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Estimation of Heterosis and Specific Combining Ability for Yield, Quality, Pest and Disease Incidence in Eggplant (*Solanum melongena* L.)

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ABSTRACT
Heterosis study is the one method widely utilized for the selection of superior cross combinations. Since the exploitation of heterosis has become commercially feasible and more attention is being paid to study the phenomenon of hybrid vigour in this crop. A study was made to assess the nature and extent of relative heterosis, heterobeltiosis and standard heterosis using forty eggplant hybrids along with their respective parents. Among the 40 hybrids, the hybrid obtained from the cross Alagarkovil Local x Annamalai (L_4xT_1), Palamedu Local x Punjab Sadabahar (L_5xT_3), Palamedu Local x EP 65 (L_5xT_4) and Keerikai Local x KKM 1 (L_7xT_2) were found to be suitable for heterosis breeding. Per se performance of parents revealed that the lines Alavayal local (L_1), Sedapatty local (Green) (L_2) and the tester Annamalai (T_1) were identified as the good parents for further breeding programme to exploit high yield along with low incidence of pest and diseases.
Keywords: *Eggplant, Hybrid vigour, selection*

INTRODUCTION

Eggplant (*Solanum melongena* L.) is an important vegetable of tropical and subtropical regions of the world and has originated in India. In India, its cultivation is scattered all over the country especially in Tamil Nadu, Karnataka, Andra Pradesh, Maharashtra, Rajasthan and Gujarat. Eggplant fruits have high nutritive value and high market demand. Therefore, its cultivation is most lucrative and remunerative. In India, eggplant cultivation is dependent upon the seedling selections from open pollinated varieties and hybrids. Though the eggplant improvement work started as early as 1900s but it took long time to start with concentrated efforts on genetic improvement and still exploration for a better cultivar is going on, as most of the commercial cultivars lack one or the other desirable traits [12]. In the face of increasing population, there is a need for increased production and productivity levels of eggplant. In view of very high local preferences for colour, shape, taste, there are specific genotypes suited for specific locality. It is not possible to have one common cultivar to suit different localities and local preferences. It is therefore required to improve the yield potential of eggplant types through hybridization, may yield good hybrids or hybrid derivatives [15]. However, for the development of effective heterosis breeding programme in eggplant, one need to have the information about genetic architecture and estimated prepotency of parents in hybrid combinations. In India, productivity of eggplant is low as compared to the other eggplant growing countries, owing to use of low yielding cultivars grown for local preference and their susceptibility to pests and diseases [11]. The present production, however, is not proportionate to the country's demand. Therefore, the crop deserves a deep deliberation for improvement. Being a centre of origin, eggplant has a huge genetic divergence in india which offers much scope for improvement through heterosis breeding. The effort could enhance its quality and productivity without sacrificing the consumers choice. The required goals of increasing productivity in the quickest possible time can be achieved only through heterosis breeding which is feasible in this crop [8]. The estimation of heterosis for yield and its component characters would therefore is useful to judge the best hybrid combination for exploitation of superior hybrids. Growth and productivity of eggplant crop is largely hampered by the incidence of shoot and fruit borer in particular and many other pests and diseases (little leaf) in general. Therefore, it is necessary to have the security of crop through inbuilt resistance. Only few reports are available pertaining to the extent of hybrid vigour in eggplant on yield, quality, pest and disease resistance. Hence, the present study was taken up with the following objectives 1) to estimate the magnitude of heterosis in the hybrids 2) to study the specific combining ability effects of hybrids for different traits.

MATERIALS AND METHODS

The experiment was conducted during *kharif* 2010-2011 at College Orchard, Agricultural College and Research Institute, Madurai which is situated at 9°5 latitude and 78°5 longitude and at an elevation of 147 m above MSL. Ten lines were crossed with four testers through Line x Tester mating design to derive the 40 F_1 hybrids. Forty hybrids along with 14 parents were raised in a Randomized Block Design with three replications. Thirty days-old seedlings raised in the nursery beds were transplanted on the ridges adopting a spacing of 60 x 60 cm. Thirty plants were maintained for each hybrid and parent in each replication. Recommended cultural practices were followed uniformly to all the hybrids and parents as per the Tamilnadu Agricultural University Crop Production Guide (2005). Observations were recorded in five randomly selected plants in each replication. The data recorded for nine biometrical traits *viz*., calyx length, fruit pedicel length, shoot borer infestation, fruit borer infestation, little leaf incidence, ascorbic acid content, total phenols content, number of fruits per plant and fruit yield per plant in 14 parents and forty hybrids were used for estimating heterosis. The selections were made in the F_1 hybrids based on fruit shape, colour, size and fruit yield per plant. The superior hybrids were selected and selfed. The seeds were collected from the selfed fruits and stored for further breeding programme. The magnitude of heterosis in hybrids was expressed as percentage of increase or decrease of a character over mid parent (d_i), better parent (d_{ii}) and standard hybrid (d_{iii}) and was estimated following the formula of [6]. The significance of magnitude of the relative heterosis, heterobeltiosis and standard heterosis was tested at error degrees of freedom by the formula as suggested by [17].

Shoot borer infestation (%)

The number of shoots affected by borer and total number of shoots per plant were recorded and the per cent of shoot borer infestation was worked out.

Fruit borer infestation (%)

The numbers of fruits affected by borer and total number of fruits harvested were recorded and the per cent of fruit borer infestation was worked out.

Little leaf incidence (%)

The number of plants affected by little leaf and total number plants available was recorded and the per cent of little leaf incidence was worked out.

Quality traits

Ascorbic acid (mg/100g)

Ascorbic acid content was estimated by volumetric method as suggested by [1]. The dried fruits were powdered and passed through 40 mesh sieve. The powdered sample (1g) was dissolved in 4 per cent oxalic acid, the volume made up to 100 ml and then centrifuged for 30 minutes at 5000 rpm. Supernatant (5 ml) solution was taken out and 100 ml of 4 per cent oxalic acid was added into that and titrated against the dye solution. (Dye solution was prepared by mixing 42 mg of sodium bicarbonate with small volume of distilled water and 52 mg of 2,6 – Dichlorophenol indophenol dissolved in it and the final volume was made up to 200 ml with distilled water). The titre value was V_2 ml. Ascorbic acid (100 ml) was dissolved in 100 ml of 4 per cent oxalic acid and 10 ml of this solution was taken out and diluted to 100 ml with 4 per cent oxalic acid. From this solution, 5 ml was taken out and 10 ml of 4 per cent oxalic acid was added and titrated against the dye solution till the appearance of pink colour. This titre value was V_1 ml. Amount of ascorbic acid (mg100g^{-1}) in the sample was calculated using the following formula,

$$\text{Ascorbic acid} = \frac{0.5\text{mg}}{V_1\text{ml}} \times \frac{V_2\text{ml}}{5\text{ml}} \times \frac{100\text{ml}}{\text{weight of the sample}} \times 100$$

Total phenols (mg/100g)

Folin ciocalteau reagent method was followed for estimating the total phenols [2]. One gram of fruit sample was ground to paste using 10 ml of 80 per cent ethanol. The content was centrifuged for 20 minutes at 10,000 rpm. The supernatant solution (1ml) was taken in a boiling tube and added with one ml of folin ciocalteau reagent and two ml of 20 per cent sodium carbonate. The mixture was heated for exactly one minute on a water bath. After cooling, the volume was made up to 25 ml with distilled water and read in a spectronic-20 colorimeter at 725 nm wavelength against a reagent blank with one ml of distilled water. The standard graph was drawn and the amount of phenol content in each sample was calculated and expressed as $mg100g^{-1}$.

RESULTS AND DISCUSSION

The analysis of variance for nine characters is presented in Table 1. The results revealed that the parents showed significant differences for all the characters. The variance due to the lines were significant for all the traits under study indicating the existence of enormous amount of genetic variability for growth and yield attributes among the lines (females). Similarly, testers (males) exhibited significant difference for all the traits. The interaction between lines x testers was also significant for yield, quality and other traits studied.

