Trait's association, cause and effect analyses in Indian mustard [*Brassica juncea* (L.) Czern & Coss]

Sanghamitra Rout, Bijaya Sur, Supratim Sadhu, Tulsi Saran Ghimiray, Hossain Ali Mondal, Lakshmi Hijam, Moumita Chakraborty and Suvendu Kumar Roy

ISSN: 0975-928X

Volume: 10

Number:4

EJPB (2019) 10(4):1482-1494

DOI:10.5958/0975-928X.2019.00191.1

https://ejplantbreeding.org

Electronic Journal of Plant Breeding, 10 (4): 1482-1494 (Dec 2019) DOI: 10.5958/0975-928X.2019.00191.1
ISSN 0975-928X

Research Article

Trait's association, cause and effect analyses in Indian mustard [*Brassica juncea* (L.) Czern & Coss]

Sanghamitra Rout[1], Bijaya Sur[1], Supratim Sadhu[2], Tulsi Saran Ghimiray[3], Hossain Ali Mondal[4], Lakshmi Hijam[5], Moumita Chakraborty[5] and Suvendu Kumar Roy[5*]

[1]Research Scholar, Department of Genetics and Plant Breeding, UBKV, Pundibari, Cooch Behar, West Bengal, India
[2]M.Sc. Student, Department of Genetics and Plant Breeding, UBKV, Pundibari, Cooch Behar, West Bengal, India
[3]Regional Research Station, New Alluvial Zone, Directorate of Research, UBKV, Pundibari, Cooch Behar, West Bengal, India
[4]Regional Research Station, *Terai* Zone, Directorate of Research, UBKV, Pundibari, Cooch Behar, West Bengal, India
[5]Department of Genetics and Plant Breeding, UBKV, Pundibari, Cooch Behar, West Bengal, India
E-Mail: suvendukumarroy@gmail.com

(Received: 02 May 2019; Revised: 27 May 2019; Accepted: 03 Jun 2019)

Abstract

In a study carried out with 71 genotypes of Indian mustard under sub-Himalayan condition during *rabi* 2017-18, it was found that all the genotypes differed significantly for yield and its attributing traits. Both GCV and PCV were found to be higher for height up to first fruiting branch, aphid count and penetration force indicating high variability in the genotypes. High heritability along with high genetic advance was observed for height up to first fruiting branch, primary branches per plant, secondary branches per plant, siliquae per plant and 1000 seed weight. The trait association study revealed that secondary branches per plant and siliquae per plant had positive significant association with seed yield per plant. Path coefficient analysis indicated that penetration force exhibited the highest direct effect on seed yield. Siliquae per plant and secondary branches per plant exhibited high direct positive effect and positive association with seed yield per plant. On the basis of all the eleven traits taken together, the genotype PRD-2013-9 (rank-1) was the best.

Key words

Variability, Heritability, Genetic Advance, Correlation, Path Analysis

Introduction

Brassica juncea (L.) Czern & Coss, also known by the name of Indian mustard, belongs to the plant family *Brassiceae* (*Cruciferae*) or the mustard family. In the trade, it is commonly referred to as mustard along with four other closely related cultivated oilseed species viz. *Brassica rapa*, *Brassica napus*, *Brassica carinata* and *Eruca sativa*. Over the past couple of decades, this crop has become one of the most important sources of vegetable oil in the world. Continuous improvement in mustard has resulted in nutritionally superior edible oil and meal as an important source of protein in animal feed. Mustard crops is commercially cultivated in more than 60 countries and major producer include China, Canada, India, Australia, France, Germany, United Kingdom, Poland, Ukraine, Russia, USA and Czech Republic (Ministry of Environment, Forest and Climate Change and DRMR, GOI, 2016). *Brassica juncea* is used as a source of oil, vegetable, condiments and fodder. The oil content of the seeds ranges from 38- 46%. The conventional varieties of *B. juncea* are high in Erucic acid (~40-50%) as well as in glucosinolates (180-200 micro moles. Seed yield is the result of many traits, which are interdependent. Breeders always look for genetic variation among traits to select desirable types. The assessment of genetic parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance (GA%) is a pre-requisite for making effective selection. Some of these traits are highly associated among themselves and with seed yield. The analysis of the relationship among these traits and their association with seed yield is essential to establish selection criteria (Singh *et al*., 1990). Path-coefficient technique splits the correlation coefficients into direct, and indirect effects via alternative traits or pathways, and thus permits a critical examination of components that influence a given correlation, and can be helpful in formulating an efficient selection strategy (Sabaghnia *et al.*, 2010). Hence, the present study was planned to estimate the variability, heritability, genetic advance, trait association and direct and indirect effects of attributing traits on yield among the 71 Indian mustard genotypes with respect to 11 yield related traits.

Materials and Methods

The field trial was carried out at Instructional Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, during *rabi* season

2017-18. The experimental material consisted of 71 diverse genotypes of mustard collected from three diverse sources namely Pulses and Oilseed Research Station (PORS), Berhampur, West Bengal, Banaras Hindu University (BHU), Varanasi, Uttar Pradesh and Directorate of Rapeseed and Mustard Research (ICAR-DRMR), Bharatpur, Rajasthan (Table 1). The experiment was conducted in Randomized Complete Block Design with three replications. The genotypes were sown in a 3 row plot of 3 meter length. The row to row spacing was kept at 30 cm and plant to plant distance was maintained at 15 cm by proper thinning. All cultural practices essential for a good crop stand were carried out. Fertilizer dose of 40:40:40 kg/ha (N: P_2O_5: K2O) was applied at the time of sowing and 40 kg N per ha was applied after first irrigation (36 days after sowing), second irrigation was applied at 72 days after sowing. Five randomly selected competitive plants from each genotype in each replication were used for the purpose of recording the observations for the eleven traits. The data was recorded on Plant height(cm), height upto first fruiting branch (cm), primary branches per plant, secondary branches per plant, siliquae per plant, aphid count (% incidence) and seed yield per plant (g). Days to 50%flowering was done on plot basis in each replication. Seeds per siliquae were estimated from 10 random siliqua from each replication. The 1000 seed weight was estimated from five samples of 1000 seeds from each replication. The penetration force (kpascal) (Mondal *et al.*, 2017) was estimated from six apical twigs of 10 cm taken randomly from each replication. Genotypic and phenotypic coefficients of variance were worked out as proposed by Burton and Devane (1953). Heritability was calculated as per Allard (1960). The genotypic correlation coefficients were estimated from the analysis of variance and covariance as suggested by Searle (1961). The direct and indirect effects at genotypic level were estimated by taking seed yield as dependent variable using path coefficient analysis suggested by Sewall Wright (1921) and Dewey and Lu (1959). The calculations were performed using the software WINDOW STAT version 8.6 from INDOSTAT services, Hyderabad, India.

An overall ranking of 71 genotypes of mustard was done for eleven traits, out of which 9 were yield attributing traits and the remaining two were aphid count and penetration force, as per rescaling index method suggested by Iyenger and Sudarshan (1982).

