

Original Research Article **Analysis of Heterosis and Heterobeltiosis for Earliness, Yield and its contributing traits in okra (*Abelmoschus esculentus* L. Moench)**

ABSTRACT

Thirty-six F1 hybrids were generated from nine lines and four testers through line x tester mating design, these F1's along with 13 parents and 1 commercial check (Punjab-8) were evaluated to study the magnitude and direction of heterosis for growth and earliness over various characters in okra. Significant heterosis was found over better parent (Heterobeltiosis), mid parent and commercial checks for all the traits studied in desirable direction. The present study showed that the crosses L3 x T2 (19.04, 15.41, 8.28), L5 x T2 (41.90, 14.55, 7.47), L8 x T3 (23.75, 6.48, 8.46) recorded significant positive heterosis for yield per plant over mid parent, better parent and over standard check. Same hybrid L3 x T2 exhibited negative and highly significant heterosis for days to 50% flowering and days to first picking (-11.65,-12.00, -8.33) and (-11.79, -12.12, -15.94) respectively that are earliness character over mid parent, better parent and standard check. These hybrids may further be tested over various locations before release for commercial cultivation. High estimates of heterosis obtained in hybrid combinations revealed considerable genetic divergence among the parental lines and reveals good scope for commercial exploitation of heterosis in okra.

Keywords: Heterosis, Okra, Better Parent, Mid Parent, Standard Check, Heterobeltiosis.

1. INTRODUCTION

Okra, which belongs to the Malvaceae family, is a plant with a chromosome number of $2n = 8x = 72$ or 144, and it is believed to have originated from Southeast Asia [1]. Okra (*Abelmoschus esculentus* L. Moench) is a valuable vegetable crop grown in tropical and subtropical regions around the world. It is very popular in India due to its ease of cultivation, consistent yield, and adaptability to varying moisture conditions. Tender okra fruits are eaten as a vegetable in India, Brazil, West Africa, and other places. Okra falls under the category of often cross-pollinated crops, with outcrossing rates ranging from 4 to 30%. Due to its monoadelphous stamen condition, large flowers that can be easily emasculated, and high level of seed production with a single pollination, it is a crop of significant interest to breeders and geneticists [2].

It is also available dehydrated and canned. As a fresh vegetable, okra has enormous export potential. The term heterosis refers to a phenomenon in which F1 exhibits greater or lesser vigour than the parents. This phenomenon was dubbed the stimulus of heterozygosity by Shull in 1908 [3]. The presence of heterosis is common in plant species, but the degree of expression varies greatly. Vijayaraghavan and Warier, 1946 [4] were the first to report hybrid vigour in okra.

Studies have shown that the extent of significant heterosis is positively correlated with the diversity among parental materials [5-7]. Therefore, selecting appropriate parental genotypes with desirable economic traits is a crucial step in every hybridization program. A high-yielding genotype's superiority may or may not be passed down to its offspring. As a result, useful gene combinations in the form of high combining inbred determine the success of a breeding programme. The selection of suitable parents is an important prerequisite for heterosis exploitation. The selection of parents solely based on phenotypic performance is not a sound procedure. As a result, it is critical that parents be chosen based on their ability to combine. In the current study, the line x tester mating design was used to assess genetic potentialities. The degree of heterosis provides a foundation for genetic diversity and a guide for selecting desirable parents for developing superior F1 hybrids to exploit hybrid vigour and for developing gene pools for future breeding programmes. With this in mind, the current study was carried out to determine the magnitude of heterosis for fruit yield and its attributes traits in okra.

2. MATERIALS AND METHOD

The current study, titled "Analysis of Heterobeltiosis and Heterosis for Earliness, Yield and its contributing traits in okra (*Abelmoschus esculentus* L.)," was carried out at the LPU agriculture research farm during the summer and kharif seasons of 2022. The experiment took place on black cotton soil. The experimental material included 13 parents (9 lines and 4 testers), 36 F₁ hybrids, and one commercial check (Punjab-8) Materials used in the breeding programme tabulated in Table 1. Thirty-six crosses were built during the summer of 2022. The materials listed above (50) were used in the experiment to study heterosis. A Randomized Block Design with three replications was then used to evaluate this material. Panse and Sukhatme's [8] analysis of variance (ANOVA) for Randomized Block Design was used (1985). Fonseca and Peterson (1968) [9] and Meredith and Bridge (1972) [10] provided methods for calculating heterobeltiosis and standard heterosis, respectively.

Table 1. Material Used in Breeding Program

SN	Female (Lines)	Male (Tester)	Commercial check
1	9428 (L1)	9450 (T1)	Punjab 8
2	212 (L2)	212 (T2)	
3	1979 (L3)	551 (T3)	
4	8185 (L4)	552 (T4)	
5	4922 (L5)		
6	4008 (L6)		
7	4009 (L7)		
8	3033 (L8)		
9	2535 (L9)		

2.1 Estimation of Heterosis

The estimation of heterosis was estimated in relation to mid-parent, better parent and standard check hybrid values. They were thus, calculated as per cent increase or decrease in hybrid (F1) over its better parent (BP) and standard check (SC) values in the desirable direction was calculated using the following formula given by Fonseca and Patterson (1968) [9].

$$\text{Heterosis over mid parent (MP)} \quad MP\% = \frac{F1 - MP}{MP} \times 100$$

Where,

F1 = Mean performance of F1 hybrid

MP = Mean performance of mid parent

$$\text{Heterosis over Better parent (BP)} \quad BP\% = \frac{F1 - BP}{BP} \times 100$$

Where,

F1 = Mean performance of F1 hybrid

BP = Mean performance of better parent.

$$\text{Heterosis over standard check (SC)} \quad SC\% = \frac{F1 - SC}{SC} \times 100$$

Where,

F1 = Mean performance of F1 hybrid

SH = Mean performance of standard check

3. RESULTS AND DISCUSSION

The phenomenon of heterosis is nowadays used as an important and efficient tool for achieving higher yields [11]. Analysis of variance for 12 traits (Table 2), demonstrated that both parents and their hybrids differed significantly among themselves indicating the existence of high genetic variability in the experimental population. The heterosis of crosses for different traits was mentioned in Table 2.

