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Heterosis in Cherry Tomato [*Solanum lycopersicum* (L.) var. Cerasiforme Mill.] for Quality

E. Venkadeswaran[1*], Irene Vethamoni P.[1], Arumugamt[2], Manivannan N.[3], Harish S.[4] and Sujatha R.[1]
[1]*Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu*
[2]*Horticultural College and Research Institute, Periyakulam, Tamil Nadu*
[3]*Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu*
[4]*Agricultural College and Research Institute, Madurai, Tamil Nadu*
**Email : e.venkadeswaran@gmail.com*

Abstract

A trial comprising eight parents and their fifty-six F_1(s) was conducted in aRandomized Block Design with two replications at university orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. Heterosis was estimated in fifty-six single experimental cross hybrids, obtained by eight parental lines namely LE 13 (P_1), LE 87 (P_2), LE 1223 (P_3), VGT 89 (P_4), IIHR 2753 (P_5), IIHE 2754 (P_6), Pant Cherry Tomato 1(P_7) and Pusa Cherry Tomato 1 (P_8) for quality traits. Lara, a F_1 hybrid was used as check hybrid. On the basis of heterosis the hybrids *viz.,* P_3 x P_2 (LE 1223 x LE 87), P_2 x P_5 (LE 87 x IIHR 2753) and P_7 x P_5 (Pant Cherry Tomato 1 x IIHR 2753) expressed the best standard heterosis over check for quality attributes. P_8 and P_7 proved their potential as female parent in hybrid combinations for expressing high heterotic values for fruit firmness, pericarp thickness and shelf life. P_3 proved its high potential either male as well as female parent in the hybrid combinations for expressing high heterotic values with high lycopene, total carotenoids and total antioxidant.

Key words : *Cerasiforme, cherry tomato, F_1hybrid, heterosis, lycopersicum, quality.*

Introduction

Cherry tomato [*Solanum lycopersicum* (L.) var. *cerasiforme* Mill.] is a popular, table purpose tomato with small fruits with a bright red colour resembling a cherry and having an excellent taste. Cherry tomato often called 'salad tomato' and being high content of antioxidant and phytochemical compounds, it is needless to emphasis the importance of quality parameter for fresh and processed produce. Heterosis in tomato was first observed by (1) for higher yield and more number of fruits. Since then, heterosis for yield, its components and quality traits were extensively studied. The hybrids have generated interest among the breeders for the possibility of combining a complex of valuable attributes in a genotype. Hybrids offer opportunities for improvement in productivity, earliness, uniformity and quality (2). In cherry tomato exploitation of heterosis has become a potential tool in improvement though it is self-pollinated crop. The cherry tomatoes developed for fresh market and processing should have distinct quality characteristics (3, 4). The expression of heterosis is highly associated with specific combining ability of the crosses. Diallel analysis is one of the efficient biometrical tools for evaluation of lines for their general combining ability and to identify the crosses with high specific combining ability. The study was aimed at to estimate the heterosis of F_1 hybrids in cherry tomato for fruit quality.

Materials and Methods

The experimental material consisting of eight cherry tomato parents *viz.,* LE 13 (P_1), LE 87 (P_2), LE 1223 (P_3), VGT 89 (P_4), IIHR 2753 (P_5), IIHR 2754 (P_6), Pant Cherry Tomato 1(P_7) and Pusa Cherry Tomato 1 (P_8) were selected based on their superiority in the yield and quality traits and were crossed in full diallel fashion. The resulting, fifty-six F_1(s) along with eight parents and commercial checks were evaluated in a Randomized Block Design with two replications. Lara, aF_1 hybrid (Known You Seed (I) Pvt. Ltd., Pune) was used as check hybrid. The experiment was conducted in the university orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. The quality parameters *viz.,* fruit firmness (5), pericarp thickness, shelf life of fruits (6), total soluble solids, total sugars (7), ascorbic acid (1), titrable acidity (8), lycopene (9), total carotenoids (10) were studied. The mean values were used to estimate heterosis per cent under three categories (11).

i. Relative heterosis (di)

Deviation of hybrid from mid parent

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$d_i = x$

Where,

x = mean value of hybrid

x = mid parental value

ii. Heterobeltiosis (d_{ii})

Deviation of hybrid from better parent

$d_{ii} = x$

Where,

x = mean value of better parent

iii. Standard heterosis (d_{iii})

Deviation of hybrid from check hybrid

$d_{iii} = x$

Where,

x = mean value of standard check hybrid

Test of significance of heterosis

Significance of estimates of heterosis was tested at error degrees of freedom.

