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Research Article

Standard heterosis and phenotypic correlation studies on yield contributing traits and quality parameters in tomato (*Solanum lycopersicum* L.)

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Abstract
Hybrids show better performance than varieties in terms of yield and quality. Heterosis breeding provides a way to develop hybrids to uplift yield and quality. In the current study, 21 hybrids generated through line × tester mating design were evaluated along with the standard check, Arka Rakshak, in a randomized block design to investigate the magnitude of standard heterosis. Significant difference was observed among the genotypes pertaining to days to 50% flowering, plant height (cm), fruits per plant, fruit weight (g), fruit girth (cm) and seeds per fruit. Estimation of standard heterosis in desirable direction was identified for all characters. NTL-14-08 × DVRT-2, NTL-14-08 × GT-6 and NTL-14-08 × GT-7 are the top three crosses that showed higher positive standard heterosis for fruit yield per plant (kg). The heterotic response in hybrids for different characters is in general agreement with the *per se* performance of hybrids. Phenotypic correlation study indicated that the number of fruits per plant is positively correlated with fruit yield per plant and negatively correlated with days to 50% flowering with significance.

Keywords: Tomato, heterosis, fruit yield, hybrid, phenotypic correlation

INTRODUCTION

Attaining nutritional stability within the nation relies on the sufficient consumption of vegetables, as they serve as cost-effective reservoirs of proteins, vitamins and minerals (Srinivasulu and Singh, 2021). Tomato (*Solanum lycopersicum* L.) is the second most popular vegetable in the world after potato. India ranks third in the production with the productivity of 25 T/Ha (Anon, 2018). It belongs to the large family Solanaceae with chromosome number of 2n=24 (x=12) and originated from South America. Tomato is a self-pollinated warm season crop equitably resistant to heat, drought and grows well in broad range of soil and climatic conditions (Angadi and Dharmatti, 2012). Tomato is rich in antioxidants, minerals and vitamins; therefore, consumption of tomatoes and tomato-based products enhance skin health, reduce the risk of heart disease and cancer and trim down bad cholesterol. Because of its potential importance, tomato gained huge demand.

Ever growing population and shrinking of cultivable land demand increased the productivity of tomato per unit urea of land. Compared to normal varieties, hybrids produce more yields per plant. Heterosis breeding provides an opportunity to develop hybrids that are superior to parents with greater potential for yield and quality. Heterosis is a measure of the superiority of F_1's over the parents and it can be computed in comparison with mid patent, better parent and commercial check varieties and referred as average heterosis, heterobeltiosis and standard heterosis, respectively. However, the performance of a hybrid in comparison to the commercial variety would determine its commercial potential. Heterosis in tomato was first reported by Hedrick and Booth (1908) for yield and increased fruit number per plant. It is also observed that through heterosis breeding 20 to 50 % yield increment was reported in tomato as early as 1965 (Chaudhary *et al*., 1965).

Selection of complex traits like yield is difficult as they are controlled by polygenes. Understanding the association between yield and its contributing traits would help in the indirect selection of complex traits to improve productivity. Hence, the current research was carried out to estimate the standard heterosis to identify the best F_1 hybrids and correlation analysis to study the association between the traits.

MATERIALS AND METHODS

The current experiment was conducted at the Main Sugarcane Research Station, Navsari Agricultural University, Navsari, during *rabi,* 2020. The experimental material consisted of 32 genotypes, which included seven lines *viz.,* NTL-15-01, NTL-14-11, NTL-12-10, NTL-15-05, NTL-14-02, NTL-14-04 and NTL-14-08, three testers *viz.,* DVRT-2, GT-6 and GT-7, 21 hybrids generated by crossing the above parents in L×T fashion during *kharif,* 2019 and one standard check, Arka Rakshak. The genotypes were raised in a randomized block design with three replications with 90 cm spacing between the rows and 45 cm spacing between the plants within the row. A successful crop was raised by implementing the recommended package of practices.

