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Heterosis breeding in pumpkin (*Cucurbita moschata* Duch. *ex* poir.) for small size, thick flesh with high yield and β-carotene

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Abstract
Heterosis breeding can be used to achieve improvement in quantity, quality, and productivity of pumpkin (*Cucurbita moschata* Duch. *ex* Poir.). A Line x Tester mating design was used to study standard heterosis for small size, thick flesh, beta carotene, yield and yield-related characters in pumpkin during 2016-2017. Eighteen hybrids, developed by crossing six lines with three testers and a commercial check, 'Arjuna', were evaluated for small size, thick flesh, β carotene, yield and yield related characters and indicated presence of heterotic vigor. The hybrid 'Ambili' x 'Pusa Viswas' had highest negative standard heterosis for the fruit weight followed by 'Saras x CO 2'. Heterosis for days to appearance of the first female flower, flesh thickness, crude fibre and fruit yield per vine was in the desired direction in 'Odisha Local' x 'Pusa Viswas'. Estimates of standard heterosis for fruit yield indicated that hybrid 'Rajasthan Local' x 'Pusa Viswas' had the highest positive value followed by hybrid 'Ambili' x 'Pusa Viswas'. These hybrids had high heterosis for most component traits and can be used for exploitation of heterosis and released as promising hybrids after multi-location testing.

Keywords: standard heterosis, beta carotene, pumpkin, small size

Introduction
Heterosis is a genetic phenomenon and refers to expression of increased or decreased hybrid vigor over the mid-parent (relative heterosis), better parent (heterobeltiosis) and the standard parent (Standard heterosis) in plant breeding. Hybridization to exploit heterosis commercially or for selection of promising recombinants in subsequent generations is the prime objective of heterosis breeding. Heterosis in cross-pollinated crops has the potential to increase yield. Superior recombinants identified in subsequent generations could be evaluated for commercial exploitation as cucurbits do not show inbreeding depression. The search for development of a quick and convenient way of combining desirable characters has assumed greater significance in production of F_1 hybrids in pumpkin (*Cucurbita moschata* Duch. ex Poir.). However, commercial usefulness of a hybrid would depend on its performance compared to the best commercial variety available. The monoecious character, conspicuous and solitary flowers, large seed number per fruit and wide variability for yield, size, and shape of fruit make pumpkin useful for commercial breeding. Though several high-yielding varieties have been developed, the best potential can be achieved by developing hybrids with high yield and superior quality. A wide range of variability in vegetative and fruit characters is available in genotypes. However, little attention has been paid to its genetic improvement. Hybrid vigor can be substantially increased by crossing genetically diverse inbreds and heterosis obtained from genetic diversity among parents [9]. Previous research on pumpkin heterosis by Mohanty [5], Sirohi and Ghorui [12] and Mohanty and Prusti [6], with different parents and hybrids, has determined effects only on yield characters. In pumpkin the major problem is large-sized fruit (4-5 kg), which is not preferred by some consumers. Medium-sized whole pumpkin is preferred over cut pieces. Small fruit can be packed and transported without damage. Development of pumpkin hybrids with small to medium-sized fruit (1-1.5 kg) is necessary. The possibility of controlling fruit size can strengthen heterosis breeding with available combinations of parents. Line x Tester analysis helps in selection of desirable parents and appropriate breeding procedures by measuring general combining ability (GCA), specific combining ability (SCA) variances, and their effects and the genetic components of variance [11]. The concept of combining ability helps the breeder to determine

the nature of gene action involved in the expression of quantitative traits of economic importance. This study was undertaken using new parental combinations to obtain hybrids with small to medium-sized fruit with higher yield and improved fruit quality.

Materials and Methods

The investigation was carried out at Department of Vegetable Crops, Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, during 2016-17, with eighteen F_1 hybrids (obtained by crossing six lines and three testers through line x tester mating design) along with the standard check, 'Arjuna' from East West Seeds (P) Ltd. Field experiments with the hybrids were laid out in Randomized Block Design with two replications and five plants per replication at a spacing of 1.5 x 2.0 m^2. Recommended package of practices of TNAU was followed to grow a successful crop of pumpkin [1]. Observations were recorded in five randomly selected plants in each replication on important quantitative traits, viz., vine length (m), days to first female flower appearance, node number for first female flower appearance, sex ratio, days to first harvest, fruit number per vine, fruit weight (kg), flesh thickness (cm) and fruit yield per vine (kg) besides quality traits such as ascorbic acid content (mg/l00g), beta carotene content (µg/g) and crude fibre content of the fruit (%). Statistical analysis of data was done to estimate *per se* values and degree of significance of various traits [8]. Standard heterosis in F_1 hybrids was estimated for each trait based on the mean values.