Table 2: Analysis of variance of various characters

Source of Variation	Df	Days to 50% Flowering	Days to First Picking	Plant Height	Number of Internodes	Number of Branches	Fruit Length (Commercial Maturity)
Replication	2	0.19	1.45	0.67	0.03	0.13	0.01
Genotypes	49	14.45**	34.59**	831.14**	5.95**	2.72**	3.61**
Error	98	0.59	1.09	0.30	0.01	0.17	0.03

Source of Variation	Df	Fruit Length (Final Maturity)	Number of Fruits per Plant	Number of Seeds per Fruit	100 Seed Weight	Fruit Weight	Yield per Plant
Replication	2	0.01	0.61	0.06	0.00	0.04	26.70
Genotypes	49	3.61**	20.75**	7.82**	2.26**	4.92**	8642.50**
Error	98	0.03	0.82	0.05	1.15	0.04	110.70

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

Days to 50% flowering and Days to First Picking both were observed to have significant and negative heterosis, reflecting the earliness in flowering and fruit maturity, respectively. Such traits are preferable by the farmers for their economic sustainability (Owusu, 2015) (Table 2). For days to 50% flowering, the crosses L3 x T1 (-9.80, -11.54, -4.17), L3 x T2 (-11.65, -12.00, -8.33), L4 x T4 (-8.80, -12.98, -5.00), L9 x T2 (-8.80, -9.52, -5.00), L9 x T3 (-10.16, -11.54, -4.17) showed negative significant heterosis over mid, better parent and standard check, respectively (Table 3).

For days to first picking, total 14 crosses showed negative significant heterosis over mi and better parent along with standard check. The crosses L2 x T1 (-9.47, -15.13, -6.52), L3 x T1 (-10.95, -17.11, -8.70), L3 x T2 (-11.79, -12.12, -15.94), L4 x T4 (-7.97, -14.77, -

7.97), L5 x T4 (-16.67, -22.82, -16.67), L6 x T1 (-18.06, -22.37, -14.49), L6 x T2 (-4.48, -5.88, -7.25), L6 x T3 (-5.38, -7.69, -4.35), L7 x T1 (-4.66, -12.50, -3.62), L7 x T2 (-5.79, -7.58, -11.59), L9 x T2 (-8.24, -12.93, -7.25), L9 x T3 (-22.07, -23.13, -18.12) recorded significant negative heterosis over mid and better parent and over standard check (Table 3).

For plant height, total 9 crosses exhibited positive and significant heterosis over mid and better parent along with over standard check. The crosses L1 x T1 (51.73, 37.53, 19.82), L1 x T4 (57.95, 49.54, 30.28), L3 x T3 (69.44, 55.92, 44.43), L4 x T3 (28.66, 13.63, 5.25), L5 x T1 (30.19, 17.83, 3.01), L5 x T4 (58.74, 50.05, 31.17), L6 x T1 (45.98, 15.39, 40.66), L7 x T4 (59.28, 50.80, 31.39), L9 x T4 (29.85, 27.46, 3.01) recorded positive and significant heterosis over mid and better parent along with over standard check. These results were in agreement with Yadav *et al.* 2023 [11]; Hadiya *et al.* 2018 [12]; Shwetha *et al.* 2021 [3] and Shinde *et al.* 2023 [14].

For number of internodes, the crosses L1 x T1 (18.99, 14.63, 17.50), L1 x T4 (26.58, 21.95, 25.00), L3 x T3 (29.27, 20.45, 32.50), L5 x T4 (14.63, 6.82, 17.50), L6 x T1 (24.71, 12.77, 32.50), L7 x T4 (26.58, 21.95, 25.00), L9 x T4 (11.39, 7.32, 10.00) recorded positive and significant heterosis over mid and better parent along with over standard check.

For number of branches per plant, the crosses L4 x T1 (87.50, 50.00, 66.67), L5 x T1 (150.00, 150.00, 66.67), L6 x T3 (100.00, 75.00, 55.56), L8 x T3 (52.94, 44.44, 44.44), L8 x T4 (50.00, 36.36, 66.67) recorded positive and significant heterosis over mid and better parent along with over standard check. Result in favour with Rynjah *et al.* 2020 [21].

For fruit length at commercial maturity, the cross L9 x T4 (18.78, 10.91, 6.22) recorded positive and significant heterosis over mid and better parent along with over standard check. The same hybrid also recorded positive and significant heterosis over mid and better parent along with over standard check for fruit length at final maturity. These results are similar to results obtained by Kapadia *et al.* 2021 [15]; Bhatt *et al.* 2015 [16] and Prakash *et al.* 2023 [17].

For number of fruits per plant, the cross L5 x T4 (31.62, 16.67, 13.24) exhibited positive and significant heterosis over mid and better parent along with over standard check. For number of seeds per fruit, the crosses L3 x T3 (7.05, 5.19, 3.40), L4 x T3 (2.81, 2.59, 1.28), L7 x T4 (5.31, 5.31, 1.28) exhibited positive and significant heterosis over mid and better parent along with over standard check.

