



# A Brief Study on Heterosis in Indian Brinjal for Horticultural Traits

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## Authors' contributions

This work was carried out in collaboration among all authors. Author SK carried out plant hybridization, data recording, data analyses and did first drafting of manuscript. Author VKS managed the crop management. Author SA conceptualized the research, was responsible for parental line maintenance, did plant hybridization, and edited and finalised the manuscript. Authors DK and Niharika helped in data recording. Author TC did plant hybridization. Author CK was responsible for disease screening. Authors Sanjay Sahay and Sangeeta Shree did the literature survey. All authors read and approved the final manuscript.

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## ABSTRACT

Brinjal is one of the most popular vegetables grown throughout the world and heterosis has been extensively used in developing hybrids in the crop. 11 F<sub>1</sub> hybrids of brinjal were developed through crossing of 7 brinjal genotypes selected on the basis of divergence in the late kharif season of 2022-23. These 11 F<sub>1</sub> hybrids along with the parental lines and check Pusa Hybrid-6 were evaluated in Randomized Block Design in the late kharif season of 2023-24 and were transplanted in three replications, with spacing of 75 cm x 60 cm. Direction and magnitude of heterosis was studied for various yield attributing characters. Negative standard heterosis which is favoured for earliness traits was observed in ten hybrids for days to 50% flowering trait. For total yield, 4 hybrids exhibited significant heterobeltiosis and 5 hybrids showed significant standard heterosis. Based on heterosis from total yield (q/ha) point of view, Pant Samrat x Swarna Mani (53.40 %), Sabour Krishnakali x Pant Samrat (33.65%) and Sabour Krishnakali x Swarna Mani (30.58 %) were top performers for total yield as compared to standard check- Pusa Hybrid-6. The estimates of heterobeltiosis and standard heterosis effects were moderate to high in the positive direction for most of the yield and its contributing components.

*Keywords: Brinjal; hybrid vigour; heterobeltiosis; standard heterosis; yield.*

## 1. INTRODUCTION

Brinjal (*Solanum melongena* L.), with a chromosome number of  $2n=24$ , belongs to the Solanaceae family and is widely cultivated throughout India and is regarded as one of the most economical crops (Pramanik et al., 2012). According to Vavilov (1928), the Indo-Burma region is the primary center of origin for brinjal. Brinjal is a very versatile crop that may be grown all year round in a variety of agroclimatic conditions. India is the second-largest producer of brinjal after China, accounting for 26% of the global brinjal production (FAOSTAT, 2023). It contributes 9% to the total vegetable production in the country, the main brinjal-producing states in India being West Bengal, Odisha, Gujarat, Bihar, and Madhya Pradesh (Anonymous, 2024). Brinjal is cultivated across approximately 682.20 thousand hectares in India, with a production of 12986.57 thousand metric tonnes, and in Bihar, it is particularly significant, covering an area of about 53.70 thousand hectares, with a production of 1127.00 thousand metric tonnes and a productivity of 20.82 metric tonnes per hectare (Anonymous, 2024).

Brinjal is a nutrient-rich vegetable rich in dietary fibre, protein, vitamins, minerals as well as bioactive compounds and antioxidants (Chioti et al., 2022). Exploitation of hybrid vigour in brinjal has been a useful strategy for breeders for improving yield and other economic traits (Rajashree et al., 2023). Brinjal was one of the first vegetable crops in which hybrids were adopted by farmers, with hybrids now covering more than 50% of the cultivated area across

different parts of the country. Consumer preferences for brinjal vary with region, with differences in colour, size, and shape. As a result, it is important to develop high-yielding brinjal varieties or hybrids that cater to regional tastes. Nagai and Kida (1926) were among the first to observe hybrid vigour in crosses involving various Japanese types. It is now common practice for breeders looking to increase yield and other economically significant traits in brinjal to use hybrid vigor. Heterosis breeding's main objective is to significantly increase crop plants' productivity and quality. In brinjal, heterosis breeding is possible because it offers the potential to increase productivity in the shortest possible time (Kakikazi, 1931). Production can be efficiently increased by Identifying and utilizing highly productive hybrids. According to Hochholding and Hoecker (2007), hybrids' potential can be evaluated by comparing their performance to that of the better parent (heterobeltiosis) and mid-parent (average heterosis). In contrast to relative heterosis, which compares the hybrid to the average of both parents, heterobeltiosis compares the hybrid's performance to the best parent, making it a more realistic and useful metric (Lamkey and Edwards, 1999).

