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Heterosis Studies for Growth and Yield Attributing Traits in Cucumber (*Cucumis sativus* L.)

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Abstract

The present investigation was carried out to estimate the heterosis of seventeen promising and diverse parents and varieties of cucumber selected on the basis of genetic variability. The selected parental namely comprised of 36 F_1's developed by crossing 17 lines for nineteen yield contributing traits during *Zaid*– 2018 in randomized block design with three replications. Out 36 F_{1s} the best five crosses on the basis of desirable and significant heterobeltiosis performance and for fruit yield per plant were $L_7 \times T_2$, $L_{12} \times T_2$, $L_{11} \times T_2$, $L_9 \times T_2$ and $L_{10} \times T_3$. These crosses also showed better parent heterosis for some other traits as well. The extent of standard heterosis of five best crosses for fruit yield per plant over pooled which revealed that there was a great scope of realizing higher yield in cucumber through heterosis breeding. Crosses $L_{12} \times T_2$, $L_9 \times T_2$, $L_7 \times T_2$, and $L_{10} \times T_3$ were found as the top common crosses which showed significant positive and desirable standard as well better parent heterosis and high *per se* performance for fruit yield per plant in over pooled. Out of these top four crosses three crosses namely $L_{12} \times T_2$, $L_9 \times T_2$ and $L_7 \times T_2$ were also found significant heterosis over better as well standard parent for number of fruits per plant during pooled.

***Key words*:** *Cucumis sativus* L., Heterosis, heterobeltiosis, Fruit yield

Cucumber (*Cucumis sativus* L.) is a member of the family Cucurbitaceae, which comprises of 117 genera and 825 species in warmer parts of the world [1]. It is thought to be one of the oldest vegetable crops and has been found in cultivation for over 3000 years in India [2] where [3] estimated 36 genera and 100 species. Cucumber is a thermophillic and frost-susceptible crop, growing best at temperature above 20°C. The crop is grown in throughout the world, is the second most widely cultivated cucurbit after watermelon and ranks fourth among the economic vegetables in Asia after tomato, onion and cabbage [4]. Today, Cucumber is nutritionally very rich in vitamins and minerals.

The cucumber is native to the North-West of India and has been cultivated from at least 3000 years. The calyx and corolla of staminate, pistilate and hermaphroditic flower are five lobed. The staminate flower have three stamens (two have bilocular anthers and the third has one anther, pistilate flowers are epigynous. Cucumber is open-pollinated and self-compatible. Pollination is takes placed by insects mainly bees and air.

Heterosis breeding has been recognized as practical tool in providing breeder a means for increasing yield and other economic traits. The hybrid vigour or the superiority of the F1 hybrids over parents may be manifested in terms of high productivity, uniformity in improved qualities, built in resistance, environmental adoptions, earliness etc. However, it never happens that each hybridization is accompanied by manifestation of hybrid vigour. Only certain pair of parents gives heterotic progeny. Therefore, exploitation of heterosis involving locally adapted cucumber genotypes to identify the good hybrids for both growth parameters and yield [5].

MATERIALS AND METHODS

The experimental materials for the present study comprised of eight promising and diverse parents and varieties of cucumber selected on the basis of genetic variability from the germplasm stock maintained in the Department of Vegetable Science, Kalyanpur, of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh) India. The selected parental namely comprised of 36 F_1's developed by crossing 12 lines (k-100, K-512, K-40, K-1, 5- URC-11-1, Panjab Naveen, Pusa Barkha, Poinsett-76, Pahari Barsati, Poinsett, Swarn Ageti, Pusa Uday with 3 testers (PCUC-8, Swarna Poona and Boro Patana) and 2 check variety (Kalyanpur Green, Pusa Sanyog) during *zaid* and summer 2018-19.

The experiments were conducted in a randomized complete block design (RBD) with three replications to assess the performance of 36 F_1 hybrids and their 12 lines 3testers and 2 checks. The crop was planted in rows spaced at 2.5 meters apart with a plant to plant spacing of 0.50 meter.

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Observations were recorded on nineteen quantitative traits viz., days to first male flower appearance, days to first female flower appearance, number of node for first male flower, number of node for first female flower, number of branches per plant, vine of length at 60 DAS (cm), number of fruit per vine at 60 DAS, days to first fruit set, number of fruit per plant, length of fruit (cm), diameter of fruit (cm), number of node per vine, average weight of fruit (kg), duration of crop (days), fruit yield (kg) / plant, days to first fruit picking, T.S.S (Total Soluble Solids (Brix), specific gravity of fruit and dry matter (%).

RESULTS AND DISCUSSION

The heterosis was estimated as per cent increase or decrease of F1 values over the better parent (BP) and standard variety (SV1) standard variety (SV2). The estimates of heterobeltiosis and standard heterosis for all the traits in thirty-six F_1 during *Zaid*, 2020 (E1), Zaid, 2021 (E2) and over seasons (pooled) are presented in (Table 1). The negative estimates of heterosis were considered desirable for all maturity traits viz., days to first male and female flower initiation, node number to first male and female flower appearance and days to first fruit harvest. However, for rest of the characters positive estimates of heterosis were considered desirable. Character-wise heterosis estimated in the F_1 hybrids are described in ensuing sub-Out of 36 F_1 hybrids, 10 crosses over better parent, 19 cross over first standard variety and 27 crosses over second standard variety showed significant and negative heterosis in days to male flower initiation, similar results were also reported by Dogra *et al*. [6], Kaur and Dhall [7], Preethi *et al*. [5]. 12 crosses over better parent, 18 cross over first standard variety and 19 crosses over second standard variety showed significant and negative heterosis in day to first female flower initiation [8-11]. 18 crosses over better parent, 12 crosses over first standard variety and 14 crosses over second standard variety showed significant and negative heterosis in number of nodes for first male flower similar result were also described by Kushwaha *et al*. [12].