Results and Discussion

Analysis of variance (ANOVA, Table 2) revealed significant differences among the genotypes for all the eleven traits studied viz; Plant height (cm), height upto first fruiting branch (cm), days to 50% flowering, primary branches per plant, secondary branches per plant, siliquae per plant (cm), seeds per siliqua, 1000 seed weight (g), penetration force (kpascal), aphid count (% incidence) and seed yield per plant (g). This indicated wide spectrum of variation among the genotypes. Such significant difference was reported by Bibi (2016), Sandhu *et al.* (2017), Devi (2018) and Tiwari (2019) for days to 50% flowering, primary branches per plant and seed yield per plant; Devi (2018), Sandhu *et al.* (2017), Tiwari (2019) for 1000 seed weight; Meena (2017) for plant height, secondary branches per plant and number of seeds per siliqua.

The range of GCV and PCV was suggested by Sivasubramanian and Madhavamenon (1973). Results from the present study (Table 3), in this context, indicated that phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were low (<10%) for plant height (9.13 and 9.18) and seeds per siliqua (4.34 and 7.78). These results are in agreement with Gangapur *et al.* (2011) and Islam *et al.* (2015) for plant height; Rameeh *et al.* (2016) and Synrem *et al.* (2014) for seeds per siliqua. Moderate GCV and PCV (10-25%) for days to 50% flowering (10.32 and 10.51), primary branches per plant (21.06 and 23.83), secondary branches per plant (21.05 and 22.99), siliquae per plant (21.75 and 23.59) and 1000 seed weight (20.39 and 20.54). Such findings were observed by Gangapur *et al.* (2011) and Singh *et al.* (2011) in case of primary branches per plant; Meena *et al.* (2017) and Afrin *et al.* (2011) in case of secondary branches per plant and siliquae per plant where as Islam *et al.* (2015) observed such finding in 1000 seed weight. High GCV and PCV (>25%) for height up to first fruiting branch (31.07 and 31.71), aphid count (28.69 and 49.19) and penetration force (25.50 and 34.05). This is in confirmation with the findings of Roy *et al.* (2018) for height up to first fruiting branch. Seed yield per plant had moderate GCV (20.55) and high PCV (32.89). PCV and GCV values for the different traits did not differ much which indicating the greater role of genetic factors influencing the expression of these traits. Few traits like seeds per siliqua, aphid count, penetration force and seed yield per plant showed greater difference, which indicated the greater influence of the environment in the expression of these traits.

The estimates of heritability (Table 3) were categorized into 3 major groups, i.e. high heritability (> 60%), moderate heritability (30 to 60%), and low heritability (<30%). Range of heritability as low, medium and high was classified by Johnson *et al.* (1995). The traits exhibiting high heritability for plant height (98.86), height upto first fruiting branch (96.02), days to 50% flowering (96.30), primary branches per plants (78.13), secondary branches per plant (83.84), siliquae per plant (85.05) and 1000 seed weight (98.46). High heritability was observed by Sikawar *et al.* (2017) in case of plant height; Roy *et al.* (2018) in case of height upto first fruiting branch; Afrin *et al.* (2011) and Bind *et al.* (2014) in case of days to 50% flowering; Lodhi *et al.* (2014) and Tiwari *et al.* (2017) in primary branches per plants, secondary branches per plant and siliquae per plant; Lodhi *et al.* (2014) and Bind *et al.* (2014) for 1000 seed weight. Moderate heritability for seeds per siliqua (31.12), aphid count (34.01), penetration force (56.09) and seed yield per plant (39.03). Moderate heritability has been reported by Islam *et al.* (2015) for seeds per siliqua and Gangapur *et al.* (2011) for seed yield per plant. Most of the traits expressed high heritability (>60%) except seeds per siliqua, aphid count, penetration force and seed yield per plant. None of the traits showed low heritability.

The estimates of genetic advance (Table 3) were categorized into three major groups, i.e. high genetic advance (above 20%), moderate genetic advance (10-20%) low genetic advance (less than 10%). It was classified by Johnson *et al.* (1955). Genetic advance as percentage of mean was exhibited low (<10%) by seeds per siliquae (4.99). Low genetic advance for seeds per siliquae has been reported by Bind *et al.* (2014); moderate (10-20%) for plant height (18.70) reported by Islam *et al.* (2015) and high (> 20%) for height up to first fruiting branch (62.72), days to 50% flowering (20.86), primary branches per plant (38.36), secondary branches per plant (39.71), siliquae per plant (41.33), 1000 seed weight (41.67), aphid count (34.46), penetration force (39.33) and seed yield per plant (26.44). High genetic advance were obtained by Sikarwar *et al.* (2017) and Tiwari *et al.* (2017) for primary branches per plant, secondary branches per plant and siliquae per plant; Lodhi *et al.* (2014) for 1000 seed weight. Most of the traits expressed high genetic advance as percentage of mean except plant height which showed moderate genetic advance as percentage of mean and seeds per siliqua expressed the lowest genetic advance as percentage of mean. Any traits simultaneously expressing high heritability (h^2) and genetic advance as percentage of mean are under additive gene control and can be improved by appropriate selection. The traits height up to first fruiting branch, primary branches per plant, secondary branches per plant, siliquae per plant and 1000 seed weight expressed high heritability along with high genetic advance as percentage of mean, indicating their additive gene control and possibility of improvement through appropriate selection. Such high heritability with high genetic advance has been reported by Lodhi *et al.* (2014) and Tiwari *et al.* (2017) for primary branches per plant; Afrin *et al.* (2011) and Sikawar *et al.* (2017) for secondary branches per plant; Mondal *et al.* (2000) for 1000 seed weight.

To analyze the extent of mutual relationship among different traits, study of correlation coefficient would be quite beneficial in formulating a suitable selection criterion. This information may be used in predicting the correlated response to direct selection as well as in practicing indirect selection. In the present investigation the correlation coefficients were estimated among the eleven traits at genotypic level (Table 4). In genotypic correlation analysis it was found that plant height had positive association with height up to first fruiting branch (0.715), days to 50% flowering (0.625) and primary branches per plant (0.244). Height up to first fruiting branch had positive association with days to 50% flowering (0.571) and primary branches per plant (0.301). Primary branches per plant was positively associated with only one trait i.e. secondary branches per plant (0.303) where as secondary branches per plant was positively associated with siliquae per plant (0.501) and seed yield per plant (0.354). The siliquae per plant had positive association with seed yield per plant (0.560). Aphid count had positive association with penetration force (0.412) which is quite contradictory to natural situation where the aphid count should decrease with increase in penetration force as increased penetration force reduces the suction of sap from the twigs. In the overall assessment of the trait association analysis it was found that secondary branches per plant and siliquae per plant had positive association with seed yield per plant. This indicates that selection for these traits could definitely yield higher productivity as they exhibited correlated response with seed yield. The positive association for secondary branches per plant and siliquae per plant with seed yield was observed by Afrin *et al.* (2011), Uddin *et al.* (2013), Helal *et al.* (2014), Islam *et al.* (2015), Rameeh *et al.* (2016) and Roy *et al.* (2018).

