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# Combining ability and character association analysis for seed yield and its contributing traits in Indian mustard (*Brassica juncea* L.)

**Nagendra Maurya and AK Singh**

**Abstract**
The experiment conducted on 10×10 half diallel fashion in Indian mustard (*brassica juncea* L.) were assessed to work out the combining ability and character association analysis for seed yield and its contributing traits. The analysis of variance showed that GCA effects were highly significant or significant for all the characters *viz.*, days to 50 per cent flowering, days to maturity, number of primary branches per plant, number of secondary branches per plant, number of siliquae on main raceme, length of siliqua, number of seeds per siliqua, 1000- seed weight, oil content and seed yield per plant in $F_1$ as well as $F_2$ generations. The SCA effects were also highly significant or significant for all the eleven characters in both the $F_1$ and $F_2$ generations. Seed yield per plant reveled GCA effects were negative and significant in both $F_1$ and $F_2$generations for Varuna, Rohini, Krishna and Vaibhav. The GCA effects of NDRE-4 and RH-9304 were negative and highly significant in $F_2$ but positive and highly significant in $F_1$. Seed yield per plant revealed that the 32 crosses in $F_1$ and 39 crosses in $F_2$ showed positive and significant SCA effects. Only three crosses *viz.*, Rohini × RH-9304, Vardan × RH-9304 and Maya × Pusa Mahak in $F_1$ and three crosses Rohini × Vardan, Vardan × RH-9304 and Maya × RH-819 in $F_2$ also showed negative and highly significant SCA effects. On the basis of *per se* performance in $F_1$, the best cross combination for seed yield per plant was Krishna × RH-9304 (11. 03). In the $F_2$ generation, the best cross combination was Vaibhav × Maya (10. 62). Strongly positive correlation were those observed between seed yield per plant and number of secondary branches per plant (0. 44), 1000-seed weight and plant height ($r^g$ = 0. 299) and between seed yield per plant and 1000-seed weight ($r^g$ = 0. 293) in $F_2$ generation. Hence selection for the higher values of these traits will be desirable to increase seed yield.

**Keywords:** *Brassica juncea*, general combining ability, specific combining ability, correlation, seed yield

## Introduction
Indian mustard (*Brassica juncea* L.) is an important oil seed crop of the world. Indian mustard is major *Rabi* oilseed crop of northern India. It has 38 to 42% oil and 24% protein. The development of superior variety could be done by reshuffling the genes through hybridization from suitable parents. Moreover, it is also necessary to know about the nature and magnitude of gene action responsible for controlling the inheritance of various yield attributes along with combining ability of three parents and their cross combination in order exploit them in further crop improvement programme. Average yield of mustard is very low compared to its genetics potential. To make available high yield is one of the most important purposes for most oilseed growers. As known seed yield is a complex character that can be determined by several components. In order to attract the attention to which one has greatest influence on seed yield. Correlations between yield and yield component have repeatedly been analyzed in traditional cultivars of mustard with a high oil per cent by Singh and Singh (1997) [3].

## Materials and methods
The study was designed to work out the status of combining ability and character association analysis effects of these different traits on seed yield per plant among 45$F_1$'s of Indian mustard (*brassica juncea* L.). The ten parents *viz*. Varuna, Rohini, Krishna, Vaibhav, Vardan, Maya, NDRE-4, RH-9304, RH-819, and Pusa Mahak were crossed in half diallel fashion to produce 45$F_1$'s. Ten parents and their 45$F_1$ 's were grown in a randomized block design with three replication. Each parent and $F_1$'s were grown in single row of 5m length with row to row and plant to plant distance of 45 and 15cm, respectively in each replication during *Rabi*

(post rainy) 2010-2011 at the experimental research farm of Tilakdhari Post Graduate College, Jaunpur, (Uttar Pradesh). Recommended cultural practices were adopted in order to raise a healthy crop. Mean values of sample for various traits were subjected to combining ability analysis method II model I of Griffing (1956). The observation were recorded on eleven different seed yield traits *viz*., days to 50% flowering, days to maturity, plant height (cm), primary and secondary branches per plant, number of siliquae on main raceme, length of siliqua, number of seeds per siliqua, test weight (g), oil contents (%) and seed yield per plant (g). Statistical analysis was done using the mean data the correlation analysis was used as suggested by Robinson *et al.* (1951) [2].

**Result and discussion**

The summary of analysis of variance for general combining ability (GCA) and specific combining ability (SCA) for 11 characters in $F_1$ and $F_2$ generations are presented in Table 1. The analysis of variance showed that GCA effects were highly significant or significant for all the characters *viz*., days to 50 per cent flowering, days to maturity, number of primary branches per plant, number of secondary branches per plant, number of siliquae on main raceme, length of siliqua, number of seeds per siliqua, 1000- seed weight, oil content and seed yield per plant in $F_1$ as well as $F_2$ generations. The SCA effects were also highly significant or significant for all the eleven characters in both the $F_1$ and $F_2$ generations.

The estimates of general combining ability (GCA) effects in $F_1$ and $F_2$ generations for all the 11 characters are presented in Table 2 and 3, respectively. Early flowering is desirable character for this crop. Therefore, negative GCA effects are desirable. The varieties *viz*., Varuna, Rohini, Krishna and Vaibhav showed significantly negative GCA effects while Maya, NDRE-4, RH-819 and Pusa Mahak showed significantly positive GCA effects in $F_1$ generation. In $F_2$ generations significant and negative GCA effects were observed for the varieties Varuna, Rohini, Vaibhav, Vardan and RH-9304. The undesirable significant and positive GCA effects were observed Krishna, Maya, NDRE-4 and Pusa Mahak for this trait. Varuna in $F_1$ and Vaibhav in $F_2$ were the best general combiner for early flowering. Days to maturity is observed that GCA effects were negative and significant for the varieties *viz.,* Varuna, RH-9304, RH-819 and Pusa Mahak in $F_1$ and $F_2$ both the generations. Rest of the varieties showed positively significant GCA effects in both the $F_1$ and $F_2$ generations except non-significant GCA effect shown by Rohini in the $F_1$ generation. Plant height is significantly negative GCA effects were recorded for the varieties NDRE-4 and RH-9304 in $F_1$ and for Rohini, Maya and NDRE-4 in $F_2$. The varieties, Krishna, Vaibhav and RH-819 showed significantly positive GCA effects in $F_1$ while in $F_2$ Krishna, Vaibhav, Vardan and RH-9304 showed significant positive GCA effects. These results indicated that RH-9304 in $F_1$ and NDRE-4 were the best combiners for dwarfness. Number of primary branches per plant is observed that GCA effects were negative and significant for Rohini, Krishna, NDRE-4, RH-9304 and RH-819 in $F_1$ and Varuna, Rohini and RH-819 in $F_2$. The positive and significant GCA effects were observed for Varuna, Vaibhav, Vardan, Maya and Pusa Mahak in $F_1$ and Krishna, Vaibhav, Vardan, Maya and Pusa Mahak in $F_2$ generation. The *per se* performance and GCA effects indicated that Vaibhav and Maya were the best general combiners in $F_1$ and $F_2$, respectively. For number of secondary branches per plant, the GCA effects were negative and significant for Rohini, Krishna, Vaibhav, Vardan, RH-9304 and Pusa Mahak in $F_1$ and Krishna, Vaibhav, Maya, NDRE-4, RH-9304, RH-819 and Pusa Mahak in $F_2$. The significant and positive GCA effects were observed for Varuna, Maya, NDRE-4 and RH-819 in $F_1$ while, Varuna, Rohini and Vardan in $F_2$ generation. RH-819 in $F_1$ and Varuna in $F_2$ were the best general combiners. Number of siliquae on main raceme is observed that GCA effects were negative and significant in Vaibhav, Maya, NDRE-4, RH-9304, RH-819 and Pusa Mahak in $F_1$ andVaruna, Krishna, Maya and RH-9304 in $F_2$ generation. The varieties, Varuna, Rohini, Krishna, and Vardan in $F_1$ while Rohini, Vaibhav, Vardan, NDRE-4, RH-819 and Pusa Mahak in $F_2$ showed significant and positive GCA effects. Length of siliqua is observed that GCA effects of Krishna, Vaibhav, NDRE-4, RH-9304 and RH-819 in $F_1$ and Varuna, Rohini, Krishna, Vaibhav, NDRE-4 and RH-9304 in $F_2$ generation were positive and highly significant. Rohini, Vardan, Maya and Pusa Mahak had negatively significant GCA effects in $F_1$ while Vardan, Maya and Pusa Mahak exhibited negatively significant GCA effect in $F_2$ generation. On the basis of GCA effects, Vaibhav in $F_1$ and Varuna in $F_2$ were the best general combiners. Number of seeds per siliqua is observed that Krishna, Vaibhav, Vardan, Maya, NDRE-4 and RH-819 in $F_1$ and Varuna, Rohini, Krishna, Vardan, Maya and NDRE-4 in $F_2$ had positive and highly significant GCA effects. The varieties Varuna, Rohini, RH-9304 and Pusa Mahak in $F_1$ and RH-9304, RH-819 and Pusa Mahak in $F_2$ had negative and highly significant GCA effects. The *per se* performance and GCA effects indicated that NDRE-4 in $F_1$ and Rohini in $F_2$ were the best general combiners for number of seeds per siliqua. For 1000-Seed weight the varieties, Vaibhav, Maya, NDRE-4, RH-9304, RH-819 and Pusa Mahak in $F_1$ while, Krishna, Vaibhav, NDRE-4 and Pusa Mahak in $F_2$ had positive and highly significant GCA effects. The varieties, Varuna, Rohini, Krishna and Vardan in $F_1$ and Varuna, Rohini, Vardan, Maya and RH-819 in $F_2$ exhibited negative and significant GCA effects. The *per se* performance and GCA effects indicated that the NDRE-4 was the best general combiner in both the $F_1$ and $F_2$ generations. Oil content results indicated that the GCA effects of the varieties Varuna, Vaibhav, and RH-9304 in $F_1$ and Vaibhav, Vardan, Maya and RH -9304 in $F_2$ were positive and highly significant. The GCA effects of the varieties Rohini, Krishna, Maya, NDRE-4, RH-819 and Pusa Mahak in $F_1$ and Varuna, Rohini, Krishna, NDRE-4, RH-819 and Pusa Mahak in $F_2$ were negative and highly significant. The variety Vaibhav emerged as best general combiner for oil content in both generations. Seed yield per plant reveled GCA effects were negative and significant in both $F_1$ and $F_2$generations for Varuna, Rohini, Krishna and Vaibhav. The GCA effects ofNDRE-4 and RH-9304 were negative and highly significant in $F_2$ but positive and highly significant in $F_1$. The varieties, Vardan, Maya, NDRE-4, RH-9304, RH-819 and Pusa Mahak in $F_1$ and Vardan, Maya, RH-819 and Pusa Mahak showed positive and significant GCA effects in $F_2$ generation. The variety, RH-819 was the best general combier for seed yield per plant in both the $F_1$ and $F_2$ populations.