## 2. MATERIALS AND METHODS

The present experiment was conducted at the vegetable research farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India. Seven diverse inbred lines of brinjal, Sabour Krishnakali (P<sub>1</sub>), Muktakeshi (P<sub>2</sub>), IIHR-563 (P<sub>3</sub>), Swarna Mani (P<sub>4</sub>), BRBR-01 (P<sub>5</sub>), Sel 91-2 (P<sub>6</sub>)

and Pant Samrat (P<sub>7</sub>) which is collected and maintained at vegetable farm section, selected on basis of previous variability and diversity studies. 11 F<sub>1</sub> hybrids were developed through random crossing in the late kharif season of 2022-23. These 11 F<sub>1</sub> hybrids along with the seven parental lines and check Pusa Hybrid-6 were evaluated in Randomized Block Design in the in the late kharif season of 2023-24 and were transplanted in August 2023 in three replications, following a spacing of 75 cm x 60 cm.

Observations on various yield and attributing traits, viz., Days to 50 % flowering, Plant height (cm), Plant spread (cm), Average fruit weight (g), Fruit length (cm), Fruit girth (cm), numbers of fruit per plant, Fruit yield per plant (kg) and Total yield (q/ha). The extent of heterosis was examined by analyzing quantitative traits. Heterosis was expressed as the percentage increase or decrease in the mean values of F<sub>1</sub> hybrids compared to the better parent (heterobeltiosis), and the standard variety was calculated using the method proposed by (Fonseca and Patterson, 1968) and Hayes et al. (1955), respectively. Heterosis was estimated as follows:

- 1) Heterobeltiosis or Heterosis over better parent (BP) (%) =  $\frac{F_1 - BP}{BP} \times 100$
- 2) Standard heterosis or Heterosis over the standard checks (SC) (%) =  $\frac{F_1 - SC}{SC} \times 100$

Where, F<sub>1</sub> = Mean value of F<sub>1</sub>, BP = Mean value of better-parent and SV = Mean value of standard variety.

The mean data was analyzed using the INDOSTAT 2.0 software to calculate the heterosis percentage for different parameters. Heterosis was estimated from the mean values, and its significance was evaluated using a t-test.

### 3. RESULTS AND DISCUSSION

The heterosis and heterobeltiosis for the plant growth, reproductive, fruit morphological and yield and attributing traits have been presented in Tables 1, 2 and 3.

Earliness is one of the most important factors influencing crop duration, which is assessed in terms of days to 50% flowering. The range for better parent heterosis for days to 50% flowering were 19.12% (Sel 91-2 x IIHR-563) to 3.45% (Sabour Krishnakali x Pant Samrat) all were significant positive and for standard heterosis it was -7.50% (Pant Samrat X Swarna Mani and Muktakeshi x IIHR-563) to 0.57% (Sel 91-2 x IIHR-563). Among 11 hybrids 4 hybrids (Muktakeshi x IIHR-563, Pant Samrat x Swarna Mani, Sabour Krishnakali x Pant Samrat and Swarna Mani x Muktakeshi) showed significant negative heterosis over standard check. Because of the trait's earliest appearance, breeders preferred negative heterosis. The estimates of heterobeltiosis were low to moderate in positive direction while standard heterosis effects were low in negative as well as in positive direction. The results were in accordance with the findings of Reddy et al. (2011), Reddy and Patel (2014) and Rajashree et al., (2023).

**Table 1. Heterosis for fruit morphological and yield traits**

Characters	Days to 50 % flowering		Plant height (cm)		Plant spread (cm)	
	BPH	SH	BPH	SH	BPH	SH
Crosses						
Sabour Krishnakali x IIHR-563	13.43 **	-1.42	-24.44 **	8.29	2.11	8.48
Sabour Krishnakali x Muktakeshi	5.79 *	-4.77	-26.55 **	5.27	10.56 *	17.46 **
Sabour Krishnakali x Pant Samrat	3.45	-6.88 **	-19.10 **	15.94 **	16.90 **	24.19 **
Sabour Krishnakali x Swarna Mani	4.15	-4.95	-21.07 **	13.12 **	13.38 **	20.45 **
IIHR-563 x BRBR-01	15.00 **	-0.05	1.94	12.32 *	-2.48	-11.72 *
Muktakeshi x IIHR-563	6.43 *	-7.50 **	-18.49 **	-4.19	-3.1	-6.48
Sel 91-2 x Sabour Krishnakali	13.97 **	-3.77	-21.63 **	12.32 *	7.43	18.95 **
Sel 91-2 x BRBR-01	18.38 **	-0.05	-16.05 **	7.61	-6.76	3.24
Sel 91-2 x IIHR-563	19.12 **	0.57	2.76	31.72 **	-6.76	3.24
Pant Samrat x Swarna Mani	1.36	-7.50 **	2.71	21.98 **	14.39 **	18.95 **
Swarna Mani x Muktakeshi	4.08	-5.02 *	-27.80 **	-14.25 **	14.73 **	10.72 *