For fruit weight, the cross L9 x T3 (17.46, 6.99, 8.29) exhibited positive and significant heterosis over mid and better parent along with over standard check. For yield per plant, the cross L3 x T2 (19.04, 15.41, 8.28), L5 x T2 (41.90, 14.55, 7.47), L6 x T2 (32.83, 14.50, 7.42), L8 x T3 (23.75, 6.48, 8.46) exhibited positive and significant heterosis over mid and better parent along with over standard check (Table 2). These results are in accordance with Yadav *et al.* 2023 [11]; Shinde *et al.* 2023[14]; Vekariya *et al.* 2020 [15]; Nanthakumar *et al.* 2021 [18] and Kerure and Pitchaimuthu, 2018-19 [19-20].

4. CONCLUSION

The phenomenon of heterosis is used as an important tool for achieving better yields in plants. The present study showed that the crosses L3 x T2, L5 x T2, L8 x T3 recorded significant positive heterosis for yield per plant over mid parent, better parent and over standard check. These hybrids may further be tested over various locations before release for commercial cultivation.

REFERENCES

1. Sutar S, Patil P, Aitawade M, John J, Malik S, Rao S, Yadav S, Bhat KV. A new species of *Abelmoschus medik.*(Malvaceae) from Chhattisgarh, India. Genetic resources and crop evolution. 2013;60:1953-8.
2. Verma A, Sood S, Singh Y. Combining ability studies for yield and contributing traits in okra (*Abelmoschus esculentus* L. Moench). Journal of Applied and Natural Science. 2016;8(3):1594-8.
3. Shull GH. The composition of a field of maize. Journal of Heredity. 1908 Jan 1(1):296-301.
4. Vijayaraghavan C, Warriar VA. Evaluation of high yielding hybrids in bhendi (*Hibiscus esculentus*). In Proceedings of 33rd Indian Science Congress 1946 (Vol. 33, p. 33).
5. Jindal SK, Arora D, Ghai TR. Heterobeltiosis and combining ability for earliness in okra (*Abelmoschus esculentus* (L.) Moench). J Crop Improv. 2009;36(2):59- 66.
6. Mohapatra MR, Acharya P, Sengupta S. Variability and association analysis in okra. Indian Agric. 2007; 51:17- 26.
7. Reddy MT. Genetic diversity, heterosis, combining ability and stability in okra (*Abelmoschus esculentus* (L.) Moench). PhD. thesis. Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad, 2010.
8. Panse VG, Sukhatme PV. Statistical methods for agricultural research. ICAR, New Delhi. 1985;8:308-18.
9. Fonseca S, Patterson FL. Hybrid Vigor in a Seven-Parent Diallel Cross in Common Winter Wheat (*Triticum aestivum* L.) 1. Crop Science. 1968 Jan;8(1):85-8.
10. Meredith Jr WR, Bridge RR. Heterosis and gene action in cotton, (*Gossypium hirsutum* L.). Crop Science. 1972 May;12(3):304-10.
11. Yadav KA, Dhankhar SK, Singh DA, Singh UD, Yogita. Exploitation of combining ability and heterosis potential for improvement in okra (*Abelmoschus esculentus*) genotypes. Indian Journal of Agricultural Sciences. 2023 Feb 1;93(2):127-32.
12. Hadiya DN, Mali SC, Baraiya VK, Patel AI. Studies on assessment of heterosis for fruit yield and attributing characters in okra [*Abelmoschus esculentus* (L.) Moench]. IJCS. 2018;6(5):1919-1923.
13. Shwetha A, Mulge R, Khot RK. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench] for growth and earliness parameters through half diallel analysis. Pharma Innovation. 2021;10(6):1250-1254.

14. Shinde SL, Zate DK, Rathod AH, Cheke SA. Heterosis studies by using L x T design for yield and yield contributing traits in okra (*Abelmoschus esculentus* (L.) Moench). *Pharma Innovation* 12(1):228-237.
15. Vekariya RD, Patel AI, Modha KG, Kapadiya CV, Mali SC, Patel AA. Estimation of Heterosis, Gene Action and Combining Ability over Environments for Improvement of Fruit Yield and its Related Traits in Okra [*Abelmoschus esculentus* (L.) Moench]. *Int. J. Curr. Microbiol. App. Sci.* 2020;9(9):866-81.
16. Bhatt JP, Patel NA, Acharya RR, Kathiria KB. Heterosis for yield and its related traits in Okra (*Abelmoschus esculentus* L. Moench). *Electronic Journal of Plant Breeding*. 2016 Jun 13;7(1):189-96.
17. Prakash G, Halesh GK, Fakrudin B. Heterosis and Combining Ability Studies in Okra [*Abelmoschus esculentus* (L.) Moench] for Yield and Yield Contributing Traits. *Biological Forum – An International Journal*. 2023 15;(1):206-211.
18. Nanthakumar S, Kuralarasu C, Gopikrishnan A. Heterosis and Combining Abilities Studies in Okra [*Abelmoschus esculentus* (L.) Moench]. *Current Journal of Applied Science and Technology*, 2021; 40(30), 25–33.
19. Kerure P, Pitchaimuthu M. Heterosis Studies in Okra (*Abelmoschus esculentus* L. Moench). *Int. J. Curr. Microbiol. App. Sci.* 2018;7(09):1851-1862.
20. Kerure P, Pitchaimuthu M. Evaluation for heterosis in okra (*Abelmoschus esculentus* L. Moench). *Electronic Journal of Plant Breeding*. 2019 Mar 30;10(1):248-255.
21. Rynjah S, Arumugam T, Mohankumar S, Kamala Kannan A. Exploitation of heterosis for yield and yield related traits in okra (*Abelmoschus esculentus* (L.) Moench). *IJCS*. 2020;8(4):886-893.

