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Heterosis Study in Tomato (*Lycopersicon esculentum* Mill.)

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ABSTRACT

The present investigation on diallel analysis was conducted in tomato to study the magnitude of heterosis in tomato for fourteen characters including fruit yield and its related components. The experimental material comprising of five genetically diverse parental lines and their twenty hybrids (including reciprocals). Significant differences among genotypes were obtained for all the traits. In order of merit, the five promising hybrids *viz.,* NTE 2 x NTE 3, NTE 2 x NTE 4, NTE 2 x NTE 1, NTE 1 x NTE 5 and NTE 1 x NTE 2 exhibited standard heterosis range of 104.40 to 201.19 and 90.15 to180.20 over commercial checks, GT 2 and JT 3, respectively.

Key words *Tomato, diallel, heterosis, fruit yield*

Tomato (*Lycopersicon esculentum* Mill.) is a solanaceous vegetable, originated in Peru Ecuador region (Rick and Burtler, 1965). Tomato is an annual or short lived perennial herbaceous plant. It is a typical day neutral and is mainly self pollinated, but a certain percentage of cross-pollination also occurs. It is a warm season crop reasonably resistant to heat and drought and grows under wide range of soil and climatic conditions (Angadi and Dharmatti, 2012). Although tomato is a self pollinated crop, heterosis is being commercially exploited on large scale. At present in getting more and more popular (Baishya, *et al.* 2001). Heterosis breeding as a tool for genetic improvement in tomato has been advocated by Duhan, *et al.* 2005 (b) and Premalakshme, *et al.*, 2006

The present investigation was undertaken to study and generate information about standard heterosis. A judicious choice of parents promotes an improvements process leading to a well planed hybridization programme in tomato crops.

MATERIAL AND METHODS

The experiment was conducted at the Regional Horticultural Research Station (R.H.R.S.) farm, ASPEE college of Horticulture and Forestry, Navsari Agricultural University, Navsari during the *Rabi* 2013. The material consists of five genotypes (NTE 1, NTE 2, NTE 3, NTE 4 and NTE 5) were crossed with a diallel mating design (including reciprocals). The resulting 20 F-$_1$ hybrids along with 5 parents and two commercial check varieties (GT 2 and JT 3) were evaluated in randomized block design with three replications. In 3.0 m long double row plots each genotype accommodating ten plants was grown at a spacing of 60 x 60 cm where data were collected from randomly selected five plants. The recommended cultural practices were adopted for growing a healthy crop. All of the parents, F_1s and checks were used in the study to determine the days to 50 % flowering, plant height, number of primary branches per plant, number of secondary branches per plant, number of fruits per plant, average fruit weight, average fruit length, average fruit girth, fruit yield per plant , number of locules per fruit, number of seeds per fruit, total soluble solids, Titrable acidity and ascorbic acid. Heterosis and heterosis percentage (%) were calculated over commercial checks obtained by Turner, 1953 and Hayes, *et al.*, 1955.

RESULTS AND DISCUSSION

The analysis of variance revealed significant genotypic differences for all the characters under study suggesting the presence of sufficient genetic diversity (Table 1).

Mean performances of parents and hybrids:

The mean performances of five parents in the present study indicated that no single parental genotype was superior in respect of all the traits studies (Table 2). However, NTE 1 was superior for number of secondary branches per plant, number of fruits per plant, average fruit girth, fruit yield per plant, number of locules per fruit and number of seeds per fruit. NTE 3 was superior for days to 50 % flowerings, number of primary branches per plant, average fruit length and ascorbic acid.

None of the twenty hybrids were superior for all the traits studied. However, NTE 2 x NTE 1 was superior for average fruit girth and number of locules per fruit. NTE 2 x NTE 3 was superior for average fruit length and fruit yield per plant.

Heterosis:

The range of heterosis for days to 50 per cent flowering over the commercial check (GT 2) ranged from -29.55 to -3.03 and over commercial check (JT 3) range from -21.85 to 7.56. Fifteen crosses showed significant negative heterosis over GT 2 and seven crosses have shown

Table 1. Analysis of variance for parents and hybrids in respect of 14 characters in tomato

Sr. No.	Characters	Mean sum of square		
		Replication	Treatments	Error
	d.f.	2	24	48
1.	Days to 50 per cent flowering	27.25	40.48**	11.63
2.	Plant height (cm)	378.30*	257.87**	82.47
3.	Number of primary branches per plant	3.10	14.58**	3.32
4.	Number of secondary branches per plant	247.60**	229.07**	36.63
5.	Number of fruits per plant	0.12	0.65**	0.24
6.	Average fruit weight (g)	0.27	1.22**	0.28
7.	Average fruit length (cm)	81.95	995.26**	366.49
8.	Average fruit girth (cm)	19.86	2655.98**	103.05
9.	Fruit yield per Plant (kg)	0.02	10.67**	0.09
10.	Number of locules per fruit	0.63	2.79**	0.25
11.	Number of seeds per fruit	0.26	1.10**	0.30
12.	T.S.S. (^{o}brix)	0.02	0.16**	0.04
13.	Titrable acidity (%)	10.86	36.96**	7.30
14.	Ascorbic acid (mg per 100 g)	163.59	1606.99**	63.90