't' for relative heterosis = x

't' for heterobeltiosis = x

't' for standard heterosis = x

Where,

Me = error variance

Results and Discussion

The estimates of heterosis was computed for all quality traits studied in the fifty-six cross combinations of cherry tomato and expressed in percentage over mid parental value (*di* - relative heterosis), better parental value (*dii* - heterobeltiosis) and standard heterosis over check hybrid Lara (*diii* - standard heterosis). The relative heterosis (*di*) for fruit firmness of fifty-six cherry tomato hybrids developed ranged from -31.18 per cent (P_2 x P_7) to 35.73 per cent (P_7 x P_3) and only four hybrids registered positive and significant values (Table-1). The heterobeltiosis (*dii*) for fruit firmness was the highest in the hybrid P_7 x P_3 (34.87 per cent) followed by P_8 x P_2 (14.76 per cent) and only three hybrids registered positive and significant values. The highest heterosis over standard checks (*diii*) Lara was observed in the hybrid P_7 x P_3 as 6.29 per cent. The parents P_7 and P_8 proved their potential as female parent in hybrid combinations for expressing high heterotic values. Cherry tomato processing industry requires fruits that are firm, having thick pericarp and small locule area. Heterosis for fruit firmness was also reported by (12). The heterosis for mid parental value (*di*) for pericarp thickness of fifty-six cherry tomato hybrids of the study ranged from -39.98 per cent (P_5 x P_3) to 84.22 per cent (P_8 x P_2) and seventeen hybrids exhibited positive and significant heterotic values. The heterotic value over better parent (*dii*) was high and positively significant in the hybrid P_8 x P_7 (72.09 per cent) and ten hybrids registered positive and significant values for this trait. The highly heterotic hybrids for pericarp thickness were noted as P_8 x P_2, P_8 x P_7, P_8 x P_4 and P_6 x P_2 with significant and high relative heterosis and heterobeltiosis. The standard heterosis (*diii*) over Lara ranged from -51.96 per cent (P_7 x P_8) to 24.51 per cent (P_8 x P_3). Higher heterosis over check hybrid Lara noted only in the crosses P_8 x P_3, P_8 x P_2, P_8 x P_4 andP_4 x P_3. The parent P_8 proved its potential as female parent in hybrid combinations for expressing high heterotic values. These results were observed to be in accordance with findings of (12) and (13). Cherry tomato is universally accepted salad vegetable for its nutritional value. Another factor that is especially important for fresh market cherry tomato is the shelf life of fruit. For shelf life of fruits, mid parental value (*di*) of fifty-six cherry tomato hybrids, varied from -21.37 per cent (P_5 x P_3) to 31.91 per cent (P_8 x P_7) and totally twenty-one hybrids recorded significant values for this trait. The positive and significant better parent heterosis (*dii*) for this trait was highest in the hybrid P_8 x P_7 (29.17 per cent) followed by P_8 x P_2 (23.08 per cent) and P_6 x P_2 (17.31 per cent). Out of fifty-six hybrids, nine hybrids exhibited heterobeltiotic values for this trait. The hybrids P_8 x P_7, P_8 x P_2, P_8 x P_4 andP_6 x P_2 were highly heterotic over mid and better parents for prolonged shelf life. The hybrid P_8 x P_3 recorded the highest standard heterosis (*diii*) over check Lara (10.34 per cent) and seven hybrids recorded positive and significant values over standard check. P_8 as female parent contributed much to the enhanced shelf life due to thick pericarp. Similar results were illustrated by (14).

Total soluble solids are the main quality components of cherry tomato fruits. The reducing sugars, glucose and fructose are the major components of the soluble solids. The relative heterosis (*di*) value for total soluble solids of fifty-six cherry tomato hybrids ranged from -21.23 per cent (P_8 x P_1) to 48.81 per cent (P_2 x P_5) and as much as of thirty-four hybrids recorded positive and significant values. The heterobeltiosis (*dii*) for this trait ranged from -21.87 per cent (P_8 x P_1) to 43.66 per cent (P_2 x P_5) and thirty hybrids exhibited positive and significant heterobeltiosis values. In this study, high relative heterotic and heterobeltiotic hybrids were observed to be P_2 x P_5, P_3 x P_2, P_6 x P_4, P_7 x P_5, P_2 x P_6 and P_7 x P_1. The highest positive and significant standard heterosis (*diii*) was registered in the hybrid P_3 x P_2 (4.29 per cent) over

Table-1 : Heterosis for fruit firmness, pericarp thickness and shelf life in cherry tomatohybrids.