All the genotypes were studied for 13 characters *viz*., days to 50% flowering, plant height (cm), branches per plant, fruits per plant, fruit yield per plant (kg), fruit weight (g), fruit length (cm), fruit girth (cm), locules per fruit, seeds per fruit, Total Soluble Solids (TSS), titrable acidity and ascorbic acid. Observation for days to 50% flowering was recorded by counting days from the date of transplanting on a total plant basis for each accession in each replication, separately. Field data pertaining to the remaining traits was recorded on five randomly selected plants. TSS was estimated using Erma hand refractometer. Titrable acidity and ascorbic acid content were measured according to the method developed by Rangana (1986).

Statistical methods: Analysis of variance (ANOVA) was calculated for each character by following the standard statistical procedure (Panse and Sukhatme, 1978). Heterosis was estimated in terms of Standard heterosis (expressed over the standard check). Heterosis was measured as the proportion of deviation of the value from the standard check (Shull, 1952). The estimation was expressed in percentage.

The test of significance for standard heterosis was conducted as under,

$$t = \frac{\overline{F_1} - \overline{SC}}{S.E.\ (\overline{F_1} - \overline{SC})}$$

The standard error (S.E.) and critical difference (C.D.) were estimated by using following formula,

$$S.E.(\overline{F_1} - \overline{SC}) = \sqrt{2M_e/r}$$

$$C.D = \sqrt{2M_e/r} \times t\ value\ (at\ 5\%\ and\ 1\%\ levels\ of\ significance)$$

Where,

M_e = Error mean sum of squares

r = Number of replication

t = Table ‘t’ value at error degrees of freedom

The significance of heterosis was tested by comparing the calculated value of ‘t’ with the tabulated value of ‘t’ at 5% and 1% levels of significance.

The phenotypic correlation coefficients were calculated for all possible pairs of the studied characters as illustrated by Al-Rawi and Khalf-Allah (1980).

RESULTS AND DISCUSSION

Results from the analysis of variance (ANOVA) (**Table 1**) revealed that means squares due to treatments (parents and F_1s) were significant for all the characters except locules per fruit. This indicated that the selected material was appropriate for the study of manifestation of heterosis. These observations are in tune with earlier studies by Yadav *et al*. (2013), Mali and Patel (2014), Dagade *et al*. (2015a), Kumar and Singh (2016), Panchal *et al*. (2017), Raj *et al*. (2018) and Gautam *et al*. (2018).

The mean values of 10 parents and their 21 F_1s for all the traits showed significant differences (**Table 2**). Both the crosses and the parents showed high variation in their mean performances for most of the characters. Investigation of the respective mean performance values among parental genotypes revealed that NTL-12-10 recorded the shortest duration to attain 50% flowering, NTL-15-01 exhibited high total soluble solids (TSS) levels, NTL-14-11 displayed a greater number of fruits per plant, along with higher concentrations of ascorbic acid and titrable acidity, NTL-14-02 presented an elevated count of branches and locules per fruit, NTL-14-08 manifested greater values for fruit weight, fruit length, and fruit girth, DVRT-2 showcased superior fruit yield per plant, and GT-6 recorded greater plant height, thereby attaining the highest performance scores within the studied dataset. It indicates none of the genotypes was found to be superior for all the characters and denotes the existence of variation in the parents, which helps in the selection of

Table 1. Analysis of variance for parents and hybrids in respect of 13 characters in tomato

S. No.	Characters	Mean sum of squares		
		Replications	Treatments	Error
	d.f.	2	30	60
1	Days to 50 per cent flowering	22.27	29.48*	17.54
2	Plant height (cm)	146.43	863.77**	85.79
3	Branches per plant	1.49	9.47*	5.74
4	Fruits per plant	37.52	709.34**	115.76
5	Fruit yield per plant (kg)	0.09	2.85**	1.31
6	Fruit weight (g)	38.5	484.52**	25.8
7	Fruit length (cm)	0.29	1.88*	1.14
8	Fruit girth (cm)	8.48	14.54**	5.17
9	Locules per fruit	0.67	1.89	1.16
10	Seeds per fruit	5.83	4057.82**	128.75
11	TSS	0.13	0.81*	0.4
12	Titrable acidity	0.001	0.012*	0.007
13	Ascorbic acid	11.56	16.33**	7