Result and Discussion

There were differences between parents and hybrids for all traits which indicating the presence of standard heterosis presented in Table 1. *Per se* performance of parents indicated that the line 'Odisha Local' was best because it expressed good performance for days to first flower appearance, number of fruits per vine, flesh thickness, number of seeds per fruit, ascorbic acid, crude fibre, beta carotene and fruit yield per vine presented in Table 2. The line 'Rajasthan Local' had good performance for fruit yield per vine, fruits number per vine, flesh thickness, days to first harvest, sex ratio, days to first female flower appearance and quality traits ascorbic acid and beta carotene content.

Among testers, 'Pusa Viswas' had superior average performance for node number for first female flower appearance, fruit yield per vine, flesh thickness and the quality characters ascorbic acid, crude fibre and beta carotene. Tester 'CO 2' also exhibited superiority for days to first female flower appearance, sex ratio, number of fruits per vine, less fruit weight, number of seeds per fruit, seed weight per fruit and fruit yield per vine.

Heterotic vigour over the standard parent (CO 2) was exhibited in hybrids for days to first female flower appearance, fruit weight, flesh thickness, fruit yield per vine and beta carotene content presented in Table 3,4,5. These characters can be used to identify high quality hybrids. The heterosis over the standard parent for beta carotene was highest among all traits followed by fruit yield per vine. Among 18 hybrids, fourteen hybrids expressed significant positive standard heterosis for fruit yield per vine, twelve hybrids for beta carotene, fourteen hybrids for number of fruits per vine, seven hybrids for flesh thickness and only one hybrid for fruit weight. Lowest negative significant standard heterosis was observed for fruit weight in cross L_2 X T_2 (-64.97 %) which indicate that this hybrid may be selected for small size fruit in pumpkin. Earliness is an important trait which contribute in the positive direction of development of commercially important hybrid [14]. In pumpkin, days for first female flower appearance and node for first female flower appearance are indices of earliness. Among seed parents, CO1 was earliest followed by Odisha Local and CO 2 among pollen parents for days to first female flower appearance. 'Ambili' was good seed parent for node number at which first female flower appear followed by Mysore Local. Among pollen parents Pusa Viswas was good for same traits followed by CO 2. Among hybrids, L_5 x T_1 was best followed by L_4 x T_2 since standard heterosis was in a desirable direction for days to first female flower appearance. Similar results were obtained by Arun Kumar and Sirohi [2] in bottle gourd. Negative standard heterosis for node number for first female flower appearance was exhibited by L_6 x T_3 followed by L_4 x T_2 and L_6 x T_1 since negative significant standard heterosis for earlier node is favorable in the direction of earliness of the fruit maturity.

Knowledge on extent of sex ratio of gourds provides an idea of the ability of the crop to set fruit which is an important contributing factor to early yield. A lower sex ratio is favorable. Negative and significant heterosis over the standard parent was exhibited by the hybrid L_4 x T_3 followed by L_2 x T_1 and L_4 x T_1 for this trait. All eighteen hybrids had negative significant standard hetrosis for this trait. Similar results were reported by Karuppiah *et al.* [3] in LA-4 genotype of ridge gourd. Earliness, in terms of days to first harvest was favorable in hybrids L_5 x T_1 followed by L_4 x T_1.

Fruit number per vine is a direct contributor to yield and its heterosis contribute towards total yield. The hybrid 'L_2 x T_2' followed by L_3 x T_2 and L_5 x T_2 had higher positive significant standard heterosis for fruit number per vine. Similar findings were observed by Tamil Selvi *et al.* [13] in pumpkin. Consumer preference is for small to medium - sized fruit. Among hybrids, L_2 x T_2 followed by L_3 x T_3 and L_1 x T_1 can be selected for small size fruit since these hybrids had highest negative standard heterosis which is in direction of desirable trait by consumers. Similar results were obtained by Vidya *et al.* [15] in pumpkin. Higher flesh thickness of fruit is a desirable quality trait. The positive significant standard heterosis exhibited by hybrids L_4 x T_2 followed by L_4 x T_3 and L_5 x T_3 which favours increased flesh thickness. Seven hybrids expressed significant positive standard heterosis for this trait. Similar results were obtained by Vidya *et al.* [15] in pumpkin.

