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EXPLORING THE IMPACT OF HETEROSIS IN BRINJAL (*SOLANUM MELONGENA* L.) CULTIVATION AND YIELD QUALITY

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Abstract

The experiment was conducted to study the mean performance and heterosis for various traits in brinjal. Seven genotypes were crossed using a half diallel mating design, generating 21 hybrids that were evaluated along with parental lines and check variety (Kashi Taru). Analysis showed significant variability among genotypes and hybrids for studied traits. Superior parental genotypes based on performance were PPL, Arka Harshita and PPC. Promising hybrid combinations were PPL × Arka Harshita, PPC × LC-1, and LC-3 × Arka Harshita excelling in many traits. These hybrids show potential for wider testing and use in brinjal breeding programs. The findings underscore the value of hybrid development to advance brinjal cultivation and yield quality across diverse growing conditions.

Introduction

Brinjal (*Solanum melongena* L.) is one of the most cultivated vegetables grown in tropical and subtropical regions of India. It belongs to the Solanaceae family, possesses a diploid chromosome number of 2n=2x=24. It is a nutritive crop rich in vitamins B and C. The edible portion of brinjal comprises approximately 92.7% water, 4% carbohydrates, 1.4% protein, 1.3% fiber, 0.3% fats, and 0.3% minerals (Tripathi *et al.* 2014).

Heterosis, is a natural phenomenon in which hybrid offspring of genetically heterogeneous individuals perform superior or inferior than the mid-parent value (average heterosis), superior parent (heterobeltiosis), or check cultivar (standard heterosis) (Ramya *et al.* 2018).Brinjal is particularly amenable to the exploitation of hybrid vigor due to its large bud size, high percentage of crossed fruit set and substantial seed production per fruit. The objective of heterosis breeding programs is to develop hybrids with enhanced yield and quality. This can be achieved by creating varieties capable of withstanding various biotic and abiotic stresses, thereby augmenting hybrid vigor. Utilizing local genotypes for crossing can enhance the efficacy of heterosis breeding, as these genotypes are well-adapted to the local environment. By amalgamating desirable qualitative and quantitative traits from different parents, superior genotypes can be developed.Heterosis breeding has been recognized as a potential tool for breeders to elevate the genetic yield in brinjal (Das and Barua 2001), it aids in achieving the goals of improving brinjal quality and productivity.Exploitation of hybrid vigor has become a potential tool for improvement in eggplant. Hence, the study has been undertaken to estimate the magnitude of heterosis for various horticultural traits in brinjal.

Materials and Methods

The present investigation was carried out at the Experimental Farm, Department of Vegetable Science, College of Horticulture and Forestry, Neri, Hamirpur, HP, India. The experimental material used in the present study comprised of seven brinjal genotypes (PPL, Pusa Anupam,

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PPC, LC-1, LC-2, LC-3 and Arka Harshita)which were crossed in half diallel mating design during *kharif*, 2023 to obtain twenty-one cross combinations. Thetwenty-one F1 crosses along with seven parental genotypes and one check Kashi Taru were evaluated in RCBD withthree replications during summer, 2024. The observations were recorded on days to 50%flowering, number of flowers per inflorescence, days to first picking, average fruit weight (g), fruit shape index, number of fruits per cluster, number of fruits per plant, harvest duration, plant height (cm), number of primary branches per plant, yield per plant (kg), number of seeds per fruit, 100 seed weight (g), ascorbic acid (mg/100g)(Rangana 1976) and TSS (º Brix). The data for various traits was subjected to statistical analysis.The average performance of both parents and hybrids was evaluated along with heterosis in comparison to the better parent and the standard parent, heterosis over better parent and standard check was calculated as follows:

Per cent heterosis over the better parent = $\frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$

$\overline{BP}$ = Better Parent

Per cent heterosis over check = $\frac{\overline{F_1} - \overline{Check}}{\overline{Check}} \times 100$