Evaluation of parents based on mean might result in identification of different sets of parents as promising ones. [3] Reported that parents with high mean may be able to transmit their superior traits into hybrids and hence they insisted the need for combining ability of parents also. Mean performance of Parents for various traits were given in Table 2 to 6. On the basis of mean values, the line Alavayal Local (L_1) possessed high mean for six characters *viz.,* fruit pedicel length, calyx length, shoot borer infestation, little leaf incidence, ascorbic acid content, total phenols and fruit yield per plant and Sedapatty local (Green) (L_2) which showed significantly high mean values for six traits (fruit pedicel length, calyx length, number of fruits per plant, shoot borer infestation, fruit borer infestation and fruit yield per plant). Among the testers, Annamalai (T_1) was identified as best parent, since it showed high mean for four traits *viz.,* number of fruits per plant, fruit borer infestation, ascorbic acid content and fruit yield per plant. An analysis of *per se* performance of the parents with regard to fruit yield per plant and other desirable traits revealed that production of elite hybrids with the aforesaid parents will led to fixation of heterotic effects through the isolation of high yielding homozygous lines with better quality and lesser incidence of pest and disease in advance generation. [4] also reported the production of hybrids in crosses involving both the parents with high *per se* for yield and its component traits in eggplant. Similarly, 4 [5] inferred crosses involving two good general combiners to be of particular merit in practical eggplant breeding programmes and suggested bi-parental mating among the F_2 progenies for evolving of better genotypes through the combination of desirable attributes. Thus an overview of *per* se performance of parents revealed that the lines Alavayal local (L_1), Sedapatty local (Green) (L_2) and the tester Annamalai (T_1) were identified as the good parents for further breeding programme to exploit high yield along with low incidence of pest and diseases.

Hybridization is the most important method of crop improvement. The basic idea of hybridization is to combine favourable genes present in different parents into a single genotype. The utilization of hybrids thus obtained are utilized in two different ways *viz*., (i) forwarding to further generations and selecting superior segregants and releasing best recombinants after attaining homozygosity and (ii) utilizing the F_1 hybrids commercially with a view to exploit heterosis. The genetic architecture of progenies will be improved by the effective recombination of parents in a cross combination. To get outstanding recombinants in segregating generations, the parents of the hybrids must be good general combiners for the characters to which improvement is sought. In case of hybrids with significant *sca* effects, selection in early segregating generation is likely to fail as the *sca* effects mask the true performance of the selected plants. Therefore, it will be useful to select only those hybrids showing parents with significant *gca* effects and non significant *sca* effects for recombination breeding, since it is likely to throw segregants with favourable genes derived from both the parents [9, 10]. The exploitation of hybrid vigour was judged by the *per se* performance, *sca* effects and standard heterosis of hybrids [13]. Hence, the hybrids obtained by

Line x Tester fashion in the present investigations were evaluated for their suitability for heterosis breeding.

The prime criterion used for the evaluation of hybrids was based on *per se* performance of different characters. The hybrid L_4xT_1 which recorded significantly favourable mean values for the characters *viz.,* number of fruits per plant, shoot borer infestation, fruit borer infestation, little leaf incidence, total phenol content and fruit yield per plant. This was followed by L_7xT_2 exhibited significantly favourable mean performance for yield and quality traits viz., calyx length, number of fruits per plant, fruit borer infestation, total phenols content and fruit yield per plant. Hence, the above said hybrids could be outstanding ones for improving growth, yield and quality traits coupled with lower incidence of pest and diseases.

The second important criterion for the evaluation of hybrids is the *sca* effects. [16] Reported that specific combining ability is due to non additive gene action. The *sca* effect of hybrids has been attributed to the combination of positive favourable genes from different parents or might be due to the presence of linkage in repulsion phase [14]. Hence, selection of hybrids based on *sca* effects would excel in their heterotic effect. Hybrids with significantly favourable *sca* effects in the present investigation are discussed hereunder. In the present study, the hybrid L_3xT_3 excelled with superior *sca* effect for seven characters *viz.,* number of fruits per plant, shoot borer infestation, fruit borer infestation, little leaf incidence, ascorbic acid content, total phenol content and fruit yield per plant. The crosses $L_{10}xT_3$, L_8xT_1, L_6xT_2, L_7xT_3 and L_7xT_2 were the good specific combiners for majority of yield attributing characters including fruit yield.

The third important criteria to assess the hybrids for heterosis breeding was through mid parent (Relative heterosis), better parent (Heterobeltiosis) and standard variety (Standard heterosis). Though, the three bases of heterosis are important, [7] suggested that the heterotic expression over standard variety should alone be given due importance for commercial exploitation of hybrid vigour and hence the crosses, which showed significantly high value of standard heterosis over Annamalai (T_1) for yield and yield components, quality, pest and disease traits have been taken into account in the present discussion. It was interesting to note that none of the hybrids expressed favourable standard heterosis for all the characters. The hybrids L_7 x T_2 registered significant standard heterosis over its parents for calyx length, Total phenol content and fruit yield per plant. Whereas the hybrid and L_6 x T_1 showed better heterosis values for the traits fruit pedicel length, ascorbic acid content and little leaf incidence. For the traits shoot borer infestation and little leaf incidence the hybrid L3 x T_3 can be chosen for lesser incidence of pest and disease. The hybrid L_8 x T_1 recorded superior standard heterosis for fruit borer infestation. From the foregoing, it was clear that above said hybrids are highly suitable for heterosis breeding. The hybrids suitable for heterosis breeding based on *per se* performance, *sca* effects and standard heterosis for individual traits are presented in Table 9. Based on these three criteria, the hybrid L_4xT_1 was suitable for heterosis breeding since it expressed high values for five important characters (number of fruits per plant, shoot borer infestation, little leaf incidence, total phenols content and fruit yield per plant). The hybrids L_5xT_3, L_5xT_4 and L_7xT_2 could be considered as next best as it showed high values under those three criteria for four and three important traits, respectively. As a whole, on perusal of data for hybrids based on *per se* performance, *sca* effects and standard heterosis, the hybrids Alagarkovil Local x Annamalai (L_4xT_1), Palamedu Local x Punjab Sadabahar (L_5xT_3), Palamedu Local x EP 65 (L_5xT_4) and Keerikai Local x KKM 1 (L_7xT_2) were found to be suitable for heterosis breeding.

Table 1. Analysis of variance for parents and hybrids with respect to 9 characters

Source	df	FPL	CL	NF/P	SBI	FBI	LLI	ACC	TPC	FY/P
Hybrids	39	1.4005*	1.0970*	161.9557*	54.4746*	63.3535*	69.4393*	12.9752*	533.5026*	0.6288*
Lines	9	2.1125*	2.5695*	197.8137*	104.8571*	80.0248*	128.8896*	24.3787*	998.8697*	0.9020*
Testers	3	0.4415*	0.5407*	234.2205*	41.9781*	34.1338*	70.4679*	33.1344*	55.7529*	0.4214*
Line x Testers	27	1.2698*	0.6680*	141.9736*	39.0689*	61.0430*	49.5083*	6.9342*	431.4635*	0.5608*
Errors	78	0.0216	0.0424	1.8176	0.9524	2.1378	0.8543	0.1632	4.1422	0.0100

Significant at 5% level; CL – Calyx length (cm); FPL – Fruit pedicel length (cm); NF/P – Number of fruits per plant
SBI – Shoot borer infestation (%); FBI – Fruit borer infestation (%)
LLI – Little leaf incidence (%); ACC – Ascorbic acid content (mg/100g)
TPC – Total phenols content (mg/100g); FY/P – Fruit yield per plant (kg)

Table 2. *Per se* performance and magnitude of heterosis for calyx length and fruit pedicel length in eggplant

