Original Research Article ……..

International Journal of Agricultural Invention

(online available at www.agriinventionjournal.com)

International Journal of Agricultural Invention **10(2): 59-63: July-December, 2025**

ISSN: 2456 – 1797 (P)

Heterobeltiosis and inbreeding depression for yield and agronomic traits in Indian Mustard (*Brassica juncea* L. Czern. & Coss.) across two environments

Mithalesh Kumar, *Ajay Kumar

Department of Genetics and Plant Breeding, Janta Mahavidyalaya, Ajitmal, Auraiya, U.P., India

***Corresponding email**: *drakvermagpb@gmail.com*

ARTICLE INFO

Original Research Article

Received on August 09, 2025

Revised on August 16, 2025

Accepted on September 09, 2025

Published on September 13, 2025

Article Authors

Mithalesh Kumar, Ajay Kumar

Corresponding Author Email

drakvermagpb@gmail.com

PUBLICATION INFO

International Journal of Agricultural Invention (IJAI)

RNI: UPENG/2016/70091

ISSN: 2456-1797 (P)

Vol.: 10, **Issue:** 2, **Pages:** 59-63

Journal Homepage URL

http://agriinventionjournal.com/

DOI: 10.46492/IJAI/2025.10.2.11

ABSTRACT

The four genetically diverse parental lines were crossed with well-adapted released varieties to generate promising hybrids. The results demonstrated significant variability in heterobeltiosis and inbreeding depression across different crosses and two environments (E1 and E2). In PR 36 × Rohini, seed yield per plant exhibited negative heterobeltiosis (-12.37% in E1 and -16.55% in E2), suggesting hybrid weakness. However, traits like siliquae per plant (19.51%) and number of seeds per siliqua (4.65%) showed positive heterobeltiosis, indicating genetic potential for selection. Inbreeding depression was notably high for plant height (4.10%) and seed yield (-19.77%) in E2, suggesting genetic instability. In PRE 11 × CS 60, moderate to high heterobeltiosis was observed for the number of secondary branches per plant (10.52%) and siliquae per plant (29.37%) in E2. However, seed yield per plant (-16.29%) exhibited negative heterobeltiosis, and inbreeding depression was significantly high (-28.61%) in E1, indicating a strong impact of selfing on yield- related traits. PRE 15 × CS 58 exhibited high heterobeltiosis in siliqua length (36.36%) and seeds per siliqua (9.30%), indicating a high genetic potential for selection. However, seed yield per plant showed negative heterobeltiosis (-8.87% in E1, -1.07% in E2), and inbreeding depression was notable for seed yield (12.94%) and plant height (-5.72%), emphasizing the need for hybrid stabilization. PRL 26 × Giriraj showed negative heterobeltiosis in days to flowering and plant height, but positive heterosis for siliquae per plant (3.59%) and seed yield per plant (6.18%) in E2. The highest inbreeding depression was observed for seed yield (-35.18%) in E1, indicating genetic susceptibility to selfing.

KEYWORDS

Mustard, Heterobeltiosis, Inbreeding Depression, Yield, Agronomic Traits, Environment

HOW TO CITE THIS ARTICLE

Kumar, M., Ajay Kumar, A. (2025) Heterobeltiosis and inbreeding depression for yield and agronomic traits in Indian Mustard (*Brassica juncea* L. Czern. & Coss.) across two environments, *International Journal of Agricultural Invention,* 10(2): 59-63. DOI: 10.46492/IJAI/2025.10.2.11

Indian mustard (*Brassica juncea* L.) is one of the most important oilseed crops, significantly contributing to edible oil production in India. Hybridization in mustard plays a key role in genetic improvement through heterosis breeding. The present study aimed to analyze heterobeltiosis (H) and inbreeding depression (ID) in mustard hybrids for seed yield and agronomic traits across different environments. The present investigation has been undertaken to study the heterosis in F_1 over better parent (heterobeltiosis) and inbreeding depression over F_2 segregating generation for yield and agronomic traits in Indian Mustard (*Brassica juncea* L. Czern & Coss) across two environments.

Heterosis, or hybrid vigor, is a fundamental genetic phenomenon where the F_1 hybrid exhibits superiority over its parents for traits such as biomass, growth rate, and yield. This is a critical tool in plant breeding for breaking yield plateaus and enhancing crop productivity. In the context of Indian mustard, the exploitation of heterosis has been identified as a promising strategy to achieve substantial yield gains to meet the growing domestic demand for edible oils (Gupta *et al*., 2010). Heterobeltiosis, a specific measure of heterosis where the hybrid is compared to the better parent, is particularly valuable for breeders as it indicates the potential of a cross to produce offspring that outperform even the best existing varieties.