Quality parameters are very important factors in hybrid development. In pumpkin ascorbic acid and beta carotene are quality factors. Estimates of standard heterosis for ascorbic acid were positive and significant in L_5 x T_2 followed by L_4 x T_2 and L_5 x T_3. The hybrids L_3 x T_2 followed by L_1 x T_1 and L_1 x T_2 has positive significant standard heterosis for beta carotene content. Similar results were obtained by Pandey *et al.* [7] in pumpkin. Hybrids L_5 x T_2 followed by L_2 x T_2 and L_4 x T_2 had higher positive and significant standard heterosis over the standard parent for fruit yield per vine. Fifteen hybrids had positive significant values for standard heterosis fro fruit yield. Similar results were observed by Kushawa and Hari Har Ram [4] and Singh and Rajesh Kumar [10] in bottle gourd.

The performance of parents and hybrids combinations was supported by average values. Higher values in hybrids for fruit yield could be attributed to high heterosis for beta carotene and fruit number per vine. Evaluation of hybrids based on average and standard heterosis indicated that L_5 x T_2

was adjusted as the best hybrid since it recorded the highest mean, *sca* and standard heterosis fro traits of study viz., fruit weight and total yield per vine. Ambili x Pusa Viswas (L_2 x T_2) could also be adjusted as the best combination through less days for first female flower appearance, less fruit weight, more fruit number per vine, crude fibre content and fruit yield per vine. Saras x Pusa Viswas could also be adjusted as the best combination for beta carotene, since it recorded highest mean, *sca* and standard heterosis for beta carotene content.

Table 1: Analysis of variance for yield components and quality components of pumpkin genotypes

Source	Df	Mean sum of square																
		Vine length (m)	Days to first female flower appearance	Node number for first female flower appearance	Sex ratio	Days to first harvest	No. of fruit per vine	Fruit weight (kg)	Fruit equ. Diameter (cm)	Fruit polar diameter (cm)	Flesh thickness (cm)	No. of seed/ fruit	Seed wt./ fruit (g)	100 seed wt. (g)	Ascorbic acid content (mg/100 g)	Crude fiber (%)	β carotene (μg/g)	Fruit yield/vine (kg)
Replication	1	0.150	0.054	0.031	0.135	2.910	0.013	0.004	0.095	0.024	0.003	0.698	0.721	0.046	0.005	0.002	0.025	0.008
Genotype	26	28.430*	853.660*	469.050*	63.910*	2013.19*	2704.2*	2.108*	81.960*	48.980*	74.53*	28284.14*	24896.04*	78.140*	11.846*	13.620*	643.04*	49.56*
Error	26	16.730	0.3850	0.0750	0.0437	1.1950	0.2447	0.0014	0.0242	0.0417	0.0152	6.7120	3.0355	0.0297	0.0091	0.0017	0.1595	0.0198