Entry	*Per se value*	Calyx length (cm)			*Per se value*	Fruit pedicel length (cm)		
		MP	BP	SV		MP	BP	SV
Alavayal Local	2.45*				5.57*			
Sedapatty Local (Green)	3.45*				6.03*			
Kariapatty Local	3.72*				4.58			
Alagarkovil Local	3.84*				5.42*			
Palamedu Local	4.65				5.11			
Melur Local	4.76				4.76			
Keerikai Local	5.54				4.19			
Nilakottai Local	2.42*				7.04*			
Singampunari Local	3.34*				5.37			
Sedapatty Local (Blue)	3.54*				4.98			
Annamalai	3.96				4.12			
KKM 1	3.28*				3.44			
Punjab Sadabahar	4.41				4.75			
EP 65	3.28*				5.44*			
L_1 X T_1	1.74*	-45.81**	-56.14**	-56.14**	4.40	-9.12**	-20.96**	6.88*
L_1 X T_2	1.88*	-34.34**	-42.62**	-52.53**	4.03	-10.54**	-27.60**	-2.11
L_1 X T_3	2.84	-17.30**	-35.68**	-28.37**	5.35*	3.75	-3.83	30.04**
L_1 X T_4	2.20*	-23.26**	-32.99**	-44.44**	4.38	-20.45**	-21.38**	6.32*
L_2 X T_1	2.02*	-45.50**	-48.99**	-48.99**	3.88	-23.56**	-35.67**	-5.83
L_2 X T_2	2.10*	-37.59**	-39.19**	-46.97**	3.98	-16.02**	-34.02**	-3.40
L_2 X T_3	2.25*	-42.77**	-48.98**	-43.18**	4.10	-23.87**	-31.91**	-0.32
L_2 X T_4	1.74*	-48.34**	-49.61**	-56.06**	4.96*	-13.46**	-17.70**	20.49**
L_3 X T_1	2.20*	-42.71**	-44.44**	-44.44**	4.25	-2.15	-7.06*	3.32
L_3 X T_2	2.52*	-27.97**	-32.26**	-36.36**	4.46	11.22**	-2.55	8.34**
L_3 X T_3	3.14	-22.84**	-28.87**	-20.79**	4.90*	5.04*	3.09	19.03**
L_3 X T_4	3.88	10.80**	4.30	-2.02	6.50*	29.83**	19.56**	57.89**
L_4 X T_1	3.15	-19.18**	-20.37**	-20.37**	4.75	-0.49	-12.48**	15.30**
L_4 X T_2	2.90	-18.54**	-24.54**	-26.77**	4.25	-4.21	-21.70**	3.16
L_4 X T_3	2.48*	-39.90**	-43.76**	-37.37**	4.95*	-2.72	-8.73**	20.24**
L_4 X T_4	3.36	-5.71	-12.58**	-15.15**	5.80*	6.81**	6.68**	40.89**
L_5 X T_1	2.44*	-43.22**	-47.42**	-38.30**	5.00*	8.42**	-2.09	21.46**
L_5 X T_2	2.10*	-46.99**	-54.81**	-46.97**	4.58	7.13**	-10.31**	11.26**
L_5 X T_3	3.76	-17.04**	-19.15**	-5.13	5.05*	2.43	-1.11	22.67**
L_5 X T_4	2.58*	-35.01**	-44.55**	-34.93**	5.53*	4.90*	1.72	34.33**
L_6 X T_1	2.42*	-44.55**	-49.19**	-38.97**	6.00*	35.24**	26.14**	45.75**
L_6 X T_2	3.16	-21.33**	-33.57**	-20.20**	5.58*	36.18**	17.38**	35.63**
L_6 X T_3	3.09	-32.65**	-35.11**	-22.05**	4.43	-6.76**	-6.80*	7.69*
L_6 X T_4	2.26*	-43.78**	-52.49**	-42.93**	4.22	-17.27**	-22.44**	2.43
L_7 X T_1	2.10*	-55.80**	-62.12**	-46.97**	4.00	-3.65	-4.46	-2.83
L_7 X T_2	1.54*	-65.15**	-72.28**	-61.20**	4.44	16.38**	6.05	7.85*
L_7 X T_3	1.56*	-68.65**	-71.86**	-60.61**	3.62	-19.02**	-23.84**	-12.06**
L_7 X T_4	2.32*	-47.43**	-58.15**	-41.41**	3.36	-30.17**	-38.20**	-18.38**
L_8 X T_1	1.76*	-44.93**	-55.64**	-55.64**	4.58	-17.87**	-34.91**	11.26**
L_8 X T_2	1.40*	-50.85**	-57.27**	-64.65**	4.68	-10.69**	-33.49**	13.68**
L_8 X T_3	1.60*	-53.25**	-63.79**	-59.68**	3.42	-41.98**	-51.40**	-16.92**
L_8 X T_4	1.90*	-33.37**	-42.13**	-52.02**	4.30	-31.05**	-38.89**	4.45
L_9 X T_1	2.44*	-33.24**	-38.47**	-38.47**	4.60	-3.02	-14.34**	11.74**
L_9 X T_2	1.92*	-41.96**	-42.51**	-51.52**	4.74	7.56**	-11.73**	15.14**
L_9 X T_3	1.64*	-57.68**	-62.81**	-58.59**	5.74*	13.47**	6.95**	39.51**
L_9 X T_4	2.28*	-31.15**	-31.74**	-42.42**	4.44	-17.83**	-18.33**	7.85*
L_{10} X T_1	2.46*	-34.49**	-37.96**	-37.96**	4.86	6.74**	-2.58	17.98**
L_{10} X T_2	2.42*	-28.90**	-31.54**	-38.80**	4.30	2.14	-13.65**	4.53
L_{10} X T_3	2.52*	-36.52**	-42.78**	-36.28**	5.12*	5.24*	2.81	24.45**
L_{10} X T_4	1.70*	-50.17**	-51.98**	-57.07**	4.50	-13.56**	-17.17**	9.39**
SEd	2.34	0.13	-56.14**		0.12	0.11	0.13	
CD at 5%	4.69				0.23			

Table 3. *Per se* performance and magnitude of heterosis for number of fruits and shoot borer infestation in eggplant

Entry	*Per se value*	Number of fruits per plant			*Per se value*	Shoot borer infestation (%)		
		MP	BP	SV		MP	BP	SV
Alavayal Local	25.89				22.86*			
Sedapatty Local (Green)	33.06*				20.65*			
Kariapatty Local	30.85*				27.31			
Alagarkovil Local	27.43				25.47			
Palamedu Local	23.42				19.34*			
Melur Local	31.49*				22.14*			
Keerikai Local	27.37				21.40*			
Nilakottai Local	25.44				17.89			
Singampunari Local	33.34*				22.66*			
Sedapatty Local (Blue)	25.17				21.58*			
Annamalai	37.92*				26.67			
KKM 1	31.07*				27.87			
Punjab Sadabahar	30.94*				23.09*			
EP 65	26.99				21.68*			
L_1 X T_1	35.60*	11.59**	-6.12	-6.12	22.86*	15.07**	6.85*	6.85*
L_1 X T_2	24.65	-18.23**	-28.35**	-35.00**	20.65*	-14.94**	-22.58**	-19.11**
L_1 X T_3	20.52	-27.76**	-33.66**	-45.88**	27.31	-18.98**	-19.38**	-30.21**
L_1 X T_4	28.04	6.05	3.88	-26.05**	25.47	5.86*	3.14	-11.60**
L_2 X T_1	43.02*	21.22**	13.45**	13.45**	19.34*	12.60**	-0.11	-0.11
L_2 X T_2	26.22	-22.26**	-23.77**	-30.85**	22.14*	38.76**	20.79**	26.21**
L_2 X T_3	36.92*	15.39**	11.69**	-2.63	21.40*	10.89**	5.04	-9.07**
L_2 X T_4	29.97	-0.19	-9.35*	-20.97**	17.89	6.66*	4.12	-15.35**
L_3 X T_1	33.29	-3.11	-12.21**	-12.21**	22.66*	-16.84**	-17.82**	-15.84**
L_3 X T_2	22.30	-31.59**	-35.17**	-41.19**	21.58*	-30.11**	-30.80**	-27.70**
L_3 X T_3	28.10	-8.96*	-9.17*	-25.90**	26.67	-29.55**	-35.00**	-33.43**
L_3 X T_4	19.55	-32.33**	-36.51**	-48.44**	27.87	-8.36**	-17.81**	-15.82**
L_4 X T_1	41.00*	25.47**	8.11*	8.11*	23.09*	-20.62**	-22.41**	-22.41**
L_4 X T_2	43.93*	42.11**	27.72**	15.85**	21.68*	2.67	-1.75	2.66
L_4 X T_3	28.03	-3.96	-9.41*	-26.09**	28.50	32.88**	26.66**	20.96**
L_4 X T_4	32.92	20.98**	20.01**	-13.19**	21.57*	20.88**	11.90**	6.86*
L_5 X T_1	30.19	-1.57	-20.39**	-20.39**	18.61*	10.76**	-4.46	-4.46
L_5 X T_2	44.47*	53.82**	29.29**	17.27**	23.58*	18.54**	0.41	4.91
L_5 X T_3	42.24*	55.41**	36.54**	11.39**	26.64*	20.25**	10.50**	-4.35
L_5 X T_4	43.36*	72.01**	60.63**	14.35**	33.66	16.71**	10.41**	-10.24**
L_6 X T_1	28.60	-17.60**	-24.58**	-24.58**	24.25*	17.62**	7.62**	7.62**
L_6 X T_2	40.00*	21.41**	16.29**	5.49	22.58*	-11.13**	-20.26**	-16.69**
L_6 X T_3	25.46	-18.43**	-19.15**	-32.85**	22.45*	25.20**	22.62**	6.15*
L_6 X T_4	32.84	12.30**	4.28	-13.40**	19.28*	-1.67	-2.68	-19.22**
L_7 X T_1	19.98	-38.82**	-47.32**	-47.32**	17.75*	20.57**	8.66**	8.66**
L_7 X T_2	41.04*	32.84**	19.30**	8.22*	22.45*	17.74**	4.08	8.75**
L_7 X T_3	26.36	-9.61*	-14.79**	-30.49**	20.69*	14.00**	9.83**	-4.92
L_7 X T_4	30.09	10.67*	9.87*	-20.65**	27.38*	14.09**	13.34**	-7.85**
L_8 X T_1	39.52*	24.76**	4.23	4.23	32.26	55.70**	30.07**	30.07**
L_8 X T_2	38.87*	29.92**	13.01**	2.51	28.50	36.59**	12.14**	17.17**
L_8 X T_3	25.61	-9.13*	-17.21**	-32.45**	25.48*	36.27**	20.94**	4.69
L_8 X T_4	41.62*	58.75**	54.19**	9.76**	27.98	20.20**	9.68**	-10.82**
L_9 X T_1	42.96 *	20.58**	13.29**	13.29**	25.51*	5.41*	-2.51	-2.51
L_9 X T_2	36.84*	8.78**	7.10	-2.85	23.94*	36.44**	23.70**	29.25**
L_9 X T_3	21.61	-32.76**	-35.18**	-43.01**	28.70	38.46**	37.18**	18.75**
L_9 X T_4	27.98	-7.24	-16.07**	-26.21**	22.22*	25.93**	23.21**	4.69
L_{10} X T_1	19.63	-37.79**	-48.24**	-48.24**	28.31	12.26**	1.55	1.55
L_{10} X T_2	35.31*	18.55**	2.66	-6.88*	21.54*	21.42**	7.73**	12.56**
L_{10} X T_3	23.14	-17.52**	-25.20**	-38.98**	28.98	29.34**	25.12**	8.31**
L_{10} X T_4	25.56	-2.02	-5.32	-32.60**	29.00	40.75**	40.42**	14.16**
SEd	1.12	1.12	1.30		0.79	0.62	0.72	
CD at 5%	2.22				1.56			

