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Study of heterosis in tomato for yield components

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Abstract
The purpose of conducting present study was to evaluate the performance of different cross combinations of tomato for best parent heterosis and better parent heterosis regarding yield and yield related traits. For the parameters: No of fruits/plants, average Fruit weight, plant height and yield/plant. Some of the combinations showed significant positive better parent heterosis. No positive significant best parent heterosis was observed for the parameters like average Fruit weight. Significant better-parent heterosis was observed in some cross-combinations for the parameters: No of fruits/plants and yield/plant. Significant positive heterosis for yield/plant is great achievement in our study as yield/plant is the ultimate goal of tomato growers.

Keywords: Tomato, heterosis, yield, lines, testers

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most popular warm season fruit vegetable crops grown throughout the world because of its wider adaptability, high yielding potential and suitability for variety of cuisines in fresh as well as in preserved form. It is a self-pollinated crop and is a member of *Solanaceae* family with 2n = 24. Peru Ecuador region is considered to be the center of origin. Tomato is presumed to have been brought to India during the second half of the 16th century through far eastern countries. Nineteenth century plant explorers in India noted the plant to be very common, highly variable and growing as a cultivated crop as well as an escape. These materials formed the base of the first indigenous selections released as improved cultivars in the middle of the 20th century.
In India, it occupied an area of 7.91 lakh hectares with a production of 17.39 million metric tonnes with an average productivity of 22.00 metric tonne per hectare (Anon., 2015). It occupies second position among the vegetable crop in terms of production after potato. Karnataka is one of the tomato growing states covering an area of 64.32 thousand hectare with a production of 203.11 thousand metric tonnes and an average productivity of 31.58 tonnes per hectare (Anon., 2015).
In our research, our main focus is to estimate the degree of heterosis for yield and yield components for different cross combinations and to find the combination having highly yield potential to be used in further breeding programme.

Materials and Methods
The experiment was conducted at experimental plot of Biotechnology and Crop Improvement department of Kittur Rani Channamma College of Horticulture, Arabhavi, Belgaum (Dist.), Karnataka. The genotypes EC-610652 EC-608362 EC-634394 EC-638519 EC-61066 are used as female parents and L06052 TLB133 TKB133 L01942 are used as male parents.
Crossing: During the sowing season April 2016, Cherry tomato seeds were first sown on raised bed (about 18-20 cm raised) of size (1 m x 3 m) and then transplanted (30 days old seedlings) into the main field. The plots were irrigated immediately after transplanting and breeding work was initiated consequently, Crosses were made among the varieties in line x tester manner. The seed was collected from the successful crosses.
F1 evaluation: Then the collected F1 seed along with their parental varieties was sown as nursery at experimental plot of Biotechnology and Crop Improvement department of Kittur Rani Channamma College of Horticulture, Arabhavi, during the year December 2017 and plantlets were transplanted in January 2017. Plant to plant distance was kept as 30 cm and Row –Row distance was 60cm using RCBD design. The data was collected on the following

parameters: No of fruits/plant, plant height, average fruit weight (grams), Fruit diameter (cm), and yield/plant (grams).
Data was analyzed by using the soft-ware windostat. Heterosis was calculated as the percentage increase or decrease of mean F_1 performance (F_1) over the means of best parent (BTP) and better parent (BP).

$$\text{Heterosis over best parent (\%)} = \frac{\overline{F_1} - \overline{BTP}}{\overline{BTP}} \text{ X } 100$$

Where, BTP is the average of both the parent involved in development of respective F_1 hybrid.

$$\text{Heterosis over the better parent (\%)) (Heterobeltiosis)} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \text{ X } 100$$

Where, $\overline{BP}$ is the mean of the best parent among 15 parents involved in development of F_1's for each character.

Results and Discussions

All the parameters showed significant difference among the F1 and parental genotypes except flowers/cluster, where the difference was nonsignificant (Table-1).

