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**Supriya Suri**
Department of Genetics and Plant Breeding, Birsa Agricultural University Kanke, Ranchi, Jharkhand India

**Arun kumar**
Department of Genetics and Plant Breeding, Birsa Agricultural University Kanke, Ranchi, Jharkhand India

**Suruchi kumari**
Department of Genetics and Plant Breeding, Birsa Agricultural University Kanke, Ranchi, Jharkhand India

**HC Lal**
Plant Pathology, Birsa Agricultural University Kanke, Ranchi, Jharkhand India

**Savita Ekka**
Plant Pathology, Birsa Agricultural University Kanke, Ranchi, Jharkhand India

**Ashisan Tuti**
Department of Genetics and Plant Breeding, Birsa Agricultural University Kanke, Ranchi, Jharkhand India

**Elisama Xaxa**
KVK Lohardaga, Birsa Agricultural University Kanke, Ranchi, Jharkhand India

**Surya Prakash**
Department of Genetics and Plant Breeding, Birsa Agricultural University Kanke, Ranchi, Jharkhand India

**Correspondence**
**Supriya Suri**
Department of Genetics and Plant Breeding, Birsa Agricultural University Kanke, Ranchi, Jharkhand India

# Combining ability study for yied and its component in Indian mustard (*Brassica juncea* (L.) Czern & Coss)

**Supriya Suri, Arun kumar, Suruchi kumari, HC Lal, Savita Ekka Ashisan Tuti, Elisama Xaxa and Surya Prakash**

## Abstract
Combining ability analysis was undertaken diallel cross set in ten parents and their 45F1 for yield components and oil content in rapeseed (*Brassica juncea* L.) and revealed that the mean squares of general combining ability (gca) was highly significant for all the characters except for number of seed per siliqua and white rust,while the mean squares for specific combining ability (sca) was highly significant for most of the characters studies except number of seed per siliqua and 1000 seed weight that suggesting the importance of both additive and dominance component. In present investigation Bio-133-04 was observed to be the good general combiner for oil content, plant height, length of siliqua,1000 seeds weight,oil content and erucic acid. BBM07-1 was observed as good general combiner for number of siliqua per plant, seed yield per plant, oil content and erucic acid. Parent Vardan and Shivani showed highly significant positive general combining ability effects at one and five percent probability level respectively for oil content. The maximum general combining ability effect for erucic acid showed by parent Kranti and BBM07-1. The best two crosses selected on the basis of specific combining ability were RRH-615×RRH-605, RH-0305×Shivani and Bio-133×BBM07-1 for seed yield per plant. Two top crosses selected on the basis of specific combining ability were RH-0447×RRH-615, Kranti×Shivani, for oil content percent. Overall study revealed that both additive and non-additive gene actions were important in the expression of the characters under studied. These crosses could be exploited for further improvement for seed yield, yield attributing characters and oil content.

**Keywords:** Indian mustard, Diallel analysis General combining ability (gca) and specific combining ability (sca)

## Introduction
Indian mustard (*Brassica juncea* (L) Czern & Coss) is most important oilseeds crop occupying a prominent position in Indian oilseeds scenario and play vital role in oil seeds economy of the country. Rapeseed and mustard ranks third in area (21%) and production (23%) after groundnut and soybean amongst total oilseeds. The per hectare productivity of the crop is quite low in the 64.54 lakh hectare with an annual production of 67.96 lakh tones during 2015-16. (Annual report Mustard 2016-17). The nutrient requirement of oilseed crops, in general, is very high for almost all the essential mineral nutrients which are to be supplied in sufficient quantities and balanced proportion to harvest genetic potential of the crop. The low erucic acid and low glucosinolate mustard oil is widely used as cooking oil in whole world as well as in our country. The relative amount of GCA and SCA effects play a vital role in planning the most appropriate breeding programme in Indian mustard for seed yield and its relative traits.