Table 3: Estimation of heterosis over mid parent, heterobeltiosis and standard heterosis of various characters in okra

SN	Genotypes	Days to 50% Flowering			Days to First Picking			Plant Height		
		MPH	BPH	SH1	MPH	BPH	SH1	MPH	BPH	SH1
1	L1 x T1	-3.50 **	-4.62 **	3.33 *	-4.63 **	-11.84 **	-2.90 ns	51.73 **	37.53 **	19.82 **
2	L1 x T2	5.98 **	4.72 **	10.83 **	14.18 **	12.88 **	7.97 **	-13.81 **	-27.12 **	-8.13 **
3	L1 x T3	4.28 **	3.08 *	11.67 **	7.35 **	2.10 ns	5.80 **	-15.22 **	-17.74 **	-23.80 **
4	L1 x T4	2.44 ns	-0.79 ns	5.00 **	6.25 **	5.43 **	-1.45 ns	57.95 **	49.54 **	30.28 **
5	L2 x T1	-6.20 **	-6.92 **	0.83 ns	-9.47 **	-15.13 **	-6.52 **	-15.20 **	-32.24 **	-19.78 **
6	L2 x T2	9.52 **	7.81 **	15.00 **	15.47 **	15.04 **	10.87 **	-27.81 **	-30.01 **	-11.77 **
7	L2 x T3	3.88 **	3.08 *	11.67 **	4.35 **	0.70 ns	4.35 *	-12.81 **	-22.29 **	-8.01 **
8	L2 x T4	14.17 **	10.16 **	17.50 **	15.38 **	12.78 **	8.70 **	12.24 **	-6.98 **	10.12 **
9	L3 x T1	-9.80 **	-11.54 **	-4.17 **	-10.95 **	-17.11 **	-8.70 **	10.20 **	5.22 **	-18.09 **
10	L3 x T2	-11.65 **	-12.00 **	-8.33 **	-11.79 **	-12.12 **	-15.94 **	-12.38 **	-29.13 **	-10.67 **
11	L3 x T3	-1.96 ns	-3.85 **	4.17 **	-0.00 ns	-4.20 *	-0.72 ns	69.44 **	55.92 **	44.43 **
12	L3 x T4	-0.82 ns	-3.20 *	0.83 ns	0.78 ns	-0.76 ns	-5.80 **	11.75 **	11.75 **	-13.00 **
13	L4 x T1	-2.68 *	-3.05 *	5.83 **	-12.96 **	-13.82 **	-5.07 **	13.80 **	13.66 **	-19.31 **
14	L4 x T2	-0.39 ns	-3.05 *	5.83 **	-3.20 *	-8.72 **	-1.45 ns	-29.36 **	-44.79 **	-30.41 **
15	L4 x T3	-8.05 **	-8.40 **	0.00 ns	-14.38 **	-16.11 **	-9.42 **	28.66 **	13.63 **	5.25 **
16	L4 x T4	-8.80 **	-12.98 **	-5.00 **	-7.97 **	-14.77 **	-7.97 **	-4.33 **	-8.54 **	-28.80 **
17	L5 x T1	1.15 ns	0.76 ns	10.00 **	-2.33 ns	-3.29 ns	6.52 **	30.19 **	17.83 **	3.01 **
18	L5 x T2	2.75 *	-0.00 ns	9.17 **	1.78 ns	-4.03 *	3.62 *	-3.06 **	-17.91 **	3.47 **
19	L5 x T3	3.45 **	3.05 *	12.50 **	1.37 ns	-0.67 ns	7.25 **	8.59 **	5.53 **	-2.24 **
20	L5 x T4	-6.40 **	-10.69 **	-2.50 ns	-16.67 **	-22.82 **	-16.67 **	58.74 **	50.05 **	31.17 **

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

Table 3 Contd....

SN	Genotypes	Days to 50% Flowering			Days to First Picking			Plant Height		
		MPH	BPH	SH1	MPH	BPH	SH1	MPH	BPH	SH1
21	L6 x T1	-0.78 ns	-2.31 ns	5.83 **	-18.06 **	-22.37 **	-14.49 **	45.98 **	15.39 **	40.66 **
22	L6 x T2	-0.00 ns	-0.79 ns	4.17 **	-4.48 **	-5.88 **	-7.25 **	-23.51 **	-24.76 **	-5.17 **
23	L6 x T3	-2.34 ns	-3.85 **	4.17 **	-5.38 **	-7.69 **	-4.35 *	-27.42 **	-36.14 **	-22.15 **
24	L6 x T4	6.94 **	3.97 **	9.17 **	7.98 **	4.41 *	2.90 ns	7.93 **	-11.57 **	7.79 **
25	L7 x T1	-3.97 **	-6.92 **	0.83 ns	-4.66 **	-12.50 **	-3.62 *	-4.48 **	-13.42 **	-24.57 **
26	L7 x T2	-1.63 ns	-2.42 ns	0.83 ns	-5.79 **	-7.58 **	-11.59 **	-9.16 **	-23.19 **	-3.18 **
27	L7 x T3	4.76 **	1.54 ns	10.00 **	8.89 **	2.80 ns	6.52 **	-10.98 **	-13.63 **	-19.99 **
28	L7 x T4	9.54 **	8.20 **	10.00 **	17.32 **	17.32 **	7.97 **	59.28 **	50.80 **	31.39 **
29	L8 x T1	-3.76 **	-5.88 **	6.67 **	-6.16 **	-9.87 **	-0.72 ns	-25.74 **	-42.03 **	-26.85 **
30	L8 x T2	-5.38 **	-9.56 **	2.50 ns	-5.88 **	-8.57 **	-7.25 **	7.71 **	7.65 **	35.83 **
31	L8 x T3	-4.51 **	-6.62 **	5.83 **	-6.71 **	-7.69 **	-4.35 *	-35.15 **	-43.77 **	-29.06 **
32	L8 x T4	0.39 ns	-5.88 **	6.67 **	3.37 *	-1.43 ns	0.00 ns	-20.91 **	-36.05 **	-19.31 **
33	L9 x T1	-1.56 ns	-3.08 *	5.00 **	-13.04 **	-14.47 **	-5.80 **	14.41 **	7.34 **	-13.26 **
34	L9 x T2	-8.80 **	-9.52 **	-5.00 **	-8.24 **	-12.93 **	-7.25 **	1.76 **	-16.50 **	5.25 **
35	L9 x T3	-10.16 **	-11.54 **	-4.17 **	-22.07 **	-23.13 **	-18.12 **	-17.90 **	-23.14 **	-28.80 **
36	L9 x T4	6.12 **	3.17 *	8.33 **	2.19 ns	-4.76 **	1.45 ns	29.85 **	27.46 **	3.01 **
	SE±	0.54	0.63	0.6	0.75	0.86	0.77	0.22	0.26	0.5