Table 1 Estimates of heterosis (%) over better parent (BP) and two standard varieties (SV1 & SV2) for 19 characters in cucumber of pooled data

Crosses	Day to first male flower initiation			Day to female flower initiation			Number of node for first male flower		
	Pooled			Pooled			Pooled		
	BP	SV1	SV2	BP	SV1	SV2	BP	SV1	SV2
$L_1 \times T_1$	2.16	-6.69*	-8.85**	-4.05	-9.89**	-10.90**	41.74**	17.63**	12.77**
$L_1 \times T_2$	-10.44**	-12.20**	-14.23**	-10.32**	-14.07**	-15.04**	-18.49**	13.50**	8.8
$L_1 \times T_3$	7.46*	-3.54	-5.77*	-0.83	-9.13**	-10.15**	2.92	-0.31	-4.44
$L_2 \times T_1$	-3.45	-11.81**	-13.85**	-3.64	-9.51**	-10.53**	27.38**	2.38	-1.86
$L_2 \times T_2$	-9.64**	-11.42**	-13.46**	-6.35 *	-10.27**	-11.28**	-30.01**	-2.54	-6.57
$L_2 \times T_3$	10.96**	-0.39	-2.69	4.15	-4.56*	-5.64*	9.4	5.97	1.58
$L_3 \times T_1$	-1.72	-10.24**	-12.31**	-5.26*	-11.03**	-12.03**	36.87**	7.1	2.67
$L_3 \times T_2$	-15.26**	-16.93**	-18.85**	-12.70**	-16.35**	-17.29**	-32.83**	-6.46	-10.33*
$L_3 \times T_3$	7.89**	-3.15	-5.38*	2.9	-5.70*	-6.77**	8.24	4.84	0.5
$L_4 \times T_1$	5.17	-3.94	-6.15*	-5.26*	-11.03**	-12.03**	32.65**	3.64	-0.65
$L_4 \times T_2$	2.81	0.79	-1.54	4.76*	0.38	-0.75	0.14	39.44**	33.67**
$L_4 \times T_3$	8.77**	-2.36	-4.62	8.71**	-0.38	-1.5	6.73	3.38	-0.9
$L_5 \times T_1$	5	-0.79	-3.08	3.57	-0.76	-1.88	17.90*	-18.55**	-21.92**
$L_5 \times T_2$	-4.02	-5.91*	-8.08**	1.59	-2.66	-3.76	-39.53**	-15.80**	-19.29**
$L_5 \times T_3$	5.83*	0	-2.31	7.14**	2.66	1.5	10.06*	6.6	2.19
$L_6 \times T_1$	-3.94	-3.94	-6.15*	-3.77	-3.04	-4.14	19.26**	23.24**	18.14**
$L_6 \times T_2$	-5.51*	-5.51*	-7.69**	-6.42**	-5.70*	-6.77**	-33.73**	-7.72	-11.54*
$L_6 \times T_3$	-12.60**	-12.60**	-14.62**	-14.34**	-13.69**	-14.66**	-30.05**	-27.72**	-30.71**
$L_7 \times$ T1	-1.29	-9.84**	-11.92**	-4.86*	-10.65**	-11.65**	54.26**	6.56	2.15
$L_7 \times T_2$	-10.44**	-12.20**	-14.23**	-12.70**	-16.35**	-17.29**	-38.52**	-14.40**	-17.94**
$L_7 \times T_3$	3.06	-7.09**	-9.23**	5.79*	-2.66	-3.76	-11.35*	-14.13**	-17.68**
$L_8 \times T_1$	3.24	0.39	-1.92	3.1	1.14	0	17.24**	-15.28**	-18.79**
$L_8 \times T_2$	-3.21	-5.12*	-7.31**	0.39	-1.52	-2.63	-19.80**	11.67*	7.05
$L_8 \times T_3$	-0.81	-3.54	-5.77*	0.39	-1.52	-2.63	-6.48	-9.42*	-13.17**
$L_9 \times T_1$	3.45	-5.51*	-7.69**	2.02	-4.18	-5.26*	-26.72**	-18.58**	-21.95**
$L_9 \times T_2$	-8.43**	-10.24**	-12.31**	-5.16*	-9.13**	-10.15**	-10.00**	25.33**	20.14**
$L_9 \times T_3$	6.58*	-4.33	-6.54*	9.96**	0.76	-0.38	3.27	14.76**	10.01*
$L_{10} \times T_1$	-3.2	-4.72	-6.92**	-3.03	-2.66	-3.76	7.63	13.65**	8.95
$L_{10} \times T_2$	1.6	0	-2.31	0	0.38	-0.75	-41.83**	-19.00**	-22.35**
$L_{10} \times T_3$	-3.6	-5.12*	-7.31**	3.03	3.42	2.26	-23.59**	-19.31**	-22.65**
$L_{11} \times T_1$	-3.45	-11.81**	-13.85**	-8.10**	-13.69**	-14.66**	-10.28*	4.66	0.33
$L_{11} \times T_2$	-2.81	-4.72	-6.92**	-5.95*	-9.89**	-10.90**	-17.51**	14.86**	10.11*
$L_{11} \times T_3$	5.26	-5.51*	-7.69**	7.47**	-1.52	-2.63	-7.99	7.33	2.88
$L_{12} \times T_1$	4.18	-1.97	-4.23	7.66**	1.52	0.38	-30.02**	-16.48**	-19.94 **
$L_{12} \times T_2$	-13.65**	-15.35**	-17.31**	-11.11**	-14.83**	-15.79**	-30.29**	-2.93	-6.95
$L_{12} \times T_3$	3.76	-2.36	-4.62	6.45**	0.38	-0.75	-29.36**	-15.70**	-19.19**
No. of crosses with significant (+) heterosis	6	0	0	8	0	0	8	9	6
No. of crosses with significant (-) 'heterosis	8	19	27	12	18	19	18	12	14