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

Table 2: *Per se* performance of parents for different traits in Pumpkin

Parents	Vine length (m)	Days to first female flower appearance	Node number for first female flower appearence	Sex ratio	Days to first harvest	No. of fruit per vine	Fruit weight (kg)	Fruit equ. Diameter (cm)	Fruit polar diameter (cm)	Flesh thickness (cm)	No. of seed/ fruit	Seed wt./ fruit (g)	100 seed wt. (g)	Ascorbic acid content (mg/100g)	Crude fiber (%)	β carotene (mg/g)	Fruit yield/vine (kg)
L_1	4.62	50.50	7.10	24.59	94.68	3.21	3.50	24.00	14.30	3.00	190.00	19.67	10.35	6.70	1.06	19.68	9.15
L_2	4.28	47.90	5.10	15.99	82.70	4.81	4.20	16.95	18.60	3.19	108.00	8.06	7.46	7.46	1.04	4.70	13.86
L_3	3.03	54.10	8.70	28.16	79.80	1.70	2.30	15.50	21.20	3.00	128.20	17.32	13.51	7.76	1.86	15.77	2.98
L_4	4.58	44.80	11.10	14.22	78.10	5.21	4.90	23.80	13.40	3.90	405.00	25.23	6.23	9.65	2.03	24.57	25.10
L_5	3.59	46.30	14.70	19.32	74.10	4.12	4.20	28.10	17.00	4.60	345.00	23.20	6.73	9.63	1.08	15.34	16.76
L_6	3.32	44.60	9.50	25.19	105.30	2.13	3.60	20.93	23.57	2.37	102.00	12.30	12.06	2.45	1.02	6.81	2.58
Mean	3.90	48.03	9.37	21.25	85.78	3.53	3.78	21.55	18.01	3.34	213.03	17.63	9.39	7.28	1.35	14.48	11.74
T_1	3.28	45.30	7.20	25.65	90.10	2.16	3.20	16.70	11.30	3.10	220.12	21.38	9.71	4.60	0.51	11.38	2.59
T_2	4.52	55.30	6.10	24.39	89.80	2.42	4.00	17.00	21.00	3.30	180.31	17.18	13.18	7.73	1.38	11.59	5.86
T_3	3.78	27.40	6.70	23.11	102.30	3.43	2.22	20.50	9.50	2.41	290.80	28.23	9.70	4.10	1.01	7.73	4.24
Mean	3.86	42.67	6.67	24.38	94.07	2.67	3.14	18.07	13.93	2.94	230.41	22.26	10.86	5.48	0.97	10.23	4.23
SEd	0.052	0.668	0.143	0.221	1.196	0.059	0.038	0.207	0.202	0.037	3.105	0.318	0.098	0.087	0.018	0.416	0.112
CD (0.05)	0.106	1.376	0.294	0.456	2.464	0.121	0.077	0.426	0.416	0.076	6.397	0.655	0.201	0.179	0.037	0.857	0.230

Mysore Local (L_1), Ambili (L_2), Saras (L_3), Odisha Local (L_4), Rajasthan Local (L_5), CO1 (L_6), Punjab Samrat (T_1), Pusa Viswas (T_2), CO2 (T_3)

Table 3: Heterosis per cent for vine length, days to first female flower appearance, node number for first female flower appearance, sex ratio and days to first harvest

