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Estimation of heterosis in tomato (*Solanum lycopersicum* L.) for yield attributes and yield

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Abstract
The present investigation "Estimation of heterosis in tomato (*Solanum lycopersicum* L)." for yield attributing traits and yield was carried out during *rabi* 2010-11 and *kharif* 2011 at Vegetable Research Station, Rajendranagar, Hyderabad. Ten parents (EC-165749, EC-157568, EC-164838, LE-56, LE-62, LE-64, LE-65, LE-66, LE-67 and LE-68) were crossed in diallele mating design (without reciprocals). The resultant 45 F_1's were evaluated along with their parents and two standard checks (Siri and US-618) for six characters *viz.*, plant height (cm), number of primary branches per plant, days to 50% flowering, number of fruits per cluster, average fruit weight (g) and fruit yield per plant (kg). Studies on heterosis revealed that majority of the hybrids exhibited relative heterosis, heterobeltiosis and standard heterosis in desirable direction. The potential crosses viz., LE-64 × LE-66, LE-56 x LE-68, EC-157568 x LE-68 and EC-164838 x LE-66, exhibited high standard heterosis and high *per se* performance for fruit yield per plant, which offers scope for commercial exploitation through heterosis breeding.

Keywords: Tomato, Heterosis, Heterobeltiosis and Yield

Introduction
Tomato (*Solanum lycopersicum* L.) (2n=2x=24) is one of the most important solanaceous vegetable crops of Peru-Euqador origin (Rick, 1969), especially grown in the tropics and subtropics. In many countries it is considered as "poor man's orange" because of its attractive appearance and nutritive value (Singh *et al.*, 2004). Tomato also forms an important ingredient in the cocktail known as "Bloody Marry". Tomato is a moderate nutritional crop and is considered as an important source of vitamin A, vitamin C and minerals (Hari, 1997). Under Indian condition, the fruits are mainly consumed either as raw or in the preparation of chatni, pickles etc. Apart from these, lycopene is valued for its anti-cancer property (Bose *et al.*, 2002). It acts as an antioxidant and scavenger of free radicals, which is often associated with carcinogenesis. Cultivated forms are originated from Lycopersicum esculentum var. cerasiforme. Tomato also flushes out free radicals, protect against inflammation, heart diseases and prevent DNA damage in human body. In India, tomato is grown in an area of 0.882 million hectares with annual production of 18.74 million tonnes and productivity of 21.2 tonnes /ha. Therefore, present study has taken up to find out genotypes which gives higher yields.

Tomato crop has a tremendous potential for heterosis breeding. Increasing productivity through exploitation of hybrid vigour is one of the most important applications in breeding and could be successfully employed in improving the quality and productivity of crop. Exploitation of heterosis is a quick and convenient way of combining desirable characters and hence assumed greater significance in the production of hybrids. Estimates of heterosis may help in deciding whether the hybrids are of economic value and worth exploiting Keeping these points in view the present study is undertaken with the following objective to estimate the magnitude of heterosis for fruit yield and its components.

Materials and Methods
The present experiment was carried out at Vegetable Research Station, Dr. Y.S.R. Horticultural University, Rajendranagar, Hyderabad. The experimental material consisted of ten parents (EC-165749, EC-157568, EC-164838, LE-56, LE-62, LE-64, LE-65, LE-66, LE-67 and LE-68.). Ten parents were crossed with each other in diallel mating design (excluding reciprocals) during *Rabi*, 2010-11. The resultant 45 F_1s were evaluated for yield, yield contributing and quality characters. All 57 entries comprising of ten parents and 45 F_1's along with two commercial hybrids (Siri and US-618) as checks were sown during *summer*, 2011 in a randomized block design which was replicated thrice. Each entry was grown in two rows with 10 plants in each row by adopting inter row spacing of 60 cm and intra row spacing of 45

cm. In each entry, five plants were tagged randomly for recording data. The cultural practices and the plant protection measures were adapted uniformly to all the treatments, as recommended by Dr. YSRHU.

