Original Research Article

Blossoming Heterosis: Unveiling the Potential of Hybridization in Eggplant (*Solanum melongena* L.)

ABSTRACT:

A study was conducted to assess 24 crosses created through the Line × Tester mating design. These crosses were obtained from seeds collected during the *kharif* season of 2022 at the Post Graduate Research Farm, School of Agriculture, Lovely Professional University (LPU), Punjab. Alongside the hybrids, 10 parent lines and 1 check were cultivated for evaluation. The entire experiment followed a Randomized Block Design (RBD) with three replications during the *kharif* season of 2022. The mean squares of the 10 traits revealed significant differences among the entries. The hybrid JBR-20-02 x JBR-20-05 demonstrated the highest standard heterosis among all the crosses, with JBR-20-03 x JBR-21-06 ranking second in terms of total fruit yield per plant. Notably, all these crosses exhibited significant and desirable standard heterosis not only for fruit yield per plant but also for other traits, indicating their potential for improved overall performance. The application of heterosis in brinjal will aid in the production of superior cross combinations, which will help meet the expanding demand for brinjal due to its bioactive properties.

Keywords**:** Eggplant, line x tester heterosis prediction, heterobeltiosis, standard heterosis

1. Introduction

Eggplant, scientifically known as *Solanum melongena* L., is a widely cultivated vegetable, popularly referred to as brinjal or aubergine. It holds a significant position in the Indian subcontinent, often regarded as the common man's vegetable due to its year-round availability [1]. The total cultivated area for eggplant stands at approximately 1.79 million hectares, producing an impressive 51.28 million tons [2]. The production of eggplant has witnessed a remarkable growth of 50% in recent times, primarily attributed to the adoption of high-yielding varieties and hybrids [3]. Notably, farmers have shown a considerable inclination towards using eggplant hybrids to meet yield targets and market demands [4,5].

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One important factor contributing to the success of eggplant hybrids is the phenomenon of heterosis. Heterosis refers to the offspring's ability to exhibit higher or lower trait values compared to the average of either parent involved in creating the hybrid [6]. This has been evident in vegetable crops, including eggplant, where the introduction of hybrids has led to significant yield improvements over the past five decades.

Eggplant cultivation predominantly relies on cultivated varieties rather than hybrids. Being an autogamous vegetable crop, it allows for the rapid development of pure lines, but this has led to a gradual reduction in the genetic diversity of cultivated eggplant over time [7]. The large size of eggplant flowers makes hand emasculation an easy process, and successful crosses can yield varying numbers, ranging from 20 to 200, depending on the genotype [3, 8, 9]. Additionally, the discovery of male-sterility has further facilitated hybrid development in eggplant.

2. MATERIAL AND METHODS

In this research study, a total of 24 crosses were created using the Line × Tester mating design. The cross seeds were acquired during the kharif season of 2022 from the Post Graduate Research Farm, School of Agriculture, Lovely Professional University (LPU), Punjab. These 24 hybrid combinations, together with 10 parent lines and 1 check, were cultivated, and assessed using a Randomized Block Design (RBD) with three replications during the *kharif* season of 2023. To ensure the accuracy of results, special precautions were taken during pollination to prevent any chances of contamination. Hand-emasculation and pollination were performed during autumn, while the seeds of F_1 hybrids and their parent lines were sown in a nursery and later transplanted during spring. The field planting involved placing seedlings 8-10 cm tall at a spacing of 75 cm between rows and 50 cm between plants in a Randomized Block Design with three replications. Each treatment consisted of seven plants in a row, and data were recorded for five competitive plants.

The study encompassed the recording of ten observations: Days to 50% flowering, Days to first picking, Fruit length (cm), Average fruit weight (g), Fruit girth (cm), Number of fruits per plant, Number of primary branches per plant, Plant height (cm), Total fruit yield per plant (g), and Fruit borer infestation (%). Throughout the research, the developmental stages, fruit characteristics, yield parameters, and pest infestation were monitored to gain insights into the growth and productivity of the experimental plants.

Table 1. List of genotypes and check used in crossing programme

Genotype	Notation	Source
Female		
JBR-21-04	M1	Junagadh Agricultural University
JBR-20-05	M2	Junagadh Agricultural University

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JBR-20-06	M3	Junagadh Agricultural University
JBR-21-06	M4	Junagadh Agricultural University
JBR-20-07	M5	Junagadh Agricultural University
JBR-21-14	M6	Junagadh Agricultural University
		Males
JBR-20-01	F1	Junagadh Agricultural University
JBR-20-02	F2	Junagadh Agricultural University
JBR-20-03	F3	Junagadh Agricultural University
JBR-20-04	F4	Junagadh Agricultural University
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2.1 STATISTICAL ANALYSIS

Estimation of heterobeltiosis and standard heterosis

Heterobeltiosis

It was calculated as the deviation of F_1 from the better parent [10] and was expressed as per cent basis by the following formula.

$$\text{Heterobeltiosis (\%)} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

Where,

$\overline{F_1}$ = Mean performance of F_1

$\overline{BP}$ = Mean value of better parent of respective cross combination.