The estimates of specific combing ability in 45 cross combinations of 10x10 diallel cross, each in the $F_1$ and $F_2$ generation for 11 different characters are presented in Table 4 and 5. Days to 50% flowering negative SCA effects are desirable and indicated that the crosses, Varuna × Krishna, Varuna × NDRE-4, Varuna × RH-819, Rohini × Maya, Rohini × RH9-304, Vaibhav × RH-9304, Vardan × NDRE-4, Vardan × RH-819, Vardan × Pusa Mahak, Maya ×NDRE-4,

Maya × RH- 819, RH-9304 × Pusa Mahak had negative and significant SCA effects in both $F_1$ and $F_2$generations. The crosses, Varuna × Vaibhav, Varuna × Vardan, Varuna × Maya, Rohini × Krishna, Rohini × Vardan, Rohini × Pusa Mahak, Krishna × Pusa Mahak, Vaibhav × NDRE-4, Maya × Pusa Mahak, NDRE-4 × RH-9304 and RH-819 × Pusa Mahak had negative and highly significant SCA effects in $F_1$ generation, while the crosses *viz.*, Varuna × Rohini, Rohini × NDRE-4, Rohini × RH-819, Krishna × Vaibhav, Vaibhav × RH-819, Vaibhav × Pusa Mahak and Maya × RH-9304 showed negative and highly significant SCA effects in $F_2$ generation. The crosses Varuna × Vaibhav, Rohini × Pusa Mahak, Vaibhav × NDRE-4 and NDRE-4 × RH-9304 had positive and highly significant SCA effects in $F_2$ generation. The best cross combination was Varuna × RH-819 in $F_1$ and Maya × NDRE-4 in $F_2$ generation on the basis of *per se* performance and GCA effects. Days to maturity indicated that 14 crosses days to maturity in $F_1$ and 15 crosses in $F_2$ showed negative and highly significant SCA effects for the crosses, Varuna × Krishna, Varuna × Vaibhav, Varuna × Maya, Rohini × Maya, Rohini × Vardan, Rohini × NDRE-4, Krishna × Pusa Mahak, Vaibhav × Vardan, Vaibhav × Maya, Vaibhav × NDRE-4, Vaibhav × RH-9304, Vardan × RH-819, Maya × NDRE-4 and RH-9304 × RH-819 in $F_1$ and Varuna × Vaibhav, Varuna × Vardan, Varuna × Maya, Varuna × NDRE-4, Rohini × Krishna, Rohini × Vaibhav, Rohini × Pusa Mahak, Krishna × Vaibhav, Krishna × RH -9304, Krishna × RH-819, Vaibhav × Vardan, Vaibhav× Maya, Vaibhav × NDRE-4, Vardan × Maya, Maya × RH-819, and NDRE-4 × RH-819 in $F_2$ had negative and highly significant SCA effects. The crosses, Varuna × RH-9304, Krishna × Vaibhav, NDRE-4 × RH-819 and RH-819 × Pusa Mahak in $F_1$ and Varuna × Pusa Mahak, Rohini × Maya, Rohini × NDRE-4, Vaibhav × RH-819, Vaibhav × Pusa Mahak, Vardan × NDRE-4, Maya × RH-9304, NDRE-4 × RH-9304, RH-9304 × RH-819, RH-9304 × Pusa Mahak and RH-819 × Pusa Mahak in $F_2$positive and highly significant SCA effects. The cross Rohini × Vardan in $F_1$ and Vardan ×Maya in $F_2$ generation showed early maturity. Plant height indicated that the cross of Rohini × Pusa Mahak in F1 and Maya × RH-819, Varuna × Pusa Mahak and Varuna × RH-819 in $F_2$ showed positive and significant SCA effects while none of the crosses showed negative and significant SCA effects. The cross, Maya × Pusa Mahak was the shortest stature in $F_1$ and Varuna × Krishna had the shortest stature in $F_2$. Number of primary branches per plant is observed that the cross of Varuna × Rohini, Varuna × Krishna, Varuna × Vaibhav, Varuna × Vardan, Varuna × RH-819, Rohini × Vaibhav, Rohini × Maya, Rohini × Pusa Mahak, Krishna × Vaibhav, Krishna × RH-819, Krishna × Pusa Mahak, Vaibhav× Vardan, Vardan × Pusa Mahak, Maya × RH-9304, Maya × RH-819, NDRE-4 × Pusa Mahak, RH-9304 × Pusa Mahak and RH-819 × Pusa Mahak in $F_1$ and Varuna × Vardan, Varuna × Maya, Varuna × NDRE-4, Rohini × Vaibhav, Rohini × Vardan, Rohini × RH-9304, Rohini × RH-819, Rohini × Pusa Mahak, Krishna × Maya, Krishna × RH-9304, Krishna × Pusa Mahak, Vaibhav × Vardan, Vaibhav × Maya, Vaibhav × NDRE-4, Vaibhav × RH-9304, Vaibhav × RH-819, Vardan × Pusa Mahak, Maya × NDRE-4, Maya × RH-819, and NDRE-4 × Pusa Mahak in $F_2$ exhibited significant and positive SCA effects. The crosses, Rohini × Krishna, Rohini × Vardan, Rohini × RH-9304, Krishna × Maya, Vaibhav × NDRE-4, Vaibhav × RH-9304, Vaibhav × RH-819, Vardan × RH-819 and Maya × Pusa Mahak in $F_1$ and Varuna × RH-9304, Varuna × RH-819, Varuna × Pusa Mahak, Rohini × Maya, Krishna × Vaibhav, Krishna × Vardan, Vardan × Maya and Vardan × NDRE-4 in $F_2$ highly `exhibited significant and negative SCA effects. The best cross combinations on the basis of *per se* performance were Vaibhav × Vardan in $F_1$ and Krishna × Pusa Mahak in $F_2$ generation. Number of secondary branches per plant is observed that 10crosses exhibited significant and negative SCA effects in $F_1$ and 17 crosses in $F_2$ generation. The crosses, Varuna×Krishna, Varuna × Vaibhav, Varuna × NDRE-4, Varuna × RH-9304, Varuna × RH-819, Rohini × Vaibhav, Rohini ×Vardan, Rohini × Maya, Rohini × RH-9304, Rohini × RH-819, Rohini × Pusa Mahak, Krishna × Vaibhav, Krishna × Vardan, Krishna ×Maya, Krishna × NDRE-4, Krishna × Pusa Mahak, Vaibhav × Vardan, Vaibhav ×Maya, Vardan × RH-9304, Vardan × Pusa Mahak, Maya ×NDRE-4, Maya ×RH-819, Maya × Pusa Mahak, NDRE-4 ×RH-819, NDRE-4 ×Pusa Mahak, RH-9304 ×RH-819, RH-9304 ×Pusa Mahak and RH-819 ×Pusa Mahak in $F_1$ generation and Varuna×Vaibhav, Varuna×Vardan, Varuna×Maya, Varuna×RH-9304, Varuna×RH-819, Varuna×Pusa Mahak, Rohini × Krishna, Rohini × Vaibhav, Rohini × Vardan, Vardan ×RH-9304, NDRE-4 ×RH-819, RH-9304 ×RH-819 and RH-9304 × Pusa Mahak in $F_2$ generation showed positive and highly significant SCA effects. The best cross combination on the basis of *per se* performance was Rohini × RH-819 in $F_1$ and Rohini ×Vardan in $F_2$ generations. Number of siliquae on main raceme is evident that the crosses Varuna × Rohini, Varuna × Vaibhav, Rohini × Maya, Rohini × RH-9304, Rohini × RH-819, Rohini × Pusa Mahak, Rohini × NDRE-4, Krishna × RH-819, Vaibhav × Vardan, Vaibhav × NDRE-4, Vaibhav × RH-9304, Vaibhav × RH-819, Vardan × Maya, Vardan × NDRE-4, Vardan × Pusa Mahak, Maya × RH-9304, Maya × Pusa Mahak, NDRE-4 × RH-819, NDRE-4 × Pusa Mahak and RH-9304 × Pusa Mahak in $F_1$and Varuna × Rohini, Varuna × Vardan, Varuna × NDRE-4, Varuna × RH-819, Rohini × Maya, Rohini × Pusa Mahak, Krishna × NDRE-4, Krishna × RH-9304, Krishna × RH-819, Krishna ×Pusa Mahak, Vaibhav ×Vardan, Vaibhav ×Maya, Vaibhav ×Pusa Mahak, Vardan × Maya, Vardan × NDRE-4, Vardan × RH-819, Maya × RH-9304, NDRE-4 × RH-9304 and RH-819 × Pusa Mahakin $F_2$ had negative and highly significant SCA effects. Positive and significant SCA effects were observed in twenty crosses in $F_1$ and twenty two crosses in $F_2$ generations. The best cross combination on the basis of *per se* performance was Rohini ×Krishna (24. 74) in $F_1$ while Rohini ×RH-819 (14. 79) in $F_2$ generation for number of siliquae on main raceme. Length of siliqua indicated that non of the crosses any cross showed either positive or negative and significant SCA effects in $F_1$ generation but in $F_2$ generation, 26 crosses showed negative and significant and 14 crosses showed positive and significant SCA effect. The best cross combination on the basis of *per se* performance in $F_2$ was Varuna × Vaibhav (0. 51), followed by Vaibhav × RH-819(0. 41). Number of seeds per siliqua indicated that 12 crosses *viz.*, Rohini × NDRE-4, Rohini × RH-819, Krishna × RH-9304, Krishna × RH-819, Krishna × Pusa Mahak, Vaibhav × NDRE-4, Vaibhav × RH-9304, Vaibhav × RH-819, Vardan × NDRE-4, Maya × Pusa Mahak, NDRE-4 × RH-9304 and RH-9304 × RH-819 in $F_1$ and 17 crosses *viz.*, Varuna × Vaibhav, Varuna × NDRE-4, Varuna × RH-9304, Rohini × Vardan,