$\overline{Check}$ = Check Hybrid

Results and Discussion

The analysis of variance indicated substantial differences among the genotypes for all the horticultural traits, highlighting the variability present within the genetic material.Early flowering is an indicative of early production, the number of days to 50% flowering among various genotypes varied from 32.76 to 52.82 days, with an overall average of 45.09 days (Table 1). Among parents'the minimum number of days to 50% flowering was observed in Pusa Purple Long (41.70);among the F_1 cross combinations, PPL× Arka Harshita (32.76 days) took the minimum number of days.The number of flowers per inflorescence has a positive association with yield. Among parents,the Pusa Purple cluster has the highest number of flowers per inflorescence *i.e.*, 5.77. Among the crosses, the maximum number of flowers per inflorescence was reported in Pusa Anupam × PPC (4.80).Days to first picking is an important economic trait for early production.Among parents, PPL took the least days for first picking (58.43 days) and among the cross-combinations PPL× Arka Harshita has been found to be the earliest and took 46.63 days for first picking.Average fruit weight is a yield-attributing factor that is proportionately related to the overall yield. However, consumer preferences in different regions can sometimes make fruit weight a limiting parameter. Maximum average fruit weight among the parents was recorded in PPL (67.02 g) while in crosses, maximum averagefruit weight was recorded in PPL × Arka Harshita (74.73 g).Considerable variation was present with respect to fruit shape index among the genotypes.

Maximum fruit shape index of8.66 was observed in LC-1, giving long and slender fruits. Cross LC-1 × LC-3 recorded a maximum fruit shape index of 7.40 (Table 1).The number of fruits per cluster along with fruit weight is a crucial factor in determining the overall yield of the plant. The number of fruits per cluster varied from 3.41 to 1.00 with a population mean of 2.33. Among parents,the maximum number of fruits per cluster was observed in PPC (2.44), in cross combinations, PPC × Arka Harshita reflected the maximum number of fruits per cluster (3.41).Significant differences were observed among the parents and crosses for the number of fruits per plant, the maximum number of fruits per plant was observed in parent PPC (19.37).On the other hand,among crosses, Pusa Anupam × Arka Harshita (25.04) recorded the maximum number of fruits per plant.

Table 1. Mean performance of parents and hybrids for different horticultural traits.