Table 4. *Per se* performance and magnitude of heterosis for fruit borer infestation and little leaf incidence in eggplant

Entry	*Per se value*	Fruit borer infestation (%)			*Per se value*	Little leaf incidence (%)		
		MP	BP	SV		MP	BP	SV
Alavayal Local	33.75*				18.92			
Sedapatty Local (Green)	37.58*				20.74			
Kariapatty Local	38.08*				17.83*			
Alagarkovil Local	40.41				15.58*			
Palamedu Local	35.38*				10.42*			
Melur Local	39.54				24.75			
Keerikai Local	41.29				25.63			
Nilakottai Local	38.42*				16.68*			
Singampunari Local	39.58				12.45*			
Sedapatty Local (Blue)	40.02				13.86*			
Annamalai	38.18*				24.08			
KKM 1	44.57				19.55			
Punjab Sadabahar	42.61				19.76			
EP 65	28.89*				10.05*			
L_1 X T_1	35.17*	-2.22	-7.88**	-7.88**	20.74	34.57**	20.16**	20.16**
L_1 X T_2	37.96*	-3.07	-14.83**	-0.58	17.83*	17.69**	15.79**	-5.97
L_1 X T_3	40.28	5.50*	-5.47*	5.50	15.58*	9.83**	7.51*	-11.78**
L_1 X T_4	35.36*	12.89**	4.76	-7.39*	10.42*	123.82**	71.35**	34.65**
L_2 X T_1	38.48*	1.59	0.79	0.79	24.75	26.01**	17.28**	17.28**
L_2 X T_2	34.29*	-16.53**	-23.07**	-10.20**	25.63	26.31**	22.69**	5.69
L_2 X T_3	35.74*	-10.85**	-16.12**	-6.38*	16.68*	-2.56	-4.87	-18.05**
L_2 X T_4	32.05*	-3.57	-14.72**	-16.06**	12.45*	90.08**	41.10**	21.54**
L_3 X T_1	36.98*	-3.01	-3.14	-3.14	13.86*	7.10*	-6.80*	-6.80*
L_3 X T_2	42.38	2.56	-4.91	11.00**	18.92	16.90**	11.75**	-9.25**
L_3 X T_3	36.47*	-9.60**	-14.41**	-4.48	24.08	-13.60**	-17.82**	-32.56**
L_3 X T_4	39.56*	18.16**	3.90	3.62	19.55	102.65**	58.44**	17.33**
L_4 X T_1	38.82*	-1.22	-3.95	1.67	19.76	-5.57	-22.23**	-22.23**
L_4 X T_2	36.76*	-13.48**	-17.52**	-3.71	10.05*	6.11	-4.67	-22.58**
L_4 X T_3	34.40*	-17.14**	-19.28**	-9.91**	28.93	27.48**	14.00**	-6.45*
L_4 X T_4	32.96*	-4.88	-18.44**	-13.67**	22.64*	63.79**	34.72**	-12.82**
L_5 X T_1	30.33*	-17.54**	-20.56**	-20.56**	21.24*	47.49**	5.65	5.65
L_5 X T_2	36.65*	-8.32**	-17.77**	-4.01	32.42	71.15**	31.16**	6.52*
L_5 X T_3	34.78*	-10.81**	-18.38**	-8.91**	28.24	4.35	-20.31**	-34.61**
L_5 X T_4	45.57	41.81**	28.80**	19.36**	25.45*	80.39**	77.22**	-23.33**
L_6 X T_1	39.98	2.89	1.12	4.71	19.73*	-32.74**	-33.66**	-31.80**
L_6 X T_2	31.28*	-25.62**	-29.82**	-18.07**	29.26	0.53	-10.02**	-7.50*
L_6 X T_3	45.58	10.96**	6.96**	19.37**	22.44*	11.67**	0.40	3.21
L_6 X T_4	34.52*	0.90	-12.69**	-9.59**	21.85*	44.25**	1.41	4.25
L_7 X T_1	38.90*	-2.10	-5.78*	1.89	16.24*	14.89**	11.41**	18.59**
L_7 X T_2	34.62*	-19.36**	-22.33**	-9.33**	28.25	-1.50	-13.17**	-7.57*
L_7 X T_3	36.05*	-14.07**	-15.40**	-5.59	18.72*	37.24**	21.51**	29.35**
L_7 X T_4	35.69*	1.71	-13.56**	-6.52*	18.64*	36.98**	-4.66	1.50
L_8 X T_1	29.58*	-22.76**	-23.01**	-22.52**	22.52*	30.22**	10.22**	10.22**
L_8 X T_2	45.27	9.09**	1.56	18.56**	20.99*	57.59**	46.01**	18.58**
L_8 X T_3	48.86	20.59**	14.67**	27.97**	25.44*	22.13**	12.62**	-7.59*
L_8 X T_4	40.09	19.11**	4.34	5.00	25.65*	140.50**	92.71**	33.50**
L_9 X T_1	44.28	13.88**	11.86**	15.97**	15.74*	66.67**	26.43**	26.43**
L_9 X T_2	40.35	-4.10	-9.47**	5.68	18.46*	65.86**	35.73**	10.23**
L_9 X T_3	45.63	11.03**	7.09**	19.51*	16.42*	77.29**	44.51**	18.58**
L_9 X T_4	40.21	17.45**	1.58	5.32	22.27*	97.78**	78.71**	-7.59*
L_{10} X T_1	36.58*	-6.45*	-8.60**	-4.19	24.85*	53.62**	21.03**	21.03**
L_{10} X T_2	31.28*	-26.04**	-29.82**	-18.07**	25.10*	106.15**	76.13**	43.04**
L_{10} X T_3	34.02*	-17.66**	-20.16**	-10.90**	28.55	57.92**	34.35**	10.25**
L_{10} X T_4	35.82*	3.97	-10.49**	-6.17*	22.25*	166.75**	130.09**	32.45**
SEd	1.19	0.99	1.14		0.75	0.61	0.71	
CD at 5%	2.36				1.49			

Table 5. *Per se* performance and magnitude of heterosis for ascorbic acid and total phenol content in eggplant