Cross	Fruit firmness (per cent)			Pericarp thickness (per cent)			Shelf life of fruits (per cent)		
	di	dii	diii	di	dii	diii	di	dii	diii
P_1 x P_2	-10.63*	-14.35**	-38.74**	-22.19**	-32.27**	-32.11**	-10.71**	-16.67**	-13.79**
P_1 x P_3	-21.59**	-25.21**	-41.06**	-17.17**	-25.44**	-6.62	-6.45**	-9.38**	0.00
P_1 x P_4	0.00	-5.37	-24.17**	12.50*	3.42	3.68	5.17*	1.67	5.17
P_1 x P_5	-17.24**	-17.81**	-40.40**	15.12**	1.47	1.72	6.19*	0.00	3.45
P_1 x P_6	-1.33	-5.51	-26.16**	14.20*	-5.62	-5.39	6.42*	-3.33	0.00
P_1 x P_7	-22.84**	-25.96**	-42.38**	-2.85	-20.78**	-20.59**	0.00	-10.00**	-6.90*
P_1 x P_8	-18.31**	-19.44**	-42.38**	5.68	-15.89**	-15.69**	5.66*	-6.67**	-3.45
P_2 x P_1	-17.87**	-21.30**	-43.71**	-16.01**	-26.89**	-26.72**	-7.14**	-13.33**	-10.34**
P_2 x P_3	-19.72**	-26.47**	-42.05**	-13.76**	-31.31**	-13.97**	-3.45	-12.50**	-3.45
P_2 x P_4	-15.00**	-22.73**	-38.08**	24.46**	17.20**	-1.47	7.41**	3.57	0.00
P_2 x P_5	-14.15**	-18.26**	-40.73**	11.87	10.26	-15.69**	6.67*	5.66*	-3.45
P_2 x P_6	-24.42**	-30.51**	-45.70**	-2.46	-8.25	-31.86**	-0.99	-3.85	-13.79**
P_2 x P_7	-31.18**	-36.60**	-50.66**	-9.09	-15.84*	-37.50**	-6.00*	-9.62**	-18.97**
P_2 x P_8	-18.63**	-20.95**	-45.03**	-19.27**	-27.39**	-46.08**	-8.16**	-13.46**	-22.41**
P_3 x P_1	-27.31**	-30.67**	-45.36**	-36.96**	-43.25**	-28.92**	-17.74**	-20.31**	-12.07**
P_3 x P_2	-16.51**	-23.53**	-39.74**	-28.01**	-42.66**	-28.19**	-12.07**	-20.31**	-12.07**
P_3 x P_4	-20.00**	-20.66**	-36.42**	0.23	-16.24**	4.90	1.67	-4.69*	5.17
P_3 x P_5	-25.16**	-28.15**	-43.38**	-17.86**	-33.86**	-17.16**	-5.98*	-14.06**	-5.17
P_3 x P_6	-26.58**	-26.89**	-42.38**	-21.34**	-40.12**	-25.00**	-7.96**	-18.75**	-10.34**
P_3 x P_7	-14.16**	-14.71**	-32.78**	-12.35*	-34.05**	-17.40**	-1.79	-14.06**	-5.17
P_3 x P_8	-14.73**	-19.75**	-36.75**	-24.04**	-44.03**	-29.90**	-7.27**	-20.31**	-12.07**
P_4 x P_1	-10.04*	-14.88**	-31.79**	15.16**	5.87	6.13	6.90**	3.33	6.90*
P_4 x P_2	-16.82**	-24.38**	-39.40**	19.81**	12.83*	-5.15	7.41**	3.57	0.00
P_4 x P_3	-21.67**	-22.31**	-37.75**	12.18**	-6.26	17.40**	5.00*	-1.56	8.62**
P_4 x P_5	-21.91**	-25.62**	-40.40**	2.60	-2.04	-17.65**	-0.92	-3.57	-6.90*
P_4 x P_6	-23.43**	-24.38**	-39.40**	45.57**	29.45**	8.82	18.10**	10.71**	6.90*
P_4 x P_7	-21.17**	-22.31**	-37.75**	41.10**	23.62**	3.92	15.38**	7.14**	3.45
P_4 x P_8	-12.39**	-18.18**	-34.44**	10.43	-5.83	-20.83**	5.88*	-3.57	-6.90*
P_5 x P_1	-20.92**	-21.46**	-43.05**	-21.78**	-31.05**	-30.88**	-11.50**	-16.67**	-13.79**
P_5 x P_2	-17.99**	-21.92**	-43.38**	-4.07	-5.45	-27.70**	-2.86	-3.77	-12.07**
P_5 x P_3	-25.16**	-28.15**	-43.38**	-39.98**	-51.66**	-39.46**	-21.37**	-28.13**	-20.69**
P_5 x P_4	-24.51**	-28.10**	-42.38**	-1.37	-5.83	-20.83**	-0.92	-3.57	-6.90*
P_5 x P_6	-28.35**	-30.93**	-46.03**	-9.84	-16.35**	-36.03**	-5.88*	-9.43**	-17.24**
P_5 x P_7	-7.93	-11.06*	-30.79**	-9.47	-17.31**	-36.76**	-4.95	-9.43**	-17.24**
P_5 x P_8	-11.42*	-13.24**	-37.09**	-10.47	-20.51**	-39.22**	-7.07*	-13.21**	-20.69**
P_6 x P_1	-3.54	-7.63	-27.81**	1.48	-16.14**	-15.93**	0.92	-8.33**	-5.17
P_6 x P_2	-3.69	-11.44**	-30.79**	51.93**	42.90**	6.13	20.79**	17.31**	5.17
P_6 x P_3	-15.61**	-15.97**	-33.77**	8.23	-17.61**	3.19	6.19*	-6.25**	3.45
P_6 x P_4	-15.48**	-16.53**	-33.11**	5.25	-6.41	-21.32**	0.95	-5.36*	-8.62**
P_6 x P_5	3.30	-0.42	-22.19**	6.39	-1.28	-24.51**	3.92	0.00	-8.62**
P_6 x P_7	-8.28	-8.47*	-28.48**	-4.00	-5.62	-38.24**	-5.15	-6.12*	-20.69**
P_6 x P_8	0.45	-5.08	-25.83**	6.88	1.87	-33.33**	3.16	0.00	-15.52**
P_7 x P_1	-7.32	-11.06*	-30.79**	-17.24**	-32.52**	-32.35**	-9.26**	-18.33**	-15.52**
P_7 x P_2	-8.55	-15.74**	-34.44**	14.44*	5.94	-21.32**	8.00**	3.85	-6.90*
P_7 x P_3	35.73**	34.87**	6.29*	-32.38**	-49.12**	-36.27**	-14.29**	-25.00**	-17.24**
P_7 x P_4	4.82	3.31	-17.22**	1.16	-11.37*	-25.49**	0.00	-7.14**	-10.34**
P_7 x P_5	-3.96	-7.23	-27.81**	-29.12**	-35.26**	-50.49**	-12.87**	-16.98**	-24.14**
P_7 x P_6	12.95**	12.71**	-11.92**	-11.24	-12.73	-42.89**	-7.22*	-8.16**	-22.41**
P_7 x P_8	-0.22	-5.53	-26.49**	-21.60**	-24.03**	-51.96**	-8.51**	-10.42**	-25.86**
P_8 x P_1	7.51	6.02	-24.17**	-1.69	-21.76**	-21.57**	0.00	-11.67**	-8.62**
P_8 x P_2	18.14**	14.76**	-20.20**	84.22**	65.68**	23.04**	30.61**	23.08**	10.34**
P_8 x P_3	-2.68	-8.40*	-27.81**	34.93**	-0.59	24.51**	16.36**	0.00	10.34**
P_8 x P_4	14.16**	6.61	-14.57**	66.15**	41.69**	19.12**	23.53**	12.50**	8.62**
P_8 x P_5	0.23	-1.83	-28.81**	33.57**	18.59**	-9.31	15.15**	7.55**	-1.72
P_8 x P_6	4.04	-1.69	-23.18**	42.63**	35.96**	-11.03*	17.89**	14.29**	-3.45
P_8 x P_7	2.47	-2.98	-24.50**	77.60**	72.09**	8.82	31.91**	29.17**	6.90*