Rohini × Pusa Mahak, Krishna × Vaibhav, Krishna × Pusa Mahak, Vaibhav × Vardan, Vaibhav × Pusa Mahak, Vardan × Maya, Vardan × NDRE-4, Vardan × Pusa Mahak, Maya × RH-9304, Maya × RH-819, Maya × Pusa Mahak, NDRE-4 × RH-9304 and NDRE-4 × RH-819 in $F_2$ generations had positive and highly significant SCA effects. There were 18 crosses with positive and 21crosses with negative. SCA effects of significant nature in $F_2$ generation. The best cross combination on the basis of *per se* performance was NDRE-4 × RH-9304 (3. 00) in $F_1$ but Varuna × RH-9304 (3. 76) was the best combination in $F_2$ generation. 1000-Seed weight indicated that the 21 crosses in $F_1$ and 27 crosses in $F_2$ showed negative and significant SCA effects but 21 crosses in $F_1$ and 18 crosses in $F_2$ showed positive and significant SCA effects. On the basis of *per se* performance in $F_1$, the best cross combination for 1000-seed weight was Rohini × Vaibhav (0. 78) and Vaibhav × RH-819 (0. 69) was the best cross combination for 1000-seed weight in the $F_2$ generation. Oil content is observed that the 11 crosses *viz.*, Varuna × Vardan, Varuna × Maya, Varuna × NDRE-4, Rohini × Maya, Rohini × RH-819, Rohini × Pusa Mahak, Krishna × Vaibhav, Krishna × Pusa Mahak, Vaibhav× Pusa Mahak, Vardan × RH-9304 and NDRE-4 × RH-819in the $F_1$ and 20 crosses Varuna × Pusa Mahak, Rohini × Krishna, Rohini × NDRE-4, Rohini × RH-819, Rohini × Pusa Mahak, Krishna × Maya, Krishna × NDRE-4, Krishna × Pusa Mahak, Vaibhav × Vardan, Vaibhav × Maya, Vaibhav × NDRE-4, Vaibhav × RH-9304, Vaibhav × RH-819, Vardan × Maya, Vardan × NDRE-4, Vardan × RH-819, Maya × RH-9304, Maya × RH-819 and RH-9304 × Pusa Mahak in $F_2$ generation showed positive and significant SCA effects. The 11 crosses in $F_1$ and 19 crosses in $F_2$ with negative SCA effects were significant. On the basis of *per se* performance in $F_1$, the best cross combination for oil content was Krishna × Vaibhav (3. 14), followed by Rohini × Pusa Mahak (1. 42). In the $F_2$ generation Krishna × Maya (2. 75), followed by Vaibhav × NDRE-4 (2. 57) was the best cross combination for oil content. Seed yield per plant revealed that the 32 crosses in $F_1$ and 39 crosses in $F_2$ showed positive and significant SCA effects. Only three crosses *viz.*, Rohini × RH-9304, Vardan × RH-9304 and Maya × Pusa Mahak in $F_1$ and three crosses Rohini × Vardan, Vardan × RH-9304 and Maya × RH-819 in $F_2$ also showed negative and highly significant SCA effects. On the basis of *per se* performance in $F_1$, the best cross combination for seed yield per plant was Krishna × RH-9304 (11. 03). In the $F_2$ generation, the best cross combination was Vaibhav × Maya (10. 62).

The analysis of variance revealed considerable genetic diversity among the parent, cross combination as well as between parent group and cross combination group for all the characters. Analysis combining ability indicated that mean sum of square due to the both general and specific combining ability were significant for all the characters except length of siliqua, 1000 seed weight and seed yield suggesting importance of both additive and non-additive gene effects in the inheritance of these characters. Similar finding where earlier worker (Singh *et al.*, 2008, Singh and yadav *et al.*, 2005) [5, 6, 10]. Relative magnitude of non-additive gene effect was predominant in controlling the inheritance of plant height, no. of primary branches and seed yield per plant, whereas additive gene effect were found predominant for controlling the inheritance of rest of the other characters. A persusal of general combining ability (GCA) effect of parent indicated that none of the parent was found to be good general combiner for all the traits. Parents Varuna (length of siliqua) Rohini (day to maturity, Plant height), Krishna (days to maturity) Varuna (days to 50% flowering) RH-9304 (days to 50% flowering) Pusa Mahak (plant height) at can be calculated parent Pusa Mahak, possess desirable allele for most of the characters. Here these parents could be used in future for improvement of respective characters.

Parents phenotypic correlation coefficient of plant height was negative and significant with days to 50 per cent flowering ($r^p$= -0. 693**). The phenotypic correlations between remaining 54 character pairs were non-significant in either positive or negative direction. The estimate of genotypic correlation coefficient among 11 traits in parent. There were strong positive correlation between plant height and days to maturity ($r^g$ = 0. 739) and between seed yield per plant and oil content ($r^g$ = 0. 709). Plant height and days to 50 per cent flowering were negatively strongly correlated ($r^g$ = -0. 872). Similarly, negative and strong correlation occurred between primary branches per plant and days to 50 per cent flowering [Table 6]. In $F_1$ population correlation coefficient between different traits is presented in Table 7. Days to maturity showed positive and highly significant association with days to 50 per cent flowering ($r^p$ = 0. 516**). Plant height showed significant and positive phenotypic correlation with number of primary branches per plant. The estimate of genotypic correlation coefficient between different characters showed close parallelism with their corresponding phenotypic correlation coefficients, the genotypic correlation were higher in magnitude than corresponding phenotypic correlations. Days to maturity showed strong positive genotypic association with day to 50 per cent flowering ($r^g$ = 0. 657). Strong positive association was also observed between number of siliquae on main raceme and days to 50 per cent flowering ($r^g$ = 0. 442). Plant height also showed high order positive genotypic correlation with number of primary branches per plant. In $F_2$ Population seed yield per plant had highly significant and positive association with number of secondary branches per plant ($r^p$ = 0. 421). The estimates of genotypic correlation coefficient between different characters, showed close parallelism with their corresponding phenotypic correlation coefficients. Strongly positive correlation were those observed between seed yield per plant and number of secondary branches per plant (0. 44), 1000-seed weight and plant height ($r^g$ = 0. 299) between seed yield per plant and 1000-seed weight ($r^g$ = 0. 293) in $F_2$ generation [Table 8].