It was also observed that plant height, days to 50% flowering and secondary branches per plant had negative association with aphid count and penetration force. Height up to first fruiting branch had negative association with 1000 seed weight (-0.236), aphid count (-0.200), penetration force (-0.280) and seed yield per plant (-0.461). Primary branches per plant was negatively associated with seeds per siliqua (-0.337), penetration force (-0.197) and seed yield per plant (-0.215). Aphid count was negatively associated with seed yield per plant (-0.199). It was observed that seed yield was negatively correlated with height up to first fruiting branch, primary branches per plant and aphid count. Such negative correlation with seed yield were observed by Islam *et al*., (2015) for primary branches per plant. From the correlation study involving the present set of 71 mustard genotypes,

positive correlation (significant) with seed yield was observed only in case of secondary branches per plant and siliquae per plant.

Even though the correlation coefficient are quite helpful in determining the components of complex traits like yield, however, an exact picture of the relative importance of direct and indirect influence of each component trait is not provided by such studies. Path coefficient analysis (Sewall Wright, 1921; Dewey and Lu, 1959) under such circumstances plays an important role in partitioning of the correlation coefficient into direct and indirect effects of a set of independent variable on the dependent variable and determines the component traits on which selection can be based for improvement in yield. In the present investigation the path coefficient analysis was estimated among the eleven traits (Table 5). Correlation of height up to first fruiting branch with seed yield per plant was negative and its direct effect (-0.983) was also negative. But the coefficient of correlation was more than the direct effect. This indicates the high positive indirect effect of height upto first fruiting branch on seed yield via plant height and days to 50% flowering, is nullified by the high negative direct effect of height upto first fruiting branch on seed yield. So this trait can never help to improve seed yield in the given set of 71 mustard genotypes. Primary branches per plant had negative correlation with seed yield per plant although its direct effect (0.086) was positive and low. But direct effect was more than the coefficient of correlation. This indicates that the indirect negative effects through other attribute i.e. height up to first fruiting branch, siliquae per plant, 1000 seed weight, aphid count and penetration force have enhanced the negative relationship of primary branches per plant with seed yield per plant. Association of siliquae per plant with seed yield per plant was positive and its direct effect (0.407) was also high and positive. But the coefficient of correlation was more than the direct effect. This indicates that the indirect positive effects of siliquae per plant is supplemented through plant height, days to 50% flowering, secondary branches per plant, 1000 seed weight and aphid count, of which the via effect through plant height was highest.

The highest positive direct effect on yield was of penetration force followed by days to 50% flowering. High positive direct effect was reported by Uddin *et al.* (2013), Singh *et al.* (2013) and Rameeh *et al.* (2016) and Roy *et al.* (2018) for days to 50% flowering. However, penetration force had no association with seed yield and it was evident from the low coefficient of correlation with seed yield (0.116) which was mainly due to the negative effects of penetration force as seed yield via plant height, days to 50% flowering, primary branches per plant, secondary branches per plant, siliquae per plant, seeds per siliqua, 1000 seed weight and aphid count. This negative effect could be the reason behind the positive correlation of penetration force with aphid count and subsequently not having any association with seed yield. An interesting finding here is that the very high direct effect of penetration force is totally nullified by the negative effects via the other traits. Hence for the present set of genotypes, emphasis for selection cannot be laid on penetration force. Secondary branches per plant had positive correlation with seed yield per plant and its direct (0.111) effect was also positive, although low and was less than the coefficient of correlation. This indicated that the indirect positive effects are more than indirect negative effect and the former have supplemented to the positive association of secondary branches per plant with seed yield per plant. The indirect positive effect of secondary branches per plant on seed yield was observed via plant height, height upto first fruiting branch, primary branches per plant, siliquae per plant, seeds per siliqua and aphid count. The highest direct negative effect was of the height upto first fruiting branch followed by aphid count. Aphid count had negative correlation with seed yield per plant and its direct effect (-0.345) was also negative. But the coefficient of correlation was more than the direct effect. This indicated that the indirect negative effect of aphid count via other attributes i.e. plant height, days to 50% flowering, secondary branches per plant and siliquae per plant have enhanced the negative relationship of aphid count with seed yield per plant

A perusal of the above results revealed that plant height, days to 50% flowering, secondary branches per plant siliquae per plant and penetration force had moderate to high positive effect on seed yield. However, among these five traits, only secondary branches per plant and siliquae per plant were ultimately positively associated with seed yield and were controlled by additive genes, due to their high heritability and genetic advance. Therefore in order to exercise a suitable selection programme it would be worth to concentrate on these traits for improvement in yield of mustard. Indirect contribution of the traits is mainly due to indirect effects of the trait through other component traits. Indirect selection through such traits having high or moderate positive effect on seed yield and would also be rewarding in yield improvement.

An overall ranking of 71 genotypes of mustard was done for eleven traits (Table 6), out of which nine were yield attributing traits and the remaining two were aphid count and penetration force, as per rescaling index method suggested by Iyenger and Sudarshan (1982). From the rescaling index value the ranking was done for 71 genotypes according to their rescaled index value (Roy *et al.* 2017). The genotypes which gave the same index value were given the same rank. It shows that on the basis of all the eleven traits including aphid count, the genotype PRD-2013-9 was the best and had the highest rescaled index value of 6.62 and ranked first followed by the genotypes RH-0923 having rescaled index value of 6.41 (rank-2) which was closely followed by another genotype RGN-389 which had rescaled index value of 6.27 (rank 3). In this way all the 71 genotypes were ranked according to their rescaled index values and the best among them could be selected.

Acknowledgement
The authors are thankful to the Dean-Faculty of Agriculture and Department of Genetics and Plant Breeding for funding the experiment. The infrastructural and farm facility provided by the Directorate of Research is duly acknowledged. The authors would also like to acknowledge the help received from the Hon'ble Vice-Chancellor, U.B.K.V., West Bengal, India in facilitating the availability of some of the Mustard genotypes from Directorate of Rapeseed and Mustard Research (ICAR-DRMR), Bharatpur, Rajasthan and BHU, Varanasi.

References

Afrin, K.S., Mahmud, F., Bhuiya, Md.S.R. and Rahim, Md. A. 2011. Assesment of genetic variability among advance line of *Brassica napus* L. *Agron Glasnikafrin* 4-5.

Allard, R. W. 1960. Principles of plant breeding. *John Willy and Sons, Inc*, New York.

Anonymous (2016). Ministry of Environment, Forest, Climate Change and Directorate of Rapeseed Mustard Research, Bharatpur, GOI : Series of crop specific biology document.

Bibi, T., Rauf, S., Mahmood, T., Haider, Z. and Ud-Din, S. 2016. Genetic variabilty and heritability studies in relation to seed yield and its component traits in mustard (*Brassica juncea* L.). Academic Journal of Agricultural Research. **4**(8):478-482.

Bind, D., Singh, D. and Diwedi, V. K. 2014. Genetic variability and character association in Indian mustard [*Brassica juncea* (L.) Czerns and Coss]. *Agric Sci dig* **34** (3): 183-188.

Burton, G. W. 1952. Quantitative inheritance in grasses Proc. 6th Int Grass Land Cong **1**: 227.

Burton, G.W. and Devane, E.H. 1953. Estimating heritability in tall Fescue (*Festuca arundinacea*) from replicated clonal martial. *Agron J*, **45**: 478-481.