.... *Continued.....*

Crosses	Number of node for first female flower			Number of branches per plant			Vine of length at 60DAS		
	Pooled			Pooled			Pooled		
	BP	SV1	SV2	BP	SV1	SV2	BP	SV1	SV2
$L_1 \times T_1$	11.54 **	4.27	-0.89	9.87 *	-22.04 **	-21.78 **	-32.72 **	-24.13 **	-27.12 **
$L_1 \times T_2$	21.51 **	34.51 **	27.84 **	43.36 **	22.07 **	22.49 **	9.41	23.38 **	18.51 **
$L_1 \times T_3$	-15.79 **	5.99 *	0.73	-46.67 **	-42.62 **	-42.42 **	-21.17 **	10.44	6.08
$L_2 \times T_1$	15.86 **	22.89 **	16.79 **	-32.29 **	-43.26 **	-43.07 **	11.95 *	30.88 **	25.72 **
$L_2 \times T_2$	-10.79 **	-1.24	-6.14 **	-8.86 **	-22.39 **	-22.12 **	3.69	21.22 **	16.44 *
$L_2 \times T_3$	-20.16 **	0.49	-4.49 *	14.90 **	23.63 **	24.05 **	-49.07 **	-28.65 **	-31.46 **
$L_3 \times T_1$	2.89	9.38 **	3.96	-31.37 **	-51.31 **	-51.14 **	-10.6	-14.32 *	-17.70 **
$L_3 \times T_2$	-15.40 **	-6.35 **	-10.99 **	-15.27 **	-27.85 **	-27.61 **	23.72 **	18.56 **	13.89 *
$L_3 \times T_3$	-28.15 **	-9.57 **	-14.05 **	-42.47 **	-38.10 **	-37.88 **	-32.96 **	-6.08	-9.79
$L_4 \times T_1$	16.99 **	9.64 **	4.2	-7.90 *	-22.13 **	-21.86 **	-16.96 **	-3.04	-6.86
$L_4 \times T_2$	27.57 **	41.21 **	34.21 **	-9.25 **	-22.72 **	-22.46 **	-37.19 **	-26.66 **	-29.56 **
$L_4 \times T_3$	6.65 **	34.22 **	27.57 **	-21.19 **	-15.20 **	-14.91 **	-18.55 **	14.10 *	9.6
$L_5 \times T_1$	-8.55 **	-21.65 **	-25.54 **	79.98 **	27.70 **	28.14 **	28.00 **	20.67 **	15.91 *
$L_5 \times T_2$	-27.11 **	-19.32 **	-23.32 **	-34.68 **	-44.38 **	-44.19 **	16.57 *	-0.68	-4.6
$L_5 \times T_3$	-7.41 **	16.53 **	10.76 **	17.74 **	26.69 **	27.12 **	-45.22 **	-23.26 **	-26.29 **
$L_6 \times T_1$	27.00 **	28.25 **	21.89 **	82.01 **	29.15 **	29.59 **	30.89 **	23.39 **	18.52 **
$L_6 \times T_2$	-14.68 **	-5.56 *	-10.24 **	54.88 **	31.89 **	32.34 **	50.93 **	24.47 **	19.56 **
$L_6 \times T_3$	-39.10 **	-23.35 **	-27.15 **	-36.04 **	-31.18 **	-30.95 **	-24.89 **	5.22	1.07
$L_7 \times$ T1	45.27 **	28.94 **	22.54 **	-41.61 **	-41.71 **	-41.51 **	0.25	-5.5	-9.23
$L_7 \times T_2$	7.73 **	19.25 **	13.34 **	-18.35 **	-18.49 **	-18.21 **	65.23 **	37.53 **	32.10 **
$L_7 \times T_3$	-17.89 **	3.34	-1.78	-23.41 **	-17.59 **	-17.30 **	-48.65 **	-28.07 **	-30.90 **
$L_8 \times T_1$	24.28 **	1.98	-3.08	15.84 **	15.68 **	16.07 **	6.4	22.16 **	17.34 **
$L_8 \times T_2$	-7.30 **	2.62	-2.47	-17.46 **	-17.58 **	-17.30 **	8.29	24.32 **	19.42 **
$L_8 \times T_3$	-28.37 **	-9.85 **	-14.32 **	-6.75 *	0.34	0.68	-31.27 **	-3.71	-7.51
$L_9 \times T_1$	1.13	-20.20 **	-24.15 **	-19.52 **	-13.42 **	-13.13 **	19.60 **	12.75	8.3
$L_9 \times T_2$	-24.46 **	-16.38 **	-20.52 **	22.81 **	32.12 **	32.57 **	-12.55	-27.89 **	-30.73 **
$L_9 \times T_3$	-42.52 **	-27.66 **	-31.24 **	-21.92 **	-15.99 **	-15.70 **	-25.27 **	4.69	0.56
$L_{10} \times T_1$	-24.95 **	-16.06 **	-20.22 **	-9.63 *	-35.88 **	-35.65 **	4.54	-1.45	-5.34
$L_{10} \times T_2$	-11.69 **	-1.23	-6.13 **	53.19 **	30.44 **	30.89 **	9.52	-9.26	-12.84 *
$L_{10} \times T_3$	-14.41 **	7.72 **	2.38	-41.50 **	-37.05 **	-36.83 **	-46.62 **	-25.23 **	-28.18 **
$L_{11} \times T_1$	-10.17 **	3.78	-1.36	-4.03	-18.62 **	-18.34 **	34.87 **	27.14 **	22.13 **
$L_{11} \times T_2$	-38.27 **	-28.68 **	-32.21 **	-2.17	-16.69 **	-16.41 **	54.46 **	38.32 **	32.87 **
$L_{11} \times T_3$	-28.13 **	-9.55 **	-14.04 **	-35.88 **	-31.01 **	-30.78 **	-43.15 **	-20.36 **	-23.50 **
$L_{12} \times T_1$	-30.55 **	-29.20 **	-32.71 **	-27.45 **	-32.71 **	-32.48 **	-23.45 **	-8.47	-12.08
$L_{12} \times T_2$	-12.03 **	-2.62	-7.44 **	40.00 **	29.83 **	30.28 **	6.38	27.20 **	22.19 **
$L_{12} \times T_3$	-42.81 **	-28.02 **	-31.59 **	14.79 **	23.52 **	23.94 **	-7.67	29.34 **	24.24 **
No. of crosses with significant (+) heterosis	10	12	7	12	11	12	10	15	14
No. of crosses with significant (-) 'heterosis	24	15	20	23	24	23	15	9	10

……….*Continued*…..