\*Significant at 5% level of probability, \*\*Significant at 1% of probability. BPH (Better parent heterosis), SH (Standard heterosis)

**Table 2. Heterosis for fruit morphological and yield traits**

Characters	Average fruit weight (g)		Fruit length (cm)		Fruit girth (cm)	
	BPH	SH	BPH	SH	BPH	SH
Crosses						
Sabour Krishnakali x IIHR-563	-19.34 **	16.91 **	9.02 *	32.38 **	-12.29 **	-16.50 **
Sabour Krishnakali x Muktakeshi	-34.95 **	-5.71	43.33 **	74.05 **	-3.07	-7.72
Sabour Krishnakali x Pant Samrat	-29.33 **	2.42	24.71 **	51.43 **	-17.84 **	-21.78 **
Sabour Krishnakali x Swarna Mani	-3.71	39.56 **	5.69	28.33 **	-0.28	12.71 **
IIHR-563 x BRBR-01	31.32 **	3.94	19.24 **	4.76	9.96 *	0.17
Muktakeshi x IIHR-563	-33.25 **	-22.08 **	-1.72	-4.52	27.99 **	0.66
Sel 91-2 x Sabour Krishnakali	-8.75 **	32.25 **	-29.41 **	-14.29 **	9.96 *	15.51 **
Sel 91-2 x BRBR-01	31.43 **	11.55 *	5.15	-7.62	-5.44	-0.66
Sel 91-2 x IIHR-563	36.35 **	15.73 **	19.15 **	-21.19 **	-2.45	2.48
Pant Samrat x Swarna Mani	-17.25 **	9.97 *	20.56 **	3.33	-0.13	12.87 **
Swarna Mani x Muktakeshi	-19.37 **	7.15	38.73 **	34.76 **	4.39	17.99 **

\*Significant at 5% level of probability, \*\*Significant at 1% of probability. BPH (Better parent heterosis), SH (Standard heterosis)

**Table 3. Heterosis for yield traits**

Characters	Numbers of fruit per plant		Fruit yield per plant (kg)		Total yield (quintals per hectare)	
	BPH	SH	BPH	SH	BPH	SH
Crosses						
Sabour Krishnakali x IIHR-563	-26.67 **	-6.98	-22.16 **	-6.02	-0.41	6.36
Sabour Krishnakali x Muktakeshi	70.15 **	31.46 **	-10.53 **	8.03	14.59 **	22.38 **
Sabour Krishnakali x Pant Samrat	-7.94 *	33.77 **	-2.22	18.06 **	25.14 **	33.65 **
Sabour Krishnakali x Swarna Mani	24.38 **	-3.9	-4.57	15.22 **	22.27 **	30.58 **
IIHR-563 x BRBR-01	0.61	27.62 **	30.89 **	13.38 *	31.01 **	28.48 **
Muktakeshi x IIHR-563	7.17	35.94 **	-2.64	-19.90 **	-2.73	-9.27
Sel 91-2 x Sabour Krishnakali	-36.94 **	-19.28 **	-23.27 **	-7.36	-1.89	4.78
Sel 91-2 x BRBR-01	-35.74 **	-17.74 **	-13.39 **	-18.90 **	-13.37 **	-8.07
Sel 91-2 x IIHR-563	-14.11 **	9.94	15.36 **	8.03	15.39 **	22.45 **
Pant Samrat x Swarna Mani	-1.59	42.99 **	30.48 **	35.28 **	55.26 **	53.40 **
Swarna Mani x Muktakeshi	56.57 **	19.16 **	27.01 **	10.87 *	27.13 **	25.60 **

\*Significant at 5% level of probability, \*\*Significant at 1% of probability. BPH (Better parent heterosis), SH (Standard heterosis)