Standard heterosis

Standard heterosis referred to as the superiority of F_1 over standard hybrid and was estimated as per the formula given by [11]

$$\text{Standard Heterosis (\%)} = \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$$

Where;

$\overline{F_1}$= Mean performance of F_1

$\overline{SC}$ = Mean performance of the standard hybrid (SML 668)

The significance of estimates of heterobeltiosis and standard heterosis were tested with the help of following formulae.

S.E. of difference for heterobeltiosis and standard heterosis = (2Me/Rr)

Where;

Me = Error mean square

R = number of replications

C.D. = S.E. (d) x table value of ‘t’ at error d.f at P = 0.05 and 0.01 levels of significance

Significance of heterosis was tested using t test:

$$t = \frac{\overline{F_1} - \overline{BP} \quad \text{or SC}}{\text{S.E. of heterosis over BP or SC}}$$

Calculated t values were compared with table value at error degree of freedom for significance.

3. RESULTS AND DISCUSSION

In this research study, the investigation focused on estimating heterosis for ten important traits in eggplant hybrids. Heterosis, also known as hybrid vigor, refers to the phenomenon where the progeny of two different parent lines exhibit superior performance compared to their individual parents. The three types of heterosis analyzed were relative heterosis (F_1 value over mid-parental value), heterobeltiosis (F_1 value over better parental value), and standard heterosis (F_1 value over the standard check 'Nishant' variety). These parameters were assessed for the following traits:

For days to 50% flowering, the time from transplanting to the appearance of 50% of the plants' first flowers was recorded. Out of the 24 crosses, 12 showed negative heterosis over heterobeltiosis, indicating that these crosses exhibited desirable earliness in flowering. Moreover, 8 crosses displayed negative heterosis over standard heterosis, suggesting their early flowering tendencies. The highest desirable heterobeltiosis was observed in cross L2 x T5 (-25.14 %), while L4 x T1 showed the highest standard heterosis (30.56 %).

Next, the days to first picking trait measured the number of days from transplanting to the date of the first picking of fresh, marketable fruits. Among the 24 crosses, 20 exhibited negative heterosis over heterobeltiosis, indicating desirable early fruiting in these crosses. Additionally, 18 crosses showed negative heterosis over standard heterosis, further confirming their early fruiting nature. The highest desirable heterobeltiosis was recorded in cross L1 x T2 (-24.59 %), while L4 x T2 exhibited the highest standard heterosis (10.76 %) for this trait. For fruit length (cm), the length of five randomly selected fruits from each tagged plant was measured during the picking period, and the mean value was expressed in centimeters. Notably, none of the crosses showed positive heterosis over heterobeltiosis, suggesting no significant improvement in this trait. However, 13 crosses displayed heterosis over standard heterosis, indicating some potential for improvement. Cross L2 x T2 exhibited the highest standard heterosis (50.57 %) for fruit length. Furthermore, the average fruit weight (g) trait was determined by weighing the fruits selected for the fruit length measurement.

Only one cross showed positive heterosis over heterobeltiosis, suggesting a desirable increase in fruit weight compared to the average of the parents. Moreover, 4 crosses showed positive heterosis over standard heterosis, indicating their superior performance in terms of fruit weight. Cross L3 x T5 exhibited the highest desirable heterobeltiosis (-47.56 %), while L2 x T2 showed the highest standard heterosis (50.59 %) for average fruit weight.The research also investigated fruit girth (cm), where the girth of the fruits was measured at the middle region of each fruit in centimeters. None of the crosses exhibited positive heterosis over heterobeltiosis, indicating no significant improvement in this trait. However, 3 crosses showed heterosis over standard heterosis, suggesting some potential for enhancement. Cross L2 x T1 exhibited the highest standard heterosis (8.89 %) for fruit girth. The other traits, including number of fruits per plant, number of primary branches per plant, plant height (cm), total fruit yield per plant (g), and fruit borer infestation (%), were also evaluated for heterosis levels, providing valuable insights into the performance and productivity of the experimental crosses.

The hybrid JBR-20-02 x JBR-20-05 ranked first by expressing the highest standard heterosis followed by JBR-20-03 x JBR-21-06 for total fruit yield per plant (Table 2). All these crosses showing significant and desirable standard heterosis for fruit yield per plant also exhibited significant and desirable heterosis for other one or more traits. Similar results were reported by earlier workers like[12,13,].