The first attempt to estimate different type of gene action involved in single cross was provided by Sprague and Tatum (1942). The total genetic variation in this concept is separated into general and specific combining ability. According to them, the general combining ability measures the average performance of a parent in hybrid combinations and specific combining ability refers to those instance in which the performance of a hybrid is relatively better or worse that would be expected, on the basis of average performance of the parents involved. A relatively larger general combining ability and specific combining ability variation ratio suggested the importance of additive gene effect and a low ratio implies the presence of dominant or epistatic gene effect Griffing (1956) and Bhallur *et al.* (1979). An understanding of nature of gene action involved in the inheritance of quantitative characters is necessary for evaluating the various possible breeding procedures. A mustard improvement programme with a prime objective of increasing seed and oil yield would essentially involve a suitable breeding procedure depending on the nature of gene action

**Method and Materials**

The present investigation was carried out with a set of ten varieties of Indian mustard (*Brassica juncea*. L. Czern and Coss) Bio-133-04, RH-0447, Kranti, BBM07-1, Vardan, RH-0305, Pusa Bold, RRH-615, RRH-605 and Shivani and their forty five $F_1$'s obtained through diallel crossing excluding reciprocals. The ten parents and forty five $F_1$'s were grown in a randomized block design with two replications for thirteen quantitative characters against four check (Kranti, vardan, Pusa Bold, Shivani). The field experiments with cross materials developed in Birsa Agricultural University, Kanke, Ranchi farm during rabi season. The observation was recorded for thirteen quantitative and qualitative characters.

**Result and Discussion**

The selection of potential parental line to combine well in hybridization is very crucial to the plant breeder. To supplement this problem, combining ability analysis is of special importance as it helps in identifying potential inbred line for producing synthetics and line showing superior performance in specific combinations would be useful for hybrid production.

The Analysis of variance of combining ability revealed that mean squares of general combining ability (GCA) were highly significant at one percent probability level for plant height, number of primary branches, number of secondary branches, number of siliqua per plant, length of siliqua, 1000 seed weight, days to maturity, seed yield per plant, oil content and erucic acid (Table 1). The mean squares for specific combining ability (SCA) were significant at one percent probability level for number of primary branch, number of secondary branches, number of siliqua per plant, seed yield per plant and erucic acid while plant height and oil content were highly significant at five percent probability level Similar results were observed by Singh and Lallu (2004) and Singh (2005). The GCA and ACA variances were found significant for most of the trait under study which implies that both additive and non-additive variances are important in manifestation for most of the characters. Variance due to specific combining ability was greater than that due to general combining ability, indicating the predominance of non-additive gene effects in the expression of these seed quality traits.

The magnitude of variance estimates due to specific combining ability was higher for ten characters under study. The ratio of variance of general combining ability to that specific combining ability ($\sigma^2$gca/$\sigma^2$sca) was less than unity for eleven characters under study. The estimates for mean degree of dominance ($\sigma^2$sca/ $\sigma^2$gca)$^{1/2}$ revealed the presence of over dominance for characters under study.

The parents included in the study were categories for each of the thirteen characters in three groups viz; good, average & poor combiners based on the general combining ability effects and have been presented in the (table 2 a,b). It may be seen from the table none of the parents were found to be good general combiner for all the characters together. The good general combiners in the present study were, Bio-133-04 and RH-0447 for plant height, RH-0305 for number of primary branches, RH-0305 and Vardan for number of secondary branches,BBM07-1for number of siliqua, Bio-133-04 and Pusa Bold for length of siliuqa, Bio-133-04 for number of seeds per siliqua Bio-133-04 and RH-0447 for 1000 seed weight, Bio-133-04 showed negative significant desirable effect for days to maturity, BBM07-1 for seed yield, BBM07-1 and shivani for oil content and BBM07-1, Kranti, RRH-615, Pusa Bold, RH-0305 and Vardan for erucic acid. The average general combiners were Vardan and Shivani for number of secondary branches, and oil content. These above good and average general combiner were regarded as the best general combiners