**Table 1:** Summary of analysis of variance for general combining ability (GCA) and specific combining ability (SCA) for 11 characters in 10 parents diallel cross in *Brassica juncea* in $F_1$ and $F_2$ generations

| Source | D. F. | Generation | Days to 50% flowering | Days to maturity | Plant height (cm) | No. of primary branches/ plant | No. of secondary branches/ plant | No. of siliquae on main raceme | Length of siliqua (cm) | No. of seeds/ siliqua | 1000 - Seed weight (g) | Oil content (%) | Seed yield / plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GCA | 9 | $F_1$ | 6. 784** | 152. 168** | 267. 243** | 6. 582** | 44. 861** | 93. 225** | 0. 109** | 3. 697** | 0. 28** | 0. 758* | 21. 089** |
| | | $F_2$ | 10. 285** | 314. 138** | 366. 267** | 2. 432** | 269. 210** | 32. 880** | 0. 549** | 5. 530** | 0. 243** | 3. 396** | 22. 814** |
| SCA | 45 | $F_1$ | 17. 412** | 59. 256** | 474. 901** | 2. 815** | 72. 599** | 96. 461** | 0. 223* | 2. 763** | 0. 295* | 1. 004* | 83. 978** |
| | | $F_2$ | 23. 815** | 120. 990** | 470. 584** | 2. 421** | 104. 134** | 51. 377** | 0. 183* | 3. 908** | 0. 335* | 1. 574* | 113. 604** |
| Error | 108 | 0. 793 | 0. 793 | 1. 874 | 13. 952 | 0. 28 | 1. 023 | 1. 287 | 0. 023 | 0. 244 | 0. 028 | 0. 332 | 0. 759 |
| | | 0. 713 | 0. 713 | 1. 727 | 12. 113 | 0. 31 | 0. 532 | 0. 608 | 0. 031 | 0. 239 | 0. 014 | 0. 123 | 0. 52 |

*, **Significant at 5 and 1 per cent probability levels, respectively

**Table 2:** Estimate of GCA effects of different character in 10- parent diallele cross in *Brassica juncea* $F_1$

| S. N. | Parent | Days to 50% flowering | Days to maturity | Plant height (cm.) | No. of primary branches/ plant | No. of secondary branches/ plant | No. of siliquae on main raceme | Length of siliqua (cm.) | No. of seeds/ siliqua | 1000 seed weight (g) | Seed yield per plant (g) | Oil content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Varuna | -1. 39** | -2. 04** | 1. 41 | 0. 42** | 3. 01** | 5. 80** | 0. 00 | -092** | -0. 29** | 0. 09** | -0. 71** |
| 2 | Rohini | -0. 62** | -0. 23 | 1. 13 | -0. 78** | -0. 91** | 1. 08** | -0. 01** | -044** | -0. 15** | -0. 13** | -2. 48** |
| 3 | Krishna | -0. 45** | 1. 49 | 3. 99* | -0. 78** | -1. 27** | 2. 30** | 0. 03** | 0. 17** | -0. 01** | -0. 09** | -0. 45** |
| 4 | Vaibhav | -0. 48** | 2. 52** | 9. 38** | 1. 28** | -1. 63** | -3. 31** | 0. 17** | 0. 14** | 0. 06** | 0. 46** | -1. 62** |
| 5 | Vardan | -0. 09 | 4. 63** | 2. 58** | 0. 08** | -0. 22** | 1. 99** | -0. 14** | 0. 19** | -0. 10** | -0. 02 | 1. 51** |
| 6 | Maya | 0. 61** | 4. 52** | -1. 28 | 0. 97** | 0. 64** | -1. 62** | -0. 11** | 0. 42** | 0. 10** | -0. 33** | 0. 22** |
| 7 | NDRE-4 | 0. 91** | 1. 82** | -4. 14** | -0. 75** | 1. 17** | -1. 95** | 0. 10** | 0. 92** | 0. 18** | -0. 11** | 0. 75** |
| 8 | RH-9304 | 0. 02 | -3. 01** | -5. 09** | -0. 50 | -2. 11** | -2. 67** | 0. 01** | -0. 56 | 0. 08** | 0. 39** | 0. 73** |
| 9 | RH-819 | 0. 66** | -5. 18** | -6. 20 | -0. 25** | 3. 14** | -0. 73** | 0. 04** | 0. 56 | 0. 12** | -0. 06** | 1. 65** |
| 10 | Pusa Mahak | 0. 83** | -4. 51** | -1. 78 | 0. 31** | -1. 83** | -0. 89** | -0. 09** | -0. 14 | 0. 17** | -0. 20** | 0. 41** |
| | SE (gi) | 0. 059 | 0. 140 | 1. 046 | 0. 021 | 0. 076 | 0. 096 | 0. 001 | 0. 018 | 0. 002 | 0. 024 | 0. 056 |
| | SE (gi-gj) | 0. 132 | 0. 312 | 2. 325 | 0. 046 | 0. 170 | 0. 214 | 0. 003 | 0. 040 | 0. 004 | 0. 055 | 0. 126 |

Note: *, ** Significant at 5 and 1 per cent levels, respectively.

**Table 3:** Estimates of GCA effects of different characters in 10 parents diallel cross in *Brassica juncea* in $F_2$

| S. No. | Parents | Days to 50% flowering | Days to maturity | Plant height (cm) | No. of primary branches/ plant | No. of secondary branches/ plant | No. of siliquae on main raceme | Length of siliqua (cm) | No. of seeds/ siliqua | 1000 - Seed weight (g) | Oil content (%) | Seed yield/ plant(g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Varuna | -018** | -9. 63** | -1. 11 | -0. 84** | 11. 22** | -2. 96** | 0. 20** | 0. 14** | -0. 06** | -0. 67** | -1. 87** |
| 2 | Rohini | -074** | 0. 78** | -6. 19** | -0. 43** | 4. 78** | 1. 26** | 0. 01** | 0. 73** | -0. 19** | -0. 40** | -2. 08** |
| 3 | Krishna | 1. 26** | 0. 70** | 7. 62** | 0. 07** | -0. 39** | -0. 35** | 0. 15** | 0. 26** | 0. 06** | -0. 21** | -0. 50** |
| 4 | Vaibhav | -1. 99** | 1. 37** | 7. 64** | 0. 32** | -0. 14** | 0. 51** | 0. 09** | 0. 01 | 0. 14** | 0. 94** | -0. 19** |
| 5 | Vardan | -0. 24** | 6. 76** | 3. 73** | 0. 24** | 0. 47** | 0. 82** | -0. 36** | 0. 70** | -0. 11** | 0. 43** | 0. 91** |
| 6 | Maya | 0. 65** | 4. 01** | -5. 69** | 0. 82** | -2. 94** | -1. 38** | -0. 19** | 0. 48** | -0. 12** | 0. 70** | 1. 47** |
| 7 | NDRE-4 | 0. 82** | 5. 92** | -7. 69** | -0. 01 | -2. 39** | 2. 26** | 0. 20** | 0. 17** | 0. 21** | -049** | -0. 24** |
| 8 | RH-9304 | -0. 16** | -1. 02** | 3. 39** | -0. 04 | -4. 11** | -2. 04** | 0. 20** | -1. 08** | 0. 00 | 0. 08** | -0. 21** |
| 9 | RH-819 | -0. 07 | -3. 30** | -0. 38 | -0. 26** | -3. 67** | 0. 57** | 0. 00 | -1. 27** | -0. 12** | -0. 11** | 2. 41** |
| 10 | Pusa Mahak | 0. 65** | -5. 58** | -1. 33 | 0. 13** | -2. 83** | 1. 32** | -0. 31** | -0. 11** | 0. 19** | -0. 28** | 0. 30** |
| | SE (gi) | 0. 053 | 0. 129 | 0. 908 | 0. 023 | 0. 039 | 0. 045 | 0. 002 | 0. 017 | 0. 001 | 0. 009 | 0. 039 |
| | SE (gi-gj) | 0. 118 | 0. 287 | 2. 018 | 0. 051 | 0. 088 | 0. 101 | 0. 005 | 0. 039 | 0. 002 | 0. 020 | 0. 086 |