Devi, B. 2018. Correlation and Path analysis in Indian mustard (*Brassica juncea* L.) in agro-climatic condition of Jhasi (U.P). *J. of Pharmacognosy and Phytochem*. **7**(1): 1678-1681.

Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Argon. J.* **51**: 515-518.

Gangapur, R.D., Prakash, B.G. and Hiremath, P.C. 2011. Genetic variability studies of germplasam association in Indian Mustard under protected and unprotected condition at Bijapur, Kranataka. *Int. J. Agric. Sci.* **7** (1): 54-57.

Helal, M.M.U., Islam, M.N., Kadir, M. and Miah, M.N.H. 2014. Genetic variability, correlation and path analysis from a set of mustard (*Brassica* spp.) in Sylhet Region. *Asian. J. Pl. Sci.* **6**: 222-226

Islam, Md. S., Haque, Md.M., Bhuiyan, Md.S.R. and Hossain, Md.S. 2015. Estimation of genotypic and phenotypic coefficient of variation of yield and its contributing characters of *Brassica rapa* L. *Am. Eur. J. Agric. Environ. Sci.* **15** (10): 2029-2034.

Iyenger, N.S. and Sudarshan, P. 1982. A method of classifying regions from multivariate data. *Economic and political weekly*, special article 2048-52.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybean. *Agron. J.* **47**: 314-18

Lodhi, B., Thakral, N.K., Avtar, R. and Singh, A. 2014. Genetic variability, association and path analysis in Indian mustard (*Brassica juncea*). *J. Oilseed Brassica.* **5** (1): 26-31.

Meena, H.S., Kumar, A., Singh, V.V., Meena, P.D., Ram, B. and Kulshretha, S. 2017. Genetic variability and inter relation of seed yield with contributing trait in Indian Mustard (*Brassica juncea*). *J. Oilseed. Brassica.* **8** (2): 131-137.

Mondal, H. A., Roy, S.K., Hijam, L., Chakarborty, M., Datta, P. and Hath, T.K. 2017. Differential aphid colony establishment in Dolichos lablab varieties correlated with some plant specific factors that impact on aphid fecundity. *Am. J. Pl. Sci.* **8**: 754-769

Mondal, S.K. and Khajuria, M.R. 2000. Genetics analysis for yield attributes in mustard. *Environ. and Ecol.* **18** (1): 15.

Rameeh, V. 2016. Heritability and path coefficient analysis for quantitative traits of rapeseed advanced lines. *J. Oilseed Brassica.* **7** (2): 139-147.

Roy, S.K., Charkraborty, M., Hijam ,L., Mondal, R., Kundu, A., Kale, V.A., Ashokappa N V, Sur, B., Maying, B., Rout, S., Das, A. and Mondal, H.A. 2018. Cause and effect relationship in yield and its attributing traits in early segregating generation of mustard crosses under *terai* agro climatic zone of West Bengal, India. *Int. J. Current. Microbial. And. Appl. Sci*.**7** (3): 198-211.

Roy, S.K., Charkraborty, M., Hijam, L., Mondal, R., Kundu, A., Kale, V.A., Ashokappa, N.V., Sur, B. and Dash, S.K. 2017. Variability comparison of mustard crosses in advanced segregating generations. *Int. J. Pure. and Appl. Biosci.* **5** (6): 948-956.

Roy, S.K., Paul, S., Ghimiray, T.S. and Roy, A. 2017. Performance of flax genotypes with respect to infestation of capsule borer, *Helicoverpa armigera* (Hubner) and other yield parameters in the hills of Darjeeling, India. *J. Entom. and zoology studies* **5** (5): 276-280.

Sabaghnia, N., Dehghani, H., Alizadeh, B. and Mohghaddam, M. 2010. Interrelationships between seed yield and 20 related characters of 49 canola (*B. napus* L.) genotypes in non-stressed water-stressed environments. *Spanish. J. Agric. Res*. **8**: 356-370.

Sandhu, R., Rai, S.K., Bharti, R., Kaur, A., Gupta, S.K. and Verma, A. 2017. Studies on genetic diversity among various genotypes of *Brassica napus* L. using morphological markers *International Journal of Current Microbiology and Applied Science.* **6**(7):469-480.

Searle, S.R. 1961. Phenotypic, genotypic and environmental correlations. *Biometrics,* **47**: 474-480.

Sikarwar, R.S., Satankar, N., Kushwah, M.K. and Singh, A.K. 2017. Genetic variability, heritability, genetic advance studies in Yellow sarsoon (*Brassica rapa* var. yellow sarsoon). *Int. J. Agric. Innov. Res.* **5** (5): 2319-1473.

Singh, A., Avtar, R., Singh, D., Sangwan, O. and Balyan, P. 2013. Genetic variability, Character association and path analysis for yield components, traits under two environments in Indian mustard. *J. Oilseed Brassica.* **4** (1):43-48.

Singh, M., Tomar, A., Mishra, C.N. and Srivastava, S.B.L. 2011. Genetic parameters and character association studies in Indian mustard. *J. Oilseed Brassica.* **2** (1): 35-38.

Singh, R. P., Malik, B.P.S. and Singh, D. P. 1990. Variation for morphological characters in genotypes of Indian mustard. *Indian. J. Agric. Sci* .**57** (4): 225-230.

Sivasubramanian, V. and Madhavamenon, P. 1973. Path analysis for yield and yield component of rice. *Madras Agric. J.* **60**: 1217-1221.

Srivastava, K.K., Vimal, S.C., Giri, S.P. and Verma, A. K. 2016. Studies on seed quality parameters in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. *Int. J. Agric. Sci*. **12** (2): 241-244.

Synrem, G.J., Rangare, N. R., Myrthong, I and Bahadure, D.M. 2014. Variability studies intra specific croses in Indian mustard (*Brassica juncea*) genotypes. *IOSR. J. Agric. Veten. Sci.* **111**: 29-32

Tiwari, A.K., Singh, S.K., Tomar, A. and Singh, M. 2017. Heritability,Genetic advance and correlation coefficient analysis in Indian mustard [*Brassica juncea* **(L).**Czern and Coss]. *J. of Pharmacognosy and Phytochem.* **6** (1): 356-359.

Tiwari, V.K. 2019. Morphological parameters in breeding for higher seed yield in Indian mustard [*Brassica juncea* (L.) Czern & Coss]. *Electron. J. Plant Breed*. **10**(1):187-195.

Uddin, M.S. Bhuiyn, M.S.R., Mahmud, F. and Kabir, K. 2013. Study on correlation path coefficient in F_2 progenies of rapeseed (*Brassic rapa*). *Acad. J. Plant. Sci.* **6** (1): 13-18.

Wright, S. 1921. Correlation and causation. *J. Agric. Res.* **20**: 557-558.