Sr. No.	Parents/crosses	DTFPF	NOFPI	DTFP	AFW	FSI	NOFPC	NOFPP	HD	PH	NOPB	YPP	NOSPF	100SW	AA	TSS
1.	Pusa Purple Long (PPL)	41.70	3.64	58.43	67.02	5.78	1.60	18.59	64.04	88.11	6.12	1.43	413.06	0.32	12.50	3.92
2.	Pusa Anupam	49.22	3.57	63.10	29.42	4.38	1.56	11.88	52.59	85.85	5.6	0.66	392.08	0.33	7.56	5.03
3.	Pusa Purple Cluster (PPC)	51.90	5.77	65.08	30.68	3.92	2.44	19.37	55.50	82.84	5.49	0.69	336.33	0.35	10.09	3.56
4.	LC-1	50.54	3.40	72.22	41.62	8.66	1.22	10.64	45.45	84.91	5.51	0.65	332.15	0.28	8.75	4.16
5.	LC-2	52.82	2.75	70.98	36.41	3.88	1.00	9.86	44.27	107.84	6.5	0.71	400.50	0.30	7.17	4.37
6.	LC-3	52.45	1.20	74.49	47.83	5.27	1.01	11.07	43.44	100.65	6.09	0.68	395.27	0.30	9.87	4.21
7.	Arka Harshita	45.05	3.96	60.80	45.10	3.74	2.00	17.29	60.94	102.10	5.22	1.03	377.89	0.38	11.25	4.47
	Mean (Parents)	**49.10**	**3.47**	**66.44**	**42.58**	**5.09**	**1.55**	**14.10**	**52.32**	**93.19**	**5.79**	**0.84**	**378.18**	**0.32**	**9.60**	**4.25**
1.	PPL× Pusa Anupam	39.01	3.81	52.80	43.89	5.94	2.75	22.63	67.76	109.72	5.8	1.68	442.34	0.31	10.67	3.81
2.	PPL×PPC	37.21	4.06	53.35	54.14	4.82	2.84	20.82	66.44	116.09	5.22	1.19	504.22	0.36	12.67	4.23
3.	PPL× LC-1	44.23	3.12	57.89	41.77	6.36	2.22	19.83	62.80	109.89	6.04	1.28	409.34	0.26	10.89	4.37
4.	PPL× LC-2	40.63	2.60	61.44	42.77	4.30	1.80	17.50	67.43	113.74	6.4	1.24	405.56	0.33	11.29	5.46
5.	PPL× LC-3	46.92	3.09	62.43	67.38	5.10	2.22	20.21	61.77	107.88	6.91	1.46	386.79	0.29	8.77	4.89
6.	PPL× Arka Harshita	32.76	4.08	46.63	74.73	6.28	3.17	23.74	72.86	126.77	6.7	2.28	505.55	0.38	12.06	4.64
7.	Pusa Anupam× PPC	42.81	4.80	60.29	44.52	4.63	3.19	20.42	57.30	91.10	5.75	1.01	465.37	0.30	11.01	4.41
8.	Pusa Anupam× LC-1	45.55	3.60	61.89	46.70	5.85	2.41	19.61	58.57	94.23	5.42	1.18	457.33	0.35	12.56	4.87
9.	Pusa Anupam× LC-2	45.10	4.00	62.09	35.11	4.99	2.40	16.80	56.38	111.22	5.74	0.89	450.21	0.35	10.05	4.81
10.	Pusa Anupam× LC-3	45.30	3.80	65.40	71.44	4.76	2.44	19.40	58.51	105.23	6.08	1.42	398.78	0.31	11.44	4.73
11.	Pusa Anupam× Arka Harshita	41.68	4.11	63.95	45.84	4.61	3.12	25.04	61.89	91.03	6.78	1.51	403.00	0.42	11.69	4.14
12.	PPC×LC-1	48.34	4.07	65.95	69.90	5.15	2.81	21.57	56.22	95.55	7.02	1.35	453.37	0.36	13.43	4.56
13.	PPC×LC-2	44.57	4.60	62.63	45.55	5.13	3.06	23.43	55.29	95.27	6	1.03	415.16	0.36	10.99	4.98
14.	PPC×LC-3	48.07	4.00	63.46	67.15	5.20	3.11	21.60	55.30	107.34	8	1.37	442.67	0.36	12.57	4.38
15.	PPC×Arka Harshita	41.13	4.20	58.85	67.79	4.05	3.41	23.50	59.97	106.66	8	1.52	428.88	0.42	10.22	3.64
16.	LC-1×LC-2	45.67	1.60	67.43	45.60	5.93	1.25	14.94	50.77	99.99	5.81	0.82	413.03	0.38	8.76	4.68
17.	LC-1×LC-3	47.95	2.20	69.63	71.08	7.40	1.52	12.29	47.76	112.02	6.56	1.26	400.30	0.37	14.06	3.62
18.	LC-1×Arka Harshita	50.04	3.60	71.24	46.59	5.50	2.09	15.07	61.11	109.39	8.01	0.92	388.88	0.38	10.23	3.65
19.	LC-2×LC-3	47.97	2.40	69.28	72.37	4.74	1.27	12.44	52.57	104.89	7.08	1.50	402.02	0.37	12.50	5.96
20.	LC-2×Arka Harshita	39.93	3.40	57.25	57.07	4.75	2.15	18.75	53.37	107.24	6.98	1.00	397.37	0.40	10.66	4.65
21.	LC-3×Arka Harshita	42.85	3.20	62.40	73.75	6.72	2.66	20.66	67.57	120.99	6.69	1.64	403.96	0.31	13.75	4.71
	Kashi Taru (Check)	46.18	2.62	67.20	64.16	5.10	2.01	17.51	60.63	122.47	7.91	1.10	398.77	0.35	14.01	4.32
	Crosses mean	43.70	3.54	61.73	56.44	5.34	2.47	19.54	59.20	105.76	6.52	1.31	428.51	0.35	11.33	4.52
	Standard Error (±Mean)	1.14	0.11	1.29	1.8	0.28	0.12	0.97	1.13	2.15	0.21	0.09	4.38	0.01	0.17	0.07
	$CD_{(0.05)}$	3.26	0.33	3.67	5.15	0.81	0.35	2.78	3.21	6.11	0.6	0.26	12.46	0.03	0.49	0.20
	CV %	4.41	5.89	3.55	5.89	9.37	9.63	9.31	3.38	3.50	5.79	13.32	1.83	4.91	2.71	2.75