Plant height is an essential characteristic by which growth and vigour of the plants are assessed. For better parent heterosis, the range was -27.80% (Swarna Mani x Muktakeshi) to 2.76% (Sel 91-2 x IIHR-563) and for standard heterosis it was 31.72% (Sel 91-2 x IIHR-563) to -14.25% (Swarna Mani x Muktakeshi). Among 11 hybrids, 6 hybrids (Sel 91-2 x IIHR-563, Pant

Samrat x Swarna Mani, Sabour Krishnakali x Pant Samrat, Sabour Krishnakali x Swarna Mani, Sel 91-2 x Sabour Krishnakali and IIHR-563 x BRBR-01) showed significant positive heterosis over standard check while no hybrid showed significant positive heterosis over better parents. Similar findings were reported for plant height Rajaneesh and Maurya (2005),

Suneetha et al., (2008), Ramesh et al., (2013), Venkatanaresh et al., (2014), Kumari et al., (2019), Timmareddygar et al. (2020), Kolekar et al. (2022), Rajashree et al., (2023), Susmitha et al. (2023), Patel et al (2025).

For plant spread, the range of heterosis over better parent was  $-6.76\%$  (Sel 91-2  $\times$  BRBR-01 and Sel 91-2  $\times$  IIHR-563) to  $16.90\%$  (Sabour Krishnakali  $\times$  Pant Samrat). Among 11 hybrids, five (Sabour Krishnakali  $\times$  Muktakeshi, Sabour Krishnakali  $\times$  Pant Samrat, Sabour Krishnakali  $\times$  Swarna Mani, Pant Samrat  $\times$  Swarna Mani, Swarna Mani  $\times$  Muktakeshi) recorded significant positive heterosis over better parent. Range of standard heterosis for plant spread was  $-11.72\%$  (IIHR-563  $\times$  BRBR-01) to  $24.19\%$  (Sabour Krishnakali  $\times$  Pant Samrat). Out of 11 hybrids, 6 exhibited significant positive for heterobeltiosis and standard heterosis (Sabour Krishnakali  $\times$  Muktakeshi, Sabour Krishnakali  $\times$  Pant Samrat, Sabour Krishnakali  $\times$  Swarna Mani, Pant Samrat  $\times$  Swarna Mani, Sel-91-2  $\times$  Sabour Krishnakali, Swarna Mani  $\times$  Muktakeshi). The estimates of heterobeltiosis were low in negative as well as in positive direction while standard heterosis effects were low in negative and low to moderate positive direction. Similar findings were reported by Kumari et al. (2019).

For average fruit weight range of heterosis over better parent was  $-34.95\%$  (Sabour Krishnakali  $\times$  Muktakeshi) to  $36.35\%$  (Sel 91-2  $\times$  IIHR-563). Out of 11 hybrids, 3 (Sel 91-2  $\times$  IIHR-563, Sel 91-2  $\times$  BRBR-01, IIHR-563  $\times$  BRBR-01) showed significant positive heterosis over better parent. Variation in the range of standard heterosis was from  $-22.08\%$  (Muktakeshi  $\times$  IIHR-563) to  $39.56\%$  (Sabour Krishnakali  $\times$  Swarna Mani). Among 11 crosses, 6 crosses (Sabour Krishnakali  $\times$  IIHR-563, Sabour Krishnakali  $\times$  Swarna Mani, Sel 91-2  $\times$  Sabour Krishnakali, Sel 91-2  $\times$  BRBR-01, Sel 91-2  $\times$  IIHR-563 and Pant Samrat  $\times$  Swarna Mani) showed significant positive heterosis over better parent. The estimates of heterobeltiosis and standard heterosis were low to moderate in negative as well as in positive direction respectively. Similar findings were reported for average fruit weight by Prakash et al., (2008), Reddy and Patel (2014), Rani et al., (2018) and Kumari et al. (2019).

Variation in the range for heterobeltiosis and standard heterosis for fruit length was  $-29.41\%$  (Sel 91-2  $\times$  Sabour Krishnakali) to  $43.33\%$  (Sabour Krishnakali  $\times$  Muktakeshi) and  $-21.19\%$

(Sel 91-2  $\times$  Sabour Krishnakali) to  $74.05\%$  (Sabour Krishnakali  $\times$  Muktakeshi), respectively. Among 11 hybrids, 7 of them recorded significant positive better parent heterosis. On the other hand, 5 crosses showed significant positive heterosis over standard check. The estimates of heterobeltiosis were low to moderate in negative as well as in positive direction while standard heterosis effects were low in negative and moderate to high positive direction. Similar findings were reported by Bhushan and Singh (2013), Dubey et al., (2014), Dhaka et al., (2017) and Dharmendra et al., (2017) Abdelkader et al. (2022), Rajashree et al., (2023), Susmitha et al. (2023) and Jagruti et al., (2025).