Electronic Journal of Plant Breeding, 10 (4): 1482-1494 (Dec 2019) DOI: 10.5958/0975-928X.2019.00191.1
ISSN 0975-928X

Table 1. Sources of mustard genotypes

S.No.	Genotype	Source	S.No.	Genotype	Source
1.	B-85(Seeta)	PORS, Berhampur, West Bengal	37.	NPJ-198	PORS, Berhampur, West Bengal
2.	RW-351(Bhagarathi)	PORS, Berhampur, West Bengal	38.	JMM-927-RC	PORS, Berhampur, West Bengal
3.	RW-85-59(Sarna)	PORS, Berhampur, West Bengal	39.	DRMR-15-47	PORS, Berhampur, West Bengal
4.	RW-4C-6-3(Sanjukta Asech)	PORS, Berhampur, West Bengal	40.	RGN-389	PORS, Berhampur, West Bengal
5.	NPJ-194	PORS, Berhampur, West Bengal	41.	RAURD-214	PORS, Berhampur, West Bengal
6.	TM-276	PORS, Berhampur, West Bengal	42.	DRMR-15-14	PORS, Berhampur, West Bengal
7.	Rohini(SC)	PORS, Berhampur, West Bengal	43.	DRMR-4001	PORS, Berhampur, West Bengal
8.	KMR-15-4	PORS, Berhampur, West Bengal	44.	RGN-384	PORS, Berhampur, West Bengal
9.	PR-2012-9	PORS, Berhampur, West Bengal	45.	NPJ-197	PORS, Berhampur, West Bengal
10.	Divya-88	PORS, Berhampur, West Bengal	46.	RB-81	PORS, Berhampur, West Bengal
11.	RL-JEB-52	PORS, Berhampur, West Bengal	47.	NPJ-200	PORS, Berhampur, West Bengal
12.	Kranti-NC	PORS, Berhampur, West Bengal	48.	DRMR-15-9	PORS, Berhampur, West Bengal
13.	DRMRIJ-15-85	PORS, Berhampur, West Bengal	49.	KMR-L-15-6	PORS, Berhampur, West Bengal
14.	RH-1202	PORS, Berhampur, West Bengal	50.	PRD-2013-9	PORS, Berhampur, West Bengal
15.	NPJ-196	PORS, Berhampur, West Bengal	51.	DRMRIJ-15-66	PORS, Berhampur, West Bengal
16.	RMM-09-10	PORS, Berhampur, West Bengal	52.	RH-1368	PORS, Berhampur, West Bengal
17.	JMM-927-RC	PORS, Berhampur, West Bengal	53.	RH-1325	BHU, Varanasi, Uttar Pradesh
18.	RRN-871	PORS, Berhampur, West Bengal	54.	RGN-386	BHU, Varanasi, Uttar Pradesh
19.	KM-126	PORS, Berhampur, West Bengal	55.	RNWR-09-3	BHU, Varanasi, Uttar Pradesh
20.	SKM-1313	PORS, Berhampur, West Bengal	56.	PRD-2013-2	BHU, Varanasi, Uttar Pradesh
21.	RB-77	PORS, Berhampur, West Bengal	57.	GIRIRAJ	BHU, Varanasi, Uttar Pradesh
22.	DRMR-15-5	PORS, Berhampur, West Bengal	58.	NRCHB-101	BHU, Varanasi, Uttar Pradesh
23.	KMR-53-3	PORS, Berhampur, West Bengal	59.	RGIN-73	BHU, Varanasi, Uttar Pradesh
24.	RL-JEB-84	PORS, Berhampur, West Bengal	60.	DRMR-IJ-31	ICAR-DRMR, Bharatpur, Rajasthan
25.	Ganga	PORS, Berhampur, West Bengal	61.	NRCHB-101	ICAR-DRMR, Bharatpur, Rajasthan
26.	RGN-73-JC	PORS, Berhampur, West Bengal	62.	DRMR-150-35	ICAR-DRMR, Bharatpur, Rajasthan
27.	RH-1209	PORS, Berhampur, West Bengal	63.	RH-406	ICAR-DRMR, Bharatpur, Rajasthan
28.	PR-2012-12	PORS, Berhampur, West Bengal	64.	RH-749	ICAR-DRMR, Bharatpur, Rajasthan
29.	RGN-385	PORS, Berhampur, West Bengal	65.	Pusa mustard-25(NPJ 112)	ICAR-DRMR, Bharatpur, Rajasthan
30.	NPJ-195	PORS, Berhampur, West Bengal	66.	Pusa mustard26(NPJ 113)	ICAR-DRMR, Bharatpur, Rajasthan
31.	Maya-C	PORS, Berhampur, West Bengal	67.	Pusa mustard27(EJ 17)	ICAR-DRMR, Bharatpur, Rajasthan
32.	SKJM-05	PORS, Berhampur, West Bengal	68.	CS 54	ICAR-DRMR, Bharatpur, Rajasthan
33.	SVJ-64	PORS, Berhampur, West Bengal	69.	PHR -2	ICAR-DRMR, Bharatpur, Rajasthan
34.	Sitara-Sreenagar	PORS, Berhampur, West Bengal	70.	RL 1359	ICAR-DRMR, Bharatpur, Rajasthan
35.	RH-0923	PORS, Berhampur, West Bengal	71.	KRANTI	ICAR-DRMR, Bharatpur, Rajasthan
36.	DRMR-15-16	PORS, Berhampur, West Bengal			

PORS - Pulses and Oilseed Research Station; BHU-Banaras Hindu University; DRMR- Directorate of Rapeseed Mustard Research

Table 2. Analysis of variance (ANOVA) for eleven traits in Indian mustard

Sources of variation	d.f.	Plant height (cm)	Height upto first fruiting branch (cm)	Days to 50 % flowering	Primary branches per plant	Secondary branches per plant	Siliquae per plant	Seeds per siliqua	1000 seed weight (g)	Aphid count (% incidence)	Penetration force (kpascal)	Seed yield per plant (g)
Replication	2	2.71	14.36	0.33	0.62	4.77	1091.91	0.31	1.45	7.82	321.78	75.10
Treatment	70	727.92*	999.71*	67.10*	2.37*	12.44*	4181.39*	1.66*	2.90*	42.40*	2069.92*	16.71*
Error	140	2.82	13.64	0.85	0.20	0.75	213.49	0.70	0.015	16.65	428.39	5.72

* significant at 5% level of probability

Table 3. Genetic parameters for eleven traits in Indian mustard

Sl. No.	Traits	Mean	Range		GCV (%)	PCV (%)	Heritability (broad sense) (%)	Genetic advance as percent of mean
			Lowest	Highest				
1	Plant height (cm)	170.25	125.67	212.93	9.13	9.18	98.86	18.70
2	Height upto first fruiting branch (cm)	58.35	21.33	153.00	31.07	31.71	96.02	62.72
3	Days to 50 % flowering	45.55	35.00	57.00	10.32	10.51	96.30	20.86
4	Primary branches per plant	4.04	2.33	7.13	21.07	23.83	78.13	38.36
5	Secondary branches per plant	9.38	3.47	15.20	21.05	22.99	83.84	39.71
6	Siliquae per plant	166.81	72.27	252.40	21.75	23.59	85.05	41.33
7	Seeds per siliqua	12.99	10.60	14.93	4.34	7.78	31.12	4.99
8	1000- seed weight(g)	4.81	2.20	9.07	20.38	20.55	98.46	41.67
9	Aphid count (% incidence)	10.21	4.35	25.47	28.69	49.19	34.01	34.46
10	Penetration force (kpascal)	91.74	46.93	192.70	25.50	34.05	56.09	39.34
11	Seed yield per plant (g)	9.31	3.19	15.50	20.55	32.89	39.03	26.44