*, **Significant at 5 and 1 per cent probability levels, respectively

**Table 4:** Estimates of specific combining ability (SCA) effects of the crosses for different characters in 10 parents diallel cross in *Brassica juncea* in $F_1$

| S. No. | Cross | Days to 50% flowering | Days to maturity | Plant height (cm) | No. of primary branches/ plant | No. of secondary branches/ plant | No. of siliquae on main raceme | Length of siliqua (cm) | No. of seeds/ siliqua | 1000- Seed weight (g) | Oil content (%) | Seed yield/ plant(g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Varuna×Rohini | 1. 49* | 3. 35* | 6. 54 | 1. 18** | -4. 69** | -8. 76** | -0. 28 | -0. 94** | 0. 51** | -0. 69* | 4. 40** |
| 2 | Varuna×Krishna | -3. 01** | -5. 37** | -10. 99 | 1. 18** | 8. 67** | 5. 35** | -0. 45 | -2. 89** | -1. 10** | -0. 43 | -0. 40 |
| 3 | Varuna×Vaibhav | -2. 32** | -6. 40** | 8. 96 | 1. 46** | 7. 69** | -3. 37** | 0. 41 | -1. 19** | -0. 11** | -0. 24 | 0. 10 |
| 4 | Varuna×Vardan | -3. 70** | -3. 51* | 7. 10 | 0. 65** | 0. 28 | 3. 65** | -0. 38 | 0. 09 | -0. 48** | 0. 57* | 6. 57** |
| 5 | Varuna×Maya | -1. 73* | -4. 40** | 12. 29 | 0. 43 | -0. 25 | 16. 93** | -0. 01 | -0. 14 | 0. 30 | 0. 67* | 5. 69** |
| 6 | Varuna×NDRE-4 | -1. 37* | -3. 37* | 23. 82* | 0. 15 | 6. 89** | 13. 93** | -0. 42 | -0. 97** | -0. 40** | 1. 20** | 2. 20** |
| 7 | Varuna×RH-9304 | -0. 15 | 5. 80** | 1. 10 | -0. 10 | 9. 17** | 2. 65* | -0. 69 | 0. 17 | 0. 41** | 0. 46 | 6. 15** |
| 8 | Varuna×RH-819 | -5. 12** | -0. 70 | 10. 21 | 0. 65** | 10. 92** | 13. 04** | -0. 86 | -0. 94** | 0. 24** | 0. 13 | -0. 67 |
| 9 | Varuna×Pusa | 0. 05 | 2. 96 | 7. 12 | -0. 24 | -6. 11** | 3. 54** | 0. 47 | 0. 42* | -0. 02 | 0. 39 | 10. 57** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mahak | | | | | | | | | | | |
| 10 | Rohini×Krishna | -4. 12** | -10. 18** | -0. 04 | -2. 63** | -7. 08** | 24. 74** | -0. 84 | -3. 03** | 0. 75** | -0. 56* | 3. 94** |
| 11 | Rohini×Vaibhav | -1. 01 | -2. 20 | 7. 57 | 3. 32** | 6. 28** | 4. 35** | -0. 42 | 0. 00 | 0. 78** | -1. 41** | 0. 34 |
| 12 | Rohini×Vardan | -3. 15** | -15. 98** | -8. 96 | -1. 15** | 6. 19** | 11. 38** | 0. 46 | -1. 39** | -1. 18** | 0. 15 | 1. 39* |
| 13 | Rohini×Maya | -2. 51** | -6. 20** | 6. 23 | 2. 62** | 5. 33** | -5. 01** | 0. 10 | -0. 61** | -0. 42** | 0. 76** | 0. 70 |
| 14 | Rohini×NDRE-4 | -1. 15 | -7. 51** | 19. 76 | -0. 32 | -4. 19** | 9. 99** | 0. 29 | 1. 11** | 0. 22** | -0. 17 | 7. 89** |
| 15 | Rohini×RH-9304 | -2. 26** | 1. 99 | -6. 63 | -0. 90** | 2. 75** | -4. 29** | -0. 39 | -0. 30 | -0. 52** | 0. 11 | -2. 08** |
| 16 | Rohini×RH-819 | -0. 90 | 3. 49* | 17. 48 | -0. 15 | 14. 17** | -7. 90** | 0. 11 | 1. 59** | -0. 22** | 0. 99** | 4. 75** |
| 17 | Rohini×Pusa Mahak | -2. 40** | 2. 82 | 29. 07* | 0. 62** | 3. 47** | -5. 07** | 0. 14 | -0. 72** | 0. 21** | 1. 42** | 7. 88** |
| 18 | Krishna×Vaibhav | 1. 07 | 4. 41** | -2. 63 | 0. 65** | 5. 97** | 2. 79* | 0. 11 | 0. 29 | -0. 08** | 3. 14** | 7. 72** |
| 19 | Krishna×Vardan | -0. 32 | -1. 04 | -6. 15 | -0. 15 | 2. 89** | 4. 15** | -0. 48 | 0. 34 | 0. 07** | -0. 51 | 6. 11** |
| 20 | Krishna×Maya | -1. 01 | -2. 59 | 6. 04 | -1. 04** | 9. 03** | 6. 10** | 0. 13 | -1. 22** | 0. 37** | 0. 11 | -0. 51 |
| 21 | Krishna×NDRE-4 | -0. 32 | -2. 90 | 13. 23 | 0. 01 | 2. 50** | -5. 23** | -0. 41 | -0. 39 | -0. 35** | -0. 28 | 3. 87** |
| 22 | Krishna×RH-9304 | -1. 43* | 2. 93 | 8. 18 | -0. 24 | -3. 56** | 4. 49** | 0. 01 | 1. 09** | 0. 06* | -0. 81** | 11. 03** |
| 23 | Krishna×RH-819 | -0. 73 | 2. 77 | 20. 62 | 1. 51** | -2. 14* | -4. 79** | 0. 04 | 0. 64** | 0. 37** | -0. 80** | 0. 74 |
| 24 | Krishna×Pusa Mahak | -4. 90** | -10. 90** | 24. 87* | 1. 96** | 2. 50** | 3. 38** | -0. 03 | 1. 67** | -0. 03 | 0. 59* | 2. 44** |
| 25 | Vaibhav×Vardan | 1. 34* | -8. 07** | 25. 46* | 3. 46** | 5. 92** | -3. 90** | 0. 27 | -0. 30 | 0. 10** | 0. 23 | 0. 37 |
| 26 | Vaibhav×Maya | -0. 65 | -6. 95** | -1. 35 | 0. 23 | 4. 06** | 3. 04** | -0. 42 | -1. 19** | -0. 70** | 0. 07 | 4. 50* |
| 27 | Vaibhav×NDRE-4 | -2. 29** | -10. 26** | 19. 85 | -1. 04** | -5. 47** | -7. 96** | -0. 66 | 0. 97** | -0. 89** | -0. 04 | -0. 73 |
| 28 | Vaibhav×RH-9304 | -3. 40** | -4. 43** | 25. 79* | -1. 63** | -3. 19** | -4. 57** | -0. 44 | 1. 45** | -0. 27** | -1. 52** | 2. 79** |
| 29 | Vaibhav×RH-819 | -0. 37 | -0. 59 | 4. 57 | -1. 88** | -1. 78* | -3. 85** | 0. 73 | 2. 00** | 0. 67** | 0. 02 | 7. 90** |
| 30 | Vaibhav×Pusa Mahak | 0. 80 | -0. 26 | -4. 85 | -0. 43 | -1. 47 | 10. 65** | -0. 18 | -1. 64** | -0. 30** | 0. 80** | 7. 31** |
| 31 | Vardan×Maya | 0. 96 | -2. 40 | 5. 12 | 0. 43 | -1. 69 | -9. 93** | 0. 16 | 0. 09 | 0. 18** | 0. 38 | 6. 53** |
| 32 | Vardan×NDRE-4 | -1. 68* | 2. 96 | 3. 32 | -0. 18 | 1. 11 | -7. 60** | 0. 22 | 2. 25** | 0. 05* | 0. 52 | 2. 81** |
| 33 | Vardan×RH-9304 | -0. 12 | 1. 46 | 14. 93 | -0. 43 | 4. 39** | 9. 79** | 0. 07 | -2. 94** | -0. 06* | 1. 16** | -1. 77** |
| 34 | Vardan×RH-819 | -2. 09** | -8. 04** | 7. 04 | -1. 68** | -0. 53 | 4. 18** | -0. 23 | -2. 39** | 0. 14** | -1. 00** | 5. 84** |
| 35 | Vardan×Pusa Mahak | -2. 59** | -1. 70 | 5. 62 | 1. 10** | 3. 78** | -7. 98** | -0. 26 | 0. 31 | 0. 31** | -2. 24** | 4. 38** |
| 36 | Maya×NDRE-4 | -4. 37** | -4. 93** | 21. 18 | 0. 26 | 2. 92** | 11. 35** | 0. 19 | 0. 03 | -0. 47** | -2. 37** | 4. 85** |
| 37 | Maya×RH-9304 | -0. 15 | 1. 24 | 27. 79* | 2. 35** | -5. 81** | -8. 93** | 0. 08 | -1. 83** | -0. 07* | -0. 73* | 3. 19** |
| 38 | Maya×RH-819 | -3. 12** | -2. 59 | 15. 23 | 1. 10** | 8. 28** | 10. 13** | -0. 25 | -0. 61** | 0. 14** | 0. 00 | 4. 72** |
| 39 | Maya×Pusa Mahak | -1. 95** | -1. 26 | -32. 52** | -1. 46** | 3. 25** | -7. 07** | 0. 28 | 1. 09** | 0. 60** | -0. 51 | -1. 40* |
| 40 | NDRE-4×RH-9304 | -2. 12** | -1. 40 | -14. 35 | 0. 40 | -0. 67 | -1. 26 | -0. 43 | 3. 00** | 0. 41** | 0. 13 | 3. 36** |
| 41 | NDRE-4×RH-819 | -0. 09 | 6. 10** | 20. 24 | -0. 52* | 4. 75** | -3. 21** | 0. 00 | -2. 44** | -0. 75** | 0. 91** | 3. 26** |
| 42 | NDRE-4×Pusa Mahak | -1. 26 | 1. 10 | 2. 68 | 1. 26** | 10. 06** | -10. 04** | -0. 07 | -0. 41* | -0. 11** | -0. 41 | 3. 57** |
| 43 | RH-9304×RH-819 | -3. 54** | -6. 07** | -11. 96 | 0. 23 | 5. 69** | 6. 18** | -0. 17 | 2. 03** | -0. 29** | -0. 12 | 9. 42** |
| 44 | RH-9304×Pusa Mahak | -2. 37** | 2. 27 | 16. 62 | 1. 35** | 10. 67** | -5. 65** | 0. 29 | -0. 94** | 0. 38** | 0. 49 | 0. 19 |
| 45 | RH-819×Pusa Mahak | -2. 34** | 6. 77** | 22. 73 | 3. 43** | 4. 42** | 4. 40** | -0. 34 | -0. 39 | -0. 56** | -1. 51** | 1. 31* |
| 46 | ±(SIJ) | 0. 673 | 1. 590 | 11. 838 | 0. 238 | 0. 868 | 1. 092 | 2. 021 | 0. 207 | 0. 024 | 0. 282 | 0. 644 |
| 47 | ±(SIJ-SIK) | 1. 455 | 3. 435 | 25. 580 | 0. 514 | 0. 1. 877 | 2. 359 | 0. 043 | 0. 448 | 0. 052 | 0. 609 | 1. 393 |
| 48 | ±(SIJ-SKL) | 1. 322 | 3. 123 | 23. 254 | 0. 467 | 0. 170 | 2. 145 | 0. 039 | 0. 407 | 0. 047 | 0. 554 | 1. 266 |