Crosses	Number of fruits per plant			Day to first fruit set			Number of fruits per vine at 60DAS		
	Pooled			Pooled			Pooled		
	BP	SV1	SV2	BP	SV1	SV2	BP	SV1	SV2
$L_1 \times T_1$	20.68 **	4.81	8.01 **	5.26 **	-2.44	-4.44 **	16.93 **	26.16 **	22.49 **
$L_1 \times T_2$	-10.36 **	-21.85 **	-19.47 **	0.68	3.48 *	1.37	-9.48 **	14.13 **	10.81 **
$L_1 \times T_3$	-17.93 **	-8.91 **	-6.12 *	-21.03 **	-20.21 **	-21.84 **	-21.97 **	14.12 **	10.81 **
$L_2 \times T_1$	-7.60 *	-29.35 **	-27.19 **	-2.53	-5.92 **	-7.85 **	-18.84 **	4.11	1.08
$L_2 \times T_2$	-22.62 **	-32.54 **	-30.48 **	-13.56 **	-11.15 **	-12.97 **	-28.48 **	-8.26 *	-10.92 **
$L_2 \times T_3$	-36.81 **	-29.87 **	-27.73 **	-5.52 **	-4.53 **	-6.48 **	-38.27 **	-9.72 **	-12.34 **
$L_3 \times T_1$	1.55	-29.12 **	-26.96 **	-0.71	-2.79	-4.78 **	-34.05 **	2.07	-0.89
$L_3 \times T_2$	44.15 **	25.67 **	29.51 **	-20.34 **	-18.12 **	-19.80 **	-29.49 **	9.13 *	5.96
$L_3 \times T_3$	-5.55 *	4.82	8.03 **	-8.28 **	-7.32 **	-9.22 **	-35.15 **	0.37	-2.54
$L_4 \times T_1$	39.83 **	2.59	5.72 *	-9.18 **	-3.48 *	-5.46 **	-11.26 **	0	-2.9
$L_4 \times T_2$	-14.63 **	-25.57 **	-23.30 **	-0.98	5.23 **	3.07	-30.43 **	-12.28 **	-14.83 **
$L_4 \times T_3$	-5.49 *	4.89	8.10 **	-7.87 **	-2.09	-4.10 *	-21.98 **	14.11 **	10.79 **
$L_5 \times T_1$	15.27 **	-12.82 **	-10.16 **	5.12 **	7.32 **	5.12 **	-12.43 **	6.22	3.14
$L_5 \times T_2$	44.05 **	25.58 **	29.42 **	-11.53 **	-9.06 **	-10.92 **	-6.90 *	17.38 **	13.98 **
$L_5 \times T_3$	-8.60 **	1.44	4.54	-21.84 **	-20.21 **	-21.84 **	-24.03 **	11.11 **	7.89 *

$L_6 \times T_1$	15.32 **	12.71 **	16.16 **	-18.71 **	-16.72 **	-18.43 **	0.8	31.32 **	27.51 **
$L_6 \times T_2$	24.30 **	21.49 **	25.20 **	-4.75 **	-2.09	-4.10 *	-2.74	26.71 **	23.04 **
$L_6 \times T_3$	-24.92 **	-16.67 **	-14.12 **	-7.48 **	-5.23 **	-7.17 **	-20.52 **	16.25 **	12.87 **
$L_7 \times$ T1	-29.49 **	-24.64 **	-22.34 **	2.21	-3.14	-5.12 **	-28.41 **	-16.90 **	-19.31 **
$L_7 \times T_2$	-25.72 **	-20.61 **	-18.18 **	-23.39 **	-21.25 **	-22.87 **	-36.81 **	-20.33 **	-22.65 **
$L_7 \times T_3$	-36.19 **	-29.18 **	-27.01 **	-4.48 **	-3.48 *	-5.46 **	-28.42 **	4.69	1.65
$L_8 \times T_1$	-7.70 **	-8.61 **	-5.82 *	-14.33 **	-8.36 **	-10.24 **	14.41 **	7.17	4.06
$L_8 \times T_2$	-4.91	-5.85 *	-2.97	-9.12 **	-2.79	-4.78 **	-13.47 **	9.10 *	5.93
$L_8 \times T_3$	15.69 **	28.40 **	32.32 **	-21.17 **	-15.68 **	-17.41 **	-12.93 **	27.35 **	23.65 **
$L_9 \times T_1$	53.44 **	22.80 **	26.55 **	-7.45 **	-9.06 **	-10.92 **	14.72 **	9.37 *	6.19
$L_9 \times T_2$	30.19 **	13.50 **	16.97 **	-22.37 **	-20.21 **	-21.84 **	4.56	31.83 **	28.01 **
$L_9 \times T_3$	-9.39 **	0.57	3.64	-7.93 **	-6.97 **	-8.87 **	-21.64 **	14.61 **	11.28 **
$L_{10} \times T_1$	40.02 **	16.00 **	19.54 **	-12.67 **	-8.71 **	-10.58 **	-1.02	16.40 **	13.02 **
$L_{10} \times T_2$	42.53 **	24.26 **	28.05 **	-16.00 **	-12.20 **	-13.99 **	1.27	27.68 **	23.97 **
$L_{10} \times T_3$	-43.47 **	-37.25 **	-35.34 **	-5.00 **	-0.7	-2.73	-36.46 **	-7.07	-9.77 **
$L_{11} \times T_1$	-4.35	-22.97 **	-20.62 **	-11.93 **	-12.54 **	-14.33 **	-13.39 **	-6.42	-9.13 *
$L_{11} \times T_2$	-19.71 **	-30.00 **	-27.86 **	-20.34 **	-18.12 **	-19.80 **	-26.97 **	-7.92 *	-10.60 **
$L_{11} \times T_3$	-28.16 **	-20.26 **	-17.83 **	-7.93 **	-6.97 **	-8.87 **	-36.19 **	-6.68	-9.39 **
$L_{12} \times T_1$	-5.61	-29.87 **	-27.73 **	-12.67 **	-8.71 **	-10.58 **	14.42 **	7.58 *	4.45
$L_{12} \times T_2$	3.33	-9.91 **	-7.16 *	-12.67 **	-8.71 **	-10.58 **	-11.49 **	11.59 **	8.35 *
$L_{12} \times T_3$	10.21 **	22.32 **	26.06 **	-5.6**	-4.88 **	-6.83 **	-17.18 **	21.13 **	17.62 **
No. of crosses with significant (+) heterosis	13	10	14	5	3	3	4	20	18
No. of crosses with significant (-) ‘heterosis	18	19	18	27	26	30	27	6	9