Electronic Journal of Plant Breeding, 10 (4): 1482-1494 (Dec 2019) DOI: 10.5958/0975-928X.2019.00191.1
ISSN 0975-928X

Table 4. Association (correlation) between yield and its attributing traits at genotypic level in Indian mustard

Traits	Height upto first fruiting branch (cm)	Days to 50 % flowering	Primary branches per plant	Secondary branches per plant	Siliquae per plant	Seeds per siliqua	1000- seed weight (g)	Aphid count (% incidence)	Penetration force (kpascal)	Seed yield per plant (g)
Plant height (cm)	0.715*	0.625*	0.244*	0.014	0.181	-0.138	-0.162	-0.219*	-0.397*	0.002
Height upto first fruiting branch (cm)		0.571*	0.301*	-0.088	0.008	-0.149	-0.236*	-0.200*	-0.280*	-0.461*
Days to 50 % flowering			0.070	-0.048	0.127	-0.108	0.069	-0.298*	-0.528*	0.085
Primary branches per plant				0.303*	-0.072	-0.337	-0.058	0.153	-0.197*	-0.215*
Secondary branches per plant					0.501*	-0.191	-0.135	-0.217*	-0.244*	0.354*
Siliquae per plant						0.066	0.093	-0.060	-0.112	0.560*
Seeds per siliqua							0.140	-0.006	0.137	0.077
1000- seed weight (g)								0.178	-0.133	0.152
Aphid count (% incidence)									0.412*	-0.199*
Penetration force (kpascal)										0.116

* significant at 5% level of probability

Table 5. Direct (diagonal) and indirect (off-diagonal) effects of different attributing traits on seed yield in Indian mustard

Traits	Plant height (cm)	Height upto first fruiting branch (cm)	Days to 50 % flowering	Primary branches per plant	Secondary branches per plant	Siliquae per plant	Seeds per siliqua	1000- seed weight (g)	Aphid count (% incidence)	Penetration force (kpascal)	Correlation with seed yield per plant (g)
Plant height (cm)	**0.450**	-0.703	0.297	0.021	0.002	0.074	0.002	-0.012	0.076	-0.204	0.002
Height upto first fruiting branch (cm)	0.322	**-0.983**	0.271	0.026	-0.010	0.003	0.002	-0.018	0.069	-0.144	-0.461*
Days to 50 % flowering	0.281	-0.561	**0.475**	0.006	-0.005	0.052	0.002	0.005	0.103	-0.272	0.085
Primary branches per plant	0.109	-0.296	0.033	**0.086**	0.034	-0.029	0.005	-0.004	-0.052	-0.101	-0.215*
Secondary branches per plant	0.006	0.086	-0.022	0.026	**0.111**	0.204	0.003	-0.010	0.075	-0.125	0.354*
Siliquae per plant	0.081	-0.008	0.060	-0.006	0.056	**0.407**	-0.001	0.007	0.021	-0.058	0.560*
Seeds per siliqua	-0.062	0.147	-0.051	-0.029	-0.021	0.027	**-0.016**	0.010	0.002	0.071	0.077
1000- seed weight (g)	-0.073	0.232	0.032	-0.005	-0.015	0.038	-0.002	**0.074**	-0.061	-0.068	0.152
Aphid count (% incidence)	-0.098	0.196	-0.141	0.013	-0.024	-0.024	0.0001	0.013	**-0.345**	0.021	-0.199*
Penetration force (kpascal)	-0.178	0.276	-0.251	-0.017	-0.027	-0.045	-0.002	-0.010	-0.142	**0.514**	0.116

* Significant at 5% level of probability; Residual value (G) = 0.344

Electronic Journal of Plant Breeding, 10 (4): 1482-1494 (Dec 2019) DOI: 10.5958/0975-928X.2019.00191.1
ISSN 0975-928X

Table 6. Mean performance of the mustard genotypes and their ranking on the basis of rescaled index value as suggested by Iyengar and Sudarshan (1982)