For fruit girth, range of heterobeltiosis varied from  $-17.84\%$  (Sabour Krishnakali  $\times$  Muktakeshi) to  $-27.99\%$  (Muktakeshi  $\times$  IIHR-563). Range of standard heterosis varied from  $-21.78\%$  (Sabour Krishnakali  $\times$  Pant Samrat) to  $17.99\%$  (Swarna Mani  $\times$  Muktakeshi). Among 11 hybrids, 3 were recorded significant positive for heterobeltiosis (Muktakeshi  $\times$  IIHR-563, IIHR-563  $\times$  BRBR-01 and Sel 91-2  $\times$  Sabour Krishnakali) and standard heterosis (Pant Samrat  $\times$  Swarna Mani, Sel 91-2  $\times$  Sabour Krishnakali and Swarna Mani  $\times$  Muktakeshi) over check. The estimates of heterobeltiosis and standard heterosis were low to moderate in negative as well as in positive direction respectively. Significant positive heterosis was also earlier reported by Prabhu et al., (2004), Makani et al., (2013), Kumari et al., (2019) and Jagruti et al., (2025).

The range for better parent heterosis and standard heterosis for number of fruits per plant varied from  $-36.94\%$  (Sel 91-2  $\times$  Sabour Krishnakali) to  $70.15\%$  (Sabour Krishnakali  $\times$  Muktakeshi) and  $-19.28\%$  (Sel 91-2  $\times$  Sabour Krishnakali) to  $42.99\%$  (Pant Samrat  $\times$  Swarna Mani) respectively. Top three crosses in terms of heterosis over better parent were Sabour Krishnakali  $\times$  Muktakeshi ( $70.15\%$ ), Swarna Mani  $\times$  Muktakeshi ( $56.57\%$ ) and Sabour Krishnakali  $\times$  Swarna Mani ( $24.38\%$ ) and for standard heterosis the most superior three crosses were Pant Samrat  $\times$  Swarna Mani ( $42.99\%$ ), Muktakeshi  $\times$  IIHR-563 ( $35.94\%$ ) and Sabour Krishnakali  $\times$  Pant Samrat ( $33.77\%$ ). Out of 11 hybrids, 3 crosses showed significant positive heterosis over better parent while 6 crosses recorded significant and positive standard heterosis over check. The estimates of heterobeltiosis were low to moderate in negative and moderate to high positive direction while standard heterosis effects were low to moderate

in negative as well as in positive direction respectively. Similar findings were reported by Balwani et al., (2017), Sivakumar et al., (2017), Kumari et al., (2019), Kolekar et al. (2022), Naveen et al. (2022) and Susmitha et al. (2023), Rajashree et al., (2023) and Jagruti et al., (2025).

Yield in any crop is the final product of different yield components. This ultimate produce in the plant is expressed through mutual balancing of characters. Range of heterobeltiosis for yield per plant ranged from -23.27% (Sel 91-2 × Sabour Krishnakali) to 30.89% (Muktakeshi × BRBR-01). Standard heterosis ranged -19.90% (Muktakeshi × IIHR-563) to 35.28% (Pant Samrat × Swarna Mani). Top three performer in terms of heterosis over better parent were IIHR-563 × BRBR-01 (30.89%), Pant Samrat × Swarna Mani (30.48%) and Swarna Mani × Muktakeshi (27.01%) while for standard heterosis the top three performer were Pant Samrat × Swarna Mani (35.28%), Sabour Krishnakali × Pant Samrat (18.06%) and Sabour Krishnakali × Swarna Mani (15.22%). Among 11 hybrids, 4 and 5 crosses were recorded significant positive heterosis over better parent and standard check, respectively. The estimates of heterobeltiosis and standard heterosis effects were low to moderate in negative as well as positive direction respectively. The results are congruent with the findings of Chowdhury et al., (2010) and Makani et al., (2013) Patel et al., (2017), Kumari et al., (2019) and Rajashree et al., (2023) for heterobeltiosis and standard heterosis.

