied climatic tolerance and high nutritive value. Tomato fruit contains different classes of antioxidants such as carotenoids (β-carotene, lycopene), phenolic compound and α-tocopherol (Vitamin E). Therefore, it is one of the most important "protective foods" for its special nutritive value (Krinsky, 1994) [17]. Tomato is also known as "poor man′s apple" due to the micronutrients existing at low concentration. Tomato has several medicinal values, i.e. the pulp and juice of the fruit were found as mild aperients, a promoter of gastric secretions and blood purifier. The fruit is rich in lycopene, which may have beneficial health effects and considered as the "world′s most powerful natural antioxidant" (Jones, 1999) [14].

The awareness of consumers for nutritional security demands more varieties of higher quality; thereby tomato breeding strategies focused not only for increasing fruit yield but quality continues to be of great interest. High soluble sugar and lycopene content were highly desirable not only in processing tomato cultivars but also in fresh-market cultivars due to their important contribution to the overall flavour and nutritional value of tomatoes (Cuartero and Fernandez, 1999) [8].

The line × tester analysis furnishes useful information on identification of superior parents and crosses with their general and specific combining ability effects, respectively. Combining ability studies in self-pollinated crops is useful to select the best combining parents, which on crossing would produce more desirable recombinants; such studies also elucidate the nature and magnitude of gene action in the inheritance of fruit yield and its components. The combining ability studies in varying environment provides precise information as environmental effects play an important role, and greatly influence the magnitude of gene effects. With this perspective, the present investigation was undertaken for the combining ability analysis using line × tester analysis over three environments in tomato.

Materials and Methods

1. Experimental site

The field experiment was conducted at Main Vegetables Research Station, Anand Agricultural University, Anand. Geographically, Anand is located in Agro-Climatic Zone III (Middle Gujarat) of Gujarat state and situated at 22° 35' North latitude, 72° 55' East latitude and an altitude of 45.01 meters above mean sea level. The soil of the experimental site is sandy loam locally known as "*Goradu Soil*" and alluvial in origin, deep, well drained and fairly moisture retentive. The climatic conditions of the area represent the tropical conditions with semi-arid region.

2. Experimental materials

The experimental materials were developed by crossing four lines with twelve males (testers) in a line × tester mating system during the *kharif-rabi* season of the year 2015-16 (Table 1). The lines were transplanted in four separate blocks, whereas, testers were also transplanted in a separate contiguous blocks. The F_1 seeds were produced by manual hybridization i.e. hand emasculation and pollination. In tomato crop anthesis occurs between 8 to 12 A.M., hence, well developed flower buds likely to open in next morning were emasculated and covered with white colour tissue paper bags during evening hours. On the next day morning (between 7 to 10 A.M.), pollens from different male parents were collected separately and then emasculated flower buds were pollinated by the respective pollen parent. The pollinated flower buds were again covered with red colour tissue paper bags and were labelled accordingly. Simultaneously, for the seeds of parental lines, underdeveloped flower buds of each parent were selfed and seeds were collected accordingly.

Thus, the experimental materials consisted of 65 entries comprising forty eight hybrids, four female lines and twelve male lines as testers were evaluated along with one standard hybrid (Arka Rakshak) as check during *kharif-rabi* season of the year 2016-17.

3. Experimental details

The experimental materials were evaluated in Randomized Complete Block Design (RCBD) with three replications under three artificially created environments i.e. Early sowing (E_1), Timely sowing (E_2) and Late sowing (E_3) using three sowing dates in same year. Experimental unit having single row of 3.6 m length accommodated 8 plants using 90 cm between and 45 cm within plant distance. For the above mentioned environments E_1, E_2 and E_3, the seedlings of 65 genotypes were raised in nursery on 15th July, 2016; 5th September, 2016 and 19th October, 2016, respectively. Then, approximately four weeks old seedlings were transplanted in the field on 16th August, 2016; 3rd October, 2016 and 17th November, 2016 for environments E_1, E_2 and E_3, respectively.

4. Cultural practices

The recommended package of agronomical practices and plant protection measures obligatory to raise healthy crop were followed both in nursery as well as in field.

5. Characters studied

The observations were recorded on five randomly selected (tagged) competitive plants of each experimental unit in each replication except days to flowering and days to first fruit ripening, as were recorded on population basis. For quality traits, the observations were recorded on randomly selected sample of fruits from each genotype. The procedure adopted for recording observations of different characters is as under.

5.1 Fruit yield per plant (kg)

The ripe red fruits harvested at every picking from the randomly tagged five plants of each experimental unit were weighed in grams and weights were added for all the pickings to get the total yield and it was averaged to obtain average fruit yield in kilograms per plant.

5.2 Days to flowering

The number of days taken from transplanting to flower initiation in 50 per cent plants of the experimental unit were recorded for each genotype in each replication.

5.3 Days to first fruit ripening

The number of days taken from transplanting to ripening of the first fruit on the selected plant of the experimental unit were recorded for each genotype in each replication.

5.4 Plant height (cm)

The length of the main stem from cotyledonary node to the terminal tip was measured in centimeters as plant height at the time of last picking for each genotype in each replication.

5.5 Number of fruits per plant

The number of ripe red fruits harvested from all the tagged five plants in each experimental unit were counted at every picking and were summed to work out average number of fruits per plant.

5.6 Fruit weight (g)

At the time of third picking, 20 fruits were taken randomly from the harvested fruits of tagged plants of each experimental unit to measure fruit weight. The fruit weight was measured in grams, it was computed as the ratio of total fruit weight to number of fruits.

5.7 Number of locules per fruit

The fruits used for measurement of fruit weight were subjected for counting the number of locules per fruit, fruits were cut transversely and locule were counted for each fruit, and then average number of locules was worked out.

5.8 Number of seeds per fruit

The fruits used for measurement of number of locules per fruit were subjected for counting the number of seeds per fruit. After seed extraction, total number of seeds of 20 fruits were counted with the help of automatic seed counter and then average number of seeds per fruit was calculated.

5.9 1000 seed weight (g)
The seeds used for counting number of seeds per fruit were subjected for measurement of 1000 seed weight in grams.