*Significant at 5 % level, **Significant at 1 % level

significant negative heterosis over JT 3. Heterosis for tallness exhibited by F_1s over the commercial check (GT 2) ranged from 29.96 to 184.67 and over commercial check (JT 3) ranged from 33.24 to 191.85. All crosses showed significant positive heterosis over both commercial checks. The heterosis in positive direction for number of primary and secondary branches per plant is desired. The magnitude of heterosis for number of primary branches per plant under consideration ranged from -2.04 to 66.72 for commercial check GT 2 and 6.12 to 80.61 for commercial check JT 3. For number of secondary branches per plant, nine and fifteen crosses showing significant positive heterosis over commercial checks, GT 2 and JT 3, respectively.

The per cent heterosis for number of fruits per plant ranged from -13.75 to 53.61 over GT 2 and -11.92 to 56.89 over JT 3. The range of heterosis varied from 20.34 (NTE 3 x NTE 2) to 107.91 (NTE 1 x NTE 2) and 16.46 (NTE 3 x NTE 2) to 101.21 (NTE 1 x NTE 2) over both checks, GT 2 and JT 3, respectively for average fruit weight. For average fruit length per cent heterosis varied from -15.71 to 28.54 over commercial check GT 2 and -11.29 to 35.28 over commercial check JT 3. The per cent heterosis for average fruit girth over commercial check (GT 2) ranged from 14.19 to 54.29 and over commercial check (JT 3) ranged from 21.72 to 64.47.

Heterosis in desirable direction over commercial checks were observed in respect of all the characters. The magnitude of heterosis over check (GT 2) for fruit yield per plant under consideration ranged from -20.93 (NTE 3 x NTE 5) to 201.19 (NTE 2 x NTE 3) and over check (JT 3) ranged from -26.44 (NTE 3 x NTE 5) to 180.20 (NTE 2 x NTE 3). Sixteen and thirteen crosses showing positive heterosis over commercial checks, GT 2 and JT 3, respectively. The heterosis for fruit yield per plant observed

Table 2. Range of mean and heterosis per cent for yield and quality attributing characters in tomato

Sr. No.	Characters	Range of mean		Range of heterosis over	
		Parents	Crosses	GT-2	JT-3
1.	Days to 50 per cent flowering	38.33 to 43.33	31 to 42.67	-29.55 to -3.03	-21.85 to 7.56
2.	Plant height (cm)	121.7 to 146.9	95.58 to 209.36	29.96 to 184.67	33.24 to 191.85
3.	Number of primary branches per plant	9.6 to 13.93	10.4 to 17.7	-2.04 to 66.72	6.12 to 80.61
4.	Number of secondary branches per plant	40.13 to 57.77	34.90 to 77.73	-20.02 to 78.14	-4.64 to 112.37
5.	Number of fruits per plant	51.07 to 68.43	48.24 to 82.94	-13.75 to 53.61	-11.92 to 56.89
6.	Average fruit weight (g)	68.67 to 124.4	71 to 122.67	20.34 to 107.21	16.46 to 101.21
7.	Average fruit length (cm)	4.36 to 6.53	4.4 to 6.71	-15.71 to 28.54	-11.29 to 35.28
8.	Average fruit girth (cm)	4.42 to 6.16	4.61 to 6.23	14.19 to 54.29	21.72 to 64.47
9.	Fruit yield per plant (kg)	2.92 to 8.51	2.68 to 8.44	-20.93 to 201.19	-26.44 to 180.20
10.	Number of locules per fruit	2.2 to 6.6	1.8 to 4.73	10.00 to 136.67	-10.00 to 136.67
11.	Number of seeds per fruit	94 to 144	81.28 to 156.55	13.21 to 143.95	4.20 to 122.38
12.	T.S.S. (^{o}brix)	3.72 to 5.97	3.45 to 5.42	-32.29 to 6.27	-19.44 to 26.44
13.	Titrable acidity (%)	1.07 to 1.20	0.84 to 1.80	-59.71 to -13.16	11.56 to 140.44
14.	Ascorbic acid	24.66 to 27.64	21.99 to 34.44	-4.87 to 48.98	-19.03 to 26.80

Table 3. Promising hybrids for fruit yield per plant with standard checks, their SCA, GCA effects and component characters showing significant desired heterosis in tomato