.... *Continued.....*

Crosses	Length of fruit (cm)			Number of nodes / wine			Diameter of fruit (cm)		
	Pooled			Pooled			Pooled		
	BP	SV1	SV2	BP	SV1	SV2	BP	SV1	SV2
$L_1 \times T_1$	-29.99 **	-14.19 **	-16.07 **	1.57	-24.52 **	-3.35 *	-18.58 **	6.94	12.49 **
$L_1 \times T_2$	-11.50 **	20.25 **	17.61 **	-14.80 **	-33.73 **	-15.14 **	-6.61 *	26.46 **	33.02 **
$L_1 \times T_3$	40.91 **	20.34 **	17.70 **	-11.03 **	-34.32 **	-15.90 **	-1.58	13.00 **	18.86 **
$L_2 \times T_1$	-24.94 **	-7.99 **	-10.01 **	-9.82 **	-32.99 **	-14.19 **	-17.44 **	8.45 *	14.08 **
$L_2 \times T_2$	-9.11 **	23.48 **	20.77 **	-9.41 **	-29.54 **	-9.77 **	-22.02 **	5.59	11.08 **
$L_2 \times T_3$	60.06 **	17.84 **	15.25 **	55.96 **	10.25 **	41.17 **	-1.23	24.30 **	30.75 **
$L_3 \times T_1$	-40.34 **	-26.87 **	-28.47 **	26.53 **	6.26 **	36.06 **	-18.76 **	6.71	12.25 **
$L_3 \times T_2$	-45.59 **	-26.07 **	-27.70 **	27.58 **	7.14 **	37.19 **	-20.08 **	8.21 *	13.83 **
$L_3 \times T_3$	33.33 **	-1.84	-4.00 *	4.20 **	-12.50 **	12.05 **	-4.58	7.64 *	13.23 **
$L_4 \times T_1$	-14.33 **	5.01 **	2.7	28.83 **	-4.26 **	22.59 **	-12.27 **	15.23 **	21.22 **
$L_4 \times T_2$	-17.56 **	12.01 **	9.55 **	38.34 **	7.61 **	37.79 **	-21.36 **	6.48	12.01 **
$L_4 \times T_3$	32.94 **	-2.13	-4.28 *	-11.23 **	-38.06 **	-20.68 **	-21.83 **	-3.05	1.99
$L_5 \times T_1$	-5.67 **	15.63 **	13.09 **	-20.19 **	-31.32 **	-12.05 **	-21.40 **	3.24	8.60 *
$L_5 \times T_2$	-23.15 **	4.41 *	2.12	-18.98 **	-30.27 **	-10.71 **	-24.95 **	1.62	6.9
$L_5 \times T_3$	-14.28 **	-5.27 **	-7.35 **	-11.17 **	-23.55 **	-2.1	-14.57 **	-6.63	-1.78
$L_6 \times T_1$	0.7	23.44 **	20.73 **	10.65 **	-14.04 **	10.07 **	32.09 **	-10.80 **	-6.17
$L_6 \times T_2$	-38.97 **	-17.08 **	-18.90 **	-2.42	-24.10 **	-2.81	-21.36 **	6.48	12.01 **
$L_6 \times T_3$	-24.55 **	-28.13 **	-29.71 **	4.05 *	-19.16 **	3.51 *	-7.35 *	9.41 **	15.09 **
$L_7 \times$ T1	-20.70 **	-2.79	-4.93 **	-4.89 **	-16.50 **	6.92 **	24.93 **	-1.39	3.73
$L_7 \times T_2$	-37.01 **	-14.42 **	-16.30 **	-10.21 **	-21.18 **	0.93	-18.63 **	10.18 **	15.90 **
$L_7 \times T_3$	38.73 **	2.13	-0.11	-15.53 **	-25.85 **	-5.05 **	18.78 **	22.95 **	29.33 **
$L_8 \times T_1$	-2.03	20.09 **	17.45 **	-8.42 **	-31.95 **	-12.86 **	27.39 **	-4.63	0.32
$L_8 \times T_2$	-4.80 **	29.34 **	26.50 **	10.25 **	-14.25 **	9.81 **	-14.44 **	15.85 **	21.87 **
$L_8 \times T_3$	39.35 **	20.18 **	17.54 **	17.19 **	-18.23 **	4.70 **	22.36 **	-3.59	1.42
$L_9 \times T_1$	-3.24 *	18.60 **	16.00 **	31.82 **	-2.04	25.43 **	-18.47 **	7.10 *	12.66 **
$L_9 \times T_2$	-9.49 **	22.97 **	20.27 **	15.85 **	-9.89 **	15.39 **	23.41 **	3.7	9.09 *
$L_9 \times T_3$	-19.09 **	-20.51 **	-22.26 **	4.83 *	-25.53 **	-4.64 **	-21.27 **	-7.10 *	-2.27
$L_{10} \times T_1$	-17.35 **	12.22 **	9.76 **	33.42 **	5.77 **	35.43 **	-8.75 **	19.86 **	-26.09 **
$L_{10} \times T_2$	-31.03 **	-6.29 **	-8.35 **	18.26 **	-6.26 **	20.04 **	22.22 **	5.32	10.79 **
$L_{10} \times T_3$	-4.53 **	29.63 **	26.78 **	4.59 **	-17.09 **	6.17 **	-16.22 **	6.17	-11.68 **
$L_{11} \times T_1$	5.35 **	29.13 **	26.29 **	8.70 **	-6.35 **	19.92 **	21.20 **	3.51	8.88 *
$L_{11} \times T_2$	-8.65 **	24.11 **	21.39 **	-17.33 **	-28.78 **	-8.81 **	-16.83 **	12.61 **	18.46 **
$L_{11} \times T_3$	48.52 **	29.19 **	26.35 **	-12.23 **	-24.38 **	-3.17	-13.36 **	-9.72 **	-5.03
$L_{12} \times T_1$	-4.58 **	16.96 **	14.39 **	-0.77	-26.26 **	-5.58 **	10.04 **	18.16 **	24.30 **