5.10 Pericarp thickness (mm)
The fruits used for measurement of fruit weight and number of locules per fruit were subjected for measurement of pericarp thickness (mm). After dissecting the fruit, pericarp thickness was measured at two places per fruit with the help of Vernier Calliper and averaged over five fruits.

5.11 Fruit firmness (N)
Fruit firmness was judged as per the method reported by Nandasana (2005) [20] using Texture Analyser TA XT2i instrument, a microprocessor analysis system developed by Stable Micro Systems England. To obtain a great amount of analytical flexibility, the texture analyser was interfaced with an IBM PC with software called 'Texture Expert' which facilitate to view the data in a graphical format, finding multiple peaks, areas and averages and saving of data on the disk. The results were read directly from the saved graphs in computer directly.
For each test a single tomato fruit of fourth picking was placed centrally on blank plate secured on the heavy duty platform. The Texture Analyser measures force, distance and time. The compression test was used to evaluate the force required to rupture the tomato fruits under quasi stable loading. At the same time, the force applied and corresponding deformations was observed from computer and results were saved on the disk. In this way this test was conducted for five tomato fruits and fruit firmness (N) were calculated averaged over five fruits.

5.12 Shelf life (Days)
At the time of third picking, five fruits were taken randomly from the harvested fruits of tagged plants of each experimental unit to measure shelf life. Shelf life was measured in days and it was observed by storing the fruits at room temperature.

5.13 Moisture content (%)
For each genotype of each replication, moisture content was estimated as per procedure developed by A.O.A.C. (1980)[3] using composite sample of ripe fruits of fourth picking, it was estimated as per cent moisture.

5.14 Total soluble solids (^{0}Brix)
Total Soluble Solids (TSS) content in the fruit pulp was measured by using Zeiss hand refractometer, the refractometer reading expressed the per cent of TSS. The trait was measured from the harvest of fourth picking, randomly selected five fruits from the harvest of each experimental unit were subjected for TSS measurement, and then average was computed.

5.15 Total soluble sugar (mg/100 g)
The character was measured from the harvest of the fourth picking of every treatment of each replication. Total soluble sugar of mature tomato fruit was determined by phenol sulphuric acid method as described by Dubois (1956) [11].

5.16 Lycopene content (mg/100 ml)
The character was measured for the harvest of the fourth picking of every treatment of each replication. Nagata and Yamashita (1992) [19] developed simple method for simultaneous determination of pigments of tomato. One grams fruit sample was taken and all the pigments were extracted with 10 ml acetone-hexane solution (4:6) at once, then optical density of the supernatant at 663, 645, 505 and 453 nm were measured by spectrophotometer at the same time. Lycopene content was calculated as

$$\text{Lycopene (mg/100 ml)} = -0.0458 \times A_1 + 0.2040 \times A_2 + 0.3720 \times A_3 - 0.0806 \times A_4$$

Where, A_1, A_2, A_3 and A_4 were absorbance at 663, 645, 505 and 453 nm, respectively.

5.17 β-carotene content (mg/100 ml)
β-carotene content was also determined simultaneously with lycopene content as described by Nagata and Yamashita (1992) [19]. β-carotene content was calculated as

$$\beta\text{-carotene (mg/100 ml)} = 0.2160 \times A_1 - 1.2200 \times A_2 - 0.3040 \times A_3 + 0.4520 \times A_4$$

Where, A_1, A_2, A_3 and A_4 were absorbance at 663, 645, 505 and 453 nm, respectively.

6. Statistical analysis
Combining ability analysis was computed on the collected data as mean values for each character for parents and hybrids were analyzed separately for each environment as well as pooled over environments using statistical procedure reviewed by Singh and Chaudhary (1977) [27], on the basis of design II of Comstock and Robinson (1952) [7] and as further extended by Cockerham (1954, 1956) [5, 6] and Kempthrone (1957) [16]. This analysis was used for obtaining estimates of general and specific combining ability variances and effects.

Results and Discussion
The concept of general and specific combining ability as a measure of gene action was proposed by Sprague and Tatum (1942) [29]. An average performance of a line in a series of hybrid combinations termed as general combining ability and can be recognized as a measure of additivity of genes. Whereas, specific combining ability defined as the deviation from the expected performance of specific hybrid combination on the basis of average performance of lines involved, and can be regarded as a measure of non-additive gene action resulted from both intra-allelic and inter-allelic gene actions.
The importance of combining ability has been well emphasized, because often phenotypically superior or equally performing promising parents always don't result in a desired cross combination and give superior off-springs in segregating generations, whereas, some cross combinations may give promising segregants. The genetic components analysis alongwith combining ability analysis refers powerful tool to discriminate good as well as poor combiners, and to choose appropriate parental material in breeding programme. Combining ability analysis was carried out in the present study to obtain information on selection of better parents and cross combinations for their further use in hybrid breeding programme.

Analysis of variance for combining ability

Analysis of variance for combining ability in individual environment may give to bias estimates of genetic variances influenced by environment factors. Therefore, analysis of variance for combining ability over environments was done and the mean squares for various characters are presented in Table 2.

The result of pooled analysis over environments revealed that the magnitude of variance for the environments were significant for all the characters except 1000 seed weight. Mean squares due to lines were significant for fruit yield per plant, plant height, fruit weight, number of seeds per fruit and 1000 seed weight; whereas, mean square due to testers were found significant for all the characters except days to first fruit ripening. This indicated significant contribution of testers than lines towards general combining ability variance component for most of the traits. The variance due to lines × testers interaction was significant for all the characters and used as a measure of specific combining ability variance.

The interaction of lines × environments was recorded non-significant for all the characters, which indicated that GCA variance of lines was not influenced by the environment for all the traits. The interaction of testers × environments was found significant for all the characters except days to flowering, days to first fruit ripening, pericarp thickness, shelf life, moisture content, total soluble solids and β-carotene content. The SCA variance found more sensitive to environmental fluctuations as evident by the significance of mean square due to lines × testers × environments interaction for fruit weight, shelf life, total soluble sugar, lycopene content and β-carotene content.