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

Table 3 Contd....

SN	Genotypes	Number of Internodes			Number of Branches			Fruit Length (Commercial Maturity)		
		MPH	BPH	SH1	MPH	BPH	SH1	MPH	BPH	SH1
1	L1 x T1	18.99 **	14.63 **	17.50 **	28.57 *	12.50 ns	0.00 ns	4.86 **	0.88 ns	-14.18 **
2	L1 x T2	-0.00 ns	-6.38 **	10.00 **	-4.35 ns	-26.67 **	22.22 ns	-6.09 **	-10.79 **	-15.67 **
3	L1 x T3	-3.53 **	-6.82 **	2.50 **	-50.00 **	-50.00 **	-55.56 **	-18.24 **	-18.71 **	-30.85 **
4	L1 x T4	26.58 **	21.95 **	25.00 **	-15.79 ns	-27.27 **	-11.11 ns	-13.07 **	-17.92 **	-21.39 **
5	L2 x T1	-10.59 **	-19.15 **	-5.00 **	20.00 ns	0.00 ns	0.00 ns	10.08 **	7.90 **	-11.69 **
6	L2 x T2	-6.38 **	-6.38 **	10.00 **	0.00 ns	-20.00 **	33.33 **	6.06 **	-1.05 ns	-6.47 **
7	L2 x T3	-9.89 **	-12.77 **	2.50 **	-29.41 **	-33.33 **	-33.33 **	-11.24 **	-12.43 **	-26.37 **
8	L2 x T4	10.59 **	-0.00 ns	17.50 **	-20.00 *	-27.27 **	-11.11 ns	-17.37 **	-23.38 **	-26.62 **
9	L3 x T1	15.79 **	15.79 **	10.00 **	23.08 ns	14.29 ns	-11.11 ns	12.98 **	9.14 **	-7.96 **
10	L3 x T2	-10.59 **	-19.15 **	-5.00 **	-36.36 **	-53.33 **	-22.22 ns	13.77 **	7.63 **	1.74 ns
11	L3 x T3	29.27 **	20.45 **	32.50 **	6.67 ns	-0.00 ns	-11.11 ns	1.62 ns	1.47 ns	-14.43 **
12	L3 x T4	-0.00 ns	-0.00 ns	-5.00 **	11.11 ns	-9.09 ns	11.11 ns	-2.21 *	-8.05 **	-11.94 **
13	L4 x T1	7.89 **	7.89 **	2.50 **	87.50 **	50.00 **	66.67 **	2.27 *	-2.03 ns	-15.92 **
14	L4 x T2	-3.53 **	-12.77 **	2.50 **	-60.00 **	-66.67 **	-44.44 **	-10.07 **	-14.21 **	-18.91 **
15	L4 x T3	7.32 **	-0.00 ns	10.00 **	0.00 ns	-10.00 ns	0.00 ns	4.54 **	3.48 **	-11.19 **
16	L4 x T4	-0.00 ns	-0.00 ns	-5.00 **	-14.29 ns	-18.18 ns	0.00 ns	3.56 **	-1.82 ns	-5.97 **
17	L5 x T1	7.32 **	-0.00 ns	10.00 **	150.00 **	150.00 **	66.67 **	20.52 **	17.09 **	-7.96 **
18	L5 x T2	-3.30 **	-6.38 **	10.00 **	-33.33 **	-53.33 **	-22.22 ns	-4.13 **	-14.47 **	-19.15 **
19	L5 x T3	-0.00 ns	-0.00 ns	10.00 **	-14.29 ns	-25.00 ns	-33.33 **	0.63 ns	-5.33 **	-20.40 **
20	L5 x T4	14.63 **	6.82 **	17.50 **	-5.88 ns	-27.27 **	-11.11 ns	18.89 **	5.45 **	1.00 ns

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

Table 3 Contd....