*Significant at 5 per cent level, **Significant at 1 per cent level

di **-** Relative heterosis, ***dii*** **-** Heterobeltiosis, ***diii*** **-** Standard heterosis

P_1:	LE 13	**P_3:**	LE 1223	**P_5:**	IIHR 2753	**P_7:**	Pant Cherry Tomato 1
P_2:	LE 87	**P_4:**	VGT 89	**P_6:**	IIHR 2754	**P_8:**	Pusa Cherry Tomato 1

Table-2 : Heterosis for TSS, ascorbic acid and titrable acidity in cherry tomato hybrids.

Cross	Total soluble solids (per cent)			Ascorbic acid (per cent)			Titrable acidity (per cent)		
	di	dii	diii	di	dii	diii	di	dii	diii
P_1 x P_2	18.16**	13.98**	-17.40**	-1.25	-2.99*	12.04**	-25.00**	-29.41**	33.33**
P_1 x P_3	-4.92	-5.23*	-30.87**	-0.44	-2.48*	8.67**	15.38*	0.00	66.67**
P_1 x P_4	-7.81**	-11.68**	-36.00**	0.07	-4.98**	17.76**	9.09	0.00	100.00**
P_1 x P_5	5.19*	5.10	-23.84**	-2.11	-2.33	9.32**	-16.13**	-18.75**	44.44**
P_1 x P_6	5.36*	5.10	-23.84**	-3.01*	-7.54**	3.03*	-16.13**	-18.75**	44.44**
P_1 x P_7	19.54**	19.34**	-13.23**	-1.43	-2.48*	8.67**	-8.00	-23.33**	27.78**
P_1 x P_8	11.77**	10.86**	-19.67**	-0.97	-2.89*	8.21**	-4.00	-20.00**	33.33**
P_2 x P_1	23.96**	19.57**	-13.35**	-1.25	-2.99*	12.04**	-25.00**	-29.41**	33.33**
P_2 x P_3	1.78	-2.12	-28.61**	0.02	-3.72**	11.20**	7.14	-11.76*	66.67**
P_2 x P_4	6.95*	6.19*	-28.49**	0.48	-2.94**	20.29**	-20.00**	-22.22**	55.56**
P_2 x P_5	48.81**	43.66**	3.93*	-8.38**	-9.80**	4.18**	-57.58**	-58.82**	-22.22*
P_2 x P_6	40.68**	36.03**	-1.91	-2.50*	-8.60**	5.56**	-39.39**	-41.18**	11.11
P_2 x P_7	10.98**	6.89**	-22.29**	-0.96	-3.72**	11.20**	-11.11	-29.41**	33.33**
P_2 x P_8	3.87	1.00	-28.01**	-0.50	-4.12**	10.74**	3.70	-17.65**	55.56**
P_3 x P_1	24.59**	24.18**	-9.42**	-7.47**	-9.36**	1.00	-15.38*	-26.67**	22.22*
P_3 x P_2	48.68**	42.97**	4.29*	-10.88**	-14.21**	-0.92	-32.14**	-44.12**	5.56
P_3 x P_4	24.38**	18.79**	-13.35**	1.31	-5.66**	16.92**	-17.24**	-33.33**	33.33**
P_3 x P_5	7.79**	7.35**	-21.69**	-0.84	-3.08*	8.48**	-11.11	-25.00**	33.33**
P_3 x P_6	1.73	1.14	-26.22**	-1.70	-4.38**	2.19	-3.70	-18.75**	44.44**
P_3 x P_7	0.33	0.16	-26.94**	-0.12	-1.13	7.83**	23.81**	18.18*	44.44**
P_3 x P_8	14.05**	12.75**	-17.76**	0.36	0.25	7.36**	14.29	9.09	33.33**
P_4 x P_1	23.95**	18.75**	-13.95**	0.07	-4.98**	17.76**	-27.27**	-33.33**	33.33**
P_4 x P_2	18.36**	17.52**	-20.86**	0.48	-2.94**	20.29**	-31.43**	-33.33**	33.33**
P_4 x P_3	7.78**	2.94	-24.91**	1.31	-5.66**	16.92**	-10.34	-27.78**	44.44**