In present investigation Bio-133-04 was observed to be the good general combiner for plant height, length of siliqua, number of seeds per siliqua,1000 seeds weight and erucic acid. BBM07-1 was observed as good general combiner for, number of siliqua per plant, seed yield per plant and oil content and erucic acid. Parent Vardan and Shivani showed highly significant positive general combining ability effects at one and five percent probability level respectively for oil content. The maximum gca effect was showed by Kranti and BBM07-1 for erucic acid. These results were in general agreement with the finding of Sarkar *et al* (2001). Swarnkar *et al.* (2002), Singh *et al.* (2004), Singh *et al.* (2005) and Nassimi *et al*. (2006). Parents with good GCA effects and *per se* performance can be crossed to develop high yielding hybrids

Specific combining ability effect showed by different crosses for different trait under study viz; Bio-133-04×BBM07-1 for plant height, BBM07-1×Shivani and Kranti×RH-0305 for primary branches, RH-615×RH-604 and Bio-133-04×RH-0447 for number of secondary branches, Vardan×RRH-605 and RRH-615×RRH-605 for length of siliqua, RH-615×RH-605 and Kranti×Shivani for number of seeds per siliqua, Bio-133-04×RH-0447 and RH-0447× Kranti for 1000 seed weight, Bio-133-0×Pusa Bold and RH-0447×RH-0305 for days to maturity, RRH-615×RRH-605 and RH-0305×Shivani for seed yield per plant, Pusa Bold× RRH-615 and BBM07-1×RRH-605 recorded highly negative desirable *sca* effect for white rust, RH-0447×RRH-615 and Kranti×Shivani for oil content and RH-0447×RH-0305 and Pusa Bold×Shivani recorded highly negative desirable *sca* effect for fatty acid (erucic acid).(table-3) All these cross showed specific combining ability effect for most of characters. The present study showed that both additive and non additive gene actions were important in the expression of the characters studied. However, the magnitude of non additive effects was greater than that of additive effects. These crosses having significant GCA effect, SCA effect and Per se performance could be exploited for further improvement for seed yield, yield attributing characters and oil content.

**Table 1(a):** AVOVA for combining ability, & estimates of variance for genetic components in diallel crosses in Indian mustard

| Source of variance | Character DF | Days to 50 % flowering | Plant height (cm) | No. of primary branches | No. of secondary branches | No. of siliquae/plant | Length of siliquae (cm) Length of siliquae |
|---|---|---|---|---|---|---|---|
| GCA | 9 | 2.721 | 120.390** | 0.454** | 3.215** | 2017.496** | 0.336** |
| SCA | 44 | 4.009 | 51.377* | 0.298** | 2.274** | 1557.319** | 0.060 |
| error | 54 | 3.513 | 19.605 | 0.103 | 0.731 | 544.334 | 0.037 |
| $\sigma^2$gca | | -0.107 | 5.771 | 0.013 | 0.078 | 38.348 | 0.023 |
| $\sigma^2$sca | | 0.496 | 31.772 | 0.195 | 1.543 | 1012.985 | 0.024 |
| $\sigma^2$gca/ $\sigma^2$sca | | -0.216 | 0.182 | 0.067 | 0.051 | 0.038 | 0.963 |

**Table 1(b):** AVOVA for combining ability & estimates of variance for genetic components in diallel crosses in Indian mustard

| Source of variance | Character/DF | No. of seeds/siliquae | 1000 seed weight (g) | Days to maturity | Seed yield/plant (g) | Disease Scoring (White rust) | Oil Content (%) | Fatty acid (Erucic acid) (%) |
|---|---|---|---|---|---|---|---|---|
| GCA | 9 | 1.285 | 1.914** | 7.577** | 4.064** | 5.778 | 9.234** | 172.407** |
| SCA | 44 | 0.700 | 0.211 | 3.196 | 7.047** | 4.061 | 0.836* | 68.988** |
| error | 54 | 0.708 | 0.129 | 2.543 | 1.41 | 3.562 | 0.354 | 0.943 |
| $\sigma^2$gca | | 0.049 | 0.142 | 0.365 | -0.249 | 0.143 | 0.699 | 8.618 |
| $\sigma^2$sca | | -0.008 | 0.082 | 0.653 | 5.636 | 0.499 | 0.481 | 68.044 |
| $\sigma^2$gca/ $\sigma^2$sca | | -6.043 | 1.738 | 0.559 | -0.044 | 0.287 | 1.453 | 0.127 |