DTFPF: days to 50% flowering, NOFPI: number of flowers per inflorescence, DTFP: days to first picking, AFW: average fruit weight, FSI: Fruit shape index, NOFPC: number of flowers per cluster, NOFPP: number of flowers per plant, HD: harvest duration, PH: plant height, NOPB: number of primary branches, YPP: yield per plant, NOSPF: number of seeds per fruit, 100SW: 100 seed weight, AA: ascorbic acid and TSS: total soluble solids

Harvest duration of various genotypes ranged from 72.86 to 43.44 days, PPL recorded the longest harvest duration of 64.04 days and among crossesPPL × Arka Harshita recorded the longest harvest duration of 72.86 days (Table 1). The maximum plant height among parents was recorded in LC-2 (107.84 cm);among crosses,PPL× Arka Harshita was reported to have a maximum plant height of 126.97cm.The number of fruit bearing branches is an important growth parameter as it relates to the vigor of the plant. For all the genotypes the number of primary branches per plant ranged from 8.01 to 5.22 with a population mean of 6.39 branches per plant. Among parents it varied from 5.22 (Arka Harshita) to 6.50(LC-2). The maximum number of primary branches was recorded in LC-1 × Arka Harshita (8.01).

Yield per plant varied from 2.28 to 0.65 kg, being maximum in PPL × Arka Harshita which was statistically different from all other cross combinations. Among parents, PPL recorded the maximum yield of 1.43 kg per plant.The number of seeds per fruit is an important trait in hybridization programs. The maximum number of seeds per fruit was observed in PPL (413.06), whereas, among crosses, themaximum number of seeds per fruit was recorded in PPL × Arka Harshita (505.55).Seed weight is an index of seed vigour among parents Arka Harshita recorded a maximum 100 seed weight of 0.38g on the other hand, a maximum 100 seed weight of 0.42g was found in two crosses,*i.e.*,Pusa Anupam × Arka Harshita and PPC × Arka Harshita.

Ascorbic acid content ranged from 7.17 to 14.06mg/100g with a population mean of 11.09 mg/100g among all the genotypes, maximum ascorbic acid content was recorded in PPL (12.50 mg/100g), and cross combination showing higher values for ascorbic acid was LC-3 × Arka Harshita (13.75mg/100g) (Table 1). TSS is an important qualitative parameter that measures the carbohydrates, organic acids, proteins, fats and minerals of the fruit. Among parents, the average TSS value ranged from 5.03 ºB (Pusa Anupam) to 3.56 ºB (PPC), whereas, the TSSvalueforcrosses variedfrom 5.96 ºB (LC-2 × LC-3)to3.62ºB(LC-1 × LC-3).

