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Studies on heterosis and combining ability for yield and yield attributes in Tomato (*Lycopersicon esculentum* Mill.)

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Abstract
Eight genetically divers parents of tomato (*Lycopersicon esculentum* Mill.) were crossed in diallel mating design without reciprocal to know heterosis for plant height. In order of merit the two best performing F_1 hybrids (ATL-13 x ATL-9744, IIVR-Sel-2 x ATL-9744) exhibited heterosis percentage of 0.22 in E_1 and 118.79 in E_2 respectively for marketable fruit weight and fruit yield over the standard check, IIVR-Sel-2 x H-36, IIVR Sel-2 x Manithoiba, IIHR-3 x Manithoiba and IIHR-3 x Manithoiba in E_2 yielding 74.63 over the standard parent, these promising crosses also recorded positive sca. The high performing crosses for important characters showed that in general these crosses involved high x high, high x medium, medium x low and high x low general combiners. The low x low crosses giving high sca values may be due to the genetic diversity of the parents and non-allelic interaction.

Keywords: Tomato (*Lycopersicon esculentum* Mill.), Heterosis, general combining ability (gca), specific combing ability (sca)

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 776 thousand ha with an annual production of 18911 thousand metric tonnes Anonymous (2016-17). Today hybrids are gaining popularity due to their high productivity, better quality and adaptation to environmental condition. Combining ability analysis helps the breeder in selecting suitable genotypes as parents for hybridization and selection. Considering this, an investigation was undertaken for development of F_1 hybrids with good yield and quality traits by using diallel analysis as suggested by Hayman (1954) [2] Askel and Johnson (1963) [1].

Materials and methods
The present investigation was undertaken at main experiment station, Department of Vegetable Science Narendra Dev University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad. Eight parents (p^1) were intercrossed to obtain in all possible combinations (p^2) including reciprocals, resulting in a full diallel cross. The eight parents and the twenty eight F_1 crosses were evaluated in a randomized block design with three replications at 60x50 cm spacing. Thirty-six plants were maintained for each cross as well as parents in each replication. Five randomly selected plants in each cross under each replication were used for recording observations on plant height; number of fruits per plant, average fruit weight, yield per plant, number of primary branches per plant, diameter of fruit and length of fruit The standard procedure was used to estimate the general and specific combining ability.

Results and discussion
The mean performance of parents, hybrids and best hybrid heterosis percent are presented in the table-1. The analysis of variance for combining ability and estimates of GCA of parents and SCA of hybrids are presented in table-2&3. The plant height ranged from 47.00 (ATL-9744) to 93.8 (H-36) among the parents and 49.33 (IIHR-3 × H-86) to 107.66 (IIHR-3×IIVR SCL-2) among the hybrids for the plant height, the minimum value was considered as the best parent to work out the heterosis (table-1). Positive heterosis of plant height over better parents ranged from 0.22 % (ATL-13× ATL-9744) in E1 to 118.79 % (IIVR Sel-2 × ATL-9744) in E_2. None of the hybrids expressed negative heterosis over the best parent

Combining ability analysis was carried out with a view to identify the best combiners and to isolate the superior F_1 hybrids. The parent IIVR sel-2(17.38) in E_2 showed highly significant GCA effects. Four hybrids exhibited significant positive GCA effects with the maximum effect in ATL-9744× H-36 (23.59). In the present study, the parent IIVR Sel-2 was tallest and some parent alone recorded highly significant effect. The hybrid IIHR-3 × IIVR Sel-2 which had highest mean performance (107.66) the same hybrids also recorded positive significant SCA effects. In this cross combination the parents IIVR Sel-2 and ATL-13 recorded negative & positive GCA effects, the parent ATL-13 was used as a male parent, the hybrids had recorded the tallest plant height. The SCA variance was less than GCA thus indicating the role of additive gene action. Mishra & Khanna (1977) [3] observed significant GCA effects for plant height and Singh and Mittal (1978) found significant SCA effects for plant height.