*, ** Significant at 5 and 1% levels, respectively

parents for the crossing programme for a particular trait to generate transgressive segregants. Among the calculated mean values for hybrid combinations, NTL-14-02 × GT-6 exhibited the shortest duration to reach 50% flowering, while NTL-14-08 × DVRT-2 reported the highest values for both fruits per plant and yield per plant. Furthermore, NTL-14-08 × GT-6 displayed the greatest values for fruit weight, fruit, fruit girth and titrable acidity. In addition, NTL-14-05 × DVRT-2 recorded the highest total soluble solids (TSS), and NTL-14-04 × GT-6 exhibited the highest concentration of ascorbic acid. The crosses that recorded maximum performance in a particular character had one of the parents with appreciable performance in that character. These results are in agreement with studies by Kumar and Pal (2018) and Bhalala and Acharya (2019).

The estimation of standard heterosis has commercial importance by providing information on the superiority of F_1s over the commercial check. In the present study, it is worked out by comparing 21 F_1s with a standard check (Arka Rakshak) statistically. The magnitude of heterosis and its range for 21 hybrids over the standard check are presented in Table 3. Among the 21 hybrids, NTL-14-02 × GT-6 (-9.02%), NTL-12-10 × GT-7 (-8.27%) and NTL-14-08 × DVRT-2 (-7.52%) had desirable negative standard heterosis for days to 50% flowering. The crosses NTL-15-01 × GT-6 (25.94%), NTL-14-05 × DVRT-2 (16.27%), NTL-14-05 × GT-7 (15.39%) and NTL-14-08 × GT-7 (14.34%) for plant height, NTL-14-05 × DVRT-2 (60.65%) and NTL-14-11 × GT-7 (49.10%) for number of branches, NTL-14-08 × DVRT-2 (68.34%), NTL-15-01 × DVRT-2 (35.48%) and NTL-14-05 × DVRT-2 (35.72%) for fruits per plants, NTL-14-08 × GT-6 (45.38%) and NTL-14-08 × GT-7 (14.35%) for fruit weight, NTL-14-08 × GT-6 (60.65%) and NTL-14-08 × GT-7 (55.48%) for fruit girth, and NTL-14-02 × GT-6 (61.82%) and NTL-14-04 × DVRT-2 (52.73%) for locules per fruit, exhibited significantly positive standard heterosis. Similarly, Yadav *et al*. (2013), Mali and Patel (2014), Dagade *et al*. (2015), Kumar and Pal (2018), Ramana *et al*. (2018), Gautam *et al*. (2018), Dharva *et al*. (2018), Kumar *et al*. (2019a), Kumar *et al*. (2019b) and Kumari *et al*. (2020) also observed significant heterosis for the above traits. Significant negative standard heterosis for number of seeds per fruit was observed in NTL-14-05 × GT-6 (-52.80%), NTL-14-05 × GT-7 (-36.34%), NTL-14-05 × DVRT-2 (28.61%), NTL-14-02 × GT-7 (-26.96%), NTL-14-11 × GT-7 (-24.66%) and NTL-12-10 × DVRT-2 (-22.83%). High positive standard heterosis was noted in NTL-14-08 × GT-6 (19.44%) and NTL-14-08 × GT-7 (18.14%) for fruit length, NTL-14-08 × DVRT-2 (51.79%), NTL-14-08 × GT-6 (43.61%) and NTL-14-08 × GT-7 (30.64%) for fruit yield per plant (kg). Similar results were reported by Kumar and Singh (2016).

Quality parameters have great significance in the tomato processing industry. Among them, TSS, titrable acidity and ascorbic acid are prime parameters in tomato. From the crosses, NTL-14-05 × DVRT-2 (28.73%) for TSS, NTL-14-04 × DVRT-2 (39.22%), NTL-14-08 × GT-6 (39.22%), NTL-14-11 × DVRT-2 (34.73%), NTL-12-10 × GT-6 (34.73%) and NTL-12-10 × DVRT-2 (30.24%) for titrable acidity, and the cross NTL-14-04 × GT-6 (18.91%) for ascorbic acid, exhibited significantly positive standard heterosis. Kumar *et al*. (2013), Mali and Patel (2014), Kumar *et al*. (2019a), Kumar *et al*. (2019b) and Kumar *et al*. (2019c) also reported significantly positive standard heterosis for these quality parameters.