For days to 50% flowering maximum negative significant heterobeltiosis was observed in cross PPL × Arka Harshita, whereas the highest useful significant heterosis was reflected by PPL × Arka Harshita (Table 2).Thepresent resultsareinconformitywiththefindingsof Pandey and Yadav (2018), Kalaiyarasi *et al.* (2018), and Makasare*et al.*(2020).For the number of flowers per inflorescence the highest significant positive heterobeltiosis was exhibited by cross combination Pusa Anupam × LC-2; on the other hand, maximum economic heterosis was recorded in cross Pusa Anupam × PPC.These findings are in line with Dharwad *et al.* (2011) and Reddy and Patel (2014). Maximum negative significant heterobeltiosis for days to first picking was recorded in PPL × Arka Harshita followed by PPL× Pusa Anupam and PPL × PPC. Fourteen cross combinations reflected negative significant economic heterosis, being maximum in PPL × Arka Harshita.Pandey and Yadav (2018) reported considerable heterobeltiosis and standard heterosis for days to first picking.

Average fruit weight is a yield-attributing factor that is proportionately related to the overall yield, and maximumsignificant positive heterobeltiosis was exhibited by cross PPC × LC-1, significant negative or positive standard heterosis was observed in eighteen cross combinations, ranging from 16.47 % to - 45.28 % being maximum in PPL × Arka Harshita (Table 1). These findings align with the results of Dharwad *et al.* (2011), Shitapand Patel (2017) and Makasare*et al.* (2020).Understanding the fruit shape index is crucial for breeding programs considerable heterobeltiosis of 30.87, 27.51and 22.42% was observed in cross combinations PPC × LC-2, LC-3 × Arka Harshita and LC-2 × Arka Harshita, respectively while economic heterosis of 45.10, 31.76 and 24.71 percent was observed in cross combinations LC-1 × LC-3, LC-3 × Arka Harshita and PPL× LC-1, respectively. For the number of fruits per cluster, the highestsignificant positive heterobeltiosis was observed incross PPL × Pusa Anupam; however, maximum positive significant useful heterosis was observed in cross PPC × Arka Harshita. The number of fruits per

Table 2. Heterosis (%) over better parent and standard check for various horticultural traits.