The results demonstrate that the magnitude of heterosis varied significantly across different crosses and traits. Some crosses exhibited desirable heterosis, indicating potential for improved performance, while others showed negative heterosis, signifying a decrease in the expression of certain traits. The findings provide valuable insights into the genetic potential and performance of eggplant hybrids, contributing to the development of high-yielding and resilient varieties in eggplant breeding programs.

Table 2. Heterobeltiosis and standard heterosis for yield and its and its attributing traits in brinjal

Cross No.	Genotypes	Days to 50% Flowering		Days to First Picking		Fruit Length (cm)		Average fruit weight (kg)		Fruit girth (cm)	
		BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH
C1	L1 x T1	-7.52*	-7.52*	-19.90**	-9.33**	-21.04**	10.68**	-34.91**	-25.10**	-20.30**	-4.69*
C2	L1 x T2	9.64**	9.64**	-24.59**	-17.62**	-17.29**	3.01	-42.15**	-42.15**	-16.10**	-16.10**
C3	L1 x T3	15.69**	15.69**	-5.62**	-5.62**	-15.06**	8.01**	-26.55**	-20.67*	-9.86**	-1.28
C4	L1 x T4	-20.92**	-20.92**	-6.56**	-3.71**	-33.4 **	6.42**	-47.10**	-17.18*	-16.72**	-3.86*
C5	L1 x T5	0.17	-0.98	-15.36**	-4.19**	-10.7 **	25.06**	-46.73**	-38.70**	-17.08**	-0.84
C6	L1 x T6	-9.92**	-10.95**	-10.46**	-2.19	-19.83**	0.85	-27.80**	-22.92**	-18.80**	-10.69**
C7	L2 x T1	-16.69**	-17.65**	-18.95**	-11.85**	-8.13**	16.82**	-20.93*	-14.60	-1.01	8.89**
C8	L2 x T2	-1.74	-2.86	-13.62**	-6.05**	-5.83**	50.57**	-3.82	50.59**	-10.83**	2.94
C9	L2 x T3	-15.14**	-0.16	-21.75**	-11.43**	-6.40**	31.19**	-27.38**	-16.44	-12.76**	4.32*
C10	L2 x T4	-22.08**	-8.33**	-23.37**	-16.29**	-27.24**	-9.38**	-21.27*	-34.84**	-8.75**	-23.52**
C11	L2 x T5	-25.14**	-11.93**	-5.84**	-3.33**	-19.17**	2.78	-30.39**	-24.82**	-21.95**	-14.52**
C12	L2 x T6	-7.78**	8.50**	-13.12**	-10.48**	-34.86**	4.15	-44.38**	-12.91	-20.08**	-7.75**
C13	L3 x T1	15.80**	-1.80	-14.14**	-2.81*	-15.85**	17.95**	-20.41**	-8.41	-18.67**	-2.74
C14	L3x T2	15.71**	2.29	-10.51**	-2.24	-25.87**	-7.67**	-35.00**	-34.11**	-28.21**	-20.16**
C15	L3x T3	30.24**	7.68*	0.05	-0.57	-26.45**	-6.48**	-18.93*	-12.44	-13.56**	-3.87*
C16	L3x T4	-5.62	-12.25**	-20.43**	-18.00**	-24.66**	20.45**	-14.57**	33.75**	-8.93**	5.13**
C17	L3 x T5	44.51**	22.55**	-16.87**	-5.90**	-29.68**	19.66**	-47.56**	-25.84**	-20.42**	-4.84*
C18	L3 x T6	19.59**	5.72	-11.33**	-3.14**	-42.50**	-2.16	-42.09**	-18.09*	-16.50**	-5.10**
C19	L4 x T1	57.44**	30.56**	12.09**	3.33**	-39.50**	2.95	-40.89**	-16.40	-14.45**	-2.76
C20	L4 x T2	1.93	-5.23	7.49**	10.76**	-25.91**	26.08**	-24.48**	18.23*	-13.40**	-0.03
C21	L4 x T3	-20.49**	-3.59	-6.31**	6.05**	-31.37**	-3.81	-41.49**	-32.67**	-31.82**	-18.46**
C22	L4 x T4	-11.12**	7.76*	-13.99**	-6.05**	-18.75**	1.19	-10.53	-14.90	-10.81**	-3.63
C23	L4 x T5	-23.58**	-7.35*	1.15	-7.48**	0.04	27.22**	24.53**	34.50**	-5.59**	3.40
C24	L4 x T6	-16.58**	1.14	-13.12**	-10.48**	-28.29**	14.66**	-38.42**	-3.59	-17.02**	-4.21*

*, ** denotes significance at 5% and 1% respectively.