P_4 x P_5	26.29**	21.09**	-12.40**	-9.97**	-14.33**	6.18**	-35.29**	-38.89**	22.22*
P_4 x P_6	15.66**	11.07**	-19.90**	-1.07	-10.21**	11.28**	-29.41**	-33.33**	33.33**
P_4 x P_7	-1.11	-5.41*	-31.23**	0.36	-5.66**	16.92**	14.29*	-11.11*	77.78**
P_4 x P_8	5.63*	2.01	-27.29**	0.81	-6.04**	16.46**	-7.14	-27.78**	44.44**
P_5 x P_1	25.43**	25.33**	-9.18**	-2.11	-2.33	9.32**	-29.03**	-31.25**	22.22*
P_5 x P_2	23.38**	19.11**	-13.83**	-1.64	-3.16**	11.85**	-27.27**	-29.41**	33.33**
P_5 x P_3	-4.84	-5.23*	-30.87**	-0.84	-3.08*	8.48**	11.11	-6.25	66.67**
P_5 x P_4	18.90**	14.00**	-17.52**	-3.56**	-8.23**	13.73**	-29.41**	-33.33**	33.33**
P_5 x P_6	-10.89**	-11.04**	-35.64**	-3.42**	-8.12**	2.84	6.25	6.25	88.89**
P_5 x P_7	-5.18*	-5.41*	-31.23**	-1.82	-3.08*	8.48**	23.08**	0.00	77.78**
P_5 x P_8	-4.07	-4.78	-31.11**	-1.37	-3.50**	8.02**	23.08**	0.00	77.78**
P_6 x P_1	-20.20**	-20.39**	-42.31**	-3.01*	-7.54**	3.03*	35.48**	31.25**	133.33**
P_6 x P_2	0.34	-2.98	-30.04**	-2.50*	-8.60**	5.56**	-3.03	-5.88	77.78**
P_6 x P_3	-12.57**	-13.07**	-36.59**	-1.70	-4.38**	2.19	33.33**	12.50*	100.00**
P_6 x P_4	45.78**	40.00**	0.95	-1.07	-10.21**	11.28**	-47.06**	-50.00**	0.00
P_6 x P_5	35.97**	35.75**	-1.79	-3.42**	-8.12**	2.84	-37.50**	-37.50**	11.11
P_6 x P_7	8.64**	8.20**	-21.33**	-2.72*	-6.30**	2.19	-7.69	-25.00**	33.33**
P_6 x P_8	15.88**	15.21**	-16.92**	-2.25	-5.01**	1.73	-7.69	-25.00**	33.33**
P_7 x P_1	36.62**	36.39**	-0.83	-1.43	-2.48*	8.67**	-28.00**	-40.00**	0.00
P_7 x P_2	4.68	0.82	-26.70**	-0.96	-3.72**	11.20**	-3.70	-23.53**	44.44**
P_7 x P_3	-13.75**	-13.89**	-37.19**	-0.12	-1.13	7.83**	80.95**	72.73**	111.11**
P_7 x P_4	1.80	-2.62	-29.20**	0.36	-5.66**	16.92**	7.14	-16.67**	66.67**
P_7 x P_5	42.97**	42.62**	3.69*	-1.82	-3.08*	8.48**	-30.77**	-43.75**	0.00
P_7 x P_6	20.99**	20.49**	-12.40**	-2.72*	-6.30**	2.19	-15.38*	-31.25**	22.22*
P_7 x P_8	27.48**	26.23**	-8.22**	-0.66	-1.55	7.36**	10.00	10.00	22.22*
P_8 x P_1	-21.23**	-21.87**	-43.38**	-0.97	-2.89*	8.21**	76.00**	46.67**	144.44**
P_8 x P_2	19.35**	16.05**	-17.28**	-0.50	-4.12**	10.74**	-11.11	-29.41**	33.33**
P_8 x P_3	2.31	1.14	-26.22**	0.36	0.25	7.36**	23.81**	18.18*	44.44**
P_8 x P_4	17.58**	13.55**	-19.07**	0.81	-6.04**	16.46**	-14.29*	-33.33**	33.33**
P_8 x P_5	1.91	1.15	-26.82**	-1.37	-3.50**	8.02**	0.00	-18.75**	44.44**
P_8 x P_6	1.25	0.66	-27.41**	-2.25	-5.01**	1.73	0.00	-18.75**	44.44**
P_8 x P_7	0.00	-0.98	-28.01**	-0.66	-1.55	7.36**	10.00	10.00	22.22*