Estimation of gene action

The source of variation due to lines × testers was significant for all the characters reflected importance of non-additive gene action in the inheritance of most of the characters. A perusal of variance ratio (σ^2gca/σ^2sca) also confounding the preponderance of non-additive gene action as it was less than unity for all the characters in pooled over environments (Table 2). Thus, it emphasizes the use of heterosis breeding approach to exploit available vigour in this crop. As observed in present study, the predominant role of non-additive gene action in the inheritance was observed by Bhatt *et al.* (2001) [4], Sharma *et al.* (2002) [25], Dhaliwal *et al.* (2003) [10], Singh (2005) [28], Hannan *et al.* (2007) [13], Singh and Asati (2011) [26], Shankar *et al.* (2013) [24], Yadav *et al.* (2013) [31], Agarwal *et al.* (2014) [1], Dagade *et al.* (2015) [9] and Kumar *et al*. (2015) [18] for fruit yield per plant.

General and specific combining ability effects

The general combining ability effects of the parents (four lines and twelve testers) and specific combining ability effects of the 48 crosses were estimated for all the characters in each individual environment and pooled over the environments.

Based on estimates of general combining ability effects on pooled basis for various characters, the parents were classified as good, average and poor combiners (Table 3). The parents DVRT 2, H 24, TBK 00113, Feb 4, ATL 11-05, DARL 66 and ATL 97-26 were good general combiners for fruit yield per plant because these parents recorded significant and positive general combining ability effects in all the three environments as well as in pooled over environments. Therefore, these parents were noted as good source of favourable genes for increasing fruit yield through various yield contributing characters. Bhatt *et al.* (2001) [4], Sharma *et al.* (2002) [25], Singh (2005) [28], Hannan *et al.* (2007) [13], Shankar *et al.* (2013) [24], Dagade *et al.* (2015)[9] and Aisyah *et al.* (2016) [2] also reported significant and positive gca effects for fruit yield and its component traits.

The parents, AT 3, DVRT 2, TBK 00113, Feb 4, VTG 93, SL 120 and ACTL 10-02 were good general combiners for days to flowering. Whereas, for days to first fruit ripening, parents AT 3, TBK 00113, Feb 4 and SL 120 were good general combiners. The parents DVRT 2, H 24, Feb 4, ATL 11-05 and ACTL 10-02 were good general combiners for plant height. The parents DVRT 2, H 24, TBK 00113, ATL 11-05 and ACTL 10-02 were good general combiners for number of fruits per plant. While for fruit weight, parents DVRT 2, H 24, TBK 00113, VTG 93, SL 120, ATL 11-05, NTL 14-71 and DARL 66 were good general combiners.

The parents GT 2, AT 3, H 24, TBK 00113, SL 120, ATL 11-05, JTL 12-07, NTL 14-71 and ACTL 10-02 for number of locules per fruit; GT 2, H 24, TBK 00113, Feb 4, ATL 11-05, JTL 12-07, ACTL 10-02 and ATL 97-26 for number of seeds per fruit; GT 2, AT 3, TBK 00113, ACTL 10-02 and DARL 66 were good general combiners for 1000 seed weight. The parents AT 3, H 24, TBK 00113, VTG 93, SL 120, ATL 11-05, JTL 12-07, NTL 14-71, PAU 2372 and ATL 97-26 were good general combiners for pericarp thickness. With respect to fruit firmness and shelf life, the parents H 24, TBK 00113, VTG 93, SL 120, ATL 11-05, NTL 14-71, PAU 2372 and KS 118 were considered as good general combiners except KS 118 for fruit firmness.

In case of quality characters, the parents AT 3, H 24, TBK 00113, ATL 11-05, ACTL 10-02 and DARL 66 for moisture content; AT 3, H 24, TBK 00113, ATL 11-05 and ACTL 10-02 for total soluble solids; AT 3, DVRT 2, TBK 00113, SL 120, ATL 11-05 and ACTL 10-02 for total soluble sugar; AT 3, H 24, ATL 11-05 and ACTL 10-02 were good general combiners for lycopene content, while, three parents TBK 00113, ATL 11-05 and ACTL 10-02 were good general combiners for β-carotene content.

In general, the parents H 24, TBK 00113 and ATL 11-05 were good general combiners for fruit yield per plant also were good combiners for number of fruits per plant, fruit weight, number of locules per fruit and number of seeds per fruit as well as some quality traits *viz.*, pericarp thickness, fruit firmness, shelf life, moisture content and total soluble solids (Table 3). This indicated that the parents were good combiners for fruit yield also found good combiners for two or more traits. The same results were also observed by Hannan *et al.* (2007) [13], Shankar *et al.* (2013) [24], Yadav *et al.* (2013) [31], Dagade *et al.* (2015) [9], Kumar *et al*. (2015) [18], Aisyah *et al.* (2016) [2] and Savale *et al.* (2017) [23].

The estimates of sca effects revealed that none of the hybrid was consistently superior for all the traits (Table 4). Out of 48 hybrids studied, as many as 22 cross combinations exhibited significant positive sca effects for fruit yield per plant on pooled basis. The top five hybrids on the basis of significant positive sca effects for fruit yield per plant were H 24 × DARL 66, H 24 × SL 120, AT 3 × VTG 93, AT 3 × Feb 4 and DVRT 2 × NTL 14-71 (Table 5). Of these, first three hybrids depicted significant and desirable sca effects for days to flowering, days to first fruit ripening, plant height, number of fruits per plant, number of locules per fruit and total soluble sugar. However, the remaining two hybrids manifested significant and desirable sca effects for plant height, number of fruits per plant and fruit weight. Hence, the hybrids with high sca effects for fruit yield per plant were associated with high and desired sca effects for yield contributing characters as well as some quality traits also. Significant and positive sca effects for fruit yield and its component traits have also been reported by Dhaliwal *et al.* (2003) [10], Singh (2005) [28], Hannan *et al.* (2007) [13], Shankar *et al.* (2013) [24], Yadav *et al.* (2013) [31], Agarwal *et al.* (2014) [1], Dagade *et al.* (2015) [9] and Kumar *et al*. (2015) [18].