The mean performance of length of fruit of parents ranged from3.63cm (H-24) in E_1 to 5.73cm (Manithoiba) in E_2 and in hybrids ranged from 3.26cm (Manithoiba× H-36) in E_1 to 5.72cm (IIVR Sel-2× ATL-13) in E_2. Positive heterosis over better parent ranged from 2.15 % (IIVR Sel-2× ATL-9744) in E_1 to 11.72 % (IIHR-3× H-86) in E_2, five hybrids showed positive heterosis. In case of standard check, positive heterosis ranged from 2.81 %(IIVR Sel-2 × ATL-13) in E_2 to 4.32 % (IIVR Sel-2 × ATL-13) in E_1. The highest significant and positive GCA effects was seen in varieties IIVR Sel-2(0.40), Manithoiba (0.39), ATL-13(0.26) for length of fruits and the cross combinations of IIHR-3 × H-86(0.65), Manithoiba × H-86(0.58) for length of the fruits showed highest significant SCA effects.

The mean performance of average fruit weight of parent ranged from 35.017g (ATL- 9744) in E_1 to 67.66g (H-86) in E_2 and in hybrid ranged from 34.38g (ATL-9744 × H-86) in E_1 to 67.66g (H-86) in E_2 and in hybrid ranged from 34.38g (ATL-9744 × H-86) in E_1 to 73.233g (IIHR-3 × IIVR Sel-2) in E_2. Positive heterosis of average fruit weight over better parents ranged from from0.62 % (IIVR Sel-2 × H-36) and (Manithoiba × ATL-9744) in E_1 to 18.58% (IIVR Sel-2 × Manithoiba) in E_2.

IIVR Sel-2 had the highest general combining ability of (7.31) for average fruit weight and the highest significant and positive SCA effects were shown by the crosses IIVR Sel-2 × H-24(9.98), IIVR Sel-2 × Manithoiba (9.21), ATL-9744 × H-36(8.32), IIHR-3 × IIVR Sel-2 (8.04), IIHR-3 × H-24(7.95), H-24 × H-86(7.91), Manithoiba × H-86 (7.80) and Manithoiba × H-3 (7.52) for average fruit weight.

The mean number of primary branches of parents ranged from 4.0 (ATL-13) in E1 to 8.7(H-36) in E_2 and hybrids ranged from 3.1 (IIVR Sel-2 × H-86) in E1 to 12.433 (Manithoiba × H-36) in E_2 positive heterosis of number of primary branches over better parent ranged from 1.587(IIHR-3 × H-86) in E1 to 77.30 (ATL-9744 × H-86) in E_2. The highest general combining ability (GCA) value 1.03 for number of primary branches was obtained in H-36 in E_2 and highest SCA effects for number of primary branches in crosses Manithoiba × H-36(3.64), ATL-9744 × H-86 (3.41), IIVR Sel -2 × H-36(3.38) and IIVR Sel-2 × H-24 (2.07).

The mean performance of diameter of fruit of parents ranged from 3.65 cm (Manithoiba) in E_1 to 6.23 cm (H-86) in E_2 and in hybrids ranged from 3.53 cm (IIVR Sel-2 × ATL-9744) in E_1 to 6.13 cm (IIHR-3 × IIVR Sel-2) in E_2. Positive heterosis of diameter of fruits over better parents ranged from 0.57 % (Manithoiba × H-36) in E_2 to 17.07% (Manithoiba × ATL-9744) in E_1. The highest GCA values for H-86 and H-36 for diameter of fruits were 0.37 and 0.36 in E_1 & E_2, respectively which were found to be greater than the smaller values of all the other parents under studied with a highly significant margin. The crosses IIHR-3 × IIVR Sel-2 (0.67), ATL-9744 × H-86 (0.64) and Manithoiba × H-36 (0.58) exhibited significantly the highest SCA effects for diameter of fruits.