*, **Significant at 5 and 1 per cent probability levels, respectively

**Table 5:** Estimates of specific combining ability (SCA) effects of the crosses for different characters in 10 parents diallel cross in *Brassica juncea* in $F_2$

| S. No. | Cross | Days to 50% flowering | Days to maturity | Plant height (cm) | No. of primary branches/ plant | No. of secondary branches/ plant | No. of siliquae on main raceme | Length of siliqua (cm) | No. of seeds/ siliqua | 1000-Seed weight (g) | Oil content (%) | Seed yield / plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Varuna×Rohini | -3. 46** | 3. 40* | 5. 82 | -0. 65* | -6. 88** | -2. 02** | -0. 74** | -0. 38 | -0. 23** | -0. 50** | 4. 60** |
| 2 | Varuna×Krishna | -3. 46** | 2. 48 | -20. 32 | -0. 15 | -0. 71 | 11. 26** | -0. 02 | -1. 24** | -0. 33** | -0. 24* | 3. 07** |
| 3 | Varuna×Vaibhav | 1. 79** | -5. 18** | 9. 32 | 0. 27 | 3. 04* | 7. 93** | 0. 51** | 3. 34** | -0. 19** | -0. 83** | 8. 51** |
| 4 | Varuna×Vardan | 1. 37* | -9. 24** | -18. 43 | 1. 68** | 4. 43** | -3. 24** | 0. 03 | -3. 02** | 0. 44** | 0. 01 | 4. 14** |
| 5 | Varuna×Maya | -1. 18 | -8. 82** | -5. 02 | 1. 43** | 5. 18** | 0. 29 | -0. 08** | -2. 46** | -0. 05** | -0. 19 | 3. 48** |
| 6 | Varuna×NDRE-4 | -2. 35** | -8. 74** | 11. 65 | 1. 62** | 0. 29 | -1. 35** | -0. 17** | 2. 17** | 0. 08** | 0. 04 | 2. 98** |
| 7 | Varuna×RH-9304 | -1. 04 | -0. 46 | 9. 57 | -0. 75** | 3. 68** | 6. 29** | -0. 24** | 3. 76** | -0. 16** | 0. 14 | 3. 54** |
| 8 | Varuna×RH-819 | -2. 79** | 1. 82 | 30. 34** | -1. 48** | 14. 57** | -1. 32* | -0. 90** | -2. 05** | -0. 07** | 0. 11 | 6. 20** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | Varuna×Pusa Mahak | -0. 85 | 5. 76** | 31. 62** | -1. 58** | 25. 73** | 4. 26** | 0. 08** | -1. 22** | 0. 29** | 0. 83** | -0. 54 |
| 10 | Rohini×Krishna | 0. 10 | -7. 60** | 12. 09 | -0. 23 | 23. 07** | 2. 71** | -0. 26** | -0. 52* | -0. 08** | 1. 04** | 3. 42** |
| 11 | Rohini×Vaibhav | 0. 68 | -4. 93** | 13. 40 | 0. 85** | 24. 48** | 7. 51** | 0. 24** | -0. 61* | -0. 18** | -1. 41** | 3. 74** |
| 12 | Rohini×Vardan | 0. 93 | -7. 99** | 21. 98* | 1. 27** | 27. 78** | -0. 79 | 0. 38** | 1. 03** | 0. 29** | 0. 01 | -2. 33** |
| 13 | Rohini×Maya | -1. 96** | 9. 43** | -4. 93 | -1. 65** | -8. 38** | -7. 60** | -0. 29** | -0. 08 | -0. 17** | -0. 87** | 6. 11** |
| 14 | Rohini×NDRE-4 | -6. 46** | 9. 51** | 3. 73 | -0. 48 | -10. 60** | 3. 10** | 0. 06** | -0. 44* | 0. 10** | 0. 41** | 8. 85** |
| 15 | Rohini×RH-9304 | -4. 49** | 1. 46 | 0. 98 | 1. 88** | -4. 21** | 2. 73** | 0. 12** | -0. 52* | -0. 38** | -0. 02 | 4. 67** |
| 16 | Rohini×RH-819 | -4. 57** | 1. 07 | -8. 91 | 1. 43** | -8. 99** | 14. 79** | -0. 18** | -0. 99** | 0. 18** | 0. 49** | 2. 53** |
| 17 | Rohini×Pusa Mahak | 1. 71** | -7. 65** | -3. 96 | 1. 71** | -7. 49** | -5. 96** | -0. 23** | 1. 84** | 0. 90** | 0. 78** | 5. 17** |
| 18 | Krishna×Vaibhav | -4. 64** | -13. 85** | 13. 26 | -0. 98** | -5. 68** | 3. 79** | -0. 34** | 1. 53** | -0. 07** | -0. 58** | 3. 13** |
| 19 | Krishna×Vardan | 1. 26* | 11. 10** | 15. 18 | -1. 57** | -4. 63** | 13. 82** | -0. 26** | 0. 51* | -0. 24** | -1. 56** | 9. 10** |
| 20 | Krishna×Maya | -0. 96 | 13. 85** | 19. 26 | 1. 85** | -1. 55** | 10. 35** | -0. 30** | -1. 61** | 0. 29** | 2. 75** | 1. 76** |
| 21 | Krishna×NDRE-4 | -1. 13 | 9. 60** | -18. 41 | 0. 35 | -2. 43** | -4. 63** | 0. 08** | 0. 03 | -0. 67** | 0. 62** | 2. 96** |
| 22 | Krishna×RH-9304 | 0. 51 | -5. 79** | 17. 18 | 2. 38** | 0. 62 | -6. 99** | -0. 05** | -0. 38 | -0. 02* | -1. 26** | 3. 16** |
| 23 | Krishna×RH-819 | 0. 43 | -11. 18** | 24. 62* | 0. 40 | 0. 51 | -3. 27** | -0. 12** | -0. 19 | 0. 20** | -1. 45** | 6. 63** |
| 24 | Krishna×Pusa Mahak | -0. 96 | -1. 57 | 3. 23 | 3. 55** | -2. 99** | -2. 35** | -0. 24** | 1. 31** | 0. 12** | 0. 80** | 7. 53** |
| 25 | Vaibhav×Vardan | -0. 49 | -6. 90** | -4. 52 | 1. 18** | -7. 55** | -4. 71** | -0. 76** | 2. 09** | 0. 59** | 1. 03** | 1. 82 |
| 26 | Vaibhav×Maya | -0. 96 | -10. 82** | -1. 43 | 1. 27** | -0. 46 | -1. 18* | -0. 06** | -3. 02** | -0. 95** | 1. 09** | 10. 62** |
| 27 | Vaibhav×NDRE-4 | 2. 46** | -8. 79** | 2. 23 | 1. 57** | -0. 02 | 7. 85** | -0. 56** | -1. 38** | -0. 55** | 2. 57** | 1. 87** |
| 28 | Vaibhav×RH-9304 | -2. 24** | -1. 79 | 15. 15 | 1. 56** | -4. 96** | 8. 48** | -0. 79** | -2. 80** | -0. 30** | 0. 58** | 2. 85** |
| 29 | Vaibhav×RH-819 | -5. 99** | 19. 15** | 10. 93 | 1. 02** | -2. 41** | 4. 87** | 0. 41** | -0. 94** | 0. 69** | 1. 09** | 2. 63** |
| 30 | Vaibhav×Pusa Mahak | -6. 38** | 16. 76** | 16. 54 | -0. 04 | -2. 57** | -11. 88** | 0. 29** | 2. 89** | -0. 27** | -0. 25* | 6. 80** |
| 31 | Vardan×Maya | -1. 46* | -27. 88** | -6. 18 | -1. 32** | -0. 41 | -3. 82** | -0. 09** | 0. 62** | -0. 31** | 0. 86** | 7. 85** |
| 32 | Vardan×NDRE-4 | -3. 29** | 4. 45** | 13. 82 | -0. 82** | -0. 30 | -5. 79** | -0. 31** | 0. 92** | -0. 76** | 2. 09** | 1. 04* |
| 33 | Vardan×RH-9304 | 0. 35 | 12. 48** | 18. 07 | 0. 55* | 1. 09* | -11. 49** | 0. 02 | -0. 83** | -0. 03** | -0. 54** | -2. 67** |
| 34 | Vardan×RH-819 | -4. 74** | 11. 76** | 11. 18 | 0. 10 | -7. 02** | 5. 23** | 0. 12** | -2. 63** | -1. 04** | 0. 31** | 6. 59** |
| 35 | Vardan×Pusa Mahak | -6. 79** | 7. 37** | 5. 45 | 1. 71** | -4. 52** | 4. 15** | -0. 37** | 0. 53** | -0. 68** | -0. 76** | 10. 27** |
| 36 | Maya×NDRE-4 | -6. 85** | 7. 29** | 4. 23 | 1. 60** | -0. 55 | 9. 40** | -0. 01 | -3. 52** | -0. 74** | -2. 84** | 1. 54** |
| 37 | Maya×RH-9304 | -1. 88** | 16. 23** | -11. 18 | 0. 30 | 0. 18 | -2. 63** | 0. 19** | 3. 06** | -0. 30** | 0. 71** | 0. 95* |
| 38 | Maya×RH-819 | -1. 96** | -9. 15** | 32. 59** | 0. 85** | 0. 07 | 0. 10 | 0. 29** | 1. 92** | -0. 70** | 1. 50** | -0. 49 |
| 39 | Maya×Pusa Mahak | -0. 02 | 0. 79 | 13. 54 | 0. 13 | 0. 57 | 7. 01** | 0. 13** | 2. 09** | 0. 27** | -0. 38** | 7. 42** |
| 40 | NDRE-4×RH-9304 | 1. 62** | 8. 98** | 25. 15* | 0. 46 | -0. 71 | -4. 27** | 0. 23** | 1. 70** | 0. 39** | -1. 08** | 9. 46** |
| 41 | NDRE-4×RH-819 | 0. 54 | -6. 07** | 6. 26 | 0. 68* | 1. 51** | 2. 47** | -0. 04 | 1. 89** | -0. 61** | -0. 80** | 6. 68** |
| 42 | NDRE-4×Pusa Mahak | -0. 52 | 2. 87 | 4. 87 | 1. 30** | 0. 34 | 4. 37** | -0. 26** | -2. 27** | 0. 36** | -2. 66** | -2. 25* |
| 43 | RH-9304×RH-819 | -4. 15** | 15. 87** | -0. 49 | 0. 05 | 2. 23** | 4. 10** | -0. 61** | -1. 19** | -0. 02* | -1. 70** | 10. 34** |
| 44 | RH-9304×Pusa Mahak | -5. 88** | 12. 18** | 19. 45 | -0. 34 | 1. 40** | -0. 99 | -0. 14** | -2. 02** | 0. 17** | 1. 51** | 2. 21* |
| 45 | RH-819×Pusa Mahak | 1. 04 | 8. 43** | -19. 10 | 0. 55* | -0. 05 | -9. 27** | -0. 23** | -2. 49** | -0. 78** | -0. 82** | 5. 16** |
| 46 | ±(SIJ) | 0. 604 | 1. 466 | 10. 277 | 0. 263 | 0. 452 | 0. 516 | 0. 026 | 0. 203 | 0. 011 | 0. 104 | 0. 441 |
| 47 | ±(SIJ-SIK) | 1. 307 | 3. 167 | 22. 207 | 0. 569 | 0. 977 | 1. 115 | 0. 057 | 0. 438 | 0. 025 | 0. 226 | 0. 954 |
| 48 | ±(SIJ-SKL) | 1. 188 | 2. 879 | 20. 188 | 0. 517 | 0. 888 | 1. 013 | 0. 052 | 0. 398 | 0. 023 | 0. 206 | 0. 867 |