SN	Genotypes	Number of Internodes			Number of Branches			Fruit Length (Commercial Maturity)		
		MPH	BPH	SH1	MPH	BPH	SH1	MPH	BPH	SH1
21	L6 x T1	24.71 **	12.77 **	32.50 **	0.00 ns	0.00 ns	-33.33 **	9.20 **	5.95 **	-11.44 **
22	L6 x T2	-6.38 **	-6.38 **	10.00 **	-14.29 ns	-40.00 **	0.00 ns	7.82 **	1.58 ns	-3.98 **
23	L6 x T3	-9.89 **	-12.77 **	2.50 **	100.00 **	75.00 **	55.56 **	17.21 **	16.86 **	-1.74 ns
24	L6 x T4	10.59 **	-0.00 ns	17.50 **	-41.18 **	-54.55 **	-44.44 **	-7.07 **	-12.99 **	-16.67 **
25	L7 x T1	1.27 **	-2.44 **	0.00 ns	16.67 ns	16.67 ns	-22.22 ns	3.30 **	-1.71 ns	-14.43 **
26	L7 x T2	-0.00 ns	-6.38 **	10.00 **	-4.76 ns	-33.33 **	11.11 ns	5.75 **	1.58 ns	-3.98 **
27	L7 x T3	-3.53 **	-6.82 **	2.50 **	57.14 **	37.50 **	22.22 ns	16.86 **	14.86 **	0.00 ns
28	L7 x T4	26.58 **	21.95 **	25.00 **	-17.65 ns	-36.36 **	-22.22 ns	-13.20 **	-17.14 **	-20.65 **
29	L8 x T1	-10.59 **	-19.15 **	-5.00 **	-6.67 ns	-22.22 ns	-22.22 ns	-3.19 **	-10.70 **	-16.92 **
30	L8 x T2	12.77 **	12.77 **	32.50 **	-50.00 **	-60.00 **	-33.33 **	-0.80 ns	-1.58 ns	-6.97 **
31	L8 x T3	-16.48 **	-19.15 **	-5.00 **	52.94 **	44.44 **	44.44 **	-0.28 ns	-5.08 **	-11.69 **
32	L8 x T4	-3.53 **	-12.77 **	2.50 **	50.00 **	36.36 **	66.67 **	-7.51 **	-8.83 **	-12.69 **
33	L9 x T1	3.80 **	-0.00 ns	2.50 **	0.00 ns	0.00 ns	-33.33 **	3.69 **	0.90 ns	-16.17 **
34	L9 x T2	-0.00 ns	-6.38 **	10.00 **	-14.29 ns	-40.00 **	0.00 ns	4.76 **	-1.58 ns	-6.97 **
35	L9 x T3	-10.59 **	-13.64 **	-5.00 **	28.57 *	12.50 ns	0.00 ns	21.13 **	20.41 **	1.24 ns
36	L9 x T4	11.39 **	7.32 **	10.00 **	52.94 **	18.18 ns	44.44 **	18.78 **	10.91 **	6.22 **
	SE±	0.06	0.07	0.11	0.29	0.34	0.35	0.12	0.13	0.14

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

Table 3 Contd....

SN	Genotypes	Fruit Length (Final Maturity)			Number of Fruits per Plant			Number of Seeds per Fruit		
		MPH	BPH	SH1	MPH	BPH	SH1	MPH	BPH	SH1
1	L1 x T1	3.45 **	0.63 ns	-10.61 **	6.06 *	-5.41 ns	2.94 ns	-0.00 ns	-1.31 **	-3.83 **
2	L1 x T2	-4.44 **	-7.96 **	-11.73 **	-17.88 **	-19.48 **	-8.82 **	0.22 ns	-0.85 **	-1.28 **
3	L1 x T3	-13.05 **	-13.42 **	-23.09 **	-28.36 **	-35.14 **	-29.41 **	-0.43 *	-0.87 **	-2.55 **
4	L1 x T4	-9.53 **	-13.27 **	-16.01 **	-27.14 **	-31.08 **	-25.00 **	4.62 **	3.93 **	1.28 **
5	L2 x T1	7.10 **	5.60 **	-8.75 **	3.33 ns	0.00 ns	-8.82 **	-0.66 **	-2.59 **	-3.83 **
6	L2 x T2	4.39 **	-0.78 ns	-4.84 **	-9.35 **	-18.18 **	-7.35 *	-0.86 **	-1.28 **	-1.70 **
7	L2 x T3	-8.00 **	-8.88 **	-19.74 **	8.20 *	6.45 ns	-2.94 ns	0.22 ns	-0.00 ns	-1.28 **
8	L2 x T4	-12.60 **	-17.31 **	-19.93 **	-26.56 **	-28.79 **	-30.88 **	-0.00 ns	-1.29 **	-2.55 **
9	L3 x T1	9.19 **	6.54 **	-5.96 **	9.52 **	1.47 ns	1.47 ns	5.38 **	5.38 **	-0.00 ns
10	L3 x T2	10.01 **	5.63 **	1.30 ns	2.07 ns	-3.90 ns	8.82 **	0.22 ns	-2.14 **	-2.55 **
11	L3 x T3	1.16 ns	1.05 ns	-10.80 **	-3.13 ns	-8.82 **	-8.82 **	7.05 **	5.19 **	3.40 **
12	L3 x T4	-1.61 *	-5.96 **	-8.94 **	5.97 *	4.41 ns	4.41 ns	0.67 **	-0.00 ns	-3.83 **
13	L4 x T1	1.61 *	-1.46 ns	-11.92 **	10.40 **	2.99 ns	1.47 ns	-0.66 **	-2.59 **	-3.83 **
14	L4 x T2	-7.34 **	-10.49 **	-14.15 **	-25.00 **	-29.87 **	-20.59 **	-0.43 *	-0.85 **	-1.28 **
15	L4 x T3	3.25 **	2.50 **	-8.38 **	-7.09 *	-11.94 **	-13.24 **	2.81 **	2.59 **	1.28 **
16	L4 x T4	2.60 **	-1.35 ns	-4.47 **	-5.26 ns	-5.97 ns	-7.35 *	-0.00 ns	-1.29 **	-2.55 **
17	L5 x T1	14.25 **	11.97 **	-5.96 **	26.61 **	18.97 **	1.47 ns	-0.00 ns	-2.55 **	-2.55 **
18	L5 x T2	-2.95 **	-10.68 **	-14.34 **	10.94 **	-7.79 **	4.41 ns	2.77 **	2.55 **	2.55 **
19	L5 x T3	0.44 ns	-3.81 **	-15.27 **	-8.11 *	-15.00 **	-25.00 **	-0.43 *	-1.28 **	-1.28 **
20	L5 x T4	13.54 **	4.04 **	0.74 ns	31.62 **	16.67 **	13.24 **	0.65 **	-1.28 **	-1.28 **