Hybrids	Vine length			Days to first female flower appearance			Node number for first female flower appearence			Sex ratio			Days to first harvest		
	MP het	BP het	STD het	MP het	BP het	STD het	MP het	BP het	STD het	MP het	BP het	STD het	MP het	BP het	STD het
L_1 x T_1	14.43 **	-2.16 ns	17.10**	6.68 **	1.19 ns	19.76**	10.49 **	9.72 **	18.44**	-27.31 **	-28.81 **	-25.10**	-2.23 ns	-4.59 **	-3.98**
L_1 x T_2	-23.85 **	-24.68 **	-9.84**	0.95 ns	-3.44 **	25.15**	137.88 **	121.13 **	135.38**	-38.30 **	-38.55 **	-38.02**	6.46 **	3.72 **	4.39**
L_1 x T_3	-7.38 **	-15.80 **	0.78 ns	38.13 **	6.53 **	26.08**	7.25 **	4.23 *	10.94**	-29.98 **	-32.09 **	-31.50**	22.14 **	17.60 **	27.88**
L_2 x T_1	30.69 **	15.42 **	27.98**	10.94 **	7.93 **	21.16**	34.15 **	14.58 **	23.69**	-31.84 **	-44.68 **	-41.80**	14.24 **	9.54 **	4.92**
L_2 x T_2	-2.27 *	-4.87 **	11.40**	-18.22 **	-23.69 **	-1.10 ns	43.39 **	31.64 **	20.39**	-26.50 **	-39.16 **	-39.13**	2.26 ns	-1.78 ns	-6.24**
L_2 x T_3	1.74 ns	-4.21 **	6.22**	14.48 **	-10.02 **	1.01 ns	30.51 **	14.93 **	15.44**	-19.23 **	-31.67 **	-35.23**	3.04 *	-6.83 **	1.32 ns
L_3 x T_1	2.06 ns	-1.83 ns	-16.58**	3.82 **	-4.62 **	20.93**	62.26 **	48.28 **	93.40**	-11.24 **	-15.20 **	-2.05*	11.36 **	4.99 **	0.56 ns
L_3 x T_2	2.25 ns	-14.60 **	0.00 ns	-5.12 **	-6.15 **	21.63**	59.46 **	35.63 **	76.91**	-42.04 **	-45.92 **	-37.53**	4.82 **	-1.01 ns	-5.51**
L_3 x T_3	4.55 **	-5.82 **	-7.77**	24.91 **	-5.91 **	19.29**	66.23 **	47.13 **	91.90**	-16.33 **	-23.83 **	-12.02**	2.30 ns	-8.95 **	-0.99 ns
L_4 x T_1	25.19 **	7.42 **	27.46**	16.98 **	16.34 **	23.51**	33.33 **	9.91 **	82.91**	-28.77 **	-44.64 **	-41.76**	-1.19 ns	-7.77 **	-11.66**
L_4 x T_2	-5.93 **	-6.55 **	10.88**	-4.70 **	-13.74 **	11.79**	-29.07 **	-45.05 **	-8.55**	-23.49 **	-39.44 **	-39.42**	3.51 **	-3.23 *	-7.62**
L_4 x T_3	19.14 **	8.73 **	29.02**	46.26 **	17.86 **	23.74**	67.42 **	34.23 **	123.39**	-28.48 **	-42.23 **	-45.24**	4.88 **	-7.53 **	0.56 ns
L_5 x T_1	13.25 **	8.36 **	0.78 ns	0.00 ns	-1.08 ns	7.34**	-9.59 **	-32.65 **	48.43**	-14.48 **	-25.03 **	-21.12**	0.63 ns	-8.30 **	-12.17**
L_5 x T_2	3.58 **	-7.08 **	8.81 **	-0.98 ns	-9.04 **	17.88**	21.15 **	-14.29 **	88.91**	-33.06 **	-40.02 **	-39.99**	2.27 ns	-6.67 **	-10.91**
L_5 x T_3	10.99 **	8.20 **	5.96**	36.77 **	8.86 **	18.12**	16.82 **	-14.97 **	87.41**	-30.99 **	-36.65 **	-39.95**	8.63 **	-6.34 **	1.85 ns
L_6 x T_1	-1.21 ns	-1.81 ns	-15.54**	17.02 **	16.11 **	23.27**	-25.75 **	-34.74 **	-7.05**	-11.25 **	-12.05 **	-7.47**	0.63 ns	-6.63 **	4.52**
L_6 x T_2	-0.77 ns	-13.94 **	0.78 ns	26.13 **	13.92 **	47.64**	83.33 **	50.53 **	114.39**	-6.74 **	-8.22 **	-5.17**	4.64 **	-3.06 *	8.51**
L_6 x T_3	2.54 ns	-3.70 *	-5.70 **	75.83 **	41.93 **	48.35**	-56.79 **	-63.16 **	-47.53**	-2.11 *	-6.15 **	-3.04**	11.08 **	9.50 **	22.57**
SEd	0.045	0.052	0.052	0.578	0.668	0.668	0.124	0.143	0.143	0.192	0.221	0.221	1.036	1.196	1.196

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

Mysore Local (L_1),Ambili (L_2), Saras (L_3),Odisha Local (L_4), Rajasthan Local (L_5), CO1 (L_6), Punjab Samrat (T_1), Pusa Viswas (T_2), CO2 (T_3)

MP het: Mid parent heterosis BP het: better parent heterosis STD het: Standard heterosis

