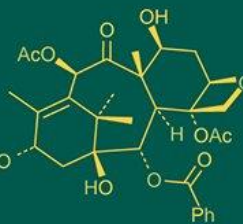
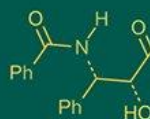


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## Useful heterosis for seed yield and its contributing characters in Indian mustard (*Brassica juncea*)

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### Abstract

Heterosis was estimated in Indian mustard for 12 quantitative characters. Seventy-two  $F_1$  crosses of mustard (*Brassica juncea*) obtained by full diallel mating design using 9 parents (ACN-264, ACN-308, ACN-315, NPJ-252, NPJ-253, GDM-4, ACN-250, TAM 108-1 and PDKV Kartik). The  $F_1$  hybrids along with parents and checks (TAM 108-1 and PDKV Kartik) were grown at AICRP on Linseed and Mustard during rabi 2025-26 in Randomized Block Design in 2 replications for evaluation to estimate the useful heterosis of crosses for seed yield and yield contributing characters. Seven crosses namely NPJ-252  $\times$  ACN-264, NPJ-252  $\times$  ACN-315, GDM-4  $\times$  ACN-315, ACN-264  $\times$  NPJ-252, ACN-315  $\times$  NPJ-252, GDM-4  $\times$  NPJ-253 and TAM 108-1  $\times$  PDKV Kartik showing significant *per se* performance and significant useful heterosis for seed yield and its contributing characters were identified as potential crosses for the exploitation in heterosis breeding. These crosses after their evaluation trials can be used for development of hybrids after conversion of female parents into male sterile line because conventional hybrid is not economically feasible in mustard.

**Keywords:** Useful heterosis, heterobeltiosis, mustard, *Brassica juncea*

### Introduction

Indian mustard [*Brassica juncea* L. Czern and Coss] belongs to family Brassicaceae and genus *Brassica*. Indian mustard is a natural amphidiploid ( $2n = 36$ ) of *Brassica rapa* ( $2n = 20$ ) and *Brassica nigra* ( $2n = 16$ ). Mustard is highly self-pollinated crop with 2-15% cross pollination which takes place due to honeybees. It contributes more than 13% to the global production of edible oil. Seeds contain 38 to 40% oil and is mainly utilized for human consumption throughout northern India for cooking as well as frying purposes.

Indian mustard occupies a major share of the rapeseed-mustard area and is primarily cultivated during the rabi season. The crop is grown extensively in states such as Rajasthan, Haryana, Punjab and Madhya Pradesh and plays an important role in meeting the country's edible-oil requirements. However, the productivity of mustard remains an important concern because of its cultivation under diverse and often resource-constrained production environments. The relatively low productivity of mustard, together with the continuing gap between domestic edible-oil production and consumption, emphasizes the need for sustained genetic improvement aimed at developing high-yielding and well-adapted genotypes.

Improvement of seed yield in Indian mustard is challenging because yield is a complex quantitative character influenced by several component traits and environmental factors. Consequently, identification and utilization of genetically diverse parents possessing desirable attributes are essential for achieving meaningful progress in breeding programmes. Genetic studies in *B. juncea* have demonstrated substantial variability among parental genotypes and their hybrids for seed yield and associated traits, with both additive and non-additive gene effects contributing to their expression.

Heterosis breeding is an important strategy for exploiting genetic divergence between parents and obtaining superior performance in their progenies. The magnitude of heterosis can be assessed in relation to the mid-parent, better parent and a standard commercial check. Heterobeltiosis represents the superiority of an  $F_1$  hybrid over its better-performing parent, whereas useful or economic heterosis indicates the superiority of a hybrid over an appropriate standard check and therefore has greater relevance from a practical breeding perspective.

Evaluation of these forms of heterosis helps in identifying cross combinations possessing desirable levels of hybrid vigour for seed yield and its contributing characters.

Several studies have demonstrated considerable heterotic expression for seed yield and yield-associated traits in Indian mustard. Yadava *et al.* (2012) <sup>[9]</sup> identified several crosses showing more than 15% heterobeltiosis together with desirable specific combining ability and *per se* performance for seed yield. Similarly, Sapakal *et al.* (2017) <sup>[7]</sup> observed substantial heterotic effects for seed yield and number of siliquae plant<sup>-1</sup>. More recently, Singh *et al.* (2025) <sup>[8]</sup> reported substantial heterotic expression among Indian mustard crosses. Hence, the present investigation was undertaken to estimate heterobeltiosis and useful heterosis in mustard crosses (*Brassica juncea*) for seed yield and its associated quantitative characters and to identify promising cross combinations for further exploitation in breeding.