Sl. No.	Genotypes	Plant height (cm)		Height upto first fruiting branch (cm)		Days to 50 % flowering		Primary branches per plant		Secondary branches per plant		Siliquae per plant		Seeds per siliqua	
		X	Rescaled Index value (A) = (X-Min)/(Max-Min)	X	Rescaled Index value (B) = (X-Min)/(Max-Min)	X	Rescaled Index value (C) = (X-Min)/(Max-Min)	X	Rescaled Index value (D) = (X-Min)/(Max-Min)	X	Rescaled Index value (E) = (X-Min)/(Max-Min)	X	Rescaled Index value (F) = (X-Min)/(Max-Min)	X	Rescaled Index value (G) = (X-Min)/(Max-Min)
1	B-85(Seeta)	140.87	0.17	24.40	0.02	36.00	0.05	4.47	0.45	11.13	0.65	210.40	0.77	13.00	0.55
2	RW-351(Bhagarathi)	143.60	0.21	32.00	0.08	37.00	0.09	4.13	0.38	9.80	0.54	191.93	0.66	14.40	0.88
3	RW-85-59(Sarna)	136.13	0.12	28.60	0.06	35.00	0.00	4.27	0.40	13.07	0.82	149.60	0.43	13.27	0.62
4	RW-4C-6-3	170.67	0.52	39.73	0.14	38.00	0.14	4.27	0.40	11.67	0.70	186.20	0.63	12.53	0.45
5	NPJ-194	125.67	0.00	35.07	0.10	36.00	0.05	3.60	0.26	11.60	0.69	114.13	0.23	13.27	0.62
6	TM-276	185.27	0.68	56.00	0.26	45.00	0.45	3.93	0.33	9.13	0.48	157.93	0.48	12.73	0.49
7	Rohini(SC)	163.73	0.44	69.47	0.37	46.00	0.50	4.13	0.38	9.93	0.55	151.33	0.44	10.60	0.00
8	KMR-15-4	166.53	0.47	54.33	0.25	46.00	0.50	4.53	0.46	11.27	0.66	252.40	1.00	13.07	0.57
9	PR-2012-9	185.07	0.68	73.87	0.40	51.00	0.73	4.93	0.54	9.80	0.54	122.07	0.28	14.13	0.82
10	Divya-88	181.20	0.64	55.00	0.26	46.00	0.50	4.60	0.47	14.07	0.90	232.33	0.89	12.93	0.54
11	RL-JEB-52	178.53	0.61	80.20	0.45	45.00	0.45	4.27	0.40	9.40	0.51	211.73	0.77	13.53	0.68
12	Kranti-NC	179.60	0.62	71.60	0.38	46.00	0.50	4.67	0.49	10.27	0.58	175.47	0.57	13.27	0.62
13	DRMRIJ-15-85	172.13	0.53	75.60	0.41	47.00	0.55	4.07	0.36	10.80	0.62	168.33	0.53	12.27	0.38
14	RH-1202	179.93	0.62	80.47	0.45	48.00	0.59	4.20	0.39	10.80	0.62	196.87	0.69	12.80	0.51
15	NPJ-196	176.07	0.58	75.47	0.41	47.00	0.55	4.33	0.42	9.60	0.52	225.67	0.85	11.87	0.29
16	RMM-09-10	179.40	0.62	60.67	0.30	47.00	0.55	3.60	0.26	8.20	0.40	175.20	0.57	13.20	0.60
17	JMM-927-RC	162.80	0.43	50.73	0.22	45.00	0.45	3.73	0.29	9.00	0.47	219.33	0.82	14.40	0.88
18	RRN-871	176.27	0.58	57.40	0.27	46.00	0.50	2.73	0.08	9.60	0.52	227.73	0.86	12.93	0.54
19	KM-126	177.87	0.60	59.80	0.29	47.00	0.55	2.40	0.01	9.87	0.55	154.13	0.45	13.13	0.59
20	SKM-1313	177.27	0.59	73.20	0.39	46.00	0.50	2.47	0.03	11.73	0.70	209.47	0.76	13.00	0.55
21	RB-77	161.80	0.41	70.20	0.37	49.00	0.64	2.33	0.00	4.80	0.11	72.27	0.00	12.80	0.51
22	DRMR-15-5	164.00	0.44	55.60	0.26	47.00	0.55	2.87	0.11	10.47	0.60	189.93	0.65	12.47	0.43
23	KMR-53-3	161.40	0.41	49.73	0.22	47.00	0.55	2.93	0.13	11.60	0.69	207.20	0.75	12.60	0.46
24	RL-JEB-84	162.13	0.42	44.13	0.17	43.00	0.36	2.60	0.06	9.13	0.48	206.33	0.74	12.53	0.45
25	Ganga	173.00	0.54	56.80	0.27	50.00	0.68	3.33	0.21	13.00	0.81	192.07	0.67	12.80	0.51
26	RGN-73-JC	165.93	0.46	61.60	0.31	49.00	0.64	3.47	0.24	9.53	0.52	189.13	0.65	12.80	0.51
27	RH-1209	179.00	0.61	64.73	0.33	47.00	0.55	3.53	0.25	9.53	0.52	198.07	0.70	13.40	0.65
28	PR-2012-12	177.40	0.59	65.40	0.33	50.00	0.68	3.53	0.25	7.73	0.36	159.33	0.48	12.67	0.48
29	RGN-385	172.33	0.53	62.80	0.31	46.00	0.50	3.27	0.20	8.80	0.45	165.07	0.52	12.67	0.48
30	NPJ-195	167.13	0.48	52.73	0.24	43.00	0.36	3.73	0.29	8.40	0.42	201.27	0.72	12.73	0.49
31	Maya-C	147.53	0.25	56.07	0.26	42.00	0.32	4.47	0.45	9.13	0.48	136.40	0.36	13.20	0.60
32	SKJM-05	141.80	0.18	47.93	0.20	43.00	0.36	4.53	0.46	9.53	0.52	174.67	0.57	13.00	0.55
33	SVJ-64	174.87	0.56	60.80	0.30	47.00	0.55	3.67	0.28	8.00	0.39	142.53	0.39	13.73	0.72
34	Sitara-Sreenagar	179.40	0.62	67.20	0.35	50.00	0.68	5.00	0.56	9.73	0.53	221.67	0.83	12.40	0.42
35	RH-0923	171.93	0.53	65.47	0.34	47.00	0.55	5.00	0.56	11.80	0.71	201.67	0.72	14.93	1.00

Electronic Journal of Plant Breeding, 10 (4): 1482-1494 (Dec 2019) DOI: 10.5958/0975-928X.2019.00191.1
ISSN 0975-928X

Table 6. Continued (Genotypes 1 to 35)

Sl. No.	Genotypes	1000 seed weight (g)		Aphid count (% incidence)		Penetration force (kpascal)		Seed yield per plant (g)		Total of the rescaled values (L)	Ranking on the basis of the total rescaled value*
		X	Rescaled Index value (**H**) = (X-Min)/(Max-Min)	X	Rescaled Index value (**I**) = (Max-X)/(Max-Min)	X	Rescaled Index value (**J**) = (X-Min)/(Max-Min)	X	Rescaled Index value (**K**) = (X-Min)/(Max-Min)	**L**=(A+B+C+D+E+F+G+H+I+J+K)	
1	B-85(Seeta)	3.27	0.16	10.91	0.69	152.57	0.72	13.51	0.84	5.07	**37**
2	RW-351(Bhagarathi)	3.70	0.22	15.93	0.45	115.25	0.47	11.30	0.66	4.63	**53**
3	RW-85-59(Sarna)	3.87	0.24	11.98	0.64	110.83	0.44	6.79	0.29	4.05	**66**
4	RW-4C-6-3	3.47	0.18	9.51	0.76	82.80	0.25	11.57	0.68	4.84	**48**
5	NPJ-194	4.77	0.37	12.01	0.64	141.45	0.65	10.20	0.57	4.18	**65**
6	TM-276	4.27	0.30	15.96	0.45	192.70	1.00	11.35	0.66	5.60	**19**
7	Rohini(SC)	4.97	0.40	15.39	0.48	93.15	0.32	8.45	0.43	4.29	**62**
8	KMR-15-4	4.67	0.36	8.44	0.81	103.20	0.39	10.71	0.61	6.07	**6**
9	PR-2012-9	4.07	0.27	9.36	0.76	88.95	0.29	9.94	0.55	5.85	**11**
10	Divya-88	4.27	0.30	9.71	0.75	82.80	0.25	8.58	0.44	5.93	**9**
11	RL-JEB-52	5.00	0.41	11.60	0.66	84.67	0.26	7.82	0.38	5.57	**21**
12	Kranti-NC	5.03	0.41	8.57	0.80	84.30	0.26	10.33	0.58	5.80	**13**
13	DRMRIJ-15-85	5.03	0.41	9.17	0.77	107.43	0.42	9.39	0.50	5.50	**25**
14	RH-1202	4.57	0.34	9.25	0.77	93.47	0.32	9.85	0.54	5.85	**12**
15	NPJ-196	4.57	0.34	10.51	0.71	78.62	0.22	9.41	0.51	5.39	**27**
16	RMM-09-10	5.47	0.48	8.91	0.78	87.17	0.28	9.80	0.54	5.37	**30**
17	JMM-927-RC	5.47	0.48	10.47	0.71	90.38	0.30	9.50	0.51	5.56	**23**
18	RRN-871	4.70	0.36	8.64	0.80	77.95	0.21	14.14	0.89	5.63	**16**
19	KM-126	4.67	0.36	5.50	0.95	77.68	0.21	9.58	0.52	5.07	**38**
20	SKM-1313	4.40	0.32	7.66	0.84	90.53	0.30	10.97	0.63	5.63	**15**
21	RB-77	4.07	0.27	7.13	0.87	69.52	0.15	5.81	0.21	3.55	**71**
22	DRMR-15-5	5.07	0.42	8.65	0.80	77.57	0.21	6.47	0.27	4.73	**51**
23	KMR-53-3	4.97	0.40	8.48	0.80	93.28	0.32	11.26	0.66	5.38	**29**
24	RL-JEB-84	4.67	0.36	7.47	0.85	116.50	0.48	10.41	0.59	4.96	**42**
25	Ganga	4.67	0.36	7.68	0.84	80.90	0.23	8.98	0.47	5.59	**20**
26	RGN-73-JC	4.63	0.35	6.37	0.90	82.82	0.25	9.36	0.50	5.32	**31**
27	RH-1209	4.97	0.40	25.47	0.00	95.15	0.33	8.76	0.45	4.78	**49**
28	PR-2012-12	4.17	0.29	7.13	0.87	90.43	0.30	6.66	0.28	4.92	**45**
29	RGN-385	4.67	0.36	5.47	0.95	101.20	0.37	7.77	0.37	5.04	**39**
30	NPJ-195	4.37	0.32	11.51	0.66	80.28	0.23	7.28	0.33	4.54	**54**
31	Maya-C	4.67	0.36	10.50	0.71	97.87	0.35	7.40	0.34	4.48	**56**
32	SKJM-05	9.07	1.00	5.26	0.96	78.10	0.21	9.31	0.50	5.52	**24**
33	SVJ-64	4.00	0.26	9.99	0.73	89.90	0.29	6.59	0.28	4.75	**50**
34	Sitara-Sreenagar	4.57	0.34	8.85	0.79	72.28	0.17	11.10	0.64	5.93	**8**
35	RH-0923	5.13	0.43	8.92	0.78	69.75	0.16	11.13	0.65	6.41	**2**