Results and Discussion

Plant height (cm)

Relative heterosis ranged from -20.95 per cent (EC-164838 x LE-56) to 43.99 per cent (LE-64 x LE-66) for plant height. Significant positive relative heterosis was recorded by 6 out of 45 hybrids, while heterobeltiosis ranged from -36.27 per cent (LE-64 x LE-65) to 40.31per cent (EC-164838 x LE-66). Four hybrids showed significant positive heterobeltiosis for this trait.

The range of standard heterosis was from -28.45 per cent (LE-65 x LE-67) to 70.49 per cent (LE-64 x LE-66) over Siri and -31.41 per cent (LE-65 x LE-67) to 63.46 per cent (LE-64 x LE-66) over US-618. Significant positive standard heterosis was recorded by 9 hybrids over Siri and 7 hybrids over US-618.

Top five crosses with better parental heterosis for plant height were LE-64 x LE-66 (63.46%), LE-56 x LE-68 (56.02%), EC-157568 x LE-68 (48.68%), EC-164838 x LE-66 (42.61%) and EC-164838 x LE-64 (37.76%) manifested significant positive heterosis over standard check US-618. Plant height and number of primary branches per plant determine the fruit bearing surface, hence these are considered as growth attributes. Higher the plant height with more number of primary branches per plant on the main stem, higher is the number of fruits per plant. Hence, positive heterosis is desirable for plant height. These findings are inconsonance with the reports of Patil *etal.* (1997), Shankar *et al*. (2013), Ahmad *et al.* (2011), Solieman *et al.* (2013) and Madhavi *et al*. (2013).

Number of primary branches per plant

Relative heterosis ranged from -25.09 (LE-62 x LE-64) to 32.16% (LE-64 x LE-66) for number of primary branches per plant. Significant positive relative heterosis was recorded by 11 out of 45 hybrids, while heterobeltiosis ranged from -36.31 per cent (LE-62 x LE-64) to 19.84 per cent (EC-164838 x LE-66). Six hybrids showed significant positive heterobeltiosis for this trait.

Standard heterosis ranged from -25.89 per cent (EC-165749 x LE-65) to 66.96 per cent (LE-64 x LE-66) over Siri and -33.06 per cent (EC-165749 x LE-65) to 50.81 per cent (LE-64 x LE-66) over US-618 respectively. Among 45 hybrids studied, 16 hybrids over Siri and 9 hybrids over US – 618 exhibited significant desirable standard heterosis.

High fruit yield in plants is manifested through enhancement in the vegetative characters like plant height and number of branches per plant. For number of primary branches per plant the crosses LE-64 x LE-66 (19.84%), LE-56 x LE-68 (19.11%), EC-157568 x LE-68 (18.25%), EC-164838 x LE-66 (17.61%) and EC-157568 x LE-68 (15.44%) revealed a heterobeltiosis of 8.45%, 13.50% and 11.68%, respectively. Top five crosses which recorded significant positive heterosis over standard check US-618 are LE-64 x LE-66 (50.81%), LE-56 x LE-68 (34.68%), EC-157568 x LE-68 (26.61%), EC-164838 x LE-66 (21.77%) and EC-164838 x LE-68 (20.16%) for this trait. Similar trend of number of primary branches per plant were reported by Patil *et al.* (1997), Shankar *et al.* (2013), Solieman *etal.* (2013) and Madhavi *et al*. (2013).

Days to 50 % flowering

Heterosis in negative direction was considered to be desirable for days to 50 % flowering. Relative heterosis ranged from -17.81 per cent (EC-157568 x LE-68) to 18.75 per cent (EC-157568 x EC-164838). Significant negative relative heterosis was recorded in 8 hybrids. In hybrids heterobeltiosis ranged from -26.23 per cent (EC-157568 x LE-68) to 17.53 per cent (EC-157568 x EC-164838). 14 hybrids showed significant desirable heterobeltiosis. 9 hybrids showed significantly negative standard heterosis over Siri and 6 hybrids over US-618 for this trait.