Most heterotic crosses	FYP	Heterosis (%) over		SCA effects	GCA effect		Significant standard heterosis for other traits in desirable direction	
		GT-2	JT-3		P1	P2	GT-2	JT-3
NTE-2 x NTE-3	8.44	201.19**	180.20**	1.65**	0.763** (G)	-0.690** (P)	DFPF, PH, NSBP, NFPP, AFW, AWL, AFG, NLF, NSF, AA	PH, NPBP, NSBP, NFPP, AFW, AWL, AFG, NLF, NSF, TA, AA
NTE-2 x NTE-4	8.22	193.34**	172.90**	1.09**	0.763** (G)	-0.268 (A)	DFPF, PH, AFW, AFG, NLF, NSF	DFPF, PH, AFW, AWL, AFG, NLF, NSF, TA
NTE-2 x NTE-1	7.82	178.83**	159.40**	-1.04**	0.763** (G)	0.890** (G)	DFPF, PH, NSBP, NFPP, AFW, AFG, NLF, NSF, AA	DFPF, PH, NFPP, AFW, AFG, NLF, NSF, TA
NTE-1 x NTE-5	6.82	143.16**	126.22**	-0.09	0.890** (G)	-0.695 (A)	DFPF, PH, NSBP, NFPP, AFW, AFG, NLF, NSF, AA	DFPF, PH, NSBP, NFPP, AFW, AWL, AFG, NLF, NSF, TA
NTE-1 x NTE-2	5.73	104.40**	90.15**	0.48**	0.890** (G)	0.763** (G)	DFPF, PH, NSBP, AFW, AFG, NLF, NSF, AA	DFPF, PH, NSBP, NFPP, AFW, AWL, AFG, NLF, NSF, TA

*Significant at 5 % level ** Significant at 1 % level

DFPF: Days to 50 % flowering PH: Plant height (cm) NPBP: Number of primary branches per plant
NSBP: Number of secondary branches per plant NFP: Number of fruits per plant AFW: Average fruit weight (g)
AFL: Average fruit length (cm) AFG: Average fruit girth (cm) FYP: Fruit yield per plant (kg)
NLF: Number of locules per fruit NSF: Number of seeds per fruit TSS: Total soluble solids (° brix)
TA: Titrable acidity (%) AA: Ascorbic acid (mg / 100 g)

by Bhatt *et al.*, 2004, Duhan, *et al.*, 2005a, Hannan, *et al.*, 2007, Sharma and Thakur, 2008 and Kumari and Sharma, 2011.

Expression of heterosis for fruit yield and its components was related to the GCA effects of parents. Most of the high heterotic crosses involved at least one parent with high GCA effects. The top five heterotic crosses over local check GT 2 and JT 3 were NTE 2 x NTE 3, NTE 2 x NTE 4, NTE 2 x NTE 1, NTE 1 x NTE 5 and NTE 1 x NTE 2. They showed significant positive standard heterosis ranging from 90.15 to 201.19 per cent for fruit yield per plant. The relative performance of these crosses in respect of 14 traits studied along with the standard check (GT 2 and JT 3) and the parental lines of these crosses are given in Table 3. The five productive crosses had higher *per se* value than the standard check in respect of almost all characters except to TSS, titrable acidity and ascorbic acid. This indicates that higher productivity in these crosses is attributed to better growth and yield parameters observed in crosses compared to parents.

In case of heterosis over both commercial checks (GT 2 and JT 3), it ranged from -10.00 to 136.67 for number of locules per fruit. The per cent heterosis for number of seeds per fruit ranged from 13.21 to 143.95 over GT 2, and 3.20 to 122.38 over JT 3. For total soluble solids, heterosis out of 20 crosses, three showed significant positive heterosis over the commercial check (JT 3). None of the crosses showed positive significant heterosis over commercial check GT 2. It ranged from -32.29 (NTE 2 x NTE 4) to 6.27 per cent (NTE 3 x NTE 5 and NTE 4 x NTE 1) in GT 2 and from -19.44 (NTE 2 x NTE 4) to 26.44 (NTE 3 x NTE 5 and NTE 4 x NTE 1) in JT 3. In case of titrable acidity, heterosis ranged from -59.71 to -13.16 per cent in GT 2 and from 11.56 to 140.44 in JT 3. The magnitude of heterosis for ascorbic acid content revealed that out of 20 crosses, twelve and five crosses showed significant positive heterosis over both checks *viz.,* GT 2 and JT 3, respectively.

This conclusion clearly indicate that only a single yield attribute with high heterosis is not sufficient to cause the quantum jump in the fruit yield but it is the combined interaction effects of major yield contributors. The critical study of these top five performing hybrids thus clearly indicates that as the high heterosis for fruit yield coupled with high heterosis for yield attributes suggest that there is a predominance of additive gene action for fruit yield heterosis.

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