The mean performance of yield per plant of parents ranged from 0.66 (Manithoiba) in E_1 to 1.78 (H-86) in E_2 and in hybrids ranged from 0.52 (IIHR-3 × IIVR Sel-2) in E_1 to 2.49 (IIHR-3 × Manithoiba) in E_2. Positive heterosis over better parents ranged from 0.29 (IIHR-3 × Manithoiba) in E_1 to 74.63 (IIHR-3 × Manithoiba) in E_2. H-24, H-36 and IIHR-3 had high combining ability for yield/plant the GCA values were 0.15, 0.09 and 0.08 respectively and the cross combination of IIHR-3 ×Manithoiba (0.89), IIVR Sel-2 × H-86 (0.55), ATL-9744 × H-36 (0.53), IIHR-3 × H-86 (0.37) and Manithoiba × H-24 (0.34) showed significantly the highest SCA effects for yield/plant. The mean number of fruits/plant of parents ranged from 14.17(IIVR Sel-2) in E_1 to 42.66 (ATL- 9744) in E_2 and in hybrids ranged from 14.05 (ATL-13 × H-86) in E_1 to 42.66 (ATL- 9744) in E_2. Positive heterosis over better parents ranged from 2.08 (Manithoiba × ATL-9744) in E_1 to 40.75 (IIVR Sel-2 × H-36) in E_2. ATL-9744 & H-24 were good GCA and had the good combining values of 4.16 and 2.04 respectively for number of fruits/plant. The crosses IIHR-3 × Manithoiba (16.19), IIVR Sel-2 × H-36 (14.12), IIHR-3 × H-24 (7.54), ATL-9744 × H-36 (5.57), H-24 × ATL-13 (5.08) exhibited significantly highest SCA effects for number of fruits per plant.

Hybrids involved in their parents exhibited positive heterosis over their parents by way of increased number of fruits and yield. Singh and Singh (1993) [5], Pujari and Kale (1994) [6], Kumar *et al*. (1955) also reported the highest heterosis for number of fruits. Many workers like Kalloo *et al.* (1974), Panday (1998), Bhett *et al.* 2004 and Joshi *et al*. (2004) found high GCA values for yield due to high GCA for number of fruits.

Table 1: Percent and Heterosis Values of parents and hybrids

Characters	Mean value of parents (Range)	Mean value of hybrid (Range)	Heterosis over better parent
Plant height (cm)	47.0 (ATL-9744) E_1 to 93.83 (H-36) E_2	49.33 (IIHR-3×H-86)E_1 to 107.66 (IIHR-3×IIVR Sel-2)E_2	0.22% (ATL-13×ATL-9744)E_1 to 118.79% (IIVR Sel-2×ATL-9744)E_2
Primary branches	4.0 (ATL-13) E_1 to 8.7 (H-36) E_2	3.1 (IIVR Sel-2×H-86)E_1 to 12.43 (MANITHOIBA×H-36)E2	1.58% (IIHR-3×H-86)E_1 to 77.30% (ATL-9744×H-86)E_2
Fruit diameter (cm)	3.650 (MANITHOIBA) E_1 to 6.233 (H-86) E_2	3.53 (IIVR Sel-2×ATL-9744)E_1 to 6.13 (IIHR-3×IIVR Sel-2)E_2	0.57% (MANITHOIBA×H-36)E_2 to 17.07% (MANITHOIBA×ATL-9744)E_1
Fruit length (cm)	3.633 (H-24)E_1 To	3.26 (MANITHOIBA×H-36)E_1 to	2.81% (IIVR Sel-2×ATL-13)E_2 to