Table 2. Mean performance of parents, check and hybrids for various characters in tomato

Genotype	days to 50% flowering	Plant height (cm)	Branches per plant	No. of fruits per plant	fruit yield per plant (Kg)	fruit weight (gm)	fruit length (cm)	fruit girth (cm)	locules per fruit	Seeds per fruit	TSS	Titrable acidity	Ascorbic acid
Female (Lines)													
L_1 - NTL-15-01	49.67	96.20	7.73	31.53	1.29	44.77	4.11	10.40	4.73	64.00	5.75	0.46	25.60
L_2 - NTL-14-11	41.33	96.80	9.70	78.80	3.40	41.38	3.95	11.00	4.00	82.67	5.10	0.53	28.02
L_3 - NTL-12-10	40.33	90.40	8.70	62.87	2.63	44.35	4.45	9.07	4.33	110.07	5.01	0.49	24.70
L_4 - NTL-14-05	43.67	100.13	10.20	53.33	2.57	42.19	3.25	7.73	3.53	48.13	5.01	0.47	22.85
L_5 - NTL-14-02	50.67	78.60	11.83	32.20	1.73	47.04	5.13	10.33	6.07	127.67	5.05	0.41	24.31
L_6 - NTL-14-04	43.33	66.73	8.07	50.67	2.36	47.21	4.46	12.07	4.60	136.33	4.12	0.45	25.41
L_7 - NTL-14-08	46.33	101.20	7.07	30.13	2.52	89.60	5.45	15.67	3.67	190.30	4.99	0.51	26.85
Male (Testers)													
T_1 - DVRT-2	41.33	112.70	11.17	78.27	3.53	46.00	4.37	10.40	4.47	92.67	4.99	0.48	26.01
T_2 - GT-6	41.00	127.73	6.73	63.33	3.10	52.83	4.48	11.45	5.00	110.80	4.89	0.51	26.63
T_3 - GT-7	50.00	112.23	8.63	44.77	2.01	46.50	4.74	11.20	3.47	116.00	4.13	0.50	24.35
Crosrs													
NTL-15-01 x DVRT-2	43.00	81.87	10.70	74.33	3.81	43.14	3.89	10.00	4.80	130.33	4.34	0.51	25.89
NTL-15-01 x GT-6	45.33	134.67	8.70	69.06	3.85	45.54	2.88	7.80	3.67	113.53	5.75	0.49	27.39
NTL-15-01 x GT-7	41.33	108.33	9.07	65.67	3.14	42.77	3.71	9.33	4.20	121.20	4.66	0.60	28.71
NTL-14-11 X DVRT-2	46.67	93.73	10.50	37.67	2.19	58.25	4.99	12.07	3.87	113.80	5.67	0.64	30.44
NTL-14-11 X GT-6	46.33	99.73	10.53	49.80	2.19	45.51	3.43	10.13	3.47	149.53	4.93	0.58	24.70
NTL-14-11 X GT-7	41.67	91.87	13.77	53.33	3.67	67.06	4.69	11.60	5.13	85.13	4.97	0.55	30.36
NTL-12-10 X DVRT-2	41.33	107.87	7.80	49.00	2.49	52.33	3.24	7.80	5.20	87.20	4.96	0.62	26.09
NTL-12-10 X GT-6	41.67	115.47	9.93	48.47	2.07	43.07	4.53	10.07	4.73	110.47	4.97	0.64	30.46
NTL-12-10 X GT-7	40.67	86.60	9.63	62.96	2.83	43.83	3.91	10.11	4.07	127.13	4.55	0.49	30.90
NTL-14-05 X DVRT-2	41.67	124.33	14.83	74.47	3.83	42.41	4.02	8.53	3.60	80.67	6.33	0.52	25.47
NTL-14-05 X GT-6	42.33	96.27	11.20	38.93	1.59	43.87	3.49	8.13	3.80	53.33	4.51	0.53	27.26
NTL-14-05 X GT-7	43.67	123.40	10.67	62.07	2.59	42.35	5.12	8.60	2.80	71.93	5.70	0.57	25.33
NTL-14-02 X DVRT-2	45.00	106.80	9.50	52.34	2.39	47.41	4.71	9.87	4.67	134.87	5.09	0.49	27.07
NTL-14-02 X GT-6	40.33	116.33	11.47	66.27	3.84	62.23	4.26	10.63	5.93	151.53	5.39	0.56	23.75
NTL-14-02 X GT-7	45.00	85.00	10.97	34.53	2.26	66.61	4.08	9.69	5.00	82.53	5.77	0.53	27.59
NTL-14-04 X DVRT-2	42.00	96.07	10.77	66.40	3.33	43.49	3.56	9.87	5.60	109.73	5.38	0.66	28.34
NTL-14-04 X GT-6	43.33	77.80	10.83	67.67	3.08	46.40	3.74	10.33	5.13	157.00	4.34	0.53	32.47
NTL-14-04 X GT-7	48.00	77.87	10.90	51.60	3.01	50.76	3.45	9.27	5.23	106.87	4.94	0.60	29.15
NTL-14-08 X DVRT-2	41.00	114.33	11.37	92.36	5.38	56.73	3.79	10.07	5.33	142.20	4.53	0.49	26.97
NTL-14-08 X GT-6	48.00	120.73	10.20	57.27	5.09	88.29	6.15	16.60	3.93	156.67	5.37	0.66	28.82
NTL-14-08 X GT-7	48.33	122.27	12.57	61.47	4.63	69.45	6.08	16.07	4.40	206.53	4.93	0.49	25.19
Standard check													
Arkarakshak	44.33	106.93	9.23	54.87	3.55	60.73	5.15	10.33	3.67	113.00	4.92	0.48	27.31
SE.m.	2.41	5.33	1.38	6.45	0.67	2.93	0.62	1.31	0.62	6.77	0.36	0.05	1.51
C.D. (5%)	6.81	15.06	3.89	18.25	1.90	8.28	1.75	3.70	1.75	19.13	1.01	0.14	4.27
CV%	6.29	9.13	7.48	14.84	6.71	7.02	5.16	7	5.08	10.92	2.77	1.16	5.04