*, **Significant at 5 and 1 per cent probability levels, respectively

**Table 6:** Estimates of genotypic and phenotypic correlation coefficients among different characters in 10 parents used in diallel cross in *Brassica juncea*

| S. No. | Characters | Days to Maturity | Plant height (cm) | No. of primary branches/ plant | No. of secondary branches/ plant | No. of siliquae on main raceme | Length of siliqua (cm) | No. of seeds/ siliqua | 1000 seed weight (g) | Oil content (%) | Seed yield /plant(g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Days to 50% flowering | $r^g$-0. 685 | -0. 872 | -0. 650 | -0. 400 | 0. 170 | -0. 393 | 0. 029 | 0. 524 | 0. 222 | 0. 500 |
| | | $r^p$-0. 449 | -0. 693** | -0. 463 | -0. 255 | 0. 064 | -0. 138 | -0. 004 | 0. 348 | 0. 224 | 0. 255 |
| 2 | Days to Maturity | $r^g$ | 0. 739 | 0. 643 | 0. 616 | -0. 091 | -0. 231 | 0. 629 | 0. 125 | -0. 251 | 0. 135 |
| | | $r^p$ | 0. 619 | 0. 502 | 0. 575 | -0. 091 | 0. 200 | 0. 534 | 0. 108 | -170 | 0. 119 |
| 3 | Plant height (c. m.) | | $r^g$ | 0. 372 | 0. 243 | -0. 219 | 0. 042 | 0. 300 | -0. 279 | -0. 339 | 0. 347 |
| | | | $r^p$ | 0. 333 | 0. 164 | -0. 146 | -0. 039 | 0. 238 | -0. 255 | -0. 311 | 0. 211 |
| 4 | No. of primary | | | $r^g$ | 0. 481 | -0. 110 | -0. 042 | 0. 019 | 0. 212 | 0. 502 | 0. 370 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | branches/ plant | | | $r^p$ | 0. 343 | -0. 040 | -0. 002 | 0. 040 | 0. 186 | 0. 267 | 0. 350 |
| 5 | No. of secondary branches/ plant | | | | $r^g$ | -0. 342 | 0. 425 | 0. 400 | 0. 156 | -0. 324 | 0. 222 |
| | | | | | $r^p$ | -0. 330 | 0. 378 | 0. 307 | 0. 148 | -0. 251 | 0. 179 |
| 6 | No. of siliquae on main raceme | | | | | $r^g$ | -0. 566 | -0. 301 | 0. 294 | 0. 349 | 0. 291 |
| | | | | | | $r^p$ | -0. 506 | -0. 263 | 0. 255 | 0. 272 | 0. 297 |
| 7 | length of siliqua (c. m.) | | | | | | $r^g$ | -0. 388 | -0. 397 | -0. 170 | 0. 393 |
| | | | | | | | $r^p$ | -0. 398 | -0. 312 | -0. 220 | 0. 406 |
| 8 | No. of seeds/ siliqua | | | | | | | $r^g$ | 0. 245 | -0. 621 | 0. 133 |
| | | | | | | | | $r^p$ | 0. 118 | -0. 444 | 0. 034 |
| 9 | 1000 seed weight (g) | | | | | | | | $r^g$ | 0. 272 | 0. 566 |
| | | | | | | | | | $r^p$ | 0. 113 | 0. 501 |
| 10 | Oil content (%) | | | | | | | | | $r^g$ | 0. 709 |
| | | | | | | | | | | $r^p$ | 0. 495 |

$r^p$ = phenotypic correlation cofficient, $r^g$ = genotypic correlation cofficient
*, ** Significant at 5 and 1 per cent probability levels, respectively