The earliness is one of the prime criterions in any crop improvement programme. The present study also brought out certain hybrids with significant earliness in days to 50% flowering. Negative heterosis is desirable for this trait over mid parent, better parent and standard check. The crosses LE-64 x LE-66 (-17.65% and -17.27%), LE-56 x LE-68 (-16.89% and -14.15%), EC-157568 x LE-68 (-15.94% and -17.92%) and EC-164838 x LE-66 (-17.81% and -15.09%) were the best four crosses which recorded significant negative relative heterosis, heterobeltiosis for this trait. The crosses LE-64 x LE-66 (-18.75%), LE-56 x LE-68 (-25.41%), EC-157568 x LE-68 (-22.32%) and EC-164838 x LE-66 (-26.23%) recorded significantly negative standard heterosis over check US-618 for this character. Similar trends of earliness were reported by Padma *et al.* (2002), Shankar *et al*. (2013) and Madhavi *et al*. (2013).

Number of fruits per cluster

The relative heterosis ranged from -1.37 per cent (EC-165749 x LE-56) to 41.77 per cent (LE-64 x LE-66). Positive significant relative heterosis was noticed in 33 out of 45 hybrids for number of fruits per cluster. The heterobeltiosis was ranged from -12.20 per cent (EC-165749 x LE-56) to 33.33 per cent (LE-64 × LE-66) with 13 hybrids showing positive significant heterobeltiosis.

Standard heterosis ranged from 15.38 per cent (LE-65 x LE-67) to 115.38 per cent (LE-64 × LE-66) over Siri and -3.23 per cent (LE-65 x LE-67) to 80.65 per cent (LE-64 x LE-66) over US-618 respectively. Among 45 hybrids studied, 44 hybrids over Siri and 35 hybrids over US – 618 exhibited significant desirable standard heterosis.

Total number of fruits per cluster is of great significance for the improvement of fruit yield in tomato. Most of the crosses recorded significant positive heterosis for this attribute. The top four crosses which registered significantly positive heterosis over better parent were LE-64 x LE-66 (26.67%), LE-56 x LE-68 (22.67%), EC-157568 x LE-68 (21.92%) and EC-164838 x LE-66 (16.67%) and the top four crosses which recorded significant positive heterosis over standard check US-618 was LE-64 x LE-66 (43.94%), LE-56 x LE-68 (39.39%), EC-157568 x LE-68 (34.50%) and EC-164838 x LE-66 (27.27%) respectively for this character. These results is in conformity with Dundi (1991), Patil *et al*. (2011), Shankar *et al*. (2013), Solieman etal.(2013) and Madhavi *et al*. (2013).

Average fruit weight (g)

The relative heterosis ranged from -30.65 per cent (EC-157568 x LE-67) to 18.12 per cent (EC-165749 x LE-62). Significant positive relative heterosis was recorded in 7 hybrids for average fruit weight. Heterobeltiosis ranged from -34.80 per cent (EC-157568 x LE-67) to 15.25 per cent (EC-165749 x LE-62) and 2 hybrids exhibited significant positive heterobeltiosis.

The range of standard heterosis was from -5.05 per cent (EC-157568 x LE-67) to 89.03 per cent (LE-64 x LE-66) over Siri and -28.30 per cent (EC-157568 x LE-67) to 29.03 per cent (LE-64 × LE-66) over US-618. Significant positive standard heterosis was recorded by 39 hybrids over Siri and 11 hybrids over US-618.

The crosses EC-165749 x LE-66, EC-165749 x LE-68, EC-165749 x EC164838 and LE-64 x LE-66 (18.12%, 16.48%, 14.92% and 14.76%) were the best four crosses which recorded significantly positive heterosis over mid parent and the crosses EC-165749 x LE-66 and EC-165749 x LE-68 (15.25 and 15.22%) were the best two crosses which recorded significant positive heterosis over better parent and the crosses LE-64 x LE-66, LE-56 x LE-68, EC-157568 x LE-68 and EC-164838 x LE-66 (29.03 %, 22.53%, 22.44%, and 20.82%) were the best four crosses which recorded highest positive heterosis over both the standard checks. Average fruit weight is directly contributed towards total yield and positively correlated with fruit yield per plant in tomato and has a key role in acceptance of produce by consumer. Hence, positive heterosis is desirable for average fruit weight. These findings are inconsonance with the reports of Shankar *et al*. (2013), Ahmad *et al.* (2011), Amit *et al.* (2012), Solieman *et al.* (2013) and Madhavi *et al.* (2013).