Successful development of hybrids in mustard relies on identifying genetically diverse parental lines that combine well to express significant and consistent heterosis for key agronomic traits (Singh *et al*., 2022). Conversely, inbreeding depression is the counterpart to heterosis, representing the reduction in fitness and performance observed when genetically related individuals are crossed, such as in selfing to produce an F_2 generation. This decline in vigor is attributed to the increased homozygosity, which exposes deleterious recessive alleles that were masked by heterozygosity in the F_1 hybrid (Akbari *et al*., 2017). A high magnitude of inbreeding depression for yield and its components poses a significant challenge for breeding programs, as it indicates genetic instability and limits the commercial viability of hybrids if farmers cannot reliably save seeds. Therefore, understanding the simultaneous expression of heterobeltiosis in F_1 and inbreeding depression in F_2 is crucial for assessing the genetic architecture of quantitative traits and for formulating effective breeding strategies to develop stable, high-yielding mustard cultivars (Singh and Gupta, 2020).

Materials and Methods

The present study aimed to evaluate heterobeltiosis and inbreeding depression for seed yield and its contributing traits in four crosses of Indian mustard. The experiment was conducted at the Agricultural Research Farm of Janta Mahavidyalaya, Ajitmal, Auraiya (U.P.). The four crosses were made during the *Rabi* 2022-23 seasons. The resulting F_1 progenies were sown and selfed to produce F_2 seeds, while the parental lines were maintained by selfing. A complete set of material consisting of 16 families (8 parents, 4 F_1s and 4 F_2s) were evaluated in a completely Compact Family Block Design with three replications during the *Rabi* 2023-24 seasons at two different locations. In the experiment, the parental lines and F_1 hybrids were planted in three rows, while the F_2 populations were planted in twenty rows. Each row was 3 meters long, with a 30 cm gap between rows and 10 cm spacing between individual plants. Standard cultural practices were followed to ensure optimal crop growth. At harvest, ten competitive plants were randomly selected from each plot of the parents and F_1s, and twenty plants were selected from each F_2 plot for data collection on various agronomic traits.

However, the number of days to 50% flowering was recorded for the entire plot. In each replication, observations were made on five randomly chosen plants from each parent and F_1 population and on twenty plants from each F_2 population. The traits recorded included the number of days to initial flowering, days to 50% flowering, days to maturity, plant height (cm), the number of primary and secondary branches per plant, the number of siliquae on the main shoot, total siliquae per plant, siliqua length (cm), the length of the main shoot (cm), the number of seeds per siliqua and seed yield per plant (g). Before flowering, the selected plants were tagged and labelled to ensure accurate tracking of observations. Mean values for each trait were calculated from the individual data recorded in each replication for every cross across the two locations. The calculation of heterosis over the better parent, referred to as heterobeltiosis and inbreeding depression were calculated for yield and other agronomic traits as determined by the procedure of (Hayes *et al*., 1955).

Results and Discussion

The results demonstrated significant variability in heterobeltiosis and inbreeding depression across environments and crosses. In PR 36 × Rohini, seed yield per plant exhibited negative heterobeltiosis (-12.37% in E1 and -16.55% in E2), suggesting hybrid weakness. However, traits like siliquae per plant (19.51%) and number of seeds per siliqua (4.65%) showed positive heterobeltiosis, indicating genetic potential for selection. Inbreeding depression was notably high for plant height (4.10%) and seed yield (-19.77%) in E2, suggesting genetic instability. In PRE 11 × CS 60, moderate to high heterobeltiosis was observed for the number of secondary branches per plant (10.52%) and siliquae per plant (29.37%) in E2. However, seed yield per plant (-16.29%) exhibited negative heterobeltiosis, and inbreeding depression was significantly high (-28.61%) in E1, indicating a strong impact of selfing on yield-related traits. PRE 15 × CS 58 exhibited high heterobeltiosis in siliqua length (36.36%) and seeds per siliqua (9.30%), indicating a high genetic potential for selection. However, seed yield per plant showed negative heterobeltiosis (-8.87% in E1, -1.07% in E2), and inbreeding depression was notable for seed yield (12.94%) and plant height (-5.72%), emphasizing the need for hybrid stabilization.