Table 1: Mean Square values for No of fruits/plant, plant height (cm), average Fruit weight (grams), Fruit diameter (cm), and yield/plant (grams) for parental genotypes and F1.

	Pl. ht	Nof	Afw	Ft.d	Yld/plt
Parents	61.76**	228.33**	339.09**	52.05**	2.27**
Crosses(f1)	186.55**	273.27**	1913.20**	28.02**	1.28**

Heterosis percentage also differed among the cross combinations for different parameters. Out of 20 crosses, thirteen crosses over better parent, and five crosses over best the parent exhibited positive and significant heterosis for plant height (Table-2 and Table-3) while, among 20 crosses, 10 crosses over better parent and 4 crosses over best parent exhibited positive and significant heterosis for No of fruits/plant. Lowest value of better parent heterosis i.e -37.78 was calculated in cross combinations EC-61066 X TKB133 (table-4). Sekhar *et al*. (2010) also found the negative value of heterosis as well as significant positive heterosis in his study. Similar results were obtained by Gul *et al*. (2010) [5] and Patwary (2013) [6].

For fruit diameter, magnitude of heterosis over better parent was significant in both the directions. The maximum and significantly positive heterosis over better parent (38.17%) and over best parent (3.51%) was observed in the cross EC-608362 X TKB133. Out of 20 crosses, 4 crosses over better parent and 1 cross over best parent exhibited significant and positive heterosis. Chauhan *et al*. (2014) [4] reported highly significant negative heterosis in his study for the parameter.

For average fruit weight, the maximum and significantly positive heterosis over the better parent (100.36%) observed in the cross EC- 610652 X TKB133, None of the cross were significantly positive for best parent. Among 20 crosses, six crosses over better parent. Agarwal *et al*. (2014) [3] found positive and significant heterosis for fruit weight and yield, however, he did not report negative heterosis for any combination. While, in the findings of Soleiman *et al*. (2013) significant negative heterosis was found for the parameter. Data collected for yield/plant, among 20 crosses, 14 crosses over better parent and 13 crosses over best parent recorded positive and significant heterosis for fruit yield per plant. The cross EC- 638519 X L06052 showed maximum and positive significant heterosis over better parent (155.26%) followed by EC- 610652 X TKB133 (148.92%). The crosses EC- 638519 X L06052 (38.86%) followed by EC- 61066 X L01942 (33.13%) showed maximum heterosis over best parent.

Table 2: Heterosis range and No of combinations showing Significant BPH and BTPH.

Parameters	Better parent heterosis%(BPH)		No of significant BPH	Best parent heterosis% (BTPH)		No of significant BTPH
	min	max		min	max	
Plant height	-7.12	20.10	13	-16.11	15.20	5
Fruit diameter	-34.35	38.17	4	-39.12	3.15	1
No of fruits/plant	-37.78	83.50	10	-37.78	15.85	4
Average fruit weight	-66.68	100.36	6	-66.68	-12.21	0
Yield/plant	-44.54	155.26	14	-46.01	38.86	13

Table 3: Better parent Hetrosis % for No of fruits/plant (N of), plant height (Pl.ht), average Fruit weight (AFW), Fruit diameter (FT.D), and yield/plant (Yld/plt)