Moreover, the highest sca effects in desired direction for various characters was exhibited by different hybrids *viz.,* GT 2 × PAU 2372 for days to flowering; H 24 × SL 120 for days to first fruit ripening and fruit firmness; AT 3 × Feb 4 for plant height; DVRT 2 × ACTL 10-02 for number of fruits per plant; GT 2 × ATL 97-26 for fruit weight and shelf life; DVRT 2 × NTL 14-71 for number of locules per fruit; GT 2 × NTL 14-71 for number of seeds per fruit; GT 2 × JTL 12-07 for 1000 seed weight; DVRT 2 × DARL 66 for pericarp thickness; AT 3 × KS 118 for moisture content and total soluble solids; DVRT 2 × TBK 00113 for total soluble sugar; AT 3 × ACTL 10-02 for lycopene content and GT 2 × DARL 66 for β-carotene content.

Generally, crosses could be grouped in to six different categories of good, average and poor general combiner parents *viz.*, G × G, G × A, G × P, A × A, A × P and P × P based on GCA effect of parents involved in a particular cross. The poor × poor cross (AT 3 × VTG 93) giving high sca values may be due to the genetic diversity of the parents and non-allelic interaction (Premalakshmi *et al.*, 2005) [22]. High sca effect manifestations of cross (H 24 × DARL 66) by which involving both the parents have high gca effects might be attributed to sizable additive × additive gene action. The good × poor combinations, besides expressing the favourable additive effect of the high parent, manifested some complementary gene interaction effects with a higher sca. Majority of cross combinations (H 24 × SL 120, AT 3 × Feb 4 and DVRT 2 × NTL 14-71) exhibiting desirable sca effects had at least one of the parents as good general combiner (Gaikwad *et al.*, 2002) [12]. The results such type of gca cross combinations which exhibited significant SCA for various traits were also reported by Hannan *et al.* (2007) [13], Shankar *et al.* (2013) [24], Yadav *et al.* (2013) [31], Agarwal *et al.* (2014) [1], Dagade *et al.* (2015) [9] and Kumar *et al*. (2015) [18].

Table 1: List of parental lines used in crossing programme

S. No.	Name	Source
Lines		
1	GT 2	Main Vegetable Research Station, AAU, Anand
2	AT 3	Main Vegetable Research Station, AAU, Anand
3	DVRT 2	Indian Institute of Vegetable Research, Varanasi
4	H 24	Indian Institute of Vegetable Research, Varanasi
Testers		
1	TBK 00113	Main Vegetable Research Station, AAU, Anand
2	Feb 4	Indian Institute of Vegetable Research, Varanasi
3	VTG 93	Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora
4	SL 120	Main Vegetable Research Station, AAU, Anand
5	ATL 11-05	Main Vegetable Research Station, AAU, Anand
6	JTL 12-07	Vegetable Research Station, JAU, Junagadh
7	NTL 14-71	ASPEE College of Horticulture and Forestry, NAU, Navsari
8	ACTL 10-02	Main Vegetable Research Station, AAU, Anand
9	PAU 2372	Punjab Agriculture University, Ludhiana
10	DARL 66	Defence Institute of Bio-Energy Research, Pithoragarh
11	ATL 97-26	Main Vegetable Research Station, AAU, Anand
12	KS 118	Department of Vegetable Science, CSAU&T, Kanpur
Standard check		
1	Arka Rakshak	Indian Institute of Horticultural Research, Bengaluru

Table 2: Analysis of variance (mean square) for combining ability, estimates of component of variance and their ratios over environments for different characters in tomato

Source of variation	df	Mean Square								
		FYP	**DF**	**DFFR**	**PH**	**NFP**	**FW**	**NLF**	**NSF**	**TW**
Replications (R)	6	0.12**	21.16**	17.91	345.70*	36.11*	10.58	0.04*	125.21**	0.045**
Environments (E)	2	8.96**	40.68**	385.36**	17180.23**	1897.51**	4390.75**	0.09**	1000.82**	0.001
Lines (L)	3	21.46**	116.10	34.07	48176.43**	1811.43	13134.06**	3.24	12281.63**	9.640**
Testers (T)	11	11.20**	99.54*	57.40	50178.79**	44189.00**	13346.08**	11.06**	12292.33**	4.649**
Lines × Testers (L × T)	33	4.22**	50.41**	157.55**	5533.10**	1241.03**	762.57**	1.49**	3127.29**	1.506**
Lines × Envt. (L × E)	6	0.05	0.98	3.37	109.26	15.58	18.51	0.02	21.11	0.003
Testers × Envt. (T × E)	22	0.14**	3.08	2.96	276.22**	33.74**	126.22**	0.02*	19.23*	0.006**
Line × Testers × Envt. (L × T × E)	66	0.04	2.91	2.40	142.97	13.27	37.79**	0.01	10.34	0.002
Pooled Error	282	0.04	4.55	9.57	139.42	15.04	12.24	0.02	34.61	0.011
σ^2 gca		0.17	0.81	-1.56	605.48	302.05	172.82	0.08	127.08	0.078
σ^2 sca		1.40	15.83	51.72	1796.71	409.25	241.59	0.49	1038.99	0.501
σ^2 gca / σ^2 sca		0.12	0.05	-0.03	0.34	0.74	0.72	0.16	0.12	0.156
Source of variation	**df**	**Mean Square**								
		PT	**FF**	**SL**	**MC**	**TSS**	**TS**	**LC**	**βC**	
Replications (R)	6	0.248**	8.42	3.19	44.26**	0.04	0.02**	0.0002	0.00008	
Environments (E)	2	0.095*	980.83**	828.11**	67.56**	2.19**	5.67**	0.0550**	0.00460**	
Lines (L)	3	2.509	142.89	125.71	196.49	4.24	1.44	0.0133	0.00199	
Testers (T)	11	43.031**	1003.31**	350.09**	363.47**	24.04**	5.83**	0.8245**	0.04909**	