Three crosses, *viz*., NTL-14-08 × DVRT-2, NTL-14-08 × GT-6 and NTL-14-08 × GT-7 were observed as the most promising hybrids with respect to higher heterosis and higher mean performance for fruit yield. All the three crosses showed positive standard heterosis for fruits per plant, a major yield component. The cross NTL-14-08 × GT-6 recorded high positive heterosis, which might be the result of significant standard heterosis in fruit weight (g) and fruit girth (cm). Similar reports were obtained by Yadav *et al*. (2013), Mali and Patel (2014) and Kumar and pal (2018). The cross NTL-14-08 × GT-7 exhibited high positive standard heterosis for plant height (cm), fruit weight (g) and fruit girth (cm). Comparable results were noted by Yadav *et al*. (2013), Mali and Patel (2014), Kumar and pal (2018) and Kumar *et al*. (2019a). A lower value of days to 50% flowering is required for earliness and early picking is a major criterion in the selection of superior tomato hybrids. Out of the three best crosses, NTL-14-08 × DVRT-2 shows standard heterosis in a desirable direction for days to 50% flowering. Similar results were reported by Kumar *et al*. (2017), Triveni *et al*. (2017) and Dharva *et al*. (2018a). In the context of quality parameters, the top yielding crosses reported standard heterosis in the positive direction for titrable acidity, TSS (except NTL-14-08 × DVRT-2) and ascorbic acid (except NTL-14-08 × DVRT-2 and NTL-14-08 × GT-7). The percent of heterosis varied from hybrid to hybrid for all the traits studied and it is observed due to the nature of gene action of the parents. This nature of heterosis aids in spotting superior cross-combinations that can be used to obtain more effective transgressive segregants.

The strength of the relationship between a pair of characters can be interpreted by their correlation coefficient values. In the present study, from the results of the phenotypic correlation coefficient (**Fig.1**), a significant positive correlation was observed for fruit yield per plant with plant height, branches per plant, number of fruits per plant, fruit weight and seeds per plant. Furthermore, Fruit weight is positively correlated with fruit length, fruit width and number of seeds per fruit; plant height is correlated with total soluble solids; and ascorbic acid was correlated with titrable acidity. Besides, a desirable and significant negative correlation was observed between days to 50% flowering and number of fruits per plant. It indicates the selection for number of fruits per plant, which could help in indirect selection of earliness and total plant yield. These results are in correspondence with Al-Aysh *et al*. (2012) for the correlations between total fruit yield per plant and fruit weight and Solieman *et al*. (2013) for the correlation of total fruit yield per plant with fruit weight and number of fruits per plant.