Entry	*Per se value*	Ascorbic acid (mg/100g)			*Per se value*	Total phenol content (mg/100g)		
		MP	BP	SV		MP	BP	SV
Alavayal Local	13.37*				67.28*			
Sedapatty Local (Green)	12.03				51.77			
Kariapatty Local	12.86*				50.54			
Alagarkovil Local	13.34*				46.04			
Palamedu Local	11.23				58.36			
Melur Local	13.58*				82.62*			
Keerikai Local	12.13				61.47*			
Nilakottai Local	13.55*				40.37			
Singampunari Local	10.58				72.23*			
Sedapatty Local (Blue)	9.88				48.28			
Annamalai	14.65*				77.27*			
KKM 1	12.49				45.33			
Punjab Sadabahar	13.83*				29.46			
EP 65	13.87*				56.05*			
L_1 X T_1	16.47*	17.54**	12.42**	12.42**	67.28*	1.90	-4.68*	-4.68*
L_1 X T_2	15.42*	19.25**	15.33**	5.28*	51.77	24.77**	4.41	-9.08**
L_1 X T_3	16.74*	23.11**	21.09**	14.29**	50.54	53.20**	10.14**	-4.09*
L_1 X T_4	14.15*	3.90	2.04	-3.39	46.04	17.15**	7.37**	-6.51**
L_2 X T_1	13.61*	2.02	-7.10**	-7.10**	58.36	-4.83*	-20.53**	-20.53**
L_2 X T_2	13.95*	13.77**	11.66**	-4.78*	82.62*	89.64**	77.84**	19.16**
L_2 X T_3	12.48	-3.47	-9.74**	-14.81**	61.47*	109.36**	64.25**	10.05**
L_2 X T_4	12.53	-3.24	-9.66**	-14.47**	40.37	-1.82	-5.57*	-31.50**
L_3 X T_1	14.47*	5.21**	-1.23	-1.23	72.23*	38.20**	14.29**	14.29**
L_3 X T_2	11.22	-11.48**	-12.73**	-23.41**	48.28	46.87**	39.30**	-8.89**
L_3 X T_3	14.33*	7.43**	3.66	-2.16	77.27*	114.19**	69.53**	10.88**
L_3 X T_4	13.18	-1.35	-4.95*	-10.01**	45.33	37.77**	31.00**	-4.97*
L_4 X T_1	12.74	-8.99**	-13.06**	-13.06**	29.46	46.10**	16.58**	16.58**
L_4 X T_2	13.95*	8.00**	4.57	-4.78*	56.05*	89.84**	88.37**	12.25**
L_4 X T_3	12.22	-10.04**	-11.62**	-16.59**	73.65	113.90**	75.38**	4.51*
L_4 X T_4	10.62	-21.94**	-23.43**	-27.51**	70.25	73.06**	57.61**	14.33**
L_5 X T_1	15.57*	20.32**	6.28**	6.28**	74.11	0.97	-11.42**	-11.42**
L_5 X T_2	11.56	-2.52	-7.44**	-21.07**	72.24	60.69**	42.81**	7.76**
L_5 X T_3	11.60	-7.38**	-16.08**	-20.80**	61.40	61.65**	21.66**	-8.20**
L_5 X T_4	10.61	-15.46**	-23.50**	-27.58**	92.07*	57.41**	54.37**	16.48**
L_6 X T_1	16.46*	16.59**	12.33**	12.33**	85.03*	-17.02**	-19.70**	-14.15**
L_6 X T_2	11.40	-12.53**	-16.03**	-22.16**	52.93	32.21**	2.38	9.45**
L_6 X T_3	11.78	-14.04**	-14.80**	-19.59**	88.31*	52.03**	3.13	10.25**
L_6 X T_4	10.87	-20.80**	-21.63**	-25.80**	70.40	40.54**	17.95**	26.10**
L_7 X T_1	14.12*	5.45**	-3.62	-3.62	85.67*	43.34**	28.68**	28.68**
L_7 X T_2	11.27	-8.46**	-9.79**	-23.07**	73.42	89.49**	64.62**	30.96**
L_7 X T_3	15.28*	17.73**	10.51**	4.30*	90.08*	85.09**	36.90**	8.91**
L_7 X T_4	11.27	-13.31**	-18.75**	-23.07**	86.73*	67.46**	60.08**	27.35**
L_8 X T_1	10.31	-26.86**	-29.60**	-29.60**	80.75*	17.81**	-10.31**	-10.31**
L_8 X T_2	14.18*	8.90**	4.65*	-3.21	88.34*	36.35**	28.89**	-24.38**
L_8 X T_3	10.62	-22.39**	-23.17**	-27.49**	68.44	103.00**	75.56**	-8.27**
L_8 X T_4	9.77	-28.74**	-29.56**	-33.31**	83.26*	39.43**	19.93**	-13.00**
L_9 X T_1	16.00*	26.83**	9.22**	9.22**	70.93	-26.42**	-28.81**	-28.81**
L_9 X T_2	14.23*	23.35**	13.90**	-2.87	90.00*	6.03**	-13.71**	-19.34**
L_9 X T_3	14.47*	18.60**	4.68*	-1.21	66.33	26.99**	-10.61**	-16.44**
L_9 X T_4	10.52	-13.92**	-24.13**	-28.17**	84.57*	35.94**	20.71**	12.84**
L_{10} X T_1	9.63	-21.46**	-34.24**	-34.24**	85.19*	56.75**	27.35**	27.35**
L_{10} X T_2	10.02	-10.43**	-19.80**	-31.60**	97.43*	48.06**	43.54**	-10.31**
L_{10} X T_3	11.50	-2.98	-16.83**	-21.50**	99.43*	50.33**	21.03**	-24.37**
L_{10} X T_4	10.61	-10.62**	-23.48**	-27.55**	101.19*	24.30**	15.69**	-16.08**
SEd	0.32							
CD at 5%	0.65				3.29			

Table 6. *Per se* performance and magnitude of heterosis for fruit yield per plant in eggplant

Entry	*Per se value*	Fruit yield per plant (kg)		
		MP	BP	SV
Alavayal Local	1.72*			
Sedapatty Local (Green)	1.86*			
Kariapatty Local	1.27			
Alagarkovil Local	1.26			
Palamedu Local	1.91*			
Melur Local	1.75*			
Keerikai Local	1.79*			
Nilakottai Local	1.27			
Singampunari Local	1.16			
Sedapatty Local (Blue)	1.37			
Annamalai	2.12*			
KKM 1	1.46			
Punjab Sadabahar	1.56			
EP 65	1.36			
L_1 X T_1	2.47*	28.65**	16.33**	16.33**
L_1 X T_2	1.35	-15.13**	-21.55**	-36.58**
L_1 X T_3	1.35	-17.60**	-21.36**	-36.42**
L_1 X T_4	1.45	-5.42	-15.34**	-31.55**
L_2 X T_1	2.07*	3.77	-2.67	-2.67
L_2 X T_2	1.42	-14.17**	-23.48**	-32.97**
L_2 X T_3	2.14*	24.95**	14.87**	0.63
L_2 X T_4	1.56	-2.80	-15.95**	-26.37**
L_3 X T_1	1.45	-14.45**	-31.71**	-31.71**
L_3 X T_2	0.99	-27.05**	-31.81**	-53.22**
L_3 X T_3	1.74	23.11**	11.54*	-18.05**
L_3 X T_4	0.93	-29.35**	-31.70**	-56.36**
L_4 X T_1	2.40*	41.73**	13.03**	13.03**
L_4 X T_2	2.32*	70.34**	59.04**	9.11*
L_4 X T_3	1.49	5.79	-4.27	-29.67**
L_4 X T_4	1.92*	46.31**	41.28**	-9.73*
L_5 X T_1	1.71	-15.44**	-19.62**	-19.62**
L_5 X T_2	2.34*	38.87**	22.30**	10.20**
L_5 X T_3	2.36*	36.08**	23.52**	11.30**
L_5 X T_4	2.21*	35.17**	15.51**	4.08
L_6 X T_1	1.48	-23.65**	-30.30**	-30.30**
L_6 X T_2	2.24*	39.56**	27.76**	5.49
L_6 X T_3	1.35	-18.31**	-22.81**	-36.26**
L_6 X T_4	1.68	7.82	-4.37	-21.04**
L_7 X T_1	1.13	-42.25**	-46.78**	-46.78**
L_7 X T_2	2.85*	75.36**	59.03**	34.07**
L_7 X T_3	1.43	-14.43**	-19.93**	-32.50**
L_7 X T_4	1.74	10.38*	-2.98	-18.21**
L_8 X T_1	2.26*	33.14**	6.28	6.28
L_8 X T_2	1.66	21.91**	13.96*	-21.82**
L_8 X T_3	1.04	-26.18**	-33.12**	-50.86**
L_8 X T_4	2.06*	57.31**	52.09**	-2.83
L_9 X T_1	2.29*	39.15**	7.69*	7.69*
L_9 X T_2	1.73	31.81**	18.54**	-18.68**
L_9 X T_3	1.22	-10.40*	-21.79**	-42.54**
L_9 X T_4	1.42	12.43*	4.42	-33.28**
L_{10} X T_1	1.12	-35.82**	-47.25**	-47.25**
L_{10} X T_2	1.85	30.81**	26.77**	-13.03**
L_{10} X T_3	1.43	-2.51	-8.55	-32.81**
L_{10} X T_4	1.45	6.73	6.34	-31.55**
SEd	0.07	0.07	0.08	
CD at 5%	0.15			