Table 1. Heterobeltiosis (%) and Inbreeding Depression (%) for yield and its components in four crosses of Indian Mustard across two environments

Crosses	Environments	Heterosis (H) and Inbreeding Depression (ID)	No. of Days to Initial Flowering	No. of Days to 50% Flowering	No. of Days to Maturity	Plant Height (cm)	No. of Primary Branches per Plant	No. of Secondary Branches per Plant	No. of Siliquae on the Main Shoot	No. of Siliquae per Plant	Siliqua Length (cm)	Length of the Main Shoot (cm)	No. of Seeds per Siliqua	Seed Yield per Plant (g)
Cross I	E1	H	0.48	6.22*	0.13	1.33	0.00	2.44	3.14	8.91	-7.69	-0.84	4.65	-12.37
		ID	1.92	0.78	-2.03	1.50	11.11	14.29	2.61	-10.91	0.00	-7.87	4.44	-2.88
	E2	H	4.93	-11.24**	-3.81**	-8.08	-18.18	-5.00	7.63	19.51	-15.39	6.41	-16.66**	-16.55
		ID	4.03	-2.24	0.00	4.10	-44.44	0.00	9.44	-7.35	-18.18	18.68	-2.50	-19.78
Cross II	E1	H	5.15	-3.33	0.24	0.57	0.00	10.53	-4.96	-13.77	9.09	5.82	6.25	7.71
		ID	5.59	-3.45	-1.69	1.31	-10.00	4.76	0.00	-1.85	8.33	3.50	-8.82	-28.62
	E2	H	0.00	1.11	1.01	-5.61	18.18	-5.00	11.57	29.38	9.09	0.00	9.09	-16.30
		ID	-2.01	-3.83	-5.26	0.99	7.69	10.53	2.22	-9.22	0.00	-4.52	2.08	17.96
Cross III	E1	H	2.92	2.67	0.00	-2.25	-10.00	15.00	0.00	-15.46	-7.69	-2.38	9.30	-8.88
		ID	7.09	-3.25	-1.49	-0.18	-33.33	8.70	-6.16	-18.86	-8.33	0.98	10.64	12.95
	E2	H	0.66	5.11	-1.75	-0.73	-8.33	-4.35	0.00	-0.09	36.37**	4.71	5.13	-1.07
		ID	8.55	0.00	-4.33	-5.72	-18.18	-13.64	0.59	-1.68	26.67	6.00	-9.76	-1.84
Cross IV	E1	H	-5.46	1.46	3.98	3.21	10.00	18.18	3.23	-0.86	0.00	2.55	2.04	-24.93
		ID	-3.85	1.44	-1.91	0.78	-18.18	23.08	1.56	-1.47	38.46	0.62	10.00	-35.19
	E2	H	-5.63	0.57	-0.47	3.31	-15.39	9.09	3.60	-18.02	-8.33	1.16	-12.20	6.19
		ID	2.99	0.00	-1.41	-2.60	-18.18	-4.17	-3.47	-8.79	9.09	-7.43	-11.11	5.14

PRL 26 × Giriraj showed negative heterobeltiosis in days to flowering and plant height, but positive heterosis for siliquae per plant (3.59%) and seed yield per plant (6.18%) in E2. The highest inbreeding depression was observed for seed yield (-35.18%) in E1, indicating genetic susceptibility to selfing. Overall, the study highlights significant genetic variation in heterobeltiosis and inbreeding depression, suggesting that selection for yield improvement should be environment-specific. These findings provide valuable insights for mustard breeding programs, enabling the development of high-yielding, stable genotypes through targeted hybridization and selection strategies.

The results align with previous studies on heterobeltiosis and inbreeding depression in Indian mustard. According to (Barupal *et al*., 2017; Singh *et al*., 2020; Sharma *et al*., 2021) significant heterosis effects were observed in mustard hybrids, particularly for yield-contributing traits such as siliqua number and plant height. Similarly (Akbari *et al*., 2017; Abhinaya *et al*., 2021; Singh and Gupta, 2020) reported that inbreeding depression was highest for seed yield, suggesting genetic instability upon selfing. These findings support our results where high inbreeding depression was noted in seed yield, particularly in PRL 26 × Giriraj (-35.18% in E1). Furthermore, earlier research by (Meena *et al*., 2019; Singh *et al*., 2020; Parmar *et al*., 2024) indicated that heterosis is more pronounced in hybrids under favourable environmental conditions, which corroborates our observation that siliqua length and secondary branches showed enhanced heterobeltiosis in E2.