### Materials and Methods

The experimental material comprised nine diverse Indian mustard (*Brassica juncea* (L.) Czern. & Coss.) parents, viz., ACN-264, ACN-308, ACN-315, NPJ-252, NPJ-253, GDM-4, ACN-250, TAM 108-1 and PDKV Kartik. The parental lines were crossed in a full diallel mating design during rabi 2024-25, resulting in 72 F<sub>1</sub> crosses. The crosses along with their nine parents were evaluated during rabi 2025-26 at the Research Field of AICRP (Linseed and Mustard), College of Agriculture, Nagpur. The experiment was conducted in a randomized block design with two replications. Each genotype was grown in a 2 m row at 45 × 10 cm spacing, accommodating 20 plants per row. Five randomly selected plants from each entry were used for recording observations. The crop was sown on second week of November 2025 and maintained following recommended agronomic and plant protection practices.

Observations were recorded for days to 50% flowering, days to maturity, plant height (cm), number of primary branches plant<sup>-1</sup>, point to first silique (cm), silique length (cm), number of seeds silique<sup>-1</sup>, number of siliquae plant<sup>-1</sup>, silique density on the main branch, 1000-seed weight (g), seed yield plant<sup>-1</sup> (g), and oil content (%). Powdery mildew severity was assessed on five randomly selected plants using the 0-9 disease rating scale, while oil content was estimated by Soxhlet extraction using petroleum ether.

The data were subjected to analysis of variance to determine the significance of differences among the genotypes following Panse and Sukhatme (1954) <sup>[6]</sup>. Heterobeltiosis was assessed by comparing the performance of each F<sub>1</sub> hybrid with its better parent, whereas useful heterosis was determined in comparison with the standard checks TAM 108-1 and PDKV Kartik. The hybrid performance (%) in comparison with better parent (heterobeltiosis) and check (useful heterosis) was calculated as per the formulae given by Fonseca (1968) <sup>[1]</sup> and Meredith and Bridge (1972) <sup>[5]</sup> respectively. The statistical significance of heterotic effects was assessed using standard errors and critical differences at the 5% and 1% probability levels.

### Results and Discussion

The analysis of variance was performed to test the difference amongst the parents and hybrids for all twelve characters. The results revealed that the mean squares due to genotypes were significant for all the characters studied i.e., days to 50% flowering, days to maturity, plant height,

number of branches plant<sup>-1</sup>, point to first silique, silique length, number of seeds silique<sup>-1</sup>, number of siliquae plant<sup>-1</sup>, siliquae density on main branch, 1000 seed weight, seed yield plant<sup>-1</sup> and oil content. The mean sum of square owing to parents was discovered to be significantly relevant for all characters. This indicates the presence of high heterogeneity among the parents. Significant mean sum of squares for crosses were found for all twelve characters analyzed, indicating significant differences between the crosses. The mean sum of square owing to interaction effects of parents vs. crosses were discovered to be relevant for all characteristics.

High mean performance together with significant useful heterosis in the desirable direction were considered as the criteria for selecting potential crosses for commercial hybrid development. The selected crosses satisfying these criteria are presented in Table 1.

Among the selected crosses, NPJ-252 × ACN-264 recorded a mean seed yield of 14.75 g plant<sup>-1</sup> and exhibited highly significant positive useful heterosis of 38.63 percent over the best check. It showed heterosis superiority over the best check for oil content, point to first silique, silique length and silique density, with significant superiority for oil content and point to first silique.

The cross NPJ-252 × ACN-315 recorded a mean seed yield of 14.40 g plant<sup>-1</sup> and showed highly significant positive useful heterosis of 35.34 percent. It exhibited heterotic superiority over the best check for number of siliquae plant<sup>-1</sup>, number of seeds silique<sup>-1</sup>, number of branches plant<sup>-1</sup> and silique length, with significant superiority for number of siliquae plant<sup>-1</sup> and number of seeds silique<sup>-1</sup>.