Table 2. (Cont…) Heterobeltiosis and standardheterosis for yield and its and its attributing traits in brinjal

Cross No.	Genotypes	No. of fruit per plant		No. of primary branches		Plant height (cm)		Total fruit yield per plant (g)		Fruit borer infestation (%)	
		BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH
C1	L1 x T1	6.31**	6.31**	-4.81	-4.81	-6.80**	1.27	-5.22**	-5.22**	-26.78**	-26.78**
C2	L1 x T2	7.75**	16.37**	8.65**	8.65**	-12.86**	-0.29	-7.97**	-7.97**	-15.25**	-15.25**
C3	L1 x T3	2.74	2.74	-16.41**	2.88	-11.63**	-4.30**	-6.68**	-6.68**	-36.95**	-36.95**
C4	L1 x T4	-0.31	-0.31	21.63**	21.63**	1.36	4.55**	-3.54**	-3.54**	-16.95**	-16.95**
C5	L1 x T5	30.59**	5.08**	2.78	6.73**	-2.81*	6.88**	-6.70**	-10.16**	27.60**	-20.85**
C6	L1 x T6	21.34**	31.05**	4.17	8.17**	-9.23**	3.86**	-1.49	-3.42**	103.34**	44.41**
C7	L2 x T1	3.56*	2.92	-14.84**	4.81	-6.47**	2.86*	-1.49	-3.25**	-36.55**	-57.63**
C8	L2 x T2	23.71**	-0.46	1.85	5.77*	-12.14**	-3.38*	15.12**	11.11**	79.41**	-6.95**
C9	L2 x T3	-3.59*	11.54**	-1.32	8.17**	-24.67**	-18.15**	3.29*	-1.46	24.90**	1.19
C10	L2 x T4	-1.13	14.38**	-14.47**	-6.25*	-16.65**	-4.64**	-4.92**	-6.79**	4.81*	-15.08**
C11	L2 x T5	-5.59**	9.23**	-16.02**	3.37	-14.75**	-7.68**	-3.03*	-4.77**	-11.09**	-27.97**
C12	L2 x T6	-11.17**	2.77	7.89**	18.27**	-3.18*	-0.14	0.70	-2.81*	-35.98**	-48.14**
C13	L3 x T1	8.36**	0.86	-10.65**	12.98**	-2.74*	5.68**	-6.66**	-9.54**	1.20	-28.31**
C14	L3x T2	27.18**	37.35**	-17.87**	3.85	-11.63**	1.11	-9.39**	-11.17**	16.95**	-16.95**
C15	L3x T3	7.12**	6.46**	-18.25**	3.37	-5.73**	2.08	1.43	-0.39	9.57**	-22.37**
C16	L3x T4	7.60**	0.15	15.97**	46.63**	-5.47**	-2.49	8.86**	5.50**	4.07	-26.27**
C17	L3 x T5	13.58**	19.69**	5.70*	15.87**	-17.23**	-10.06**	-15.88**	-1.91	21.04**	-24.92**
C18	L3 x T6	-10.94**	-3.82*	-18.42**	-10.58**	-21.08**	-9.71**	-20.02**	-6.73**	-40.33**	-57.63**
C19	L4 x T1	-3.50*	1.69	-7.42**	13.94**	-4.71**	3.19*	-17.37**	-3.65**	23.60**	-17.46**
C20	L4 x T2	-29.64**	-25.85**	-5.26*	3.85	2.38	7.22**	-20.74**	-7.58**	-29.08**	-63.22**
C21	L4 x T3	3.03	9.69**	-2.20	6.73**	-6.01**	2.13	-9.10**	-7.52**	31.35**	12.20**
C22	L4 x T4	-8.97**	-1.69	-16.30**	-8.65**	-9.75**	3.27*	-6.51**	-4.88**	-41.87**	-50.34**
C23	L4 x T5	-24.71**	-19.85**	-15.62**	3.85	-18.10**	-11.31**	-0.83	0.90	13.69**	-2.88
C24	L4 x T6	-0.29	6.15**	-7.49**	0.96	-21.74**	-19.28**	-4.30**	-2.64*	-16.87**	-28.98**

*, ** denotes significance at 5% and 1% respectively

4. CONCLUSION

In conclusion, the hybrid JBR-20-02 x JBR-20-05 exhibited significant positive heterosis for fruit length, average fruit weight, and total fruit yield per plant, as well as significant negative desirable standard heterosis over the check for fruit borer infestation yield per plant. These promising results suggest that the cross JBR-20-02 x JBR-20-05 holds great potential for commercial exploitation in agriculture. However, further investigations are essential to assess its stability for yield and other parameters before widespread adoption. Overall, this hybrid presents a valuable opportunity to enhance crop productivity and pest resistance, making it a viable option for sustainable and efficient food production.

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