Lines × Testers (L × T)	33	2.865**	222.57**	135.13**	120.86**	2.19**	1.14**	0.0255**	0.00424**	
Lines × Envt. (L × E)	6	0.001	6.66	2.59	0.38	0.06	0.03	0.0003	0.00017	
Testers × Envt. (T × E)	22	0.002	7.99*	4.28	1.18	0.05	0.04**	0.0005*	0.00007	
Line × Testers × Envt. (L × T × E)	66	0.002	4.42	3.69**	1.13	0.03	0.02**	0.0003**	0.00009**	
Pooled Error	282	0.029	4.49	1.91	7.46	0.05	0.01	0.0001	0.00005	
σ^2 gca		0.276	4.83	1.43	2.21	0.17	0.03	0.0055	0.00029	
σ^2 sca		0.954	72.72	43.81	39.91	0.72	0.37	0.0084	0.00135	
σ^2 gca / σ^2 sca		0.290	0.07	0.03	0.06	0.23	0.09	0.6498	0.21898	

*, ** Significant at P = 0.05 and P = 0.01 levels of probability, respectively. σ^2 gca = General combining ability variance, σ^2 sca = Specific combining ability variance, σ^2 gca / σ^2 sca = Variance ratios, FYP = Fruit yield per plant, DF = Days to flowering, DFFR = Days to first fruit ripening, PH = Plant height, NFP = Number of fruits per plant, FW = Fruit weight, NLF = Number of locules per fruit, NSF = Number of seeds per fruit, TW = 1000 seed weight, PT = Pericarp thickness, FF = Fruit firmness, SL = Shelf life, MC = Moisture content, TSS = Total soluble solids, TS = Total soluble sugar, LC = Lycopene content, βC = β-carotene content

Table 3: Estimates of general combining ability (gca) effects of parents for different characters based on pooled over environments in tomato

S. No.	Parents	FYP	DF	DFFR	PH	NFP	FW	NLF	NSF	TW	PT	FF	SL	MC	TSS	TS	LC	βC
Lines																		
1	GT 2	-0.51** P	-0.23 A	0.08 A	-27.57** P	-5.25** P	-9.79** P	-0.17** G	-9.59** G	-0.25** G	-0.03** P	-0.86** P	-0.52** P	1.89** P	-0.24** P	-0.13** P	-0.01** P	-0.01** A
2	AT 3	-0.17** P	-0.82** G	-0.67** G	-5.52** P	-0.91** P	-7.59** P	-0.04** G	5.49** P	-0.26** G	0.03** G	-0.09 P	-0.18 A	-0.99** G	0.08** G	0.04** G	0.01** G	-0.01** A
3	DVRT 2	0.15** G	-0.46** G	-0.11 A	16.68** G	4.29** G	3.22** G	0.24** P	12.31** P	0.33** P	-0.19** P	-0.70** P	-0.86** P	0.05 P	-0.07** P	0.14** G	-0.01** P	-0.02** A
4	H 24	0.53** G	1.51** P	0.69** P	16.41** G	1.89** G	14.17** G	-0.04** G	-8.21** G	0.18** P	0.18** G	1.65** G	1.56** G	-0.95** G	0.22** G	-0.04** P	0.01** G	-0.01** P
S.E.gi		0.01	0.15	0.22	0.85	0.28	0.25	0.01	0.42	0.01	0.01	0.15	0.10	0.20	0.02	0.01	0.002	0.002
Testers																		
1	TBK 00113	0.90** G	-1.85** G	-1.31** G	-2.29 A	3.49** G	6.98** G	-0.41** G	-25.23** G	-0.09** G	0.67** G	4.30** G	3.97** G	-2.59** G	0.17** G	0.35** G	-0.01** A	0.01** G
2	Feb 4	0.07* G	-2.54** G	-2.45** G	23.24** G	-7.43** P	0.34 A	-0.02 A	-3.10** G	-0.01 A	-0.19** P	-4.07** P	-1.68** P	1.88** P	-0.22** P	0.01 A	-0.05** P	-0.02** P
3	VTG 93	-0.30** P	-0.66* G	0.30 A	2.38 A	-16.55** P	13.71** G	1.37** P	20.90** P	0.23** P	0.40** G	2.27** G	0.49* G	1.31** P	-0.44** P	-0.13** P	-0.04** P	-0.01** A
4	SL 120	0.03 A	-1.38** G	-1.29** G	-26.16** P	-12.12** P	4.34** G	-0.17** G	2.20** P	0.16** P	0.31** G	0.61* G	1.25** G	0.98* P	-0.21** P	0.14** G	-0.06** P	-0.02** P
5	ATL 11-05	1.15** G	2.37** P	0.16 A	45.71** G	2.79** G	13.15** G	-0.07** G	-7.01** G	0.33** P	0.86** G	7.42** G	1.71** G	-4.28** G	0.41** G	0.16** G	0.06** G	0.05** G
6	JTL 12-07	-0.74** P	0.79** P	1.02* P	-42.97** P	-17.73** P	-9.79** P	-0.04* G	-17.73** G	0.22** P	0.15** G	-1.26** P	-3.66** P	2.65** P	-0.46** P	-0.61** P	-0.09** P	-0.01** P
7	NTL 14-71	-0.11** P	-0.52 A	2.52** P	-1.02 A	-18.06** P	25.90** G	-0.10** G	25.63** P	0.14** P	1.02** G	8.11** G	5.93** G	4.36** P	-1.01** P	-0.22** P	-0.05** P	-0.01** P
8	ACTL 10-02	-0.62** P	-0.85** G	-0.18 A	87.40** G	108.85** G	-52.14** P	-1.08** G	-30.18** G	-0.94** G	-3.19** P	-9.45** P	-4.64** G	-6.84** G	2.34** G	0.97** G	0.46** G	0.10** G
9	PAU 2372	-0.37** P	1.29** P	0.55 A	-20.65** P	-12.33** P	-9.29** P	0.18** P	11.49** P	0.06** P	0.23** G	0.80** G	0.60** G	1.69** G	-0.19** P	0.01 A	-0.09** P	-0.04** P
10	DARL 66	0.06* G	0.46 A	0.21 A	-36.37** P	-13.50** P	8.58** G	0.07** P	8.10** P	-0.44** G	-0.56** P	-7.05** P	-3.22** P	-1.20** P	0.04 A	-0.26** P	-0.05** P	-0.01** P
11	ATL 97-26	0.20** G	-0.13 A	-0.04 A	-27.74** P	-4.68** P	0.19 A	0.29** P	-7.16** G	0.28** P	0.28** G	0.29 A	-1.51** P	1.57** G	-0.23** P	-0.42** P	-0.05** P	-0.03** P
12	KS 118	-0.27** P	3.01** P	0.52 A	-1.52 A	-12.72** P	-1.97** P	-0.01 A	22.09** P	0.06** P	0.01 A	-1.97** P	0.77** G	0.47 A	-0.23** P	0.01 A	-0.04** P	-0.02** P
S.E.gi		0.03	0.29	0.43	1.63	0.54	0.48	0.02	0.81	0.01	0.02	0.29	0.19	0.38	0.03	0.01	0.001	0.002