*Significant at 5 per cent level, **Significant at 1 per cent level

di **-** Relative heterosis, ***dii*** **-** Heterobeltiosis, ***diii*** **-** Standard heterosis

P_1:	LE 13	**P_3:**	LE 1223	**P_5:**	IIHR 2753	**P_7:**	Pant Cherry Tomato 1
P_2:	LE 87	**P_4:**	VGT 89	**P_6:**	IIHR 2754	**P_8:**	Pusa Cherry Tomato 1

Table-3 : Heterosis for lycopene, total carotenoids and total antioxidant in cherry tomato hybrids.

Cross	Lycopene (per cent)			Total carotenoids (per cent)			Total antioxidant (per cent)		
	di	dii	diii	di	dii	diii	di	dii	diii
P_1 x P_2	-5.70	-14.95**	-12.92**	3.98	-7.01**	-2.52	3.66	-7.48	-2.94
P_1 x P_3	-5.85	-15.21**	-13.18**	7.22**	-7.72**	-3.26	7.61	-7.48	-2.94
P_1 x P_4	-6.86*	-13.52**	-11.45**	-5.68*	-16.73**	-12.71**	-5.82	-16.82*	-12.75
P_1 x P_5	-16.19**	-18.70**	-11.45**	-27.50**	-35.37**	-13.45**	-27.87**	-35.77**	-13.73
P_1 x P_6	-17.95**	-20.17**	-13.58**	-40.36**	-53.73**	-12.08**	-40.20**	-53.61**	-11.76
P_1 x P_7	-18.66**	-21.05**	-14.11**	-23.41**	-28.12**	-14.08**	-23.14**	-27.87**	-13.73
P_1 x P_8	-19.87**	-22.18**	-15.45**	-8.64**	-13.18**	1.05	-8.85	-13.45*	0.98
P_2 x P_1	11.75**	0.78	3.20	10.03**	-1.60	3.15	9.95	-1.87	2.94
P_2 x P_3	8.43*	8.25*	-10.92**	10.68**	5.97*	-12.39**	10.56	5.95	-12.75
P_2 x P_4	-1.80	-4.86	-16.51**	10.77**	9.15**	-9.77**	10.84	9.52	-9.80
P_2 x P_5	15.88**	1.71	10.79**	-3.20	-21.73**	4.83*	-3.17	-21.90**	4.90
P_2 x P_6	6.22*	-6.52*	1.20	-26.04**	-46.93**	0.84	-25.90**	-46.91**	0.98
P_2 x P_7	-12.47**	-23.13**	-16.38**	-10.96**	-24.69**	-9.98**	-10.68	-24.59**	-9.80
P_2 x P_8	-8.79**	-19.85**	-12.92**	-13.98**	-26.44**	-14.39**	-14.29*	-26.89**	-14.71
P_3 x P_1	24.33**	11.96**	14.65**	16.65**	0.40	5.25*	16.30*	0.00	4.90
P_3 x P_2	40.19**	39.97**	15.18**	34.44**	28.72**	6.41**	35.40**	29.76**	6.86
P_3 x P_4	-0.39	-3.64	-15.45**	30.32**	26.57**	1.58	30.82**	26.83**	1.96
P_3 x P_5	2.37	-10.27**	-2.26	-0.55	-22.20**	4.20	-0.93	-22.63**	3.92
P_3 x P_6	10.01**	-3.32	4.66	-20.84**	-44.67**	5.15*	-21.03**	-44.85**	4.90
P_3 x P_7	-0.63	-12.85**	-5.19	7.00**	-12.65**	4.41	7.54	-12.30*	4.90
P_3 x P_8	-5.03	-16.67**	-9.45**	0.11	-17.42**	-3.89	0.00	-17.65**	-3.92
P_4 x P_1	-13.17**	-19.38**	-17.44**	-1.93	-13.43**	-9.24**	-1.59	-13.08	-8.82
P_4 x P_2	0.39	-2.73	-14.65**	5.48	3.94	-14.08**	6.02	4.76	-13.73
P_4 x P_3	1.18	-2.12	-14.11**	16.04**	12.70**	-9.56**	15.72	12.20	-9.80
P_4 x P_5	-2.10	-11.61**	-3.73	13.29**	-9.41**	21.32**	13.24*	-9.49	21.57*
P_4 x P_6	14.27**	3.44	11.98**	-18.54**	-42.07**	10.08**	-18.84**	-42.27**	9.80