	5.733 (MANITHOIBA)E_2	5.72 (IIVR Sel-2×ATL-13)E_2	4.32% (IIHR-3×H-86)E_1
Average fruit weight (g)	35.01 (ATL-9744) E_1 to 67.66 (H-86) E_2	34.38 (ATL-9744×H-86)E_1 to 73.23 (IIHR-3×IIVR Sel-2)E_2	0.62% (IIVR Sel-2×H-36)E_2 to 18.58% (IIVR Sel-2×MANITHOIBA)E_1
No. of fruits/plant	14.17 (IIVR Sel-2)E_1 to 42.66 (ATL-9744)E_2	14.05 (ATL-13×H-86)E_1 to 42.66 (ATL-9744)E_2	2.08 ((MANITHOIBA×ATL-9744)E_1 to 40.75(IIVR Sel-2×H-36)E_2
Yield/plant	0.66 (MANITHOIBA) E_1 to 1.78 (H-36) E_2	0.52 (IIHR-3×IIVR Sel-2)E_1 to 2.49(IIHR-3×MANITHOIBA)E_2	0.29% (IIHR-3×MANITHOIBA)E_1 to 74.63% (IIHR-3×MANITHOIBA)E_2

Table 2: Estimates of General Combining ability GCA of parents in tomato

Parents	Plant height (cm)	Primary branches	Fruit diameter (cm)	Fruit length (cm)	Average fruit weight (g)	No. of fruits/plant	Yield/plant (kg)
IIVR Sel-2 E_1	6.38**	0.01	-0.24**	0.40**	5.77**	-1.65**	0.01
IIVR Sel-2 E_2	17.18**	-0.36**	-0.02	0.19**	7.31**	-4.78**	-0.07**
H-36 E_1	0.76	-0.14	0.21**	-0.41**	1.52	-1.16**	-0.03
H-36 E_2	4.15*	1.03**	0.36**	-0.16**	2.72**	-0.68	0.09**
ATL-13 E_1	0.85	-0.24**	-0.07	0.26**	-3.99**	1.15**	-0.07
ATL-13 E_2	-1.25	-0.64**	-0.26**	0.15*	-5.85**	0.86*	-0.12**
ATL-9744 E_1	3.70*	-0.01	-0.38**	-0.07	-7.57**	0.86*	-0.08**
ATL-9744 E_2	-4.75**	0.38**	-0.39**	-0.08	-9.96**	4.16**	-0.07**
SE (gi) E_1	1.82	0.09	0.07	-0.16	0.86	0.40	0.20
SE (gi) E_2	1.71	0.11	0.07	0.07	0.63	0.39	0.15
SE(gi-gs) E_1	2.76	0.14	0.11	0.06	1.30	0.60	0.31
SE(gi-gs) E_2	2.59	0.17	0.11	0.11	0.95	0.60	0.23

*significant at 0.05 probability, *significant at 0.01 probability

Table 3: Estimates of specific combining ability (sca) effects of diallel populations over environment E_1 and E_2