Sl. No	Cross	Pl.ht	N of	AFW	Ft.d	Yld/plt
1	EC-610652xL01942	14.36**	-20.32**	20.35**	-18.95**	37.85**
2	EC-610652xL06052	-6.97	10.73**	25.16**	-7.97**	111.54**
3	EC-610652xTLB133	17.05**	35.84**	-66.68 **	-23.00**	-44.54**
4	EC-610652xTKB133	20.10**	-33.74**	100.36**	31.74**	148.92**
5	EC-608362x L01942	-2.54	-16.65**	-26.49 **	-20.25**	0.72
6	EC-608362x L06052	19.08**	45.68**	-66.32 **	-2.44*	-4.29**
7	EC-608362x TLB133	7.65*	17.71**	-32.55 **	-23.26**	10.43**
8	EC-608362x TKB133	-1.52	-22.68**	-33.76 **	38.17**	24.54**
9	EC-634394x L01942	13.22**	32.61**	-29.47 **	-39.11**	37.16**
10	EC-634394x L06052	12.90**	-9.22**	11.41**	9.04**	33.80**
11	EC-634394x TLB133	1.95	-12.87**	-30.80 **	-17.26**	-0.21
12	EC-634394x TKB133	16.85**	8.22**	-26.46 **	12.18**	34.13**
13	EC-638519x L01942	15.35**	-5.95**	-4.64	0.80	62.66**
14	EC-638519x L06052	12.78*	39.91**	-4.01	-28.12**	155.26**
15	EC-638519x TLB133	9.29*	83.50**	-62.76 **	-22.18**	0.84
16	EC-638519x TKB133	-3.47	-27.22**	-1.33	-34.35**	106.77**

17	EC-61066x L01942	-7.12	-4.65*	23.15**	-23.37**	66.50**
18	EC-61066x L06052	15.20**	66.83**	-24.36 **	-16.59**	65.13**
19	EC-61066x TLB133	-0.55	8.15**	-36.38 **	-29.80**	-9.87**
20	EC-61066x TKB133	8.01*	-37.78**	13.03**	-30.88**	57.12**

*and** indicate significance of values at p=0.05 and p=0.01, respectively.

Table 4: Best parent Hetrosis % for No of fruits/plant (N of), plant height (Pl.ht), average Fruit weight (afw), Fruit diameter (Ft.d), and yield/plant (Yld/plt)

Sl. No	Cross	Pl.ht	Nof	afw	Ft.d	Yld/plt
1	EC-610652xL01942	3.13	-32.67**	-18.86**	-18.95**	10.22**
2	EC-610652xL06052	-16.11**	-32.41**	-23.65**	-24.53**	-4.40**
3	EC-610652xTLB133	12.47**	-14.24**	-66.68**	-26.61**	-46.01**
4	EC-610652xTKB133	11.38**	-33.74**	-12.42**	-8.90**	18.10**
5	EC-608362x L01942	-12.40**	-29.57**	-29.30**	-20.25**	0.72
6	EC-608362x L06052	7.04	-6.87**	-67.61**	-20.00**	-4.29**
7	EC-608362x TLB133	3.44	-24.75**	-32.55**	-26.85**	10.43**
8	EC-608362x TKB133	-8.68*	-22.68**	-36.29**	3.51**	24.54**
9	EC-634394x L01942	1.15	12.05**	-48.33**	-39.12**	29.45**
10	EC-634394x L06052	-0.34	-26.80**	-18.38**	-10.59**	26.28**
11	EC-634394x TLB133	-2.04	-29.74**	-30.80**	-21.14**	-2.86**
12	EC-634394x TKB133	8.37*	8.22**	-46.12**	-10.59**	26.59**
13	EC-638519x L01942	3.06	-20.53**	-29.91**	0.80	30.06**
14	EC-638519x L06052	-1.96	-14.59**	-29.44**	-28.20**	38.86**
15	EC-638519x TLB133	5.01	15.85**	-62.76**	-22.27**	-1.84**
16	EC-638519x TKB133	-10.49**	-27.22**	-27.48**	-34.43**	12.48**
17	EC-61066x L01942	-7.12	-19.43**	-12.21**	-18.88**	33.13**
18	EC-61066x L06052	15.20**	9.47**	-46.08**	-11.71**	24.44**
19	EC-61066x TLB133	-0.55	-29.04**	-36.38**	-25.69**	-12.27**
20	EC-61066x TKB133	8.01*	-37.78**	-19.43**	-26.83**	18.41**

*and** indicate significance of values at p=0.05 and p=0.01, respectively

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