P_4 x P_7	-13.69**	-22.03**	-15.18**	-10.09**	-24.87**	-10.19**	-9.80	-24.59**	-9.80
P_4 x P_8	-17.15**	-25.12**	-18.64**	-21.37**	-33.57**	-22.69**	-21.39**	-33.61**	-22.55**
P_5 x P_1	3.47	0.37	9.32**	2.51	-8.63**	22.37**	2.46	-8.76	22.55**
P_5 x P_2	-9.89**	-20.90**	-13.85**	-16.29**	-32.31**	-9.35**	-16.74*	-32.85**	-9.80
P_5 x P_3	12.83**	-1.10	7.72*	16.39**	-8.94**	21.95**	15.89*	-9.49	21.57*
P_5 x P_4	18.08**	6.60*	16.11**	-34.77**	-47.84**	-30.15**	-35.16**	-48.18**	-30.39**
P_5 x P_6	-24.95**	-25.18**	-18.51**	-52.33**	-59.37**	-22.79**	-52.27**	-59.28**	-22.55**
P_5 x P_7	-21.10**	-21.15**	-14.11**	-31.87**	-35.53**	-13.66**	-32.05**	-35.77**	-13.73
P_5 x P_8	-24.48**	-24.57**	-17.84**	-27.40**	-32.16**	-9.14**	-27.34**	-32.12**	-8.82
P_6 x P_1	-16.06**	-18.33**	-11.58**	-40.86**	-54.12**	-12.82**	-40.86**	-54.12**	-12.75
P_6 x P_2	-12.37**	-22.88**	-16.51**	-33.67**	-52.40**	-9.56**	-33.81**	-52.58**	-9.80
P_6 x P_3	1.33	-10.95**	-3.60	-47.09**	-63.02**	-29.73**	-46.86**	-62.89**	-29.41**
P_6 x P_4	-10.05**	-18.57**	-11.85**	-28.33**	-49.03**	-3.15	-28.26**	-48.97**	-2.94
P_6 x P_5	-6.44*	-6.72*	1.60	-37.35**	-46.60**	1.47	-37.16**	-46.39**	1.96
P_6 x P_7	-24.91**	-25.09**	-18.51**	-49.92**	-59.20**	-22.48**	-50.00**	-59.28**	-22.55**
P_6 x P_8	-19.34**	-19.49**	-12.52**	-43.30**	-54.28**	-13.13**	-43.13**	-54.12**	-12.75
P_7 x P_1	-17.15**	-19.58**	-12.52**	-22.94**	-27.68**	-13.55**	-23.14**	-27.87**	-13.73
P_7 x P_2	-15.26**	-25.58**	-19.04**	-8.99**	-23.02**	-7.98**	-8.74	-22.95**	-7.84
P_7 x P_3	-15.98**	-26.32**	-19.84**	-7.32**	-24.34**	-9.56**	-7.54	-24.59**	-9.80
P_7 x P_4	-17.89**	-25.83**	-19.31**	-7.89**	-23.02**	-7.98**	-7.84	-22.95**	-7.84
P_7 x P_5	-17.68**	-17.73**	-10.39**	-23.83**	-27.92**	-3.47	-24.32**	-28.47**	-3.92
P_7 x P_6	-26.38**	-26.56**	-20.11**	-40.96**	-51.91**	-8.61**	-41.14**	-52.06**	-8.82
P_7 x P_8	-25.78**	-25.83**	-19.31**	-22.71**	-23.73**	-8.82**	-22.82**	-23.77**	-8.82
P_8 x P_1	-19.62**	-21.94**	-15.18**	-9.02**	-13.54**	0.63	-8.85	-13.45*	0.98
P_8 x P_2	-15.20**	-25.49**	-19.04**	-7.65**	-21.03**	-8.09**	-7.39	-21.01**	-7.84
P_8 x P_3	-11.87**	-22.67**	-15.98**	4.81	-13.54**	0.63	5.10	-13.45*	0.98
P_8 x P_4	-10.64**	-19.24**	-12.25**	-0.85	-16.25**	-2.52	-1.49	-16.81**	-2.94
P_8 x P_5	-14.20**	-14.30**	-6.66	-17.75**	-23.14**	2.94	-17.97**	-23.36**	2.94
P_8 x P_6	-14.79**	-14.95**	-7.59*	-33.90**	-46.71**	1.26	-34.19**	-46.91**	0.98
P_8 x P_7	-8.88**	-8.94**	-0.93	-23.15**	-24.17**	-9.35**	-23.65**	-24.59**	-9.80