*, ** Significant at P = 0.05 and P = 0.01 levels of probability, respectively. G = Good parent having significant gca effects in desired direction, A = Average parent having either positive or negative but non-significant gca effects, P = Poor parent having significant gca effects in undesired direction, FYP = Fruit yield per plant, DF = Days to flowering, DFFR = Days to first fruit ripening, PH = Plant height, NFP = Number of fruits per plant, FW = Fruit weight, NLF = Number of locules per fruit, NSF = Number of seeds per fruit, TW = 1000 seed weight, PT = Pericarp thickness, FF = Fruit firmness, SL = Shelf life, MC = Moisture content, TSS = Total soluble solids, TS = Total soluble sugar, LC = Lycopene content, βC = β-carotene content.

Table 4: Estimates of specific combining ability (sca) effects of hybrids for different characters based on pooled over environments in tomato

S. No.	Crosses	FYP	DF	DFFR	PH	NFP	FW	NLF	NSF	TW	PT	FF	SL	MC	TSS	TS	LC	βC
1	GT 2 × TBK 00113	-0.57**	2.81**	4.42**	-25.70**	2.40**	-11.68**	0.45**	2.58	0.19**	-0.59**	-7.00**	-6.78**	2.96**	-0.12*	-0.31**	0.03**	0.01**
2	GT 2 × Feb 4	-0.05	0.40	-2.22**	-2.88	-2.46**	5.74**	0.15**	27.66**	0.22**	0.51**	5.98**	1.94**	-3.41**	0.30**	0.10**	0.01**	0.01**
3	GT 2 × VTG 93	0.37**	-2.94**	-4.08**	-14.25**	5.88**	-3.23**	0.03	-28.05**	0.52**	0.19**	0.76	2.19**	-0.47	0.23**	0.36**	-0.03**	-0.02**
4	GT 2 × SL 120	-0.58**	2.45**	4.72**	-6.56*	-6.10**	-4.21**	-0.10**	-25.31**	-0.54**	-0.87**	-7.57**	-4.73**	2.92**	-0.27**	0.07**	-0.01**	-0.01**
5	GT 2 × ATL 11-05	-0.87**	1.92**	5.06**	15.10**	-8.72**	-5.79**	0.04	-13.05**	0.18**	-0.39**	-3.94**	2.10**	0.40	-0.08	-0.60**	0.01**	0.02**
6	GT 2 × JTL 12-07	0.35**	-1.49**	-0.92	9.67**	9.75**	-6.84**	-0.63**	2.22	-0.85**	0.46**	2.21**	-0.73*	0.74	-0.10	0.12**	-0.01**	-0.02**
7	GT 2 × NTL 14-71	0.25**	-1.30*	-1.08	1.04	4.53**	-0.48	0.54**	-30.08**	0.03	-0.85**	-4.10**	-4.65**	-1.68**	0.18**	-0.21**	-0.01**	-0.01**
8	GT 2 × ACTL 10-02	0.37**	-0.08	-0.50	-22.96**	-15.36**	8.17**	0.08**	7.23**	0.11**	-0.06	3.10**	1.32**	0.57	-0.26**	0.36**	0.07**	-0.01**
9	GT 2 × PAU 2372	0.23**	-4.33**	-4.67**	35.81**	4.94**	0.99	-0.17**	-1.30	-0.30**	0.52**	3.95**	2.44**	-0.42	0.01	0.16**	-0.02**	-0.01**
10	GT 2 × DARL 66	-0.27**	4.40**	3.22**	-0.17	-0.95	-1.94*	-0.21**	24.49**	0.10**	-0.23**	-1.94**	0.29	0.18	-0.16**	0.21**	0.01**	0.04**
11	GT 2 × ATL 97-26	0.54**	-3.91**	-5.86**	-4.67	0.95	18.56**	-0.05	12.48**	0.03	0.86**	6.57**	8.01**	-2.15**	0.18**	-0.23**	-0.04**	-0.01**
12	GT 2 × KS 118	0.25**	2.06**	1.92**	15.58**	5.14**	0.72	-0.11**	21.13**	0.32**	0.14**	1.97**	-1.41**	0.37	0.10	-0.03	0.03**	-0.03**
13	AT 3 × TBK 00113	-0.23**	0.18	1.28	-28.21**	-3.15**	1.79*	-0.19**	-1.00	0.43**	-0.64**	-4.47**	-3.33**	7.65**	-0.91**	-0.36**	-0.12**	-0.05**
14	AT 3 × Feb 4	0.76**	1.43**	4.75**	36.95**	11.62**	5.76**	0.22**	-4.47**	0.41**	0.23**	-1.16*	3.74**	-0.57	-0.16**	-0.11**	-0.03**	-0.01**
15	AT 3 × VTG 93	0.95**	-2.12**	-5.56**	9.64**	18.51**	-7.99**	-0.39**	12.77**	-0.40**	0.01	1.28*	2.10**	3.89**	-0.90**	0.17**	0.04**	0.03**
16	AT 3 × SL 120	-0.22**	0.16	2.03**	7.04*	-0.65	-0.41	-0.45**	-2.37	0.37**	-0.28**	-3.28**	-3.53**	1.84**	-0.13*	-0.07**	0.01**	-0.02**
17	AT 3 × ATL 11-05	0.06	-0.37	1.47*	4.10	3.10**	1.62	0.03	11.33**	-0.34**	0.15**	0.94	0.66*	0.27	0.14*	0.14**	-0.01**	-0.02**