Fruit yield per plant (kg)

The range of relative heterosis was from -3.06 per cent (LE-65 x LE-68) to 78.19 per cent (LE-64 x LE-66) with 18 hybrids exhibiting significantly positive relative heterosis. The heterobeltiosis ranged from -11.21 per cent (LE-64 x LE-65) to 68.33 per cent (LE-64 x LE-66) and 7 hybrids recorded positive significant heterobeltiosis for fruit yield per plant.

Standard heterosis ranged from -8.57 per cent (LE-65 x LE-68) to 94.23 per cent (LE-64 x LE-66) with 15 hybrids exhibited significant positive standard heterosis over Siri and 5 hybrids exhibiting positively significant standard heterosis over US-618, it ranged from -21.00 per cent (LE-65 x LE-68) to 67.82 per cent (LE-64 x LE-66).

The hybrids LE-64 x LE-66 (67.82%), LE-56 × LE-68 (50.91%), EC-157568 x LE-68 (36.10%) and EC-164838 x LE-66 (22.51%) recorded high standard heterosis over best commercial check US-618.

Total fruit yield per plant is one of the most important traits, which deserve highest consideration in any breeding programme. Significantly positive heterosis has been observed mainly in terms of fruit yield per plant in crosses over their mid and better parents. The crosses LE-64 × LE-66, LE-56 x LE-68, EC-157568 x LE-68 and EC-164838 x LE-66 were the top four heterotic crosses manifesting an relative heterosis of 78.19%, 66.50%, 51.43%, and 37.11 % respectively, while the crosses LE-64 × LE-66, LE-56 x LE-68, EC-157568 x LE-68 and EC-164838 x LE-66 were the best four crosses displaying a heterobeltiosis of 68.33%, 60.87%, 47.46% and 36.07% respectively for fruit yield per plant. The significantly positive heterobeltiosis for fruit yield per plant could be apparently due to preponderance of fixable gene effects. Similar results were also found by Dundi (1991), Dharmatti (1995), Nagaraja (1995), Aruna and Veeraragavathatham (1996), Ghosh *et al.* (1997), Makesh *etal*. (2002), Tiwari and Lal (2004), Premalakshmi *et al.* (2005) and Indurani andVeraragavatham (2008), Shankar *et al*. (2013), Ahmad *et al.* (2011), Amit *et al.*(2012) and Madhavi *et al*. (2013). Five hybrids over US-618 and fifteen hybrids over Siri registered significant positive standard heterosis. In general, the crosses *viz.,* LE-64 × LE-66 (94.23% and 67.82%), LE-56 x LE-68 (74.65% and 50.91%), EC-157568 x LE-68 (57.52% and 36.10%), EC-164838 x LE-66 (41.78% and 22.51%) and EC-157568 x LE-56 (3.74% and 15.56%) were the outstanding crosses based on standard heterosis over Siri and US-618 respectively as far as fruit yield per plant is concerned. It is apparent that the high heterosis for fruit yield per plant may probably be due to dominance nature of genes. These results are in accordance with the earlier findings of Padma *et al*. (2002), Tiwari and Lal (2004), Shankar *et al*. (2013), Amit *et al.* (2012) and Madhavi *etal*. (2013).

Conclusion

The present investigation on heterosis revealed that high yielding hybrids were not produced by crossing two high yielding parents alone, but also by one high yielding and the other high and or average yielding parents. These findings suggest that it could be possible to achieve yield improvement in this crop through heterosis breeding, involving genetically distant germplasm lines with high or average *per se* performance as parents.