For total yield range for heterobeltiosis varied from -13.37% (Sel 91-2 × BRBR-01) to 55.26 % (Pant Samrat × Swarna Mani) Range of standard heterosis varied from -9.27% (Muktakeshi × IIHR-563) to 53.40 % (Pant Samrat × Swarna Mani). Out of 11 hybrids, 7 crosses showed significant positive heterosis over better parent and standard heterosis over check. Top three crosses in terms of heterosis over better parent were Pant Samrat × Swarna Mani (55.26%), IIHR-563 × BRBR-01 (31.01%) and Swarna Mani × Muktakeshi (27.13%) while for standard heterosis the top three performer were Pant Samrat × Swarna Mani (53.40 %), Sabour Krishnakali × Pant Samrat (33.65%) and Sabour Krishnakali × Swarna Mani (30.58 %). The estimates of heterobeltiosis and standard heterosis effects were low to moderate in negative as well as positive direction respectively. Similar findings were reported for total yield by Reddy and Patel (2015), Aswani et al., (2016), Ansari et al., (2017) and Pramila et al.

(2017). The ultimate goal of any breeding programme is target to achieve maximization of marketable yield. Since yield is a complex and polygenically inherent trait, number of fruits per plant and average fruit weight are directly contributing to yield in brinjal breeding.

The commercial use of heterosis is a significant application of genetic principles in plant breeding. The heterotic response of  $F_1$  indicates genetic variation among the parents involved. Positive relative heterosis and heterobeltiosis in a desired trend are preferred when selecting for yield and its components.

#### 4. CONCLUSIONS

The results show that all growth and yield traits exhibited higher heterosis values, indicating non-additive genetic effects. To further improve yield, research should focus on breeding programs that produce hybrids with high heterosis and combining ability, ultimately leading to enhanced yield. Pant Samrat × Swarna Mani (53.40 %), Sabour Krishnakali × Pant Samrat (33.65%) and Sabour Krishnakali × Swarna Mani (30.58 %) were top performer for total yield when compared to the standard check, Pusa Hybrid-6. The estimates of heterobeltiosis and standard heterosis effects were low in the negative direction but moderate in the positive direction for yield and its contributing components. This means that while the negative heterosis values were minimal, the positive heterosis values indicated a notable improvement in performance when the hybrids were compared to the better parent or the standard. In other words, the  $F_1$  hybrids demonstrated a moderate level of hybrid vigour, which suggests that the traits, such as yield and its components, showed potential for improvement when positive heterosis was expressed.

These moderate positive effects of heterosis can be effectively used in breeding programs to enhance the traits, as they show the possibility of higher yields and improved performance in hybrids compared to the parents. Focusing on hybrids with positive heterosis values can lead to the development of varieties with better yield potential and more favorable traits, thus benefiting crop improvement efforts.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that no generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist

## REFERENCES

- Abdelkader, M. F. M., Awad-Allah, M. M. A., El-Diasty, M. Z., Rashed, S. M. F., Azad, A., & Abdein, M. A. E. (2022). Gene action, analysis of combining ability and heterosis effects for yield, yield components and quality traits in eggplant (*Solanum melongena* L.). *The Seybold Report*, 17(12), 1329–1346.
- Anonymous. (2024). 2024-25 First advance estimates of Area and Production of Horticulture crops. Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmer's Welfare, Government of India. <https://agriwelfare.gov.in/en/StatHortEst>
- Ansari, A. M. (2017). Heterosis studies for growth, yield and its component characters in brinjal (*Solanum melongena* L.). *Journal of Pharmacognosy and Phytochemistry*, 6(4), 1920–1929.
- Aswani, R. C., Kaushik, R. A., Yadav, R. K., & Meena, R. L. (2016). Manifestation of heterosis breeding for fruit yield and its attributing traits in brinjal (*Solanum melongena*). *Indian Journal of Agricultural Sciences*, 86(6), 773–777.
- Balwani, A. K., Patel, J. N., Acharya, R. R., Gohil, D. P., & Dhruve, J. J. (2017). Heterosis for fruit yield and its component traits in brinjal (*Solanum melongena* L.). *Journal of Pharmacognosy and Phytochemistry*, 6, 187–190.
- Bhushan, K. B., & Singh, Y. V. (2013). Expression of heterosis for quantitative traits in brinjal. *Patnagar Journal of Research*, 11(3), 402–404.
- Chioti, V., Zeliou, K., Bakogianni, A., Papaioannou, C., Biskinis, A., Petropoulos, C., Lamari, F. N., & Papasotiropoulos, V. (2022). Nutritional value of eggplant cultivars and association with sequence variation in genes coding for major phenolics. *Plants*, 11, 2267. <https://doi.org/10.3390/plants11172267>
- Chowdhury, M. J., Ahmad, S., Nazim, U. M., Quaruzzaman, A. K. M., & Patway, M. M. A. (2010). Expression of heterosis for productive traits in F1 brinjal (*Solanum melongena* L.) hybrids. *Agriculturists*, 8(2), 8–13.
- Dhaka, S. K., Kaushik, R. A., Laxman, J., Shyopal, J., & Ramavtar, C. (2017). Diallel analysis for combining ability studies in eggplant (*Solanum melongena* L.). *International Journal of Chemical Studies*, 5(3), 173–183.
- Dharmendra, P., Shitap, M. S., & Patel, N. A. (2017). Heterosis studies for fruit yield and its component in long type brinjal (*Solanum melongena* L.). *Electronic Journal of Plant Breeding*, 8(4), 1169–1176.
- Dubey, R., Das, A., Ojha, M. D., Saha, B., Ranjan, A., & Singh, P. K. (2014). Heterosis and combining ability studies for yield and yield attributing traits in brinjal (*Solanum melongena* L.). *The Bioscan*, 9(2), 889–894.
- FAOSTAT. (2024). Food and Agriculture Organization statistics. Food and Agriculture Organization, Rome. <https://www.fao.org/faostat/en/#data/QCL>. Accessed on 29.03.2025.
- Fonseca, S., & Patterson, F. L. (1968). Hybrid vigour in a seven parent diallel cross in common winter wheat (*Triticum aestivum* L.). *Crop Science*, 8, 85–88.
- Hayes, H. K., Immer, F. R., & Smith, D. C. (1955). *Methods of plant breeding*. McGraw Hill Co. Inc., 2, 52–65.
- Hochholdinger, F., & Hoekenger, N. (2007). Towards the molecular basis of heterosis. *Trends in Plant Science*, 1, 427–432.
- Kakikazi, Y. (1931). Hybrid vigor in eggplant and its potential utilization. *Journal of Heredity*, 21, 253–258.
- Kolekar, R. B., Gaikwad, S. A., Girnare, V. B., & Jagtap, V. S. (2022). Studies on heterosis for yield and yield contributing characters in brinjal (*Solanum melongena* L.). *Journal of Pharmaceutical Innovation*, 11(12), 3421–3425.
- Kumari, R., Kumar, R., Akhtar, S., Verma, R. B., Chand, G., & Kishore, C. (2019). Heterosis for yield and quality traits in eggplant hybrids grown in rainy season.