$L_{12} \times T_2$	-42.56 **	-21.96 **	-23.68 **	-13.93 **	-33.05 **	-14.27 **	-8.91 **	23.33 **	29.74 **
$L_{12} \times T_3$	20.97 **	18.99 **	16.37 **	-4.34 *	-33.25 **	-14.53 **	-6.95 *	9.45 **	-15.13 **
No. of crosses with significant (+) heterosis	9	22	19	17	5	15	8	17	24
No. of crosses with significant (-) 'heterosis	25	11	14	16	30	15	28	3	3

.... Continued.....

Crosses	Average weight of fruit (kg)			Duration of crop (days)			Fruit yield (kg / plant)		
	Pooled			Pooled			Pooled		
	BP	SV1	SV2	BP	SV1	SV2	BP	SV1	SV2
$L_1 \times T_1$	-14.77 **	-34.99 **	-36.52 **	-1.89	4.57 **	4.19 **	-14.31 **	-14.15 **	-16.96 **
$L_1 \times T_2$	-9.52 *	-36.62 **	-38.11 **	0.34	9.32 **	8.93 **	12.30 *	2.16	-1.19
$L_1 \times T_3$	22.47 **	4.94	2.46	-0.68	7.13 **	6.74 **	-4.31	-7.86	-10.88 *
$L_2 \times T_1$	-16.55 **	-26.97 **	-28.70 **	-2.06	4.39 **	4.01 *	1.14	1.34	-1.99
$L_2 \times T_2$	-20.99 **	-30.85 **	-32.48 **	-5.63 **	2.82	2.45	11.73 *	2	-1.34
$L_2 \times T_3$	-2.03	-14.26 **	-16.28 **	10.51 **	19.20 **	18.76 **	8.74	4.71	1.27
$L_3 \times T_1$	-35.29 **	-40.52 **	-41.93 **	12.19 **	19.58 **	19.14 **	-3.27	-3.09	-6.27
$L_3 \times T_2$	-25.28 **	-31.33 **	-32.95 **	7.55 **	17.18 **	16.76 **	-4.52	-8.96	-11.95 *
$L_3 \times T_3$	51.69 **	39.42 **	36.13 **	0.01	7.87 **	7.48 **	-16.94 **	-20.02 **	-22.65 **
$L_4 \times T_1$	34.41 **	5.21	2.73	4.97 **	11.88 **	11.48 **	-11.70 *	-6.14	-9.22
$L_4 \times T_2$	66.30 **	30.17 **	27.10 **	-1.04	7.83 **	7.44 **	10.14 *	17.07 **	13.23 *
$L_4 \times T_3$	58.94 **	36.18 **	32.97 **	-2.03	5.67 **	5.29 **	-4.97	1.02	-2.3
$L_5 \times T_1$	12.67 **	15.81 **	13.08 **	-3.87 **	2.63	2.26	-12.27 *	-6.1	-9.18
$L_5 \times T_2$	-14.76 **	-12.38 **	-14.45 **	-1.98	6.80 **	6.41 **	-19.43 **	-13.76 *	-16.59 **
$L_5 \times T_3$	3.8	6.70 *	4.18	-2.46	5.20 **	4.82 **	-0.62	6.36	2.87
$L_6 \times T_1$	-31.54 **	-21.74 **	-23.58 **	12.18 **	19.56 **	19.13 **	-34.73 **	-34.60 **	-36.75 **
$L_6 \times T_2$	19.25 **	36.34 **	33.12 **	4.55 **	13.91 **	13.50 **	-14.24 *	-24.25 **	-26.74 **
$L_6 \times T_3$	2.33	16.98 **	14.22 **	-1.07	6.71 **	6.32 **	7.76	3.76	0.36
$L_7 \times T1$	5.47 *	27.02 **	24.02 **	-3.00 *	6.93 **	6.54 **	17.64 **	17.87 **	14.00 **
$L_7 \times T_2$	-28.92 **	-14.40 **	-16.43 **	-6.93 **	2.6	2.22	39.87 **	23.54 **	19.49 **
$L_7 \times T_3$	-19.37 **	-2.9	-5.19 *	-6.70 **	2.86	2.48	0.74	-3	-6.18
$L_8 \times T_1$	5.05	6.19 *	3.69	0.49	7.10 **	6.71 **	-7.5	-7.33	-10.37 *
$L_8 \times T_2$	-14.00 **	-13.07 **	-15.12 **	9.90 **	19.74 **	19.31 **	18.25 **	4.44	1.02
$L_8 \times T_3$	5.72 *	6.87 *	4.35	4.17 **	12.36 **	11.95 **	22.40 **	17.86 **	13.99 **
$L_9 \times T_1$	-7.66 **	8.39 **	5.83 *	0.08	6.67 **	6.28 **	5.5	5.71	2.24
$L_9 \times T_2$	-25.09 **	-12.08 **	-14.15 **	-3.95 **	4.66 **	4.28 **	37.98 **	24.71 **	20.62 **
$L_9 \times T_3$	-18.25 **	-4.05	-6.32 *	-5.34 **	2.1	1.73	9.72	5.65	2.18
$L_{10} \times T_1$	-23.66 **	-5.91 *	-8.13 **	-0.55	6.00 **	5.61 **	-1.24	-1.05	-4.3
$L_{10} \times T_2$	-7.53 **	13.97 **	11.27 **	-5.68 **	2.77	2.39	20.05 **	6.04	2.56
$L_{10} \times T_3$	-1.81	21.01 **	18.15 **	8.60 **	17.14 **	16.71 **	23.77 **	19.17 **	15.26 **
$L_{11} \times T_1$	23.07 **	5.07	2.59	-1.8	4.66 **	4.28 **	-15.74 **	-15.58 **	-18.35 **
$L_{11} \times T_2$	24.53 **	6.31 *	3.8	-4.70 **	3.84 *	3.46 *	22.09 **	15.86 **	12.06 *
$L_{11} \times T_3$	24.55 **	6.72 *	4.2	-1.34	6.42 **	6.03 **	2.41	-1.39	-4.63
$L_{12} \times T_1$	-42.36 **	-17.92 **	-19.86 **	10.07 **	17.31 **	16.89 **	-17.50 **	-17.34 **	-20.05 **
$L_{12} \times T_2$	-37.13 **	-10.48 **	-12.59 **	-3.19 *	5.48 **	5.10 **	30.67 **	25.56 **	21.44 **
$L_{12} \times T_3$	-14.73 **	21.43 **	18.56 **	-4.36 **	3.15 *	2.78	30.51 **	25.66 **	21.54 **
No. of crosses with significant (+) heterosis	12	16	11	10	30	29	13	9	9
No. of crosses with significant (-) 'heterosis	19	15	17	11	0	0	9	7	10