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

Table 3 Contd....

SN	Genotypes	Fruit Length (Final Maturity)			Number of Fruits per Plant			Number of Seeds per Fruit		
		MPH	BPH	SH1	MPH	BPH	SH1	MPH	BPH	SH1
21	L6 x T1	6.51 **	4.25 **	-8.57 **	13.79 **	13.79 **	-2.94 ns	3.98 **	2.62 **	-0.00 ns
22	L6 x T2	5.68 **	1.17 ns	-2.98 **	11.11 **	-2.60 ns	10.29 **	0.22 ns	-0.85 **	-1.28 **
23	L6 x T3	12.29 **	12.05 **	-1.30 ns	6.78 *	5.00 ns	-7.35 *	-3.04 **	-3.46 **	-5.11 **
24	L6 x T4	-5.15 **	-9.62 **	-12.48 **	-9.68 **	-15.15 **	-17.65 **	0.66 **	-0.00 ns	-2.55 **
25	L7 x T1	2.35 **	-1.24 ns	-10.80 **	0.00 ns	-1.67 ns	-13.24 **	2.00 **	1.33 **	-2.55 **
26	L7 x T2	4.20 **	1.17 ns	-2.98 **	2.19 ns	-9.09 **	2.94 ns	0.87 **	-0.85 **	-1.28 **
27	L7 x T3	12.11 **	10.72 **	0.00 ns	23.33 **	23.33 **	8.82 **	-1.09 **	-2.16 **	-3.83 **
28	L7 x T4	-9.65 **	-12.69 **	-15.46 **	9.52 **	4.55 ns	1.47 ns	5.31 **	5.31 **	1.28 **
29	L8 x T1	-2.29 **	-7.86 **	-12.66 **	-10.77 **	-19.44 **	-14.71 **	2.62 **	-0.00 ns	-0.00 ns
30	L8 x T2	-0.59 ns	-1.17 ns	-5.21 **	-2.01 ns	-5.19 ns	7.35 *	-2.35 **	-2.55 **	-2.55 **
31	L8 x T3	-0.20 ns	-3.73 **	-8.75 **	21.21 **	11.11 **	17.65 **	3.43 **	2.55 **	2.55 **
32	L8 x T4	-5.54 **	-6.54 **	-9.50 **	0.00 ns	-4.17 ns	1.47 ns	-1.95 **	-3.83 **	-3.83 **
33	L9 x T1	2.61 **	0.64 ns	-12.10 **	-10.24 **	-17.39 **	-16.18 **	-1.74 **	-4.64 **	-3.83 **
34	L9 x T2	3.46 **	-1.17 ns	-5.21 **	-13.70 **	-18.18 **	-7.35 *	-1.49 **	-2.11 **	-1.28 **
35	L9 x T3	15.07 **	14.59 **	0.93 ns	3.88 ns	-2.90 ns	-1.47 ns	1.71 **	0.42 ns	1.28 **
36	L9 x T4	13.65 **	8.08 **	4.66 **	6.67 *	4.35 ns	5.88 ns	-1.08 **	-3.38 **	-2.55 **
	SE±	0.12	0.13	0.14	0.64	0.74	0.73	0.16	0.19	0.17

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

Table 3 Contd....