- Environment and Ecology*, 37(3B), 971–978.
- Lamkey, K. R., & Edwards, J. W. (1999). The quantitative genetics of heterosis. In J. G. Coors & S. Pandey (Eds.), *Proceedings of the International Symposium on the Genetics and Exploitation of Heterosis in Crops* (pp. 31–48). ASA, CSSA, and SSSA.
- Mahla, J. S., Acharya, R. R., Pandya, M. M., Kumar, S., Patel, D. A., & Parmar, D. J. (2025). Estimation of heterosis and inbreeding depression for fruit yield attributing characters in brinjal (*Solanum melongena* L.). *International Journal of Economic Plants*, 12(Jan 1), 01–08.
- Makani, A. Y., Patel, A. L., Bhatt, M. M., & Patel, P. C. (2013). Heterosis for yield and its contributing attributes in brinjal (*Solanum melongena* L.). *The Bioscan*, 8(4), 1369–1371.
- Nagai, K., & Kida, S. (1926). Experiments on hybridization of various strains of *Solanum melongena*. *Japanese Journal of Genetics*, 4, 10–30.
- Patel, A. A., Gohil, D. P., Dhruve, J. J., & Damor, H. I. (2017). Heterosis for fruit yield and its quality characters in brinjal (*Solanum melongena* L.). *Journal of Pharmacognosy and Phytochemistry*, 6(6), 975–978.
- Patel, H. R., Patel, A. I., Patel, H. R., & Bamji, R. C. (2025). Studies on heterosis for fruit yield and its component traits over different environmental conditions in brinjal (*Solanum melongena* L.). *Plant Archives*, 25(1), 196–205.
- Prabhu, M. (2004). *Breeding for high yield with shoot and fruit borer (Leucinodes orbonalis Guen.) resistance in brinjal (Solanum melongena L.)*. Ph.D. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore.
- Prakash, H., Timmapur, P. R., Dharmatti, R. V., Patil, S. T., Kajjidoni, & Naik, K. (2008). Heterosis for yield in brinjal (*Solanum melongena* L.). *Karnataka Journal of Agricultural Sciences*, 21(3), 476–478.
- Pramanik, P., Mondal, P., & Chatterjee, M. (2012). Studies on biology of brinjal fruit and shoot borer, *Leucinodes orbonalis* (Guen.) under laboratory condition. *International Journal of Bio-Resource & Stress Management*, 3(3), 336–340.
- Pramila, M. L., Kushwaha, & Yamuna, P. S. (2017). Studies on heterosis in brinjal (*Solanum melongena* L.). *International Journal of Current Microbiology and Applied Sciences*, 6(11), 641–651.
- Rajaneesh, S., & Maurya, A. N. (2005). Hybrid vigour in eggplant (*Solanum melongena* L.). *Progress in Horticulture*, 37(1), 100–105.
- Rajashree, Kamble, C. S., Shantappa, T., Vilas, D. G., Nishani, S., Koulagi, S., & Bhavidoddi, A. K. (2023). Heterosis studies for growth, flower and yield characters in brinjal (*Solanum melongena* L.). *Biological Forum – An International Journal*, 15(11), 13–20.
- Ramesh, K. S., Arumugam, T., Anandakumar, C. R., Balakrishnan, S., & Rajavel, D. S. (2013). Heterosis expression, interrelationship, direct and indirect effects of component characters on yield in intervarietal crosses of eggplant. *African Journal of Biotechnology*, 12(45), 6366–6375.
- Rani, M., Kumar, S., & Kumar, M. (2018). Estimation of heterosis for yield and its contributing traits in brinjal. *Journal of Environmental Biology*, 39, 710–718.
- Reddy, E. E. P., & Patel, A. I. (2014). Heterosis studies for yield and yield attributing characters in brinjal (*Solanum melongena* L.). *Journal of Recent Advances in Agriculture*, 2(2), 175–180.
- Reddy, E. E. P., & Patel, A. I. (2015). Studies on gene action and combining ability for yield and other quantitative traits in brinjal (*Solanum melongena* L.). *Trends in Biosciences*, 7(5), 381–383.
- Reddy, M. S. R. K., Lingaiah, H. B., Naresh, P., Reddy, V. K. P., & Kuchi, V. S. (2011). Heterosis studies for yield and yield attributing characters in brinjal (*Solanum melongena* L.). *Plant Archives*, 11(2), 649–653.
- Sivakumar, V., Jyothi, K. U., Ramana, C. V., Rao, M. P., Rajyalakshmi, R., & Krishna, K. U. (2017). Genotype × environment interaction of brinjal genotypes against fruit borer. *International Journal of Science and Nature*, 6(3), 491–494.
- Suneetha, Y., Kathiria, K. B., Patel, J. S., & Srinivas, T. (2008). Studies on heterosis and combining ability in late summer brinjal. *Indian Journal of Agricultural Sciences*, 42(3), 171–176.
- Susmitha, J., Eswaran, R., & Senthilkumar, N. (2023). Heterosis breeding for yield and its attributes in brinjal (*Solanum melongena* L.). *Electronic Journal of Plant Breeding*, 14(1), 114–120.
- Timmareddygar, S., Pidigam, S., Natarajan, S., Amarapalli, G., & Komatireddy, R. R.

- (2020). Estimation of heterosis for yield, yield attributes and quality parameters in brinjal (*Solanum melongena* L.). *International Journal of Chemical Studies*, 9(1), 1891–1901.
- Vavilov, N. I. (1928). Geographical centres of our cultivated plants. In *Proceedings of the 5th International Genetics Congress* (pp. 342–369), Berlin, Germany, September 11–18, 1927.
- Venkataresh, B., Dubey, A. K., Tiwari, P. K., & Dabbas, M. R. (2014). Line × tester analysis for yield components and Cercospora leaf spot resistance in brinjal (*Solanum melongena* L.). *Electronic Journal of Plant Breeding*, 5(2), 230–235.

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