In the present study, hybrids exhibiting high or average *per se* performance also showed high heterosis over the commercial checks implying the role of heterosis for selection of best cross combinations. The magnitude and direction of standard heterosis varied from character to character. The potential crosses *viz.,* LE-64 x LE-66, LE-56 x LE-68, EC-157568 x LE-68 and EC-164838 x LE-66 exhibited high positive standard heterosis along with good *per se* performance for fruit yield per plant. Further, these hybrids have recorded average performance and standard heterosis for other yield attributing traits

Table 1: Estimate for relative heterosis (h1), heterobeltiosis (h2) and standard heterosis (h3) for Plant height, No. of primary branches per plant and Days to 50% flowering, No. of fruits per cluster, Average fruit weight (gm) and Fruit yield per plant (kg) in tomato

S.No	Crosses	Plant height (cm)			No. of primary branches/ plant			Days to 50% flowering			no. of fruits per cluster			Average fruit weight (g)		
		h3			h3			h3			h3			h3		
		h1	h2	US-618	h1	h2	US-618	h1	h2	US-618	h1	h2	US-618	h1	h2	US-618
1	P1xP2 EC-165749 x EC-157568	13.47	-1.17	15.92	-11.48**	-20.59**	-12.90**	13.85**	13.27**	4.72	4.23	-5.13	19.35*	-6.9	-10.64	-1.72
2	P1xP3 EC-165749 xEC-164838	19.38	10.79	12.6	7.69**	0	1.61	11.92**	10.20**	1.89	18.84**	10.81	32.26**	14.92*	10.73	20.82**
3	P1xP4 EC-165749 x LE-56	8.2	-7.91	14.13	-22.40**	-31.69**	-21.77**	7.69**	7.14*	-0.94	-1.37	-12.2	16.13	10.64	4.6	18.78**
4	P1xP5 EC-165749 x LE-62	0.21	-2	-10.79	-12.84**	-13.64**	-23.39**	9.27**	4.67	5.66*	16.42*	11.43	25.81**	8.38	7.56	10.47
5	P1xP6 EC-165749 x LE-64	-13.75	-27.67**	-7.04	-22.26**	-34.39**	-16.94**	5.31*	0	2.83	13.51*	0	35.48**	2.38	-5.13	12.47
6	P1xP7 EC-165749 x LE-65	0.24	-8.47	-20.35	-18.63**	-23.15**	-33.06**	9.36**	5.71*	4.72	16.13*	12.5	16.13	1.93	0.58	1.75
7	P1xP8 EC-165749 x LE-66	1.89	-4.05	-5.48	-3.42	-10.32**	-8.87**	8.57**	1.79	7.55**	15.94*	8.11	29.03**	18.12**	15.25*	22.53**
8	P1xP9 EC-165749 x LE-67	0.25	-12.26	-23.65	-1.96	-7.41*	-19.35**	3.52	1.98	-2.83	20.00**	12.5	16.13	-6.12	-8.14	-7.07
9	P1xP10 EC-165749 x LE-68	0.21	-3.87	-8.93	-14.16**	-20.00**	-19.35**	-2.73	-12.30**	0.94	5.88	0	16.13	16.48**	15.22*	19.13**
10	P2xP3 EC-157568 x EC-164838	20.21*	12.19	31.60**	6.87**	2.94	12.90**	18.75**	17.53**	7.55**	10.53	7.69	35.48**	-21.35**	-21.66**	-13.84