**Table 7:** Estimates of genotypic and phenotypic correlation coefficient among different character in $F_1$ generation of a 10 parents used in diallel cross in *Brassica juncea*

| S. No. | Characters | Days to Maturity | Plant height (cm) | No. of primary branches/ plant | No. of secondary branches/ plant | No. of siliquae on main raceme | Length of siliqua (cm) | No. of seeds/ siliqua | 1000-seed weight (g) | Oil content (%) | Seed yield / plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Days to 50% flowering | $r^g$ 0. 657 | -0. 115 | 0. 120 | -0. 160 | -0. 573 | 0. 442 | 0. 245 | 0. 295 | 0. 185 | 0. 301 |
| | | $r^p$0. 516** | -0. 070 | 0. 096 | -0. 120 | -0. 423 | 0. 280 | 0. 185 | 0. 250 | 0. 099 | 0. 254 |
| 2 | Days to Maturity | $r^g$ | -0. 006 | 0. 125 | -0. 065 | -0. 312 | 0. 105 | 0. 137 | 0. 162 | 0. 207 | 0. 101 |
| | | $r^p$ | 0. 011 | 0. 129 | -0. 043 | -0. 276 | 0. 085 | 0. 097 | 0. 141 | 0. 062 | 0. 080 |
| 3 | Plant height (cm) | | $r^g$ | 0. 405 | 0. 196 | 0. 011 | 0. 122 | -0. 096 | 0. 157 | 0. 033 | 0. 163 |
| | | | $r^p$ | 0. 335* | -0. 144 | 0. 024 | 0. 089 | -0. 060 | 0. 130 | 0. 000 | 0. 125 |
| 4 | No. of primary branches/ plant | | | $r^g$ | 0. 208 | -0. 206 | 0. 105 | -0. 012 | 0. 008 | -0. 056 | 0. 194 |
| | | | | $r^p$ | 0. 211 | -0. 177 | 0. 084 | -0. 022 | 0. 009 | 0. 012 | 0. 175 |
| 5 | No. of secondary branches/ plant | | | | $r^g$ | 0. 145 | -0. 067 | -0. 063 | -0. 163 | 0. 146 | 0. 166 |
| | | | | | $r^p$ | 0. 135 | -0. 039 | -0. 042 | -0. 150 | 0. 117 | 0. 149 |
| 6 | No. of siliquae on main raceme | | | | | $r^g$ | -0. 357 | -0. 507 | -0. 124 | 0. 028 | 0. 052 |
| | | | | | | $r^p$ | -0. 277 | -0. 427 | -0. 090 | 0. 039 | 0. 041 |
| 7 | Length of siliqua (c. m.) | | | | | | $r^g$ | 0. 299 | 0. 175 | 0. 273 | 0. 121 |
| | | | | | | | $r^p$ | 0. 186 | 0. 062 | 0. 160 | 0. 102 |
| 8 | No. of seeds/ siliqua | | | | | | | $r^g$ | 0. 273 | -0. 119 | 0. 333 |
| | | | | | | | | $r^p$ | 0. 194 | -0. 029 | 0. 292 |
| 9 | 1000 - seed weight (g) | | | | | | | | $r^g$ | -0. 079 | 0. 250 |
| | | | | | | | | | $r^p$ | -0. 014 | 0. 198 |
| 10 | Oil content (%) | | | | | | | | | $r^g$ | 0. 010 |
| | | | | | | | | | | $r^p$ | 0. 021 |

$r^p$ = phenotypic correlation cofficient, $r^g$ = genotypic correlation cofficient
*, ** Significant at 5 and 1 per cent probability levels, respectively

**Table 8:** Estimates of genotypic and phenotypic correlation coefficient among 10 parents used in diallel cross in *Brassica juncea*in $F_2$

| S. No. | Characters | Days to Maturity | Plant height (cm) | No. of primary branches/ plant | No. of secondary branches/ plant | No. of siliquae on main raceme | Length of siliqua (cm) | No. of seeds/ siliqua | 1000 - Seed weight (g) | Oil content (%) | Seed yield / plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Days to 50% flowering | $r^g$ -0. 211 | -0. 034 | 0. 143 | 0. 194 | -0. 179 | 0. 021 | 0. 154 | 0. 004 | -0. 090 | 0. 052 |
| | | $r^g$-0. 183 | -0. 014 | 0. 080 | 0. 175 | -0. 182 | 0. 030 | 0. 137 | 0. 007 | -0. 110 | 0. 040 |
| 2 | Days to Maturity | $r^g$ | -0. 073 | 0. 154 | -0. 411 | 0. 179 | -0. 013 | -0. 030 | -0. 064 | 0. 026 | 0. 111 |
| | | $r^p$ | -0. 071 | 0. 111 | -0. 402 | 0. 174 | 0. 013 | -0. 020 | -0. 062 | 0. 023 | 0. 104 |
| 3 | Plant hight (c. m.) | | $r^g$ | -0. 173 | 0. 172 | -0. 023 | 0. 075 | 0. 033 | 0. 299 | 0. 141 | 0. 041 |
| | | | $r^p$ | -0. 131 | 0. 160 | -0. 020 | 0. 069 | 0. 030 | 0. 248 | 0. 138 | 0. 025 |
| 4 | No. of primary branches/ plant | | | $r^g$ | -0336 | -0. 044 | -0. 045 | 0. 051 | 0. 102 | 0. 140 | 0. 077 |
| | | | | $r^p$ | -0. 265 | -0. 030 | 0. 095 | 0. 029 | 0. 053 | 0. 083 | 0. 085 |
| 5 | No. of secondary branches/ plant | | | | $r^g$ | -0. 042 | 0. 197 | 0. 085 | 0. 136 | -0. 154 | 0. 441 |
| | | | | | $r^p$ | -0. 043 | 0. 147 | 0. 072 | 0. 126 | -0. 137 | 0. 421** |
| 6 | No. of siliquae on main raceme | | | | | $r^g$ | -0. 102 | -0. 214 | 0. 066 | -0. 026 | 0. 006 |
| | | | | | | $r^p$ | -0. 062 | -0. 190 | 0. 055 | -0. 026 | 0. 003 |
| 7 | Length of siliqua (c. m.) | | | | | | $r^g$ | 0. 127 | 0. 246 | -0. 201 | 0. 234 |
| | | | | | | | $r^p$ | 0. 049 | 0. 189 | -0. 113 | 0. 142 |
| 8 | No. of seeds/ siliqua | | | | | | | $r^g$ | 0. 059 | 0. 095 | 0. 058 |
| | | | | | | | | $r^p$ | 0. 043 | 0. 109 | 0. 060 |
| 9 | 1000- Seed | | | | | | | | $r^g$ | -0. 127 | 0. 293 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | weight (g) | | | | | | | | $r^p$ | -0. 079 | 0. 258 |
| 10 | Oil content (%) | | | | | | | | | $r^g$ | 0. 007 |
| | | | | | | | | | | $r^p$ | 0. 027 |

$r^p$ = phenotypic correlation cofficient, $r^g$ = genotypic correlation cofficient
*, ** Significant at 5 and 1 per cent probability levels, respectively

**References**


1. Basalama D, Mishra AK, Kumar A, Kumar PR, Manohar SS. Evolution and characterization of elite germplasm of Indian mustard. (*Brassica juncea* L.). Oilseed Res. 2007; 2008; 24(1):27-30.
2. Robinson HF, Comstock RE, Harkey PH. Genotypic and phenotypic correlation in corn and their implication in selections in selections. Agron. J. 1951; 43:282-287.
3. Singh M, Singh G. Correlation & path analysis in Indian mustard (*B. juncea* L.) under mid hills of Sikkim. J Hills. Res (India). 1997; 10(1):10-12
4. Singh B. Character association and path analysis under dry land condition in Indian mustard (*B. juncea* L.). Cruciferae Newsletter. 2004; 25:99-100
5. Singh Mahak, Bashrat AH, Singh lokendara, Singh Baham, Dixit RK. Studies on combining ability for oil content, seed yield and its contributing characters in Indian mustard [*Brassica juncea* L.) Czern and coss.]. J Prog res., 2008a; 3:174-150.
6. Singh, Mahak, Singh, Geetakumar, Virendra, Dhaka ansu. Combining ability analysis for some metric traits related to seed yield in Indian mustard [*Brassica juncea* (L.) Czern and Coss. ]. *Prog. Agr.* 2008b; 8:57-60.
7. Singh, Mahak, Ranjeet, Srivastava SBI. Heterosis and combining ability estimates in Indian mustard [*Brassica juncea* L.) Czern and Coss]. J Oilseed res. 2009; 26:61-63.
8. Singh SK, Singh AK. Inter-relationship and path analysis for seed yield in Indian mustard. Indian J Ecol. 2010; 37(1):8-12.
9. Srivastava SBL, Rajshekhar, Singh, Mahak, Rao, Mahesh Combining ability analysis for yield and contributing characters in Indian mustard [*Brassica juncea* L.) Czern and Coss.). J Oil seed Res. 2009; 26:58-61
10. Yadav yp, Prakash R, Singh R, Singh RK, Yadav JS. Genetics of yield and its component characters in Indian mustard [*Brassica juncea* L.) Czern and Coss]. Under rainfed conditions J Oilseed Res. 2005; 22:255-258.