*Significant at 5 per cent level, **Significant at 1 per cent level

di **-** Relative heterosis, ***dii*** **-** Heterobeltiosis, ***diii*** **-** Standard heterosis

P_1:	LE 13	**P_3:**	LE 1223	**P_5:**	IIHR 2753	**P_7:**	Pant Cherry Tomato 1
P_2:	LE 87	**P_4:**	VGT 89	**P_6:**	IIHR 2754	**P_8:**	Pusa Cherry Tomato 1

standard check Lara for this trait and only three hybrids (P_3 x P_2, P_2 x P_5 and P_7 x P_5) recorded positive and significant heterotic values (*diii*) over the standard check hybrid (Table-2). The parents P_2 and P_8 proved their potential either male as well as female parent and P_5 as male parent in hybrid combinations for expressing high heterotic values with the highest total soluble solids. Similar results were obtained by (13, 14, 15). The relative heterosis for ascorbic acid content ranged from -10.88 per cent (P_3 x P_2) to -2.50 per cent (P_2 x P_6 and P_6 x P_2). Twelve out of fifty-six hybrids registered significant negative heterosis over mid parental value. Heterosis over better parent varied from -14.33 per cent (P_4 x P_5) to -2.48 per cent (P_1 x P_3, P_1 x P_7 and P_7 x P_1). Out of fifty-six hybrids, fifty hybrids exhibited negative and significant heterobeltiosis (*dii*). It was noted that none of the hybrid was negative and significant over standard check Lara for this trait. The parents P_3 and P_4 proved their potential as female parent in hybrid combinations for expressing high heterotic values with less ascorbic acid content. This is in accordance with the earlier reports of (12, 16). Relative heterosis (*di*) values estimated for titrable acidity of fifty-six cherry tomato hybrids ranged from -57.58 per cent (P_2 x P_5) to 80.95 per cent (P_7 x P_3) and totally twenty-four hybrids recorded negative and significant values. The better parent heterosis (*dii*) for this trait was negatively highest in the hybrid P_2 x P_5 (-58.82 per cent) followed by P_6 x P_4 (-50.00 per cent) and forty hybrids registered negative and significant heterobeltiosis value. In this study, hybrid combinations P_2 x P_5, P_6 x P_4, P_2 x P_6, P_6 x $P_5$and P_4 x P_5 were found to record significant and high negative *di* value for titrable acidity whereas, the hybrids P_2 x P_5, P_6 x P_4, P_3 x P_2, P_7 x $P_5$and P_2 x P_6 recorded significant and high negative *dii* value for this trait. However, none of the hybrids were negatively and significantly heterotic over check hybrid Lara except P_2 x P_5. The parents P_2 and P_6 proved their potential either male as well as female parent and P_5 as male parent in hybrid combinations for expressing high heterotic values with the lowest titrable acidity and supporting evidences for results of the present study were available from the earlier studies of (17).

Lycopene is yet another antioxidant present in cherry tomato fruits. Lycopene comprises 90-95 per cent of the total pigments present in cherry tomato. Presence of more quantity of lycopene is useful to get better colour of finished products. Evaluation of fifty-six cherry tomato hybrids revealed that positive and significant heterosis over mid parent (*di*) was recorded in ten hybrids with highest value in the hybrid P_3 x P_2 (40.19 per cent). The heterobeltiosis (*dii*) for lycopene was the highest in the hybrid P_3 x P_2 (39.97 per cent) followed by P_3 x P_1 (11.96 per cent) and P_2 x P_3 (8.25 per cent). The highest positive and significant standard heterosis (*diii*) was noted in the hybrid P_5 x P_4 over standard check Lara (16.11 per cent) for this qualitative trait (Table-3). The hybrids P_3 x P_2, P_3 x P_1, P_5 x P_4, P_2 x P_5 and P_4 x P_6 exhibited superior and significant heterosis over mid parent and check hybrid Lara whereas, only four hybrids *viz*., P_3 x P_2, P_3 x P_1, P_2 x P_3 and P_5 x P_4 recorded superior and significant heterosis over better parent. Parent P_3 and P_2 proved their high potential either male as well as female parent in hybrid combinations for expressing highheterotic values with high lycopene. These findings were in agreement with the findings of (13). The relative heterosis (*di*) for total carotenoids of fifty-six cherry tomato hybrids ranged from -52.33 per cent (P_5 x P_6) to 34.44 per cent (P_3 x P_2) and eleven hybrids had positive and significant values for this trait. The hybrids P_3 x P_2, P_3 x P_4, P_3 x P_1, P_5 x P_3 and P_4 x P_3 exhibited superior and significant heterosis over mid parent whereas, the hybrids P_3 x P_2, P_3 x P_4, P_4 x P_3 and P_2 x P_4 recorded superior and significant heterosis over better parent. The hybrids P_5 x P_1, P_5 x P_3, P_4 x P_5 and P_4 x P_6 were positively and significantly heterotic over check hybrid Lara. Parent P_3 proved its high potential either male as well as female parent in hybrid combinations for expressing high heterotic values with high total carotenoids. These results were in corroboration with findings of (18). The hybrids P_3 x P_2, P_3 x P_4, P_3 x P_1 and P_5 x P_3 exhibited superior and significant heterosis over mid parent for total antioxidant whereas, only three hybrids *viz*., P_3 x P_2, P_3 x P_4 and P_4 x P_2 recorded superior and significant heterosis over better parent. Heterosis over check hybrid Lara was higher in only three hybrids *viz*., P_5 x P_1, P_5 x P_3 andP_4 x P_5 for this trait. Parent P_3 and P_4 proved their high potential either male as well as female parent in hybrid combinations for expressing high heterotic values with high total antioxidant.

Conclusions

It can be concluded that based on heterotic values of cherry tomato hybridsP_3 x P_2 (LE 1223 x LE 87), P_2 x P_5 (LE 87 x IIHR 2753) and P_7 x P_5 (Pant Cherry Tomato 1 x IIHR 2753) have been adjudged as the best F_1 cross combinations in the present investigation. These crosses may be exploited for the development of superior hybrids of cherry tomato. The crosses, which exhibited significant heterosis can be consider superior combinations among the 56 crosses studied for fruit quality and can be utilized for commercial exploitation and determining the strategies for future cherry tomato varieties/hybrids development.

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