11	P2xP4 EC-157568x LE-56	11.67	8.68	34.69**	-18.71**	-20.42**	-8.87**	8.25**	8.25**	-0.94	5	2.44	35.48**	-16.82**	-18.13**	-7.03
12	P2xP5 EC-157568 x LE-62	5.39	-6.41	9.77	-4.07	-13.24**	-4.84	2.45	-2.34	-1.42	21.62**	15.38*	45.16**	-26.88**	-29.30**	-22.24**
13	P2xP6 EC-157568 x LE-64	-7.64	-11.68	13.52	-18.77**	-24.20**	-4.03	4.85*	-0.92	1.89	11.11*	7.14	45.16**	-18.87**	-21.80**	-7.3
14	P2xP7 EC-157568 x LE-65	5.93	-14.57	0.21	-11.21**	-24.26**	-16.94**	11.88**	7.62**	6.60*	21.74**	7.69	35.48**	-25.20**	-29.11**	-22.03**
15	P2xP8 EC-157568 x LE-66	6.65	-1.89	15.08	-5.34*	-8.82**	0	5.26*	-1.79	3.77	18.42**	15.38*	45.16**	-7.22	-8.77	0.34
16	P2xP9 EC-157568 x LE-67	6.15	-17.38	-3.09	-0.86	-15.44**	-7.26**	15.15**	12.87**	7.55**	34.33**	15.38*	45.16**	-30.65**	-34.80**	-28.30**
17	P2xP10 EC-157568 x LE-68	40.24**	26.75**	48.68**	20.31**	15.44**	26.61**	-17.81**	-26.23**	-15.09**	33.33**	28.21**	61.29**	13.18*	9.79	20.75**
18	P3xP4 EC-164838 x LE-56	-20.95*	-28.06**	-10.84	5.97**	0	14.52**	14.58**	13.40**	3.77	12.82*	7.32	41.94**	-3.29	-5.19	7.67
19	P3xP5 EC-164838 x LE-62	17.14	11.03	12.85	8.47**	1.59	3.23	4.95*	-0.93	0	25.00**	21.62**	45.16**	-10.36	-12.99*	-5.07
20	P3xP6 EC-164838 x LE-64	19.71*	7.19	37.76**	3.18	-7.01**	17.74**	-1.96	-8.26**	-5.66*	24.05**	16.67**	58.06**	-5.44	-9.2	7.64
21	P3xP7 EC-164838 x LE-65	19.03	1.62	3.28	14.41**	0.79	2.42	3	-1.9	-2.83	34.33**	21.62**	45.16**	-3.81	-8.48	-0.15
22	P3xP8 EC-164838 x LE-66	42.50**	40.31**	42.61**	19.84**	19.84**	21.77**	-15.94**	-22.32**	-17.92**	32.43**	32.43**	58.06**	10.28	8.87	18.78**
23	P3xP9 EC-164838 x LE-67	19.79	-1.63	-0.02	21.62**	7.14**	8.87**	8.16**	4.95	0	10.77	-2.7	16.13	-15.80**	-20.54**	-13.31
24	P3xP10 EC-164838 x LE-68	16.82	12.85	14.7	18.73**	18.25**	20.16**	-8.76**	-18.85**	-6.60*	26.03**	24.32**	48.39**	8.51	5.67	15.29*
25	P4xP5 LE-56 x LE-62	7.87	-6.45	15.94	-22.22**	-30.99**	-20.97**	4.90*	0	0.94	21.05**	12.2	48.39**	-11.18	-15.43*	-3.96
26	P4xP6 LE-56 xLE-64	-5.19	-6.88	19.68	-18.39**	-22.29**	-1.61	12.62**	6.42*	9.43**	8.43	7.14	45.16**	-4.7	-6.7	10.61
27	P4xP7 LE-56 x LE-65	8.64	-14.17	6.38	-19.33**	-32.39**	-22.58**	3.96	0	-0.94	29.58**	12.2	48.39**	-7.42	-13.56*	-1.84
28	P4xP8 LE-56 x LE-66	9.01	-2.17	21.25	-17.16**	-21.83**	-10.48**	2.39	-4.46	0.94	15.38**	9.76	45.16**	4.53	1.19	14.91*