Heterosis in a desirable direction was observed in F_1s for all characters, indicating the presence of variance among the parental genotypes. Among the crosses, NTL-14-08 × DVRT-2, NTL-14-08 × GT-6 and NTL-14-08 × GT-7 presented higher positive standard heterosis for fruit yield per plant (kg). Among them, NTL-14-08 × GT-6 was reported as the best hybrid with respect to yield and quality parameters. Besides, NTL-14-08 × DVRT-2 exhibited significant standard heterosis for fruits per plant, NTL-14-08 × GT-6 recorded significant standard heterosis

	PH	BPP	NFPP	FYPP	FW	FL	FG	LPF	SPF	TSS	TA	AA
DFF	-0.10	-0.06	-0.60**	-0.26	0.28	0.39*	0.38*	-0.11	0.23	0.10	-0.15	-0.17
PH		0.00	0.33	0.41*	0.14	0.17	0.06	-0.34	0.04	0.40*	0.17	-0.20
BPP			0.26	0.36*	-0.01	0.05	-0.06	0.14	-0.06	0.26	0.08	0.07
NFPP				0.75**	-0.26	-0.24	-0.16	0.04	0.09	-0.09	0.01	0.05
FYPP					0.37*	0.16	0.32	0.10	0.40*	0.04	0.12	0.11
FW						0.63**	0.78**	0.04	0.52**	0.12	0.17	0.12
FL							0.79**	-0.12	0.46**	0.06	-0.04	-0.03
FG								-0.02	0.69**	-0.10	0.08	0.12
LPF									0.16	-0.13	0.01	0.12
SPF										-0.30	0.01	0.09
TSS											0.22	-0.08
TA												0.46**

Correlation: 1.0, 0.5, 0.0, -0.5, -1.0

Fig. 1. Phenotypic coefficients of correlation values (r) for the different pairs of characters of Tomato

*, ** Significant at 5 and 1% levels, respectively

DFF=Days to 50% flowering; PH= Plant height; BPP=Branches per plant; NFPP=Number of fruits per plant; FYPP= Fruit yield per plant; FW= Fruit weight; FL= Fruit length; FG= Fruit girth; LPF= Locules per fruit; SPF= Seeds per fruit; TSS= Total soluble solids; TA= Titrable acidity; AA= Ascorbic acid

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Table 3. Estimates of heterosis for thirteen different characters in tomato