The cross GDM-4 × ACN-315 recorded a mean seed yield of 15.84 g plant<sup>-1</sup> and exhibited highly significant positive useful heterosis of 48.87 percent. It exhibited heterotic superiority over the best check for days to 50 percent flowering, days to maturity and oil content, with significant superiority for the same characters.

The cross ACN-264 × NPJ-252 recorded a mean seed yield of 12.35 g plant<sup>-1</sup>, with highly significant positive useful heterosis of 16.07 percent. It showed heterotic superiority over the best check for days to 50 percent flowering, silique length, 1000-seed weight and point to first silique, with significant superiority for the same characters.

The cross ACN-315 × NPJ-252 recorded a mean seed yield of 13.15 g plant<sup>-1</sup> and exhibited significant positive useful heterosis of 23.59 percent. It exhibited heterotic superiority over the best check for days to 50 percent flowering, days to maturity, point to first silique, silique density and 1000-seed weight, with significant superiority for days to 50 percent flowering, days to maturity, point to first silique and 1000-seed weight.

The cross GDM-4 × NPJ-253 recorded a mean seed yield of 13.64 g plant<sup>-1</sup> and showed highly significant positive useful heterosis of 28.20 percent. It exhibited heterotic superiority over the best check for number of seeds silique<sup>-1</sup>, number of siliquae plant<sup>-1</sup> and silique density, with significant superiority for number of siliquae plant<sup>-1</sup> and silique density.

The cross TAM 108-1 × PDKV Kartik recorded a mean seed yield of 16.09 g plant<sup>-1</sup> among the selected crosses and exhibited highly significant positive useful heterosis of 32.42 percent. It exhibited heterotic superiority over the best check for number of siliquae plant<sup>-1</sup>, oil content, 1000-seed weight and silique length, with significant superiority for

number of siliquae plant<sup>-1</sup>, oil content and 1000-seed weight.

Earlier studies by Deshmukh *et al.* (2021) [10], also reported that simultaneous consideration of mean performance and heterosis provides an effective basis for identifying superior

hybrids in Indian mustard. Hence, the seven crosses identified in the present study can be further exploited in heterosis breeding programmes after conversion of the female parent into a male-sterile line.

**Table 1:** Crosses selected for heterosis breeding on the basis of mean performance and useful heterosis for yield and other characters

| Sr. No | Crosses                 | Mean  | Standard heterosis over TAM 108-1 | Heterosis superior over best check for yield contributing characters | Significant superior performance over best check |
|--------|-------------------------|-------|-----------------------------------|----------------------------------------------------------------------|--------------------------------------------------|
| 1      | NPJ-252 × ACN-264       | 14.75 | 38.63**                           | OC, P to 1st S, SL, SD                                               | OC, P to 1st S                                   |
| 2      | NPJ-252 × ACN-315       | 14.40 | 35.34**                           | NOS, NOSPS, NOB, SL                                                  | NOS, NOSPS                                       |
| 3      | GDM-4 × ACN-315         | 15.84 | 48.87**                           | DT50% F, DTM, OC                                                     | DT50% F, DTM, OC                                 |
| 4      | ACN-264 × NPJ-252       | 12.35 | 16.07**                           | DT50% F, SL, 1000 SW, P to 1st S                                     | DT50% F, SL, 1000 SW, P to 1st S                 |
| 5      | ACN-315 × NPJ-252       | 13.15 | 23.59*                            | DT50% F, DTM, P to 1st S, SD, 1000 SW                                | DT50% F, DTM, P to 1st S, 1000 SW                |
| 6      | GDM-4 × NPJ-253         | 13.64 | 28.20**                           | NOSPS, NOS, SD                                                       | NOS, SD                                          |
| 7      | TAM 108-1 × PDKV Kartik | 16.09 | 32.42**                           | NOS, OC, 1000 SW, SL                                                 | NOS, OC, 1000 SW                                 |

**Note:** \* Significant at 5% level, \*\* Significant at 1% level. DTM = Days to maturity (days), NOB = Number of branches plant<sup>-1</sup>, NOS = Number of siliquae plant<sup>-1</sup>, SD = Siliquae density on main branch, OC = Oil content (%), NOSPS = Number of seeds siliqua<sup>-1</sup>, DT50% F = Days to 50% flowering, P to 1st S = Point to first siliqua (cm), SL = Siliqua length (cm), Yield = Seed yield plant<sup>-1</sup> (g), 1000 SW = 1000 seed weight (g), PH = Plant height (cm).

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