F_1 Crosses	Heterosis %	DFPF	NOFPI	DFP	AFW	FSI	NOFPC	NOFPP	HD	PH	NOPBP	YPP	NOSPF	100 SW	AA	TSS
PPL×Pusa	BP	-6.45	4.67	-9.64*	-34.51*	2.77	71.88*	21.77*	5.82*	24.53*	-5.18	17.48	7.09*	-6.06	-14.67*	-24.30*
Anupam	SC	-15.53*	45.42*	-21.43*	-31.59*	16.47*	36.82*	29.24*	11.77*	-10.42*	-26.64*	52.73*	10.93*	-12.26*	-23.86*	-11.81*
PPL×PPC	BP	-10.77*	-29.64*	-8.69*	-19.22*	-16.61*	16.39*	7.5	3.76	31.76*	-14.60*	-16.78	22.07*	2.86	1.36	7.91*
	SC	-19.42*	54.96*	-20.61*	-15.62*	-5.49	41.29*	18.90*	9.59*	-5.21*	-33.94*	8.18	26.44*	1.89	-9.56*	-2.08
PPL× LC-1	BP	6.07	-14.29*	-0.92	-37.68*	-26.56*	38.75*	6.67	-1.94	24.72*	-1.31	-10.49	-0.9	-17.71*	-12.85*	5.13*
	SC	-4.22	19.08*	-13.85*	-34.90*	24.71*	10.45	13.25	3.57	-10.27*	-23.65*	16.36	2.65	-25.47*	-22.25*	1.23
PPL× LC-2	BP	-2.57	-28.57*	5.15	-36.18*	-25.61*	12.5	-5.83	5.30*	5.47	-1.49	-13.29	-1.81	3.13	-9.68*	24.94*
	SC	-12.02*	-0.76	-8.57*	-33.34*	-15.69	-10.45	-0.06	11.22*	-7.13*	-19.06*	12.73	1.7	-6.6	-19.41*	26.39*
PPL× LC-3	BP	12.52*	-15.11*	6.85*	0.54	-11.76	38.75*	8.73	-3.54	7.18*	13.08*	2.1	-6.36*	-10.42*	-29.84*	16.06*
	SC	1.6	17.94*	-7.10*	5.02	0.01	10.45	15.42	1.88	-11.92*	-12.52*	32.73*	-3.01	-18.87*	-37.40*	13.19*
PPL× Arka	BP	-21.44*	3.03	-20.20*	11.50*	8.65	58.50*	27.71*	13.78*	24.16*	9.48	59.44*	22.39*	0.01	-3.52	3.8
Harshita	SC	-29.06*	55.73*	-30.61*	16.47*	23.14*	57.71*	35.58*	20.17*	3.51	-15.30*	107.27*	26.78*	6.6	-13.92*	7.41*
Pusa Anupam×	BP	-13.02*	-16.81*	-4.45	45.11*	5.71	30.74*	5.42	3.24	6.12	2.62	46.38*	18.69*	-13.33*	9.15*	-12.32*
PPC	SC	-7.30*	83.21*	-10.28*	-30.61*	-9.22	58.71*	16.62*	-5.49	-25.61*	-27.23*	-8.18	16.70*	-14.15*	-21.39*	2.16
Pusa Anupam×	BP	-7.46*	0.84	-1.92	12.21	-32.45*	54.49*	65.07*	11.36*	9.76*	-3.33	78.79*	16.64*	5.05	43.50*	-3.31
LC-1	SC	-1.36	37.40*	-7.90*	-27.21*	14.71	19.90*	11.99	-3.40	-23.06*	-31.45*	7.27	14.69*	-1.89	-10.37*	12.65*
Pusa Anupam×	BP	-8.37*	12.04*	-1.6	-3.57	13.93	53.85*	41.41*	7.21*	3.13	-11.65*	25.35	12.41*	5.05	32.94*	-4.44*
LC-2	SC	-2.34	52.67*	-7.60*	-45.28*	-2.16	19.40*	-4.05	-7.00*	-9.19*	-27.40*	-19.09	12.90*	-1.89	-28.27*	11.34*
Pusa Anupam×	BP	-7.96*	6.44	3.65	49.36*	-9.68	56.41*	63.30*	11.26*	4.55	-0.16	108.82*	0.89	-7.07	15.94*	-6.03*
LC-3	SC	-1.91	45.04*	-2.68	11.35*	-6.67	21.39*	10.49	-3.50	-14.08*	-23.06*	29.09*	0.01	-13.21*	-18.32*	9.49*