S. No.	Crosses	Days to 50 % flowering	Plant height (cm)	Branches per plant	Fruits per plant	Fruit yield per plant (kg)	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Locules per fruit	Seeds per fruit	TSS	Titrable acidity	Ascorbic acid
1	NTL-15-01 × DVRT-2	-3.01	-23.44**	15.88	35.48*	7.33	-28.97**	-24.39	-3.23	30.91	15.34	-11.79	7.48	-5.18
2	NTL-15-01 × GT-6	2.26	25.94**	-5.78	25.87	8.46	-25.02**	-44.00**	-24.52	0.91	0.47	16.80	3.29	0.32
3	NTL-15-01 × GT-7	-6.77	1.31	-1.81	19.70	-11.47	-29.57**	-27.88	-9.68	14.55	7.26	-5.28	25.74	5.13
4	NTL-14-11 × DVRT-2	5.26	-12.34	13.72	-31.35	-38.35	-4.09	-3.14	16.77	5.45	0.71	15.31	34.73*	11.46
5	NTL-14-11 × GT-6	4.51	-6.73	14.08	-9.23	-38.16	-25.07**	-33.43	-1.94	-5.45	32.33**	0.14	21.25	-9.56
6	NTL-14-11 × GT-7	-6.02	-14.09*	49.10*	-2.79	3.38	10.42	-8.96	12.26	40.00	-24.66**	0.95	16.04	11.19
7	NTL-12-10 × DVRT-2	-6.77	0.87	-15.52	-10.69	-29.89	-13.83*	-37.09*	-24.52	41.82	-22.83**	0.81	30.24*	-4.47
8	NTL-12-10 × GT-6	-6.02	7.98	7.58	-11.66	-41.73	-29.08**	-11.98	-2.58	29.09	-2.24	1.08	34.73*	11.55
9	NTL-12-10 × GT-7	-8.27	-19.01**	4.33	14.75	-20.11	-27.84**	-24.01	-2.19	10.91	12.51	-7.45	3.29	13.16
10	NTL-14-05 × DVRT-2	-6.02	16.27*	60.65**	35.72*	7.89	-30.18**	-21.91	-17.42	-1.82	-28.61**	28.73**	9.98	-6.73
11	NTL-14-05 × GT-6	-4.51	-9.98	21.30	-29.04	-55.08*	-27.76**	-32.21	-21.29	3.64	-52.80**	-8.27	11.38	-0.18
12	NTL-14-05 × GT-7	-1.50	15.39*	15.52	13.13	-27.07	-30.26**	-0.52	-16.77	-23.64	-36.34**	15.85	19.26	-7.25
13	NTL-14-02 × DVRT-2	1.50	-0.12	2.89	-4.61	-32.71	-21.93**	-8.55	-4.52	27.27	19.35*	3.52	3.67	-0.88
14	NTL-14-02 × GT-6	-9.02	8.79	24.19	20.78	8.27	2.46	-17.22	2.84	61.82*	34.10**	9.62	17.44	-13.04
15	NTL-14-02 × GT-7	1.50	-20.51**	18.77	-37.06*	-36.28	9.68	-20.70	-6.19	36.36	-26.96**	17.34	10.85	1.03
16	NTL-14-04 × DVRT-2	-5.26	-10.16	16.61	21.02	-6.02	-28.40**	-30.95	-4.52	52.73*	-2.89	9.35	39.22**	3.78
17	NTL-14-04 × GT-6	-2.26	-27.24**	17.33	23.33	-13.16	-23.60**	-27.32	0.06	40.00	38.94**	-11.79	12.27	18.91*
18	NTL-14-04 × GT-7	8.27	-27.18**	18.05	-5.95	-15.04	-16.43*	-33.04	-10.32	42.73	-5.43	0.41	25.74	6.76
19	NTL-14-08 × DVRT-2	-7.52	6.92	23.10	68.34**	51.79	-6.60	-26.45	-2.58	45.45	25.84**	-7.86	4.09	-1.23
20	NTL-14-08 × GT-6	8.27	12.91	10.47	4.37	43.61	45.38**	19.44	60.64**	7.27	38.64**	9.08	39.22**	5.54
21	NTL-14-08 × GT-7	9.02	14.34*	36.10	12.03	30.64	14.35*	18.14	55.48**	20.00	82.77**	0.27	3.97	-7.74
	S.Ed. ±	3.41	7.53	1.95	9.13	0.95	4.14	0.87	1.85	0.87	9.57	0.51	0.07	2.14
	C.D. (5%)	6.81	15.06	3.89	18.25	1.90	8.27	1.75	3.70	1.75	19.13	1.01	0.14	4.27
	C.D. (1%)	9.05	20.02	5.17	24.26	2.52	10.99	2.32	4.92	2.32	25.43	1.35	0.18	5.68
	Max.	9.02	25.94	60.65	68.34	51.79	45.38	19.44	60.64	61.85	82.77	28.73	39.22	18.91
	Min.	-9.02	-27.24	-15.52	-37.06	-55.08	-30.26	-44.00	-24.52	-23.64	-52.80	-11.79	3.29	-13.04

*, ** Significant at 5 and 1% levels, respectively

for fruit weight (g), fruit girth (cm) and titrable acidity, and NTL-14-08 × GT-7 exhibited significant standard heterosis for plant height (cm), fruit weight (g) and fruit girth (cm). The heterotic response in hybrids for different characters was related to the *per se* performance of hybrids in ranking. This revealed that hybrid selection based on *per se* performance would be reliable. Phenotypic correlation study indicated that the number of fruits per plant had positive correlation with fruit yield per plant and a negative correlation with days to 50% flowering. Hence, it can be used for indirect selection of plants for earliness and high yield.

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