18	AT 3 × JTL 12-07	0.15**	0.88	0.28	5.15	3.02**	-1.54	0.13**	5.72**	-0.36**	-0.30**	-2.07**	-0.33	-4.16**	0.47**	0.06**	-0.01**	0.01**
19	AT 3 × NTL 14-71	-0.18**	-0.37	-1.89*	-10.73**	-0.16	-5.79**	0.41**	27.12**	-0.18**	0.36**	2.74**	4.93**	0.31	0.31**	0.11**	0.02**	0.02**
20	AT 3 × ACTL 10-02	0.04	-1.48**	-1.19	13.93**	-17.82**	8.36**	0.08**	-0.04	-0.07**	-0.19**	-1.51**	-0.37	0.08	0.33**	-0.29**	0.09**	-0.01**
21	AT 3 × PAU 2372	-0.53**	1.49**	3.53**	-18.13**	-5.38**	-7.27**	-0.38**	0.54	0.34**	0.20**	2.75**	-0.63	-0.89	0.17**	0.01	-0.01**	0.01**
22	AT 3 × DARL 66	-0.78**	-0.57	0.19	-23.83**	-8.64**	-4.42**	-0.01	-29.75**	-0.24**	0.14**	1.08*	-0.95**	1.59*	-0.23**	-0.10**	0.02**	-0.02**
23	AT 3 × ATL 97-26	-0.91**	1.68**	0.22	-23.71**	-3.95**	-5.25**	0.58**	-2.45	0.01	0.10*	1.57**	-2.81**	-1.69**	-0.10	-0.11**	-0.03**	0.01**
24	AT 3 × KS 118	0.48**	-0.90	-5.11**	27.79**	-7.50**	15.14**	-0.02	-17.41**	0.02	0.22**	2.12**	0.51	-8.32**	1.01**	0.54**	0.01**	0.03**
25	DVRT 2 × TBK 00113	0.19**	0.71	0.83	35.62**	1.34	-3.97**	-0.43**	-6.21**	-0.63**	0.83**	7.42**	6.66**	4.91**	0.64**	0.62**	0.07**	0.03**
26	DVRT 2 × Feb 4	0.69**	-3.59**	-6.25**	6.82*	9.22**	-2.83**	-0.26**	-20.35**	-0.57**	-0.23**	-0.63	-1.60**	-0.09	0.02	0.19**	0.02**	0.01**
27	DVRT 2 × VTG 93	-0.32**	0.74	2.22**	-29.22**	-12.29**	12.31**	0.17**	3.94**	0.24**	-0.03	-0.29	-3.75**	-5.25**	0.87**	0.25**	-0.01**	-0.02**
28	DVRT 2 × SL 120	-0.43**	0.46	1.03	-20.67**	-7.50**	-1.55	0.73**	34.36**	-0.08**	0.55**	3.03**	1.44**	1.58*	-0.09	-0.15**	-0.01**	0.02**
29	DVRT 2 × ATL 11-05	0.49**	-0.29	-5.86**	-37.10**	5.11**	-4.85**	-0.12**	15.00**	-0.17**	0.38**	2.77**	-1.93**	-0.05	0.02	-0.10**	0.02**	0.01**
30	DVRT 2 × JTL 12-07	-0.25**	0.29	2.06**	5.42	-9.95**	6.48**	0.36**	4.20**	0.68**	0.06	2.17**	3.77**	1.68**	-0.06	0.07**	0.03**	0.01**
31	DVRT 2 × NTL 14-71	0.74**	0.38	-0.78	10.71**	4.24**	5.62**	-1.18**	16.64**	0.24**	-0.16**	-0.11	-2.95**	-0.09	0.01	0.09**	-0.01**	-0.02**
32	DVRT 2 × ACTL 10-02	-0.10*	1.60**	0.69	2.53	35.09**	-3.73**	-0.22**	-11.09**	-0.33**	0.19**	-0.07	-0.18	-1.45*	-0.90**	-0.61**	-0.20**	-0.01**
33	DVRT 2 × PAU 2372	-0.37**	1.57**	2.08**	-6.49*	-7.11**	-2.41**	0.49**	-16.24**	0.30**	-0.75**	-7.29**	-3.68**	2.59**	-0.22**	-0.32**	0.03**	-0.01**
34	DVRT 2 × DARL 66	-0.26**	-2.48**	-0.25	0.55	-4.35**	-3.40**	0.44**	13.97**	0.50**	0.93**	7.22**	4.11**	2.39**	-0.01	-0.14**	-0.03**	-0.01**
35	DVRT 2 × ATL 97-26	-0.13**	1.43**	2.67**	36.34**	-9.14**	5.94**	-0.24**	-17.72**	-0.02	-1.28**	-11.92**	-3.00**	0.13	0.07	0.18**	0.06**	-0.01**
36	DVRT 2 × KS 118	-0.14**	-0.82	1.56*	-4.50	-4.68**	-7.62**	0.26**	-16.48**	-0.16**	-0.49**	-2.31**	1.10**	3.46**	-0.37**	-0.08**	0.02**	-0.03**
37	H 24 × TBK 00113	0.61**	-3.71**	-6.53**	18.29**	-0.59	13.85**	0.17**	4.63**	0.02	0.40**	4.04**	3.45**	-5.70**	0.38**	0.06**	0.02**	0.01**
38	H 24 × Feb 4	-1.40**	1.77**	3.72**	-40.90**	-18.37**	-8.67**	-0.11**	-2.84*	-0.06**	-0.51**	-4.20**	-4.07**	4.08**	-0.16**	-0.19**	-0.01**	-0.01**
39	H 24 × VTG 93	-1.01**	4.32**	7.42**	33.83**	-12.10**	-1.09	0.19**	11.34**	-0.36**	-0.16**	-1.75**	-0.54	1.83**	-0.20**	-0.78**	-0.01**	0.01**
40	H 24 × SL 120	1.23**	-3.07**	-7.78**	20.19**	14.24**	6.16**	-0.18**	-6.68**	0.25**	0.61**	7.81**	6.81**	-6.34**	0.48**	0.16**	-0.01**	-0.01**
41	H 24 × ATL 11-05	0.32**	-1.26*	-0.67	17.89**	0.51	9.02**	0.05	-13.28**	0.33**	-0.14**	0.24	-0.84*	-0.61	0.08	0.55**	-0.03**	-0.03**
42	H 24 × JTL 12-07	-0.25**	0.32	-1.42	-20.24**	-2.82**	1.91*	0.15**	-12.13**	0.53**	-0.23**	-2.32**	-2.72**	1.75**	-0.30**	-0.26**	-0.01**	-0.02**
43	H 24 × NTL 14-71	-0.82**	1.29*	3.75**	-1.01	-8.64**	0.66	0.24**	-13.68**	-0.09**	0.35**	1.47**	2.67**	1.45*	-0.49**	0.01	-0.01**	-0.01**
44	H 24 × ACTL 10-02	-0.30**	-0.04	1.00	6.50*	-1.51	-12.80**	0.06*	3.90**	0.30**	0.06	-1.52**	-0.78*	0.80	0.82**	0.55**	0.05**	0.02**
45	H 24 × PAU 2372	0.67**	1.27*	-0.94	-11.19**	7.55**	8.69**	0.06*	17.00**	-0.34**	0.03	0.59	1.87**	-1.27	0.04	0.15**	-0.02**	-0.01**
46	H 24 × DARL 66	1.31**	-1.34**	-3.17**	23.45**	13.94**	9.76**	-0.23**	-8.71**	-0.37**	-0.85**	-6.36**	-3.45**	-4.16**	0.40**	0.04*	-0.02**	-0.01**
47	H 24 × ATL 97-26	0.11*	0.79	2.97**	-60.96**	12.13**	-19.24**	-0.29**	7.68**	-0.02	0.32**	3.77**	-2.20**	3.70**	-0.15*	0.16**	-0.01**	-0.02**
48	H 24 × KS 118	0.47**	-0.34	1.64*	-38.87**	-3.55**	-8.24**	-0.13**	12.77**	-0.19**	0.13**	-1.78**	-0.20	4.49**	-0.75**	-0.44**	0.01**	0.03**
S.E.sij		0.05	0.51	0.74	2.83	0.93	0.84	0.03	1.41	0.02	0.04	0.51	0.33	0.65	0.06	0.02	0.002	0.002