Pusa Anupam×	BP	-7.48*	3.79	5.18	1.64	5.25	56.00*	44.82*	1.55	-10.84*	20.99*	46.60*	2.79	11.50*	3.94	-17.68*
Arka Harshita	SC	-9.74*	56.87*	-4.84	-28.55*	-9.61	55.22*	43.00*	2.07	-25.67*	-14.21*	37.27*	1.06	18.87*	-16.54*	-4.09
PPC×LC-1	BP	-4.35	-29.46*	1.34	67.95*	-40.53*	15.16*	11.38	1.29	12.54*	27.19*	95.65*	34.80*	2.86	33.10*	9.62*
	SC	4.68	55.34*	-1.86	8.95*	0.98	39.80*	23.19*	-7.28*	-21.98*	-11.26*	22.73	13.69*	1.89	-4.14*	5.56*
PPC×LC-2	BP	-14.12*	-20.28*	-3.76	25.10*	30.87*	25.41*	20.96*	-0.39	-11.66*	-7.59	45.07*	3.66*	2.86	8.92*	13.96*
	SC	-3.49	75.57*	-6.80*	-29.01*	0.59	52.24*	33.81*	-8.81*	-22.21*	-24.07*	-6.36	4.11*	1.89	-21.56*	15.28*
PPC×LC-3	BP	-7.38*	-30.68*	-2.49	40.39*	-1.33	27.46*	11.53	-0.36	6.64*	31.24*	98.55*	11.99*	3.81	24.55*	3.88
	SC	4.09	52.67*	-5.57*	4.66	1.96	54.73*	23.36*	-8.79*	-12.36*	1.14	24.55*	11.01*	2.83	-10.30*	1.31
PPC×Arka	BP	-8.70*	-27.21*	-3.21	50.31*	3.32	39.75*	21.36*	-1.59	4.46	45.48*	47.57*	13.49*	12.39*	-9.16*	-18.57*
Harshita	SC	-10.94*	60.31*	-12.43*	5.66	-20.59*	69.65*	34.21*	-1.08	-12.91*	1.14	38.18*	7.55*	19.81*	-27.05*	-15.74*
LC-1×LC-2	BP	-9.64*	-52.94*	-5	9.56	-31.52*	2.46	40.44*	11.71*	-7.28*	-10.52*	15.49	3.13	26.67*	0.11	7.09*
	SC	-1.1	-38.93*	0.34	-28.93*	16.27*	-37.81*	-14.68	-16.26*	-18.36*	-26.48*	-25.45*	3.58*	7.55	-37.47*	8.33*
LC-1×LC-3	BP	-5.12	-35.29*	-3.59	48.61*	-14.55*	24.59	10.99	5.08	11.29*	7.71	85.29*	1.27	20.88*	42.45*	-14.08*
	SC	3.83	-16.03*	3.62	10.79*	45.10*	-24.38*	-29.81*	-21.23*	-8.54*	-16.99*	14.55	0.38	3.77	0.36	-16.20*
LC-	BP	11.08*	-9.09*	17.17*	3.3	-36.49*	4.5	-12.82	0.28	7.14*	45.14*	-10.68	2.91	0.88	-9.04*	-18.27*
1×ArkaHarshita	SC	8.36*	37.40*	6.01*	-27.38*	7.84	3.98	-13.93	0.80	-10.68*	1.26	-16.36	-2.48	7.55	-26.96*	-15.43*
LC-2×LC-3	BP	-8.54*	-12.73*	-2.4	51.31*	-10.06	25.74	12.31	18.75*	-2.74	9.03	111.27*	0.38	21.98*	26.65*	36.46*
	SC	3.88	-8.4	3.1	12.80*	-7.06	-36.82*	-28.95*	-13.29*	-14.35*	-10.41*	36.36*	0.82	4.72	-10.78*	38.04*
LC-2×Arka	BP	-11.37*	-14.14*	-5.84	26.54*	22.42*	7.5	8.44	-12.42*	-0.57	7.39	-2.91	-0.78	6.19	-5.21*	4.03
Harshita	SC	-13.53*	29.77*	-14.81*	-11.05*	-6.86	6.97	7.08	-11.97*	-12.44*	-11.76*	-9.09	-0.35	13.21*	-23.89*	7.64*
LC-3×Arka	BP	-4.88	-19.19*	2.63	54.19*	27.51*	33.00*	19.51*	10.89*	18.49*	9.79	59.22*	2.2	-17.70*	22.22*	5.37*
Harshita	SC	-7.21*	22.14*	-7.14*	14.95*	31.76*	32.34*	17.99*	11.45*	-1.21	-15.39*	49.09*	1.3	-12.26*	-1.86	9.03*