*significant at 5% probability level, **Significant at 1% probability level

**Table 2(a):** Estimates of General Combining Ability (GCA) effects of the parents for different quantitative characters

| Characters / Parents | Days to 50 % flowering | Plant height (cm) | No. of primary branches | No. of secondary branches | No. of siliquae/plant | Length of siliquae (cm) |
|---|---|---|---|---|---|---|
| Bio-133-04 | 0.675 | 5.041** | -0.308** | -0.680** | -6.183 | 0.213** |
| RH-0447 | -0.408 | 2.983* | -0.283** | -0.522* | -17.175* | 0.054 |
| Kranti(NC) | 0.467 | 0.275 | -0.058 | -0.347 | 7.275 | -0.046 |
| BBM07-1 | -0.450 | 0.533 | 0.100 | 0.120 | 17.125* | -0.114 |
| Vardan(NC) | 0.467 | -4.116** | -0.025 | 0.653* | 7.775 | -0.088 |
| RH-0305 | -0.783 | -5.158** | 0.358** | 0.787** | 11.925 | -0.172** |
| Pusa Bold(Zc) | 0.175 | -0.316 | -0.025 | -0.097 | -13.150 | 0.361** |
| RRH-615 | 0.175 | -0.200 | 0.050 | -0.005 | 1.467 | -0.044 |
| RRH-605 | -0.325 | -1.933 | 0.067 | -0.447 | -18.933** | -0.027 |
| Shivani(LC) | 0.008 | 2.891* | 0.125 | 0.537* | 9.875 | -0.137* |
| S.E (m) ± | 0.557 | 1.315 | 0.096 | 0.254 | 6.930 | 0.057 |
| CD at 5% | 1.116 | 2.637 | 0.192 | 0.509 | 13.895 | 0.115 |
| CD at 1% | 1.487 | 3.511 | 0.256 | 0.678 | 18.504 | 0.153 |

**Table 2(b):** Estimates of general combining ability effects of the parents for different quantitative characters

| Characters / Prarents | No. of seeds/siliquae | 1000 seed weight (g) | Days to maturity | Seed yield/plant (g) | Disease Scoring (White rust) | Oil content (%) | Erucid acid (%) |
|---|---|---|---|---|---|---|---|
| Bio-133-04 | 0.520* | 0.697** | -1.758** | -0.150 | 0.017 | -1.902** | 6.895** |
| RH-0447 | -0.138 | 0.571** | -0.300 | -0.484 | 0.642 | 0.057 | 4.255** |
| Kranti(NC1) | 0.328 | -0.251* | 0.617 | 0.607 | 1.392 | -0.458* | -3.301** |
| BBM07-1 | 0.137 | -0.243* | -0.175 | 2.648** | -0.817 | 0.853** | -3.437** |
| Vardan(NC2) | -0.288 | -0.549** | 0.908 | -0.356 | -0.858 | 1.356** | -1.919** |
| RH-0305 | 0.153 | -0.055 | -0.217 | 0.442 | -0.692 | -0.533** | -1.970** |
| Pusa Bold(Zc) | 0.062 | 0.147 | -0.050 | -1.079** | 0.058 | 0.127 | -2.675** |
| RRH-615 | -0.647* | 0.051 | 0.408 | 0.439 | -0.067 | 0.219 | -3.254** |
| RRH-605 | -0.138 | 0.047 | -0.383 | -0.434 | 0.308 | -0.126 | 1.980** |
| Shivani(LC) | 0.012 | -0.414** | 0.950* | 0.367 | 0.017 | 0.406* | 3.425** |
| S.E (m) ± | 0.250 | 0.107 | 0.474 | 0.353 | 0.561 | 0.177 | 0.802 |
| CD at 5% | 0.501 | 0.214 | 0.950 | 0.708 | 1.124 | 0.354 | 0.578 |
| CD at 1% | 0.667 | 0.285 | 1.265 | 0.942 | 1.497 | 0.472 | 0.770 |