Table 7. The range of heterosis (per cent) by forty hybrids over mid parent, better parent and standard variety

Characters	Mid parent	Better parent	Standard variety	Combinations
Fruit pedicel length (cm)	-41.98 to 36.18	-51.40 to 26.14	-18.38 to 57.89	The extent of heterosis over MP ranged between -41.98 (L_8 x T_3) and 36.18 (L_6 x T_2) per cent. Out of 40 hybrids thirty had significant heterosis over MP of which 14 hybrids showed significant positive heterosis. Of the 40 hybrids, nine exhibited non-significant heterosis over BP. The magnitude of heterosis over BP varied from -51.40 (L_8 x T_3) to 26.14 (L_6 x T_1) per cent. Five hybrids showed significantly positive heterosis and 25 hybrids had significant negative heterosis over better parent. The heterosis over SV ranged from -18.38 (L_7 x T_4) to 57.89 (L_3 x T_4) per cent. In twenty six hybrids there was positive significant commercial heterosis over standard variety. Ten hybrids exhibited non significant heterosis and three hybrids showed significant negative heterosis (L_7 x T_3, L_7 x T_4 and L_8 x T_3).
Calyx length (cm)	-68.65 to 10.80	-72.28 to 4.30	-2.02 to -64.65	A range of relative heterosis was measured with the least value in L_7 x T_3 (-68.65 per cent) and while it was highest in L_3 x T_4 (10.80 per cent). Thirty nine crosses showed negative significant MP values. The BP values ranged from -72.28 (L_7 x T_2) to 4.30 (L_3 x T_4) per cent. Out of forty thirty nine crosses exhibited negative significant heterobeltiosis. The standard heterosis was negative and significant in all the hybrids except L_5 x T_3 which had the non significant negative heterosis over standard variety
Number of fruits per plant	-38.82 to 72.01	-48.24 to 60.63	-48.44 to 17.27	Heterosis over MP ranged from -38.82 (L_7 x T_1) to 72.01 per cent (L_5 x T_4). Nineteen crosses exhibited positive heterosis in desirable direction *viz.,* L_1 x T_1, L_2 x T_1, L_2 x T_3, L_4 x T_1, L_4 x T_2, L_4 x T_4, L_5 x T_2, L_5 x T_3, L_5 x T_4, L_6 x T_2, L_6 x T_4, L_7 x T_2, L_7 x T_4, L_8 x T_1, L_8 x T_2, L_8 x T_4, L_9 x T_1, L_9 x T_2 and L_{10} x T_2 over MP. Expression of heterosis over BP in positive direction was observed in fourteen crosses. Heterosis in F1s over their respective better parent value ranged from -48.24 (L_{10} x T_1) to 60.63 per cent (L_5 x T_4). Significant heterosis over commercial check was recorded in 33 hybrids with nine recording positive and 23 had negative heterosis. Per cent heterosis over commercial check ranged from -48.44 per cent (L_3 x T_4) to 17.27 per cent (L_5 x T_2)
Shoot borer infestation (%)	-30.11- to 40.42	-35.00 to 40.42	-33.43 to 30.07	The lowest negative heterosis as MP was recorded in L_3 x T_2 (-30.11 per cent). A total of eight hybrids showed significant negative relative heterosis. Heterobeltiosis ranged from –35.00 (L_3 x T_3) to 40.42 (L_{10} x T_4) per cent. Out of 40 eight hybrids showed significant negative heterosis over better parent. The magnitude of heterosis over standard variety was in the range of -33.43 (L_3 x T_3) to 30.07 (L_8 x T_1) per cent. Fifteen hybrids exhibited significant negative heterosis in desirable direction.
Fruit borer infestation (%)	26.04 to 41.81	-29.82 to 28.80	-22.52 to 27.97	The negative significant mid parent values were registered in fourteen hybrids. The highest significant negative value of -26.04 per cent was measured by the cross L_{10} x T_2. Whereas the lowest value of 5.50 per cent was registered by L_1 x T_3. The negative heterobeltiosis estimates were significant in twenty five hybrids. The highest significant negative standard heterosis was measured by the hybrid L_8 x T_1 (-22.52 per cent). Totally seventeen hybrids showed significant negative heterosis and seven exhibited significant positive heterosis over standard variety
Little leaf incidence	-33.66 to	-32.74 to	-34.61 to	Negative heterosis is a welcoming feature for this trait.

(%)	130.09	166.75	43.04	The highest significant negative heterosis was recorded by the single cross L_6 x T_1 over mid parent (-32.74 per cent) and better parent (-33.66 per cent). Of 40 hybrids, 2, 7 and 16 hybrids manifested significant negative heterosis over mid parent, better parent and standard check, respectively. The magnitude of heterosis over better parent ranged from -33.66 (L_6 x T_1) to 130.09 (L_{10} x T_4) per cent. Whereas, it range between -32.74 per cent (L_6 x T_1) and 166.75 (L_{10} x T_4) per cent, -34.61 (L_5 x T_3) and 43.04 (L_{10} x T_2) per cent over mid parent and standard check respectively
Ascorbic acid content (mg/100g)	-28.74 to 26.83	-34.24 to 21.09	-34.24 to 14.29	In respect of ascorbic acid content, the positive relative heterosis was observed in fifteen hybrids, which ranged from -28.74 (L_8 x T_4) to 26.83 per cent (L_9 x T_1). A total of eleven hybrids showed positive heterobeltiosis. The highest dii value measured was 21.09 per cent (L_1 x T_3). The standard heterosis was the highest in 14.29 (L_1 x T_3) per cent. Seven hybrids registered significant and positive diii.
Total phenols content (mg/100g)	-26.42 to 114.19	-26.42 to 88.37	-31.50 to 30.96	The relative heterosis for this trait ranged from -26.42 to 114.19 per cent. As many as thirty three hybrids showed positive and significant di values with the highest in L_3 x T_3. The heterobeltiosis was highest in L_4 x T_2 (88.37 per cent) and it was lowest in L_9 x T_1 (-28.81 per cent). A total of twenty seven hybrids showed significant and positive dii. Of the 40 hybrids nineteen registered positive and significant diii values with the highest value of 30.96 per cent (L_7 x T_2)
Fruit yield per plant (kg)	-42.25 to 75.36	-47.25 to 59.04	-56.36 to 34.07	An appreciable amount of heterosis in F_1s over MP value was prevalent for the trait. Per cent heterosis of F_1s over MP value ranged from -42.25 (L_7 x T_1) to 75.36 (L_7 x T_2). Among the 40 hybrids, nineteen exhibited significant positive heterosis over MP. The hybrid obtained from the cross L_7 x T_2 (75.36 per cent) registered the highest magnitude of heterosis in positive direction followed by L_4 x T_2 (70.34 per cent), L_8 x T_4 (57.31 per cent) and L_4 x T_4 (46.31 per cent). Most of the crosses involving T_2 as tester parent exhibited significant positive heterosis over MP.