DTFPF: days to 50% flowering, NOFPI: number of flowers per inflorescence, DTFP: days to first picking, AFW: average fruit weight, FSI: Fruit shape index, NOFPC: number of flowers per cluster, NOFPP: number of flowers per plant, HD: harvest duration, PH: plant height, NOPB: number of primary branches, YPP: yield per plant, NOSPF: number of seeds per fruit, 100SW: 100 seed weight, AA: ascorbic acid and TSS: total soluble solid.

plant is of utmost importance as it is the reflection of yieldmaximum positive significant heterobeltiosis was recorded in cross Pusa Anupam × LC-1, whereas maximum positive and significant economic heterosis was found in cross Pusa Anupam × Arka Harshita. These results are consistent with the findings of Dharwad *et al.* (2011), Shitapand Patel (2017) and Kalaiyarasi *et al.* (2018).Maximum heterobeltiosis for harvest duration was recorded in LC-2 × LC-3 and cross PPL × Arka Harshita exhibited maximum significant positive standard heterosis.

Plantheight isoneofthecriticalgrowthparameters which reflects the vigour of the plant, eleven out of twenty-one F_1's reflected significantpositiveheterobeltiosis being maximum in PPL × PPC (31.76%), and none of the cross combinations surpassed the check Kashi Taru for plant height.Similar findings have also been reported by Shitapand Patel (2017), Kalaiyarasi *et al.* (2018) and Makasare*et al.* (2020).For the number of branches per plant cross combination,PPC × Arka Harshita reflected maximum positive significant heterobeltiosis; however, none of the cross combination reflected positive standard heterosis. These results are in accordance with the findings of Dharwad *et al.* (2011) and Shitapand Patel(2017). For plant yield, positive and significant heterobeltiosis was observed in twelve cross combinations, being maximum in LC-2 × LC-3 (111.27 %) and maximum useful heterosis was observed in PPL × Arka Harshita (107.27%) followed by PPL × Pusa Anupam (52.73%), and LC-3 × Arka Harshita (49.09%). Similar results have also been reported by Shitapand Patel(2017) Dishri*et al.* (2018)and Mishra *et al.* (2023).

The number of seeds per fruit is an important trait in hybridization programs, cross PPC × LC-1 exhibited maximum significant heterobeltiosis whereas maximum standardheterosiswasobserved in PPL × Arka Harshita (Table 2). Seed weight is an index of seed vigor, five crosses, showed positive and significant heterobeltiosis being maximum in LC-1 × LC-2 (26.67%) and three crosses *i.e.*, PPC × Arka Harshita (19.81%), Pusa Anupam × Arka Harshita (18.87%) and LC-2 × Arka Harshita (13.21%) showed positive significant economic heterosis.

Ascorbic acid content impartsnutritional value to the crop as it is a precursor of vitamin C; maximum positive and significant heterobeltiosis was observed in Pusa Anupam × LC-1 (43.50%), and none of the cross exhibited significant economic heterosis (Table 2).Comparable heterotic effects on ascorbic acid content were observed by Hussain *et al.* (2018) over the better parent; Kumar *et al.* (2012) over both the better parent and standard checks; and Baraskar *et al.* (2016) over the standard check. TSS is an important qualitative parameter that measures the carbohydrates, organicacids, proteins, fats and minerals of the fruithighestheterobeltiosis was registered by the cross LC-2 × LC-3 whereas maximum usefulheterosis of 38.04% was observed in cross LC-2 × LC-3.The findings of Sao and Mehta (2010), Gadhiya *et al.* (2015) and Hussain *et al.* (2018)align with the current results.

The present investigations demonstrated considerable variability among all the horticultural traits through mean performance and heterosis. Based upon mean performance, PPL andArka Harshita among the parents and PPL × Arka Harshita, Pusa Anupam × Arka Harshita, PPC × Arka Harshita and LC-3 × Arka Harshitaamong the cross combinations, showed superior performance for most of the yield and yield-contributing traits. Cross combinations, PPL × Arka Harshita, PPL × PPC and PPL × Pusa Anupam showed appreciable heterobeltiosis and useful heterosis for earliness and yield.

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