Hybrids		Plant Height (cm)	Primary branches	Fruit diameter (cm)	Fruit Length (cm)	Average Fruit Weight (g)	No. of fruits/plant	Yield/plant (kg)
IIHR-3 x IIVR- Sel-2	E_1	5.65	0.58*	0.51*	-0.18	-12.06**	-0.36**	0.27
	E_2	18.14**	1.90**	0.67**	0.15	8.04**	0.21**	-1.04
IIHR-3 x Manithoiba	E_1	-0.22	0.69*	0.39	0.09	-4.28	-0.08	16.19**
	E_2	3.25	-0.81*	0.53*	0.15	3.87*	0.89**	2.03
IIHR-3 x ATL-9744	E_1	-13.37*	1.03**	-0.05	-0.05	-0.95	0.02	2.03
	E_2	-13.10*	0.12	-0.25	-0.15	-7.92**	-0.40**	-5.40**
IIHR-3 x H-86	E_1	8.72	-0.02	0.39	0.40	-0.50	0.37**	4.06**
	E_2	-18.15**	0.59	-0.26	0.65**	1.85	0.25**	3.34**
IIVR- Sel-2 x Manithoiba	E_1	2.79	0.76**	0.01	-0.17	9.21**	0.23**	1.16
	E_2	4.40	-1.23**	-0.05	-0.11	3.29	-0.51**	-7.36**
IIVR- Sel-2x ATL-13	E_1	-6.97	0.08	-0.30	-6.97	4.93	0.07	-1.25
	E_2	3.22	-0.48	0.04	3.22	6.12**	0.25**	-0.17
IIVR- Sel-2x H-86	E_1	-4.83	-1.18**	-0.22	-0.36	6.85**	0.11**	0.94
	E_2	15.00**	-0.94**	-0.30	-0.52**	2.47	0.23**	2.90*
Manithoiba x H-24	E_1	8.15	-0.02	0.15	0.17	-0.08	0.23**	2.72*
	E_2	2.42	1.67**	0.53*	0.11	2.95	0.34**	1.67
Manithoiba x H-86	E_1	-0.63	0.32	0.58**	0.58**	7.80**	0.00	-1.64
	E_2	-10.55**	1.82**	0.38	-0.21	1.77	-0.43**	-9.07**
H-24 x H-86	E_1	0.09	-0.23	-0.26	0.08	-6.47*	-0.12*	-1.79
	E_2	9.02	-2.35**	-0.39	-0.02	-9.70**	-0.04	4.13**
ATL-13 x H-86	E_1	2.81	0.35	0.04	-0.22	0.69	0.05	0.08
	E_2	-11.91*	-1.65**	-0.07	-0.09	-5.42**	-0.41**	-5.98**
ATL-9744 x H-36	E_1	-5.04	0.33	0.17	0.10	1.81	0.12*	2.97*
	E_2	23.59**	-1.70**	0.13	-0.26	8.32	0.53**	5.57**
ATL-9744 x H-86	E_1	2.91	-0.43	0.64**	-0.20	-6.58*	-0.15**	-0.26
	E_2	16.60**	3.41**	0.50*	0.15	-4.82*	-0.03	1.55
SE(Sij)	E_1	5.59	0.29	0.22	0.22	2.64	0.05	1.22
	E_2	5.25	0.35	0.22	0.19	1.92	0.07	1.21
SE(Sij-Sik)	E_1	8.27	0.43	0.32	0.33	3.91	0.07	1.80
	E_2	7.77	0.52	0.33	0.28	2.84	0.11	1.79

*Significant at 0.05 probability, ** Significant at 0.01 probability

References

1. Askel R, Johnson LPV. Analysis of diallel cross: A worked example. *Adv. Front. Plant Sci.*, 1963; 2:37-54.
2. Hayman BI. The theory and analysis of diallel crosses. *Genetics*, 1954; 39:789-809.
3. Mishra CH, Khanna KR. Heterosis and combining ability studies for some vegetative characters in tomato (*Lycopersicon esculentum* Mill.). *Indian J.Hort*; 1977;

34:396-403.
4. Singh HN, Mittal RK. Genotypic and path analysis in tomato. Indian Agric. Res. 1976; 10:83-90.
5. Singh RK, Singh VK. Heterosis breeding in tomato (*Lycopersicon esculentum* Mill.) Ann. Agric. Res. 1993; 14(4):416-420.
6. Pujari CV, Kale PN. Heterosis studies in tomato (*Lycopersicon esculentum* Mill.). J. Maharasthra Agric. Univ. 1994; 19(1):83-85.
7. Kumar S, Banergee MK, Pratab PS. Studies on heterosis for various characters in tomato. Haryana J. Hort. Sci. 1995; 24(1):54-60.
8. Bhatt RP, Adhikari RS, Biswas VR, Narendra Kumar. Genetic analysis for qualitative and quantitaie traits in tomato (*Lycopersicon esculentum* Mill.) under open and protected environments. I.J.G.Pl.Bred. 2004; 64(2):125-129.
9. Joshi A, Vikram A, Thakur KS. Genetics of yield and horticultural traits in tomato (*Lycopersicon esculentum* Mill.) Veg. Sci. 2004; 31(2):112-117.
10. Kallo G, Singh RK Bhutani RD. Combining ability studies in tomato (*Lycopersicon esculentum* Mill.) Theor, Appl. Gen. 1974; 44:358-363.
11. Pandey Sudhakar. Genetic analysis of yield and its components in tomato, Phd. Thesis, NDUAT, Kumarganj. 1968.