Table 8. Specific combining ability effects of hybrids for different characters

Hybrids	Fruit pedicel length (cm)	Calyx length (cm)	Number of fruits per plant	Shoot borer infestation (%)	Fruit borer infestation (%)	Little leaf incidence (%)	Ascorbic acid content (mg/100g)	Total phenols content (mg/100g)	Fruit yield per plant (kg)
L_1 x T_1	-0.12	-0.36**	6.95**	4.91**	-1.34	2.07**	-0.37	1.57	0.71**
L_1 x T_2	-0.36**	-0.13	-5.98**	-2.78**	1.27	-3.57**	-0.20	-2.65*	-0.46**
L_1 x T_3	0.79**	0.53**	-2.55**	-4.11**	1.50	-3.02**	0.74**	3.09*	-0.13*
L_1 x T_4	-0.31**	-0.04	1.58*	1.98**	-1.43	4.52**	-0.16	-2.01	-0.12*
L_2 x T_1	-0.33**	0.06	7.54**	-0.67	4.02**	2.01**	-0.68**	10.98**	0.16**
L_2 x T_2	-0.11	0.22	-11.26**	5.59**	-0.35	-0.12	0.88**	18.87**	-0.52**
L_2 x T_3	-0.14	0.08	7.02**	-2.19**	-0.99	-3.89**	-0.97**	13.72**	0.51**
L_2 x T_4	0.58**	-0.37**	-3.32**	-2.74**	-2.69**	2.00**	0.77**	-21.61**	-0.15**
L_3 x T_1	-0.76**	-0.66**	6.03**	1.44*	-1.19	-0.31	0.02	9.34**	0.06
L_3 x T_2	-0.42**	-0.26*	-6.94**	-2.49**	4.04**	-0.24	-2.01**	-9.39**	-0.43**
L_3 x T_3	-0.15	0.06	6.42**	-2.39**	-3.97**	-3.91**	0.72 **	7.77**	0.63**
L_3 x T_4	1.32**	0.87**	-5.52**	3.43 **	1.12	4.46**	1.26**	-7.72**	-0.27**
L_4 x T_1	-0.17*	0.25*	3.08**	-7.04 **	3.76**	-2.05**	-0.79**	4.09**	0.26**
L_4 x T_2	-0.54**	0.08	4.03**	-1.11	1.54	-1.48**	1.64**	-0.08	0.14*
L_4 x T_3	-0.00	-0.64**	-4.31**	5.40 **	-2.93**	4.35**	-0.47 *	-4.18**	-0.37**
L_4 x T_4	0.72**	0.31*	-2.81**	2.76 **	-2.37**	-0.82	-0.38	0.18	-0.03
L_5 x T_1	-0.02	-0.20	-11.37**	-0.77	-5.82**	3.56**	2.09**	-9.24**	-0.56**
L_5 x T_2	-0.31**	-0.47**	0.98	0.97	0.32	4.43**	-0.70**	4.76**	0.04
L_5 x T_3	-0.01	0.89**	6.31**	0.13	-3.64**	-3.53**	-1.04**	-5.68**	0.38**
L_5 x T_4	0.34**	-0.22	4.04**	-0.32	9.14**	-4.45**	-0.35	10.16**	0.14*
L_6 x T_1	0.96**	-0.24*	-4.57**	2.99**	2.82**	-6.30**	2.63**	-16.57**	-0.32**
L_6 x T_2	0.67**	0.58**	4.85**	-4.26**	-6.05**	0.21	-1.15**	0.85	0.41**
L_6 x T_3	-0.64**	0.21	-2.13**	3.46 **	6.15**	4.74**	-1.12**	3.35**	-0.16**

L_6 x T_4	-0.99**	-0.55**	1.85*	-2.18**	-2.91**	1.35*	-0.38	12.37**	0.07
L_7 x T_1	0.16	0.29*	-10.8**	1.48 *	3.27**	1.40*	-0.01	4.12**	-0.77**
L_7 x T_2	0.73**	-0.19	8.24**	0.74	-1.19	-4.24**	-1.64**	5.06**	0.91**
L_7 x T_3	-0.25**	-0.46**	1.13	-1.28 *	-1.86*	6.59**	1.99**	-10.10**	-0.18**
L_7 x T_4	-0.64**	0.36**	1.46	-0.94	-0.22	-3.75**	-0.34	0.92	0.04
L_8 x T_1	0.35**	0.16	1.67*	4.76 **	10.69**	-1.39*	-2.05**	3.32**	0.39**
L_8 x T_2	0.58**	-0.11	4.86**	0.55	4.82**	1.28*	3.03**	-8.37**	-0.24**
L_8 x T_3	-0.84**	-0.21	-0.97	-1.15 *	6.32**	-3.07**	-0.91 **	5.97**	-0.54**
L_8 x T_4	-0.09	0.16	-6.66**	-4.16 **	-0.45	3.18**	-0.07	-0.92	0.39**
L_9 x T_1	-0.26**	0.44**	5.95**	-4.54**	2.34**	2.94**	1.05**	-11.79**	0.51**
L_9 x T_2	0.01	0.00	9.17**	3.17**	-1.76*	-0.30	0.50 *	-5.28**	-0.08
L_9 x T_3	0.84**	-0.57**	1.06	2.00 **	1.42	3.65**	0.36	-1.16	-0.27**
L_9 x T_4	-0.59**	0.13	-6.60**	-0.63	-2.00*	-6.29**	-1.90**	18.23**	-0.16**
L_{10} x T_1	0.18*	0.25*	-3.63**	-2.55**	2.83**	-1.92**	-1.95**	26.14**	-0.45**
L_{10} x T_2	-0.25**	0.30*	-7.73**	-0.38	-2.64**	4.04**	-0.35	-3.78**	0.24**
L_{10} x T_3	0.41**	0.10	5.97**	0.12	-2.00*	-1.91**	0.75**	-12.77**	0.14*
L_{10} x T_4	-0.34**	-0.65**	1.37	2.80 **	1.80*	-0.21	1.55**	-9.59**	0.08
SE	0.08	0.11	0.77	0.56	0.84	0.53	0.23	1.17	0.05