Table 4: Heterosis per cent for fruit characters

Hybrids	No. of fruit per vine			Fruit weight			Fruit equ. Diameter			Fruit polar diameter			Flesh thickness		
	MP het	BP het	STD het	MP het	BP het	STD het	MP het	BP het	STD het	MP het	BP het	STD het	MP het	BP het	STD het
L_1 x T_1	56.42 **	30.84 **	57.30**	-63.88 **	-65.43 **	-61.46**	-21.38 **	-33.33 **	-11.46**	28.91 **	15.38 **	18.45**	-24.59 **	-25.81 **	-21.77**
L_1 x T_2	70.52 **	49.53 **	79.78**	-54.13 **	-57.00 **	-45.22**	-16.10 **	-28.33 **	-4.81**	-34.84 **	-45.24 **	-17.44**	-33.33 **	-36.36 **	-28.57**
L_1 x T_3	29.52 **	25.36 **	61.05**	-19.23 **	-34.00 **	-26.43**	-21.80 **	-27.50 **	-3.71**	26.05 **	4.90 **	7.68**	18.41 **	6.67 **	8.84**
L_2 x T_1	52.08 **	10.19 **	98.50**	-54.05 **	-59.52 **	-45.86**	-1.93 ns	-2.65 *	-8.69**	-39.80 **	-51.61 **	-35.39**	-20.51 **	-21.63 **	-14.97**
L_2 x T_2	88.11 **	41.37 **	154.68**	-73.17 **	-73.81 **	-64.97**	-8.69 **	-8.82 **	-14.22**	-49.49 **	-52.38 **	-28.21**	-35.29 **	-36.36 **	-28.57**
L_2 x T_3	6.80 **	-8.52 **	64.79**	-22.12 **	-40.48 **	-20.38**	20.16 **	9.76 **	24.52**	-25.98 **	-44.09 **	-25.34**	-3.49 **	-15.36 **	-8.16**
L_3 x T_1	8.81 **	-2.78 ns	-21.35**	-28.73 **	-38.75 **	-37.58**	-11.80 **	-14.97 **	-21.42**	-26.15 **	-43.40 **	-13.85**	1.56 ns	0.00 ns	5.44**
L_3 x T_2	215.53 **	168.60 **	143.45**	-46.03 **	-57.50 **	-45.86**	7.69 **	2.94 *	-3.15**	-33.65 **	-33.96 **	0.50 ns	20.54 **	15.15 **	29.25**
L_3 x T_3	20.86 **	-9.62 **	16.10**	-49.56 **	-50.43 **	-63.69**	-11.11 **	-21.95 **	-11.46**	-18.57 **	-41.04 **	-10.27**	-55.64 **	-60.07 **	-59.18**
L_4 x T_1	41.93 **	0.38 ns	95.88**	-46.67 **	-55.92 **	-31.21**	-4.69 **	-18.91 **	6.81**	-2.83 ns	-10.45 **	-13.85**	-14.29 **	-23.08 **	2.04 ns
L_4 x T_2	33.68 **	-2.11 ns	91.01**	-38.20 **	-43.88 **	-12.42**	0.98 ns	-13.45 **	14.00**	-6.98 **	-23.81 **	14.86**	13.89 **	5.13 **	39.46**
L_4 x T_3	22.69 **	1.73 ns	98.50**	-41.85 **	-57.76 **	-34.08**	-18.28 **	-23.95 **	0.17 ns	-12.66 **	-25.37 **	-28.21**	23.71 **	0.00 ns	32.65**
L_5 x T_1	4.46 *	-20.39 **	22.85**	-48.65 **	-54.76 **	-39.49**	-12.95 **	-30.60 **	7.91**	-11.66 **	-26.47 **	-10.27**	-29.87 **	-41.30 **	-8.16**
L_5 x T_2	80.43 **	43.20 **	120.97**	-20.98 **	-22.86 **	3.18**	-13.53 **	-30.60 **	7.91**	-3.68 **	-12.86 **	31.37**	-21.52 **	-32.61 **	5.44**
L_5 x T_3	35.89 **	24.51 **	92.13**	-35.51 **	-50.71 **	-34.08**	-16.46 **	-27.76 **	12.34**	-13.21 **	-32.35 **	-17.44**	11.35 **	-15.22 **	32.65**
L_6 x T_1	10.02 **	9.26 **	-11.61**	-62.65 **	-64.72 **	-59.55**	-17.62 **	-25.94 **	-14.22**	-52.97 **	-65.21 **	-41.13**	-4.94 **	-16.13 **	-11.56**
L_6 x T_2	-5.05 *	-10.74 **	-19.10**	-59.21 **	-61.25 **	-50.64**	-10.89 **	-19.25 **	-6.47**	-45.25 **	-48.24 **	-12.42**	-25.93 **	-36.36 **	-28.57**
L_6 x T_3	-23.74 **	-38.19 **	-20.60**	-56.70 **	-65.00 **	-59.87**	-23.73 **	-24.51 **	-12.56**	-43.76 **	-60.54 **	-33.24**	-16.23 **	-16.84 **	-31.97**
SEd	0.0507	0.0585	0.0585	0.0325	0.0375	0.0375	0.1789	0.2066	0.2066	0.1749	0.202	0.202	0.0319	0.0368	0.0368

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

Mysore Local (L_1),Ambili (L_2), Saras (L_3),Odisha Local (L_4), Rajasthan Local (L_5), CO1 (L_6), Punjab Samrat (T_1), Pusa Viswas (T_2), CO2 (T_3)