*, ** Significant at P = 0.05 and P = 0.01 levels of probability, respectively. FYP = Fruit yield per plant, DF = Days to flowering, DFFR = Days to first fruit ripening, PH = Plant height, NFP = Number of fruits per plant, FW = Fruit weight, NLF = Number of locules per fruit, NSF = Number of seeds per fruit, TW = 1000 seed weight, PT = Pericarp thickness, FF = Fruit firmness, SL = Shelf life, MC = Moisture content, TSS = Total soluble solids, TS = Total soluble sugar, LC = Lycopene content, βC = β-carotene content.

Table 5: Promising hybrids for fruit yield per plant based on sca effects along with gca effects of parent involved and component traits with good sca effects over environments in tomato

<table>
<tr><th rowspan="2">S. No.</th><th rowspan="2">The best specific combiner hybrids</th><th rowspan="2">SCA effects</th><th colspan="2">GCA Effects</th><th colspan="4" rowspan="2">Good SCA effects for component traits</th></tr>
<tr><th>Line</th><th>Tester</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">H 24 × DARL 66</td><td rowspan="3">1.31**</td><td rowspan="3">0.53 (G)</td><td rowspan="3">0.06 (G)</td><td>DF</td><td>DFFR</td><td>PH</td><td>NFP</td></tr>
<tr><td>FW</td><td>NLF</td><td>NSF</td><td>TW</td></tr>
<tr><td>MC</td><td>TSS</td><td>TS</td><td></td></tr>
<tr><td rowspan="4">2</td><td rowspan="4">H 24 × SL 120</td><td rowspan="4">1.23**</td><td rowspan="4">0.53 (G)</td><td rowspan="4">0.03 (A)</td><td>DF</td><td>DFFR</td><td>PH</td><td>NFP</td></tr>
<tr><td>FW</td><td>NLF</td><td>NSF</td><td>PT</td></tr>
<tr><td>FF</td><td>SL</td><td>MC</td><td>TSS</td></tr>
<tr><td>TS</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">AT 3 × VTG 93</td><td rowspan="3">0.95**</td><td rowspan="3">-0.17 (P)</td><td rowspan="3">-0.30 (P)</td><td>DF</td><td>DFFR</td><td>PH</td><td>NFP</td></tr>
<tr><td>NLF</td><td>TW</td><td>FF</td><td>SL</td></tr>
<tr><td>TS</td><td>LC</td><td>βC</td><td></td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">AT 3 × Feb 4</td><td rowspan="2">0.76**</td><td rowspan="2">-0.17 (P)</td><td rowspan="2">0.07 (G)</td><td>PH</td><td>NFP</td><td>FW</td><td>NSF</td></tr>
<tr><td>PT</td><td>SL</td><td></td><td></td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">DVRT 2 × NTL 14-71</td><td rowspan="2">0.74**</td><td rowspan="2">0.15 (G)</td><td rowspan="2">-0.11 (P)</td><td>PH</td><td>NFP</td><td>FW</td><td>NLF</td></tr>
<tr><td>TS</td><td></td><td></td><td></td></tr>
</table>

** Significant at P = 0.01 level of probability. DF = Days to flowering, DFFR = Days to first fruit ripening, PH = Plant height, NFP = Number of fruits per plant, FW = Fruit weight, NLF = Number of locules per fruit, NSF = Number of seeds per fruit, TW = 1000 seed weight, PT = Pericarp thickness, FF = Fruit firmness, SL = Shelf life, MC = Moisture content, TSS = Total soluble solids, TS = Total soluble sugar, LC = Lycopene content, βC = β-carotene content.

Conclusion

The estimates of variances and their variance ratio confounded the preponderance of non-additive gene actions in the expression of all characters in pooled over environments. Use of parental lines, DVRT 2, H 24, TBK 00113 and ATL 11-05 would be more rewarding for boosting fruit yield in tomato. H 24 × DARL 66, H 24 × SL 120 and AT 3 × VTG 93 were the best cross combinations for fruit yield per plant. The present investigation suggests that heterosis breeding can be used efficiently to improve tomato yield together with good quality for processing purpose.

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