Table 9. Hybrids chosen for heterosis breeding

Characters	Mean	*sca* effects	Standard heterosis	Combination of three criteria
Fruit pedicel length (cm)	L_1xT_3, L_2xT_4, L_3xT_3, L_3xT_4, L_4xT_3, L_4xT_4, L_5xT_1, L_5xT_3, L_5xT_4, L_6xT_1, L_6xT_2, L_9xT_3, L_{10}xT_3	L_1xT_3, L_2xT_4, L_3xT_4, L_4xT_4, L_5xT_4, L_6xT_1, L_6xT_2, L_7xT_2, L_8xT_1, L_8xT_2, L_9xT_3, L_{10}xT_1, L_{10}xT_3	L_1xT_1, L_1xT_3, L_1xT_4, L_2xT_4, L_3xT_2, L_3xT_3, L_3xT_4, L_4xT_1, L_4xT_3, L_4xT_4, L_5 xT_1, L_5xT_2, L_5xT_3, L_5xT_4, L_6xT_1, L_6xT_2, L_6xT_3, L_6xT_4, L_8xT_1, L_8xT_2, L_9xT_1, L_9xT_2, L_9xT_3, L_9xT_4, L_{10}xT_1, L_{10}xT_3, L_{10}xT_4	L_1xT_3, L_2xT_4, L_3xT_4, L_4xT_4, L_5xT_4, L_6xT_1, L_6xT_2, L_9xT_3, L_{10}xT_3
Calyx length (cm)	L_1 xT_1, L_1xT_2, L_1xT_4, L_2xT_1, L_2xT_2, L_2xT_3, L_2xT_4, L_3xT_1, L_3xT_2, L_4xT_3, L_5xT_1, L_5xT_2, L_5xT_4, L_6 x T_1, L_6xT_4, L_7 x T_1, L_7 x T_2, L_7 x T_3, L_7 x T_4, L_8xT_1, L_8xT_2, L_8xT_3,L_8xT_4, L_9xT_1, L_9xT_2, L_9xT_3, L_9xT_4, L_{10}xT_1, L_{10}xT_2, L_{10}xT_3, L_{10}xT_4	L_1xT_1, L_2xT_4, L_3xT_1, L_3xT_2, L_4xT_3, L_5xT_2, L_6 x T_1, L_6xT_4, L_7 x T_3, L_9xT_3, L_{10}xT_4	All except L_5xT_3, L_3xT_4	L_1xT_1, L_2xT_4, L_3xT_1, L_3xT_2, L_4xT_3, L_5xT_2, L_6 x T_1, , L_6xT_4, L_7 x T_3, L_9xT_3, L_{10}xT_4,
Number of fruits per plant	L_1xT_1, L_2xT_1, L_2xT_3, L_4xT_1, L_4xT_2, L_5xT_2, L_5xT_3, L_5xT_4, L_6xT_2, L_7xT_2, L_8xT_1, L_8xT_2, L_8xT_4, L_9xT_1, L_9xT_2, L_{10}xT_2	L_1xT_1, L_1xT_4, L_2xT_1, L_2xT_3, L_3xT_3, L_4xT_1, L_4xT_2, L_5xT_3, L_6xT_2, L_6xT_4, L_7xT_2, L_8xT_1, L_8xT_2, L_9xT_1, L_9xT_2, L_{10}xT_3	L_2xT_1, L_4xT_1, L_4xT_2, L_5xT_2, L_5xT_3, L_5xT_4, L_7xT_2, L_8xT_4, L_9xT_1	L_2xT_1, L_4xT_1, L_4xT_2, L_5xT_3, L_7xT_2, L_9xT_1
Shoot borer infestation (%)	L_1xT_2, L_1xT_3, L_1xT_4, L_2xT_1, L_2xT_3, L_2xT_4, L_3xT_1, L_3xT_2, L_3xT_3, L_3xT_4, L_4xT_1, L_4xT_2, L_5xT_1, L_5xT_3, L_5xT_4, L_6xT_2, L_6xT_4, L_7xT_3, L_7xT_4, L_8xT_3, L_8xT_4, L_9xT_1, L_9xT_4, L_{10}xT_1	L_1xT_2, L_1xT_3, L_2xT_3, L_2xT_4, L_3xT_2, L_3xT_3, L_4xT_1, L_6xT_2, L_6xT_4, L_7xT_3, L_8xT_3, L_8xT_4, L_9xT_1, L_{10}xT_1	L_1xT_2, L_1xT_3, L_1xT_4, L_2xT_3, L_2xT_4, L_3xT_1, L_3xT_2, L_3xT_3, L_3xT_4, L_4xT_1, L_5xT_4, L_6xT_2, L_6xT_4, L_7xT_4, L_8xT_4	L_1xT_2, L_1xT_3, L_2xT_3, L_2xT_4, L_3xT_2, L_3xT_3, L_4xT_1, L_6xT_2, L_6xT_4, L_8xT_4
Fruit borer infestation (%)	L_1xT_1, L_1xT_2, L_1xT_4, L_2xT_1, L_2xT_2, L_2xT_3, L_2xT_4, L_3xT_1, L_3xT_3, L_3xT_4, L_4xT_1, L_4xT_2, L_4xT_3, L_4xT_4, L_5xT_1, L_5xT_2, L_5xT_3, L_6xT_2, L_6xT_4, L_7xT_1, L_7xT_2, L_7xT_3, L_7xT_4, L_8xT_1, L_9xT_1, L_{10}xT_1, L_{10}xT_2, L_{10}xT_3, L_{10}xT_4	L_2xT_4, L_3xT_3, L_4xT_3, L_4xT_4, L_5xT_1, L_5xT_3, L_6xT_2, L_6xT_4, L_7xT_3, L_9xT_2, L_9 x T_4, L_{10}xT_2, L_{10}xT_3	L_1xT_1, L_1xT_4, L_2xT_2, L_2xT_3, L_2xT_4, L_4xT_3, L_4xT_4, L_5xT_1, L_5xT_3, L_6xT_2, L_6xT_4, L_7xT_2, L_7xT_4, L_8xT_1, L_{10}xT_2, L_{10}xT_3, L_{10}xT_4	L_2xT_4, L_4xT_3, L_5xT_1, L_5xT_3, L_6xT_2, L_6xT_4, L_{10}xT_2, L_{10}xT_3
Little leaf incidence (%)	L_1xT_2, L_1xT_3, L_2xT_2, L_2xT_3, L_3xT_1, L_3xT_2, L_3xT_3, L_4xT_1, L_4xT_2, L_4xT_3, L_4xT_4, L_5xT_1, L_5xT_2, L_5xT_3, L_5xT_4	L_1xT_2, L_1xT_3, L_2xT_3, L_3xT_3, L_4xT_1, L_4xT_2, L_5xT_3, L_5xT_4, L_6xT_1, L_7xT_2, L_7xT_4, L_8xT_1, L_8xT_3, L_9xT_4, L_{10}xT_1, L_{10}xT_3	L_1xT_3, L_2xT_3, L_3xT_1, L_3xT_2, L_3xT_3, L_4xT_1, L_4xT_2, L_4xT_3, L_4xT_4, L_5xT_3, L_5xT_4, L_6xT_2, L_6xT_1, L_6xT_3, L_7xT_1, L_8xT_3, L_9xT_4	L_1xT_3, L_2xT_3, L_3xT_3, L_4xT_1, L_4xT_2, L_5xT_3, L_5xT_4
Ascorbic acid content (mg/100g)	L_1xT_1, L_1xT_2, L_1xT_3, L_1xT_4, L_2xT_1, L_2xT_2, L_3xT_1, L_3xT_3,	L_1xT_3, L_2xT_2, L_2xT_4, L_3xT_3, L_3xT_4, L_4xT_2,	L_1xT_1, L_1xT_2, L_1xT_3, L_5xT_1, L_6xT_1, L_7xT_3,	L_5xT_1, L_6xT_1, L_7xT_3, L_9xT_1

	L_4xT_2, L_5xT_1, L_6xT_1, L_7xT_1, L_7xT_3, L_8xT_2, L_9xT_1, L_9xT_2, L_9xT_3	L_5xT_1, L_6xT_1, L_7xT_3, L_8xT_2, L_9xT_1, L_9xT_2, $L_{10}xT_3$, $L_{10}xT_4$	L_9xT_1	
Total phenols content (mg/100g)	L_2xT_2, L_2xT_3, L_3xT_1, L_3xT_3, L_4xT_1, L_4xT_3, L_4xT_4, L_5xT_1, L_5xT_4, L_6xT_2, L_6xT_3, L_6xT_4, L_7xT_1, L_7xT_2, L_7xT_3, L_7xT_4, L_9xT_4, $L_{10}xT_1$	L_1xT_3, L_2xT_1, L_2xT_2, L_2xT_3, L_3xT_1, L_3xT_3, L_4xT_1, L_5xT_2, L_5xT_4, L_6xT_3, L_6xT_4, L_7xT_1, L_7xT_2, L_8xT_1, L_8xT_3, L_9xT_4, $L_{10}xT_1$	L_2xT_2, L_2xT_3, L_3xT_1, L_3xT_3, L_4xT_1, L_4xT_2, L_4xT_3, L_4xT_4, L_5xT_2, L_5xT_4, L_6xT_2, L_6xT_3, L_6xT_4, L_7xT_1, L_7xT_2, L_7xT_3, L_7xT_4, L_9xT_4, $L_{10}xT_1$	L_2xT_2, L_2xT_3, L_3xT_1, L_3xT_3, L_4xT_1, L_5xT_4, L_6xT_3, L_6xT_4, L_7xT_1, L_7xT_2, L_9xT_4, $L_{10}xT_1$
Fruit yield per plant (kg)	L_1xT_1, L_2xT_1, L_2xT_3, L_4xT_1, L_4xT_2, L_4xT_4, L_5xT_2, L_5xT_3, L_5xT_4, L_6xT_2, L_7xT_2, L_8xT_1, L_8xT_4, L_9xT_1	L_1xT_1, L_2xT_1, L_2xT_3, L_3xT_3, L_4xT_1, L_4xT_2, L_5xT_3, L_6xT_2, L_7xT_2, L_8xT_1, L_8xT_4, L_9xT_1, $L_{10}xT_2$, $L_{10}xT_3$	L_1xT_1, L_4xT_1, L_4xT_2, L_5xT_2, L_5xT_3, L_7xT_2, L_9xT_1	L_1xT_1, L_4xT_1, L_4xT_2, L_5xT_3, L_7xT_2, L_9xT_1

Table 10. Features of heterotic hybrids

Economic heterotic hybrids	Mean yield (kg)	Heterosis (%) over SV	F_1 s (sca effects)	Colour
L_1xT_1	2.47	16.33	0.71	Light purple
L_4 xT_1	2.40	13.03	0.26	Light green
L_4 x T_2	2.32	9.11	0.14	White
L_5xT_2	2.34	10.20	0.04	Light purple
L_5xT_3	2.36	11.30	0.38	Light green striped
L_5xT_4	2.21	4.08	0.14	Light green striped
L_6xT_2	2.24	5.49	0.41	Green striped
L_7xT_2	2.85	34.07	0.91	Purple striped
L_8xT_1	2.26	6.28	0.39	Green striped
L_9xT_1	2.29	7.69	0.51	Light purple

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