SN	Genotypes	100 Seed Wt. (g)			Fruit Wt			Yield per Plant		
		MPH	BPH	SH1	MPH	BPH	SH1	MPH	BPH	SH1
1	L1 x T1	3.66 ns	-3.66 ns	-12.80 ns	-1.78 ns	-17.34 **	-5.85 **	1.93 ns	-22.03 **	-2.83 ns
2	L1 x T2	10.74 ns	1.75 ns	9.95 ns	-19.65 **	-30.84 **	-21.22 **	-33.32 **	-41.56 **	-27.17 **
3	L1 x T3	4.57 ns	-7.29 ns	8.53 ns	-25.00 **	-35.12 **	-26.10 **	-48.78 **	-59.30 **	-49.28 **
4	L1 x T4	-2.45 ns	-6.28 ns	-15.17 ns	-20.25 **	-32.12 **	-22.68 **	-42.97 **	-53.64 **	-42.22 **
5	L2 x T1	5.21 ns	-4.48 ns	-9.00 ns	26.03 **	22.49 **	0.98 ns	30.77 **	22.77 **	-7.62 *
6	L2 x T2	10.02 ns	3.51 ns	11.85 ns	9.04 **	8.88 **	-10.24 **	-0.67 ns	-10.51 **	-16.04 **
7	L2 x T3	-12.50 ns	-20.65 ns	-7.11 ns	25.18 **	24.63 **	3.66 *	35.90 **	34.26 **	1.02 ns
8	L2 x T4	-6.10 ns	-11.94 ns	-16.11 ns	-6.01 **	-7.40 **	-23.66 **	-31.36 **	-32.58 **	-47.41 **
9	L3 x T1	12.78 ns	-4.26 ns	6.64 ns	11.11 **	5.34 **	-8.54 **	21.37 **	6.17 ns	-6.46 *
10	L3 x T2	4.54 ns	2.98 ns	14.69 ns	18.04 **	14.89 **	-0.24 ns	19.04 **	15.41 **	8.28 **
11	L3 x T3	-26.14 **	-27.94 *	-15.64 ns	1.58 ns	-0.56 ns	-13.66 **	-2.94 ns	-11.02 **	-21.61 **
12	L3 x T4	-2.19 ns	-14.47 ns	-4.74 ns	16.08 **	11.52 **	-3.17 *	21.20 **	14.25 **	0.66 ns
13	L4 x T1	-17.29 ns	-29.79 **	-21.80 ns	3.35 *	0.59 ns	-17.32 **	13.00 **	2.56 ns	-16.92 **
14	L4 x T2	-5.40 ns	-6.81 ns	3.79 ns	0.89 ns	0.89 ns	-17.07 **	-24.56 **	-29.71 **	-34.06 **
15	L4 x T3	-5.39 ns	-7.69 ns	8.06 ns	6.49 **	5.87 **	-11.95 **	-1.09 ns	-5.72 ns	-23.63 **
16	L4 x T4	-14.84 ns	-25.53 *	-17.06 ns	16.99 **	15.43 **	-5.12 **	12.50 **	10.42 **	-10.56 **
17	L5 x T1	11.63 ns	6.67 ns	-9.00 ns	29.54 **	28.53 **	-0.00 ns	64.77 **	54.31 **	1.90 ns
18	L5 x T2	4.90 ns	-6.14 ns	1.42 ns	30.26 **	25.82 **	3.41 *	41.90 **	14.55 **	7.47 *
19	L5 x T3	20.37 ns	4.05 ns	21.80 ns	-2.90 *	-6.74 **	-22.44 **	-11.98 **	-21.43 **	-42.31 **
20	L5 x T4	19.10 ns	17.78 ns	0.47 ns	17.13 **	14.63 **	-8.29 **	51.30 **	31.56 **	2.62 ns

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

Table 3 Contd....

SN	Genotypes	100 Seed Wt. (g)			Fruit Wt			Yield per Plant		
		MPH	BPH	SH1	MPH	BPH	SH1	MPH	BPH	SH1
21	L6 x T1	7.10 ns	-2.97 ns	-7.11 ns	12.42 **	11.38 **	-11.71 **	28.64 **	26.86 **	-13.84 **
22	L6 x T2	12.09 ns	5.70 ns	14.22 ns	20.85 **	18.69 **	-2.44 ns	32.83 **	14.50 **	7.42 *
23	L6 x T3	11.80 ns	1.62 ns	18.96 ns	5.41 **	2.93 *	-14.39 **	12.69 **	8.46 *	-20.36 **
24	L6 x T4	1.06 ns	-5.45 ns	-9.48 ns	-0.77 ns	-1.22 ns	-20.98 **	-12.14 **	-17.82 **	-35.90 **
25	L7 x T1	-2.18 ns	-18.88 ns	-4.27 ns	-3.15 *	-10.82 **	-17.56 **	-3.62 ns	-13.27 **	-28.38 **
26	L7 x T2	-0.21 ns	-4.42 ns	12.80 ns	4.47 **	-1.32 ns	-8.78 **	5.81 *	-0.53 ns	-6.68 *
27	L7 x T3	0.81 ns	0.40 ns	18.48 ns	0.56 ns	-4.49 **	-11.71 **	22.57 **	15.78 **	-4.40 ns
28	L7 x T4	-7.29 ns	-20.88 ns	-6.64 ns	7.50 **	0.26 ns	-7.32 **	18.30 **	15.02 **	-5.02 ns
29	L8 x T1	5.88 ns	-5.71 ns	-6.16 ns	-10.96 **	-19.34 **	-22.68 **	-22.77 **	-36.35 **	-35.16 **
30	L8 x T2	-12.33 ns	-15.79 ns	-9.00 ns	3.29 **	-4.07 **	-8.05 **	0.18 ns	-3.78 ns	-1.99 ns
31	L8 x T3	10.28 ns	2.02 ns	19.43 ns	3.27 **	-3.56 **	-7.56 **	23.75 **	6.48 *	8.46 **
32	L8 x T4	5.18 ns	-3.33 ns	-3.79 ns	-2.36 ns	-10.43 **	-14.15 **	-3.75 ns	-15.02 **	-13.44 **
33	L9 x T1	12.30 ns	-0.00 ns	-0.47 ns	-8.17 **	-18.80 **	-17.80 **	-18.72 **	-33.30 **	-31.31 **
34	L9 x T2	-14.61 ns	-17.98 ns	-11.37 ns	-11.17 **	-19.52 **	-18.54 **	-22.70 **	-26.14 **	-23.93 **
35	L9 x T3	6.35 ns	-1.62 ns	15.17 ns	17.46 **	6.99 **	8.29 **	22.07 **	4.55 ns	7.68 *
36	L9 x T4	26.42 *	16.19 ns	15.64 ns	6.06 **	-5.06 **	-3.90 **	13.02 **	-0.69 ns	2.28 ns
	SE±	0.76	0.88	0.88	0.14	0.17	0.19	7.41	8.56	9.09

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