29	P4xP9 LE-56 x LE-67	8.94	-16.83	3.07	-9.24**	-23.94**	-12.90**	9.09**	6.93*	1.89	27.54**	7.32	41.94**	-12.07*	-18.55**	-7.51
30	P4xP10 LE-56 x LE-68	42.70**	25.88**	56.02**	25.09**	17.61**	34.68**	-16.89**	-25.41**	-14.15**	32.47**	24.39**	64.52**	12.87*	7.81	22.44**
31	P5xP6 LE-62 x LE-64	-13.67	-26.26**	-5.23	-25.09**	-36.31**	-19.35**	0	-0.92	1.89	1.3	-7.14	25.81**	-19.46**	-24.84**	-10.9
32	P5xP7 LE-62 x LE-65	0	-10.51	-18.54	-9.71**	-15.45**	-25.00**	6.60**	5.61*	6.60*	20.00**	11.43	25.81**	-21.76**	-23.36**	-21.29**
33	P5xP8 LE-62 x LE-66	1.65	-2.21	-3.67	-14.41**	-19.84**	-18.55**	-4.11	-6.25*	-0.94	16.67**	13.51	35.48**	0.22	-1.48	4.74
34	P5xP9 LE-62 x LE-67	0	-14.14	-21.84	1.94	-4.55	-15.32**	9.62**	6.54*	7.55**	14.29*	2.86	16.13	-26.08**	-28.20**	-26.26**
35	P5xP10 LE-62 x LE-68	0	-1.95	-7.12	-2.98	-8.80**	-8.06**	-3.93	-9.84**	3.77	18.31**	16.67*	35.48**	-3.1	-3.42	-0.15
36	P6xP7 LE-64 xLE-65	-14.97	-33.70**	-14.8	-13.83**	-30.57**	-12.10**	6.54**	4.59	7.55**	13.89*	-2.38	32.26**	-14.11*	-21.37**	-6.79
37	P6xP8 LE-64 x LE-66	43.99**	27.18**	63.46**	32.16**	19.11**	50.81**	-17.65**	-18.75**	-14.15**	41.77**	33.33**	80.65**	14.76**	8.84	29.03**
38	P6xP9 LE-64 x LE-67	-15.48	-36.27**	-18.1	-10.67**	-28.03**	-8.87**	4.76*	0.92	3.77	11.43	-7.14	25.81**	-18.73**	-26.18**	-12.49
39	P6xP10 LE-64 x LE-68	-13.44	-24.82**	-3.38	-12.77**	-21.66**	-0.81	-6.49**	-11.48**	1.89	12.82*	4.76	41.94**	-0.28	-6.65	10.66
40	P7xP8 LE-65 x LE-66	1.84	-11.92	-13.23	-10.81**	-21.43**	-20.16**	-0.46	-3.57	1.89	7.46	-2.7	16.13	1.62	-2.12	4.06
41	P7xP9 LE-65 x LE-67	0	-4.59	-31.41**	-1.04	-1.04	-23.39**	7.77**	5.71*	4.72	3.45	0	-3.23	-20.32**	-21.00**	-22.19**
42	P7xP10 LE-65 x LE-68	0	-12.05	-16.69	-11.31**	-21.60**	-20.97**	-6.61**	-13.11**	0	9.09	0	16.13	-1.8	-4.13	-0.88
43	P8xP9 LE-66 x LE-67	1.91	-15.27	-16.53	0	-11.90**	-10.48**	7.03**	1.78	7.54**	29.23**	13.51	35.48**	-9.34	-13.38*	-7.92
44	P8xP10 LE-66 x LE-68	1.62	-0.33	-1.81	-9.16**	-9.52**	-8.06**	-5.13*	-9.02**	4.72	17.81**	16.22*	38.71**	12.44*	10.89	17.89*
45	P9xP10 LE-67 x LE-68	0	-15.54	-19.99	4.07	-8.00**	-7.26**	-4.04	-12.30**	0.94	0	-11.11	3.23	-9.88	-12.75	-9.79
	S.Ed	8.92	10.3		0.19	0.22		0.79	0.91		0.14	0.17		3.72	4.29	
	CD @ 5% Level	**17.98**	**20.76**		**0.39**	**0.45**		**1.59**	**1.83**		**0.29**	**0.33**		**7.49**	**8.65**	
	CD @ 1% Level	23.39	27.01		0.51	0.59		2.07	2.39		0.38	0.44		9.75	11.26	