The results align with previous studies on heterobeltiosis and inbreeding depression in Indian mustard. According to (Sharma *et al*., 2021) significant heterosis effects were observed in mustard hybrids, particularly for yield-contributing traits such as siliqua number and plant height. Similarly (Singh and Gupta, 2020) reported that inbreeding depression was highest for seed yield, suggesting genetic instability upon selfing. These findings support our results where high inbreeding depression was noted in seed yield, particularly in PRL 26 × Giriraj (-35.18% in E1). Furthermore, earlier studies by (Hirve and Tiwari, 1991; Thakur and Bhateria, 1993; Gupta *et al*., 2010; Meena *et al*., 2019; Patel *et al*., 2021; Shekhawat *et al*., 2021) indicated that heterosis is more pronounced in hybrids under favourable environmental conditions, which corroborates our observation that siliqua length and secondary branches showed enhanced heterobeltiosis in E2.

Conclusion

Significant genetic variation was observed in heterobeltiosis and inbreeding depression for different traits across environments. Selection of hybrids for yield improvement should be environment-specific. The study provides valuable insights for breeding programs, enabling the development of high-yielding, stable mustard hybrids.

Acknowledgements

The authors express gratitude to Dr Usha Pant, Oilseeds Breeder for providing seed material and supporting this research.

References

Abhinaya, M. Dhaduk, H. L., Manivel. P., and Kapadia, V. N. (2021) Heterosis and inbreeding depression in Indian mustard [*Brassica juncea* (L.) Czern & Coss], *Paripex-Indian Journal of Research*, 3(**10**): 52-54.

Akbari, V. R., Sasidharan, N., and Kapadia, V. N. (2017) Inbreeding depression, heritability, and genetic advance for yield and yield components in Indian mustard, *J. Pharmacogn Phytochem*., 6(**3**): 755-760.

Barupal, H. L., Sharma, A. K., Shekhawat, H. S., Kumar, P., and Kumar, M. (2017) Heterosis studies in Indian mustard [*Brassica juncea*], *International Journal of Agriculture Innovations and Research*, 6(**5**): 960-964.

Gupta, P., Chaudhary, H. B., and Lal, S. K. (2010) Heterosis and combining ability analysis for yield and its components in Indian mustard [*Brassica juncea* (L.) Czern & Coss.], *Frontiers of Agriculture in China*, 4(**3**): 299-307.

Hayes, H. K. Immer, I. R. and Smith, O. C. (1955) Methods of Plant Breeding, McGraw Hill Co. Inc., pp: 52-65.

Meena *et al.* (2019) Meena, H. S., Ram, B., Kumar, A., Singh, B. K., Meena, P. D., Singh, V. V., and Singh, R. K. (2019) Combining ability and heterosis for seed yield and its components in Indian mustard (*Brassica juncea* L.), *Journal of Agricultural Science and Technology*, **17**: 1861-1871.

Parmar, H. K., Macwana, S. S., Patel, D. A., Patel, N. B. and Patel, N. J. (2024) Genetic analysis of heterosis and inbreeding depression in Indian mustard [*Brassica juncea* (L.) Czern & Coss], *International Journal of Advanced Biochemistry Research*, 8(**9**): 1155-1161.

Patel, D. A, Patel, D. K., Patel, J. R., Prajapati, K. P., Patel, P. J., and Patel, A. B. (2021) Exploitation of heterosis for seed yield and its contributing traits in CMS-based hybrids of Indian mustard [*Brassica juncea* (L.) Czern & Coss], *International Journal of Bio-resource and Stress Management*, 12(**5**): 552-563.

Sharma *et al.* (2021) Sharma, M., Singh, D. and Gupta, P. (2021) Heterosis and combining ability analysis for yield and its components in Indian mustard (*Brassica juncea* L.), Frontiers of Agriculture in China, 4(**3**): 299-307.

Shekhawat, H. V. S., Shekhawat, S. S. and Shekhawat, U. S. (2021) Heterosis Studies in Indian Mustard [*Brassica juncea* (L.) Czern & Coss.] for Yield and its Related Attributes, *International Journal of Current Microbiology and Applied Sciences*, 10(**01**): 2268-2275.

Singh, M., and Gupta, R. (2020) Inbreeding depression and its implications in Indian mustard breeding, *Journal of Oilseed Brassica*, 11(**2**): 123-129.

Singh, B., Mishra, S. P., and Mehandi, S. (2020) Heterosis and inbreeding depression study in Indian mustard [*Brassica juncea* (L.) Czern & Coss], *International Journal of Agricultural Science*, 3(**12**): 9537-95341.

Singh, M., Choudhary, R. R., Avtar, R., Punia, R., Kumar, P., Kumari, N., and Khedwal, R. S. (2022) Heterosis for yield and its component traits in Indian mustard [*Brassica juncea* (L.) Czern & Coss.], *The Pharma Innovation Journal*, 11(**1**): 1842-1851.