*significant at 5% probability level, **Significant at 1% probability level

**Table 3:** Top two parents and crosses selected on the basis of mean performance, GCA and SCA effect

| Sl. No. | Characters | Mean performance | GCA effect | Mean performance | SCA effect |
|---|---|---|---|---|---|
| 1 | Days 50% flowering | RH-0305 | *Non* | Bio-133-04×RH-0447 | Bio-133-04×RH-0447 |
| | | Shivani | | RH-0447×RH-0305 | Bio-133-04×Kranti |
| 2 | Plant height (cm) | Vardan | Bio-133-04 | Bio-133-04×BBM07-1 | Bio-133-04×BBM07-1 |
| | | Pusa Bold | RH-0305 | RH-0447× BBM07-1 | RH-0305×Shivani |
| 3 | No. of primary branches | BBM07-1 | RH-0305 | Kranti×RH-0305 | BBM07-1×Shivani |
| | | RH-0305 | Non | BBM07-1×Shivani | Kranti×RH-0305 |
| 4 | No. of secondry branches | BBM07-1 | RH-0305 | Vardan×RH-0305 | RRH-615×RRH-605 |
| | | RH-0305 | Vardan | RH-0305×Shivani | Bio-133-04×RH-0447 |
| 5 | No. of siliquae/plant | BBM07-1 | BBM07-1 | RH-0305×Shivani | Vardan× RRH-605 |
| | | RH-0305 | Non | Kranti× BBM07-1 | RRH-615×RRH-605 |
| 6 | Length of siliquae (cm) | Pusa Bold | Pusa Bold | Bio-133-04× Pusa Bold | RH-0447× BBM07-1 |
| | | RRH-605 | Bio-133-04 | Bio-133-04× RRH-615 | RRH-615×RRH-605 |
| 7 | No. of seeds/siliqua | Pusa Bold | Bio-133-04 | Kranti× Shivani | RRH-615×RRH-605 |
| | | Kranti | Non | Bio-133-04× RH-0305 | Kranti× Shivani |

| | | | | | |
|---|---|---|---|---|---|
| 8 | 1000 seed weight (g) | RH-0447 | Bio-133-04 | Bio-133-04×RH-0447 | Bio-133-04×RH-0447 |
| | | RRH-615 | RH-0447 | Bio-133-04× RH-0305 | RH-0447× Kranti |
| 9 | Days to maturity | Bio-133-04 | Bio-133-04 | BBM07-1×Shivani | Bio-133-04×Pusa Bold |
| | | BBM07-1 | Shivani | RH-0305×Shivani | RH-0447×RH-0305 |
| 10 | Seed yield/plant (g) | BBM07-1 | BBM07-1 | RRH-615×RRH-605 | RRH-615×RRH-605 |
| | | Kranti | | RH-0305×Shivani | RH-0305×Shivani |
| 11 | White rust (%) | BBM07-1 | *Non* | BBM07-1× RRH-605 | Pusa Bold × RRH-615 |
| | | Vardan, RH-0305 | | Pusa Bold × RRH-615 | BBM07-1 × RRH-605 |
| 12 | Oil content (%) | Vardan | Vardan | Vardan × RRH-605 | RH-0447 × RRH-615 |
| | | BBM07-1 | BBM07-1 | Vardan × RRH-615 | Kranti × Shivani |
| 13 | Eucic acid (%) | RH-0305 | BBM07-1 | Kranti × BBM07-1 | RH-0447 × RH-0305 |
| | | Kranti | Kranti | BBM07-1 × Vardan | Pusa Bold × Shivani |

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