.... Continued.....

Crosses	Day to first fruit picking			Total soluble solids			Specific gravity			Dry matter (%)		
	Pooled			Pooled			Pooled			Pooled		
	BP	SV1	SV2	BP	SV1	SV2	BP	SV1	SV2	BP	SV1	SV2
$L_1 \times T_1$	6.41 **	3.75 *	-0.6	-1.13	-3.55	2.35	11.64 **	0.91	-0.44	-0.82	22.79 **	23.94 **
$L_1 \times T_2$	0.88	7.19 **	2.69	4.89	23.45 **	30.99 **	-4.79	-12.92 **	-14.08 **	-18.80 **	0.53	1.47
$L_1 \times T_3$	-20.49 **	-18.75 **	-22.16 **	-9.60 **	-16.58 **	-11.48 **	-13.58 **	-16.95 **	-18.06 **	-27.76 **	-10.56 **	-9.73 **
$L_2 \times T_1$	-0.32	-3.13	-7.19 **	-15.69 **	13.09 **	20.00 **	15.09 **	-1.35	-2.67	15.15 **	22.62 **	23.75 **
$L_2 \times T_2$	-10.29 **	-4.69 **	-8.68 **	-33.13 **	-10.30 **	-4.81	-15.96 **	-23.13 **	-24.15 **	2.3	10.00 **	11.03 **
$L_2 \times T_3$	-4.28 *	-2.19	-6.29 **	-32.26 **	-9.13 **	-3.58	-12.33 **	-15.75 **	-16.88 **	-19.71 **	-6.77 **	-5.91 **
$L_3 \times T_1$	1.23	2.5	-1.8	-34.02 **	-16.29 **	-11.17 **	15.02 **	-1.41	-2.72	-8.66 **	-5.77 **	-4.89 **
$L_3 \times T_2$	-22.65 **	-17.81 **	-21.26 **	-7.19 **	17.74 **	24.94 **	-3.44	-11.68 **	-12.86 **	-10.15 **	-3.39 *	-2.49