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

Table 1: Estimate for relative heterosis (h1), heterobeltiosis (h2) and standard heterosis (h3) for Fruit yield per plant (kg) in tomato.

S.No	Crosses	Plant height (cm)		
				h3
		h1	h2	US-618
1	P1xP2 EC-165749 x EC-157568	14.66	8.18	-0.15
2	P1xP3 EC-165749 xEC-164838	21.62**	16.11	4.53
3	P1xP4 EC-165749 x LE-56	10.58	3.54	-2.87
4	P1xP5 EC-165749 x LE-62	22.32**	20.36*	1.81
5	P1xP6 EC-165749 x LE-64	8.65	-1.06	-1.36
6	P1xP7 EC-165749 x LE-65	18.43*	13.84	-6.8
7	P1xP8 EC-165749 x LE-66	1.86	-2.04	-13.14
8	P1xP9 EC-165749 x LE-67	20.61*	16.05	-4.98
9	P1xP10 EC-165749 x LE-68	4.19	0.86	-11.78
10	P2xP3 EC-157568 x EC-164838	12.18	10.8	2.27
11	P2xP4 EC-157568x LE-56	24.19**	23.19**	15.56*
12	P2xP5 EC-157568 x LE-62	12.89	8.18	-0.15
13	P2xP6 EC-157568 x LE-64	9.05	5	4.68
14	P2xP7 EC-157568 x LE-65	13.05	2.78	-5.14
15	P2xP8 EC-157568 x LE-66	5.01	2.95	-4.98
16	P2xP9 EC-157568 x LE-67	24.46**	13.26	4.53
17	P2xP10 EC-157568 x LE-68	51.43**	47.46**	36.10**
18	P3xP4 EC-164838 x LE-56	14.54*	12.24	5.29
19	P3xP5 EC-164838 x LE-62	18.51*	14.93	3.47
20	P3xP6 EC-164838 x LE-64	19.43**	13.64	13.29
21	P3xP7 EC-164838 x LE-65	31.57**	20.97*	8.91
22	P3xP8 EC-164838 x LE-66	37.11**	36.07**	22.51**
23	P3xP9 EC-164838 x LE-67	17.59*	8.22	-2.57
24	P3xP10 EC-164838 x LE-68	9.45	7.89	-2.87
25	P4xP5 LE-56 x LE-62	12.28	6.76	0.15
26	P4xP6 LE-56 xLE-64	7.73	4.55	4.23
27	P4xP7 LE-56 x LE-65	14.01	2.9	-3.47
28	P4xP8 LE-56 x LE-66	15.07*	11.92	4.98
29	P4xP9 LE-56 x LE-67	15.69	4.51	-1.96
30	P4xP10 LE-56 x LE-68	66.50**	60.87**	50.91**
31	P5xP6 LE-62 x LE-64	-0.98	-8.48	-8.76
32	P5xP7 LE-62 x LE-65	20.57*	14.11	-3.47
33	P5xP8 LE-62 x LE-66	0.61	-1.7	-12.84
34	P5xP9 LE-62 x LE-67	12.91	6.96	-9.52
35	P5xP10 LE-62 x LE-68	8.69	6.91	-6.5
36	P6xP7 LE-64 xLE-65	1.03	-11.21	-11.48
37	P6xP8 LE-64 x LE-66	78.19**	68.33**	67.82**
38	P6xP9 LE-64 x LE-67	15.07	1.21	0.91
39	P6xP10 LE-64 x LE-68	-2.66	-8.64	-8.91
40	P7xP8 LE-65 x LE-66	9.29	1.19	-10.27
41	P7xP9 LE-65 x LE-67	10.69	10.58	-16.31*
42	P7xP10 LE-65 x LE-68	-3.06	-9.67	-21.00**
43	P8xP9 LE-66 x LE-67	21.32**	12.44	-0.3
44	P8xP10 LE-66 x LE-68	7.38	6.64	-5.44
45	P9xP10 LE-67 x LE-68	2.96	-3.97	-16.01*
S.Ed			0.15	0.17
CD @ 5% Level			**0.29**	**0.34**
CD @ 1% Level			0.38	0.44

** Significant at 1% level

* Significant at 5% level

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