MP het: Mid parent heterosis BP het: better parent heterosis STD het: Standard heterosis

Table 5: Heterosis per cent for quality attributes and fruit yield per vine

Hybrids	Ascorbic acid content			Crude fiber			β carotene			Fruit yield/vine		
	MP het	BP het	STD het	MP het	BP het	STD het	MP het	BP het	STD het	MP het	BP het	STD het
L_1 x T_1	-5.84 **	-20.60 **	-2.92 ns	24.84 **	-7.55 **	1.03 ns	159.63 **	104.88 **	294.13**	23.08 **	-21.04 **	70.69**
L_1 x T_2	-12.68 **	-18.50 **	14.96**	-14.75 **	-24.64 **	7.22**	62.84 **	29.37 **	148.88**	47.82 **	21.20 **	162.17**
L_1 x T_3	-22.22 **	-37.31 **	-23.36**	2.42 ns	0.00 ns	9.28**	78.40 **	24.24 **	139.00**	9.15 **	-20.11 **	72.81**
L_2 x T_1	4.31 **	-15.68 **	14.78**	10.97 **	-17.31 **	-11.34**	54.73 **	9.31 *	21.60**	-29.10 **	-57.92 **	37.83**
L_2 x T_2	-16.52 **	-17.98 **	15.69**	7.44 **	-5.80 **	34.02**	244.51 **	142.11 **	174.29**	42.36 **	1.26 ns	231.68**
L_2 x T_3	-8.13 **	-28.82 **	-3.10*	-8.29 **	-9.62 **	-3.09 ns	180.93 **	125.87 **	70.67**	14.70 **	-25.08 **	145.39**
L_3 x T_1	16.50 **	-7.22 **	31.39**	1.27 ns	-35.48 **	23.71**	4.31 ns	-10.21 **	38.42**	93.35 **	80.84 **	27.19**
L_3 x T_2	7.30 **	7.09 **	51.64**	-10.49 **	-22.04 **	49.48**	554.97 **	468.17 **	775.86**	128.77 **	72.50 **	138.77**
L_3 x T_3	4.55 **	-20.10 **	13.14**	-26.83 **	-43.55 **	8.25**	-18.21 **	-39.06 **	-6.06 ns	-2.08 ns	-16.73 **	-16.55**
L_4 x T_1	-11.58 **	-34.72 **	14.96**	-3.15 *	-39.41 **	26.80**	-85.87 **	-89.66 **	-75.17**	-18.38 **	-54.98 **	167.14**
L_4 x T_2	1.32 ns	-8.76 **	60.58**	9.09 **	-8.37 **	91.75**	-74.61 **	-81.32 **	-55.13**	-20.59 **	-51.04 **	190.54**
L_4 x T_3	-9.82 **	-35.75 **	13.14**	-4.61 **	-28.57 **	49.48**	-66.32 **	-77.86 **	-46.82**	-25.23 **	-56.29 **	159.34**
L_5 x T_1	-17.22 **	-38.84 **	7.48**	5.66 **	-22.22 **	-13.40**	30.61 **	13.75 **	70.58**	-35.54 **	-62.79 **	47.28**
L_5 x T_2	5.99 **	-4.47 **	67.88**	-24.39 **	-32.61 **	-4.12*	20.76 **	6.00 *	58.94**	47.32 **	-0.60 ns	293.62**
L_5 x T_3	26.88 **	-9.55 **	58.94**	3.35 *	0.00 ns	11.34**	75.99 **	32.33 **	98.44**	1.14 ns	-36.62 **	151.06**
L_6 x T_1	-9.22 **	-30.43 **	-41.61**	32.03 **	-0.98 ns	4.12*	132.44 **	85.76 **	106.65**	15.86 **	15.64 **	-29.08**
L_6 x T_2	-5.30 **	-37.65 **	-12.04**	-20.83 **	-31.16 **	-2.06 ns	8.15 *	-14.15 **	-2.74 ns	-20.57 **	-42.78 **	-20.80**
L_6 x T_3	-36.18 **	-49.02 **	-61.86**	-61.58 **	-61.76 **	-59.79**	50.89 **	41.91 **	7.23 ns	-21.76 **	-37.10 **	-36.88**
SEd	0.075	0.087	0.087	0.015	0.018	0.018	0.360	0.416	0.416	0.097	0.112	0.112

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