$L_3 \times T_3$	-7.95 **	-5.94 **	-9.88 **	-5.73 *	19.60 **	26.91 **	-3.64	-7.39 **	-8.63 **	-18.09 **	-4.90 **	-4.02 **
$L_4 \times T_1$	-7.33 **	-1.25	-5.39 **	-2.65	-5.03	0.77	14.00 **	2.99	1.62	-9.47 **	-6.61 **	-5.74 **
$L_4 \times T_2$	0.88	7.50 **	2.99	10.08 **	29.55 **	37.47 **	-1.03	-9.48 **	-10.69 **	-1.86	5.52 **	6.50 **
$L_4 \times T_3$	-4.11 *	2.19	-2.1	37.70 **	11.98 **	18.83 **	9.50 **	5.23	3.83	2.38 *	18.87 **	19.97 **
$L_5 \times T_1$	5.42 **	9.38 **	4.79 **	23.02 **	20.01 **	27.35 **	2.73	-11.22 **	-12.40 **	-1.93	11.33 **	12.37 **
$L_5 \times T_2$	-12.94 **	-7.50 **	-11.38 **	-21.75 **	-7.91 *	-2.28	1.48	-7.18 *	-8.42 **	-21.46 **	-10.84 **	-10.01 **
$L_5 \times T_3$	-19.58 **	-16.56 **	-20.06 **	30.91 **	26.64 **	34.38 **	5.06	0.97	-0.38	-15.21 **	-1.55	-0.64
$L_6 \times T_1$	-12.05 **	-8.75 **	-12.57 **	-1.43	-3.83	2.04	-19.01 **	-19.88 **	-20.95 **	6.88 **	26.87 **	28.04 **
$L_6 \times T_2$	-6.47 **	-0.63	-4.79 **	-21.75 **	-7.91 *	-2.28	5.97 *	4.83	3.43	-30.03 **	-16.95 **	-16.18 **
$L_6 \times T_3$	-6.63 **	-3.13	-7.19 **	3.6	0.35	6.48	4.55	3.42	2.04	-13.41 **	2.78 *	3.74 **
$L_7 \times$ T1	0	-1.25	-5.39 **	29.04 **	25.89 **	33.58 **	2.61	-12.05 **	-13.22 **	8.08 **	16.64 **	17.72 **
$L_7 \times T_2$	-22.06 **	-17.19 **	-20.66 **	-25.41 **	-12.22 **	-6.85 *	-18.30 **	-25.27 **	-26.27 **	-17.02 **	-10.46 **	-9.62 **
$L_7 \times T_3$	5.20 **	7.50 **	2.99	8.58 *	-11.69 **	-6.3	-19.77 **	-22.90 **	-23.92 **	-1.11	14.82 **	15.89 **
$L_8 \times T_1$	-12.57 **	-6.56 **	-10.48 **	6.32	3.72	10.06 **	8.22 *	-7.20 *	-8.44 **	-20.83 **	-1.03	-0.11
$L_8 \times T_2$	-7.60 **	-1.25	-5.39 **	-37.29 **	-26.20 **	-21.69 **	-5.4	-13.47 **	-14.63 **	-21.61 **	-2	-1.09
$L_8 \times T_3$	-12.87 **	-6.88 **	-10.78 **	27.52 **	3.71	10.05 **	-9.20 **	12.74 **	-13.90 **	-26.39 **	-7.99 **	-7.13 **
$L_9 \times T_1$	-5.03 **	-5.63 **	-9.58 **	10.31 **	7.61 *	14.19 **	6.97 *	-0.39	-1.71	17.65 **	21.38 **	22.51 **
$L_9 \times T_2$	-21.76 **	-16.88 **	-20.36 **	-1.09	16.40 **	23.52 **	-2.55	9.25 **	-10.46 **	16.92 **	25.72 **	26.88 **
$L_9 \times T_3$	-3.98 *	-1.88	-5.99 **	-12.10 **	-20.13 **	-15.25 **	7.27 *	3.09	1.71	-12.86 **	1.18	2.12
$L_{10} \times T_1$	-10.65 **	-5.63 **	-9.58 **	-6.50 *	-8.78 **	-3.21	-13.37 **	-18.73 **	-19.81 **	-13.09 **	-10.33 **	-9.50 **
$L_{10} \times T_2$	-10.29 **	-4.69 **	-8.68 **	-26.00 **	-12.91 **	-7.59 *	3.7	-2.7	-4	-10.31 **	-3.56 *	-2.66
$L_{10} \times T_3$	-4.14 *	1.25	-2.99	18.92 **	-0.17	5.93	-4.88	-8.59 **	9.81 **	-11.46 **	2.80 *	3.76 **
$L_{11} \times T_1$	-10.74 **	-9.06 **	-12.87 **	14.26 **	11.47 **	18.28 **	-22.48 **	23.40 **	24.42 **	3.22 *	6.49 **	7.47 **
$L_{11} \times T_2$	-20.88 **	-15.94 **	-19.46 **	-0.25	17.40 **	24.57 **	-0.64	-1.81	-3.12	-17.82 **	-11.63 **	-10.81 **
$L_{11} \times T_3$	-5.20 **	-3.13	-7.19 **	8.33 *	-6.99 *	-1.3	-4.08	-5.21	-6.48 *	-20.00 **	-7.11 **	-6.25 **
$L_{12} \times T_1$	-6.91 **	-3.13	-7.19 **	27.26 **	25.85 **	33.54 **	0.9	-10.95 **	12.13 **	15.22 **	18.87 **	19.97 **
$L_{12} \times T_2$	-12.35 **	-6.88 **	-10.78 **	-34.76 **	-23.22 **	-18.52 **	7.77 *	-1.43	-2.74	-17.20 **	-10.97 **	-10.14 **
$L_{12} \times T_3$	-7.51 **	-3.75 *	-7.78 **	-16.06 **	-16.99 **	-11.92 **	-4.2	7.93 **	9.16 **	-14.74 **	-1.01	-0.09
No. of crosses with significant (+) heterosis	3	5	1	11	14	16	10	4	4	8	15	12
No. of crosses with significant (-) 'heterosis	28	18	28	14	12	8	9	18	18	23	14	13

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively

24 crosses in over better parent, 15 crosses over first standard variety and 20 crosses over second standard variety showed negative and significant heterosis in node for first female flower similar result were also described by Kushwaha *et al.* [12]. 12 crosses over better parent, 24 crosses over first and second standard variety. Showed positive heterosis for number of branches per plant [13-15]. 15 crosses over better parent, 9 crosses over first standard variety and 10 crosses over second standard variety showed positive heterosis in vine length at 60 DAS, similar results were also reported by Bairagi *et al*. [13], Iranna *et al.* [16]. 13 crosses over better parent, 10 crosses over first standard variety and 14 crosses over second standard variety showed positive heterosis for number fruits per plant [17-18]. 27 cross over better parent, 26 cross over first standard variety while the same cross showed the highest negative and desirable heterosis over second standard variety in days to first fruit set. 4 crosses over better parent, 20 crosses over first standard variety and 18 crosses over second standard variety showed positive heterosis for number fruits per vine at 60 DAS [19-20]. 9 crosses over better parent, 22 crosses over first standard variety and 19 crosses over second standard variety showed positive heterosis for length of fruit [20-21]. 17 crosses over better parent, 5 crosses over first standard variety and 15 crosses over second standard variety showed positive heterosis for number of node/wine. 8 crosses over better parent, 17 crosses over first standard variety 24 crosses over second standard variety showed positive heterosis for diameter of fruit [22-23]. 12 crosses over better parent, 16 crosses over first standard variety and 24 crosses over second standard variety showed positive heterosis for Average weight of fruit (kg) [23], [21], [18]. 10 crosses over better parent, 30 crosses over first standard variety and 29 crosses second standard variety showed positive heterosis for duration of crop. 13 crosses over better parent, 9 crosses over first standard variety and 9 crosses over second standard variety showed positive desirable heterosis for fruit yield / plant [20-23]. 28 crosses over better parent, 18 crosses over first standard variety and 28 crosses over second standard variety showed significant and negative heterosis for day to first fruit picking [18]. 11 crosses over better parent, 14 crosses over first standard variety and 16 crosses in pooled showed significant and positive heterosis for T.S.S [18]. 10 crosses over better parent, 4 crosses over first standard variety and 4 crosses over second standard variety showed significant and positive heterosis for specific gravity. 8 crosses over better parent, 15 crosses over first standard variety and 4 crosses over second standard variety showed positive and significant desirable heterosis for dry matter.

CONCLUSION

Based on the above findings it may be concluded that crosses $L_{12} \times T_2$, $L_9 \times T_2$, $L_4 \times T_3$, $L_3 \times T_1$ and $L_7 \times T_2$ could be exploited as commercial hybrid in future on the formers field. Parents P_9 and P_7 could be used in future crossing programme.

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