X=Mean performance of the trait; *Ranking has been done in descending order taking the highest rescaled value as 1 (first rank) followed by other lower rescaled values from rank 2 onwards. The formulas for the index value (rescaled value) are the same for all the traits except in case of "Aphid Count" where this trait was negatively associated with yield

Electronic Journal of Plant Breeding, 10 (4): 1482-1494 (Dec 2019) DOI: 10.5958/0975-928X.2019.00191.1
ISSN 0975-928X

Table 6. Continued (Genotypes 36 to 71)

Sl. No.	Genotypes	Plant height (cm)		Height upto first fruiting branch (cm)		Days to 50 % flowering		Primary branches per plant		Secondary branches per plant		Siliquae per plant		Seeds per siliqua	
		X	Rescaled Index value (**A**) = (X-Min)/(Max-Min)	X	Rescaled Index value (**B**) = (X-Min)/(Max-Min)	X	Rescaled Index value (**C**) = (X-Min)/(Max-Min)	X	Rescaled Index value (**D**) = (X-Min)/(Max-Min)	X	Rescaled Index value (**E**) = (X-Min)/(Max-Min)	X	Rescaled Index value (**F**) = (X-Min)/(Max-Min)	X	Rescaled Index value (**G**) = (X-Min)/(Max-Min)
36	DRMR-15-16	147.67	0.25	42.13	0.16	42.00	0.32	3.53	0.25	10.80	0.62	191.73	0.66	13.20	0.60
37	NPJ-198	175.40	0.57	52.73	0.24	46.00	0.50	3.40	0.22	8.80	0.45	164.73	0.51	14.13	0.82
38	JMM-927-RC	183.60	0.66	58.80	0.28	48.00	0.59	4.00	0.35	8.20	0.40	162.20	0.50	13.40	0.65
39	DRMR-15-47	176.13	0.58	55.20	0.26	47.00	0.55	3.53	0.25	8.47	0.43	185.33	0.63	14.07	0.80
40	RGN-389	193.73	0.78	59.13	0.29	51.00	0.73	3.93	0.33	10.73	0.62	176.87	0.58	13.73	0.72
41	RAURD-214	187.47	0.71	61.67	0.31	52.00	0.77	3.53	0.25	8.27	0.41	187.33	0.64	13.53	0.68
42	DRMR-15-14	202.20	0.88	88.67	0.51	48.00	0.59	3.53	0.25	7.40	0.34	174.73	0.57	13.07	0.57
43	DRMR-4001	167.73	0.48	73.47	0.40	41.00	0.27	4.93	0.54	10.53	0.60	140.47	0.38	12.53	0.45
44	RGN-384	179.40	0.62	61.07	0.30	47.00	0.55	4.87	0.53	10.07	0.56	159.87	0.49	12.13	0.35
45	NPJ-197	179.00	0.61	67.13	0.35	47.00	0.55	4.67	0.49	10.00	0.56	142.47	0.39	12.20	0.37
46	RB-81	166.80	0.47	55.20	0.26	46.00	0.50	4.47	0.45	8.73	0.45	113.47	0.23	12.13	0.35
47	NPJ-200	141.47	0.18	21.33	0.00	39.00	0.18	4.67	0.49	10.93	0.64	88.27	0.09	11.80	0.28
48	DRMR-15-9	164.20	0.44	42.67	0.16	40.00	0.23	4.53	0.46	11.40	0.68	128.13	0.31	13.33	0.63
49	KMR-L-15-6	168.73	0.49	45.00	0.18	42.00	0.32	4.27	0.40	10.87	0.63	196.60	0.69	12.13	0.35
50	PRD-2013-9	184.13	0.67	66.47	0.34	53.00	0.82	5.60	0.68	15.20	1.00	201.80	0.72	13.00	0.55
51	DRMRIJ-15-66	183.93	0.67	57.73	0.28	52.00	0.77	4.13	0.38	7.67	0.36	168.33	0.53	12.47	0.43
52	RH-1368	178.53	0.61	49.00	0.21	43.00	0.36	4.20	0.39	9.80	0.54	118.73	0.26	12.73	0.49
53	RH-1325	181.37	0.64	56.93	0.27	50.00	0.68	4.60	0.47	8.87	0.46	128.40	0.31	12.60	0.46
54	RGN-386	191.80	0.76	58.73	0.28	53.00	0.82	4.07	0.36	10.73	0.62	179.40	0.59	12.73	0.49
55	RNWR-09-3	178.07	0.60	48.20	0.20	51.00	0.73	3.80	0.31	10.67	0.61	223.73	0.84	12.87	0.52
56	PRD-2013-2	161.73	0.41	37.67	0.12	48.00	0.59	4.13	0.38	7.60	0.35	166.87	0.53	12.67	0.48
57	RH-749	139.27	0.16	46.27	0.19	44.00	0.41	3.07	0.15	6.53	0.26	163.07	0.50	13.47	0.66
58	GIRIRAJ	166.40	0.47	50.40	0.22	43.00	0.36	2.67	0.07	5.27	0.15	126.93	0.30	13.87	0.75
59	RH-406	169.80	0.51	47.33	0.20	42.00	0.32	3.07	0.15	7.40	0.34	164.67	0.51	13.40	0.65
60	NRCHB-101	175.47	0.57	54.33	0.25	42.00	0.32	7.13	1.00	9.27	0.49	153.27	0.45	12.80	0.51
61	RGIN-73	176.07	0.58	51.60	0.23	42.00	0.32	5.53	0.67	7.47	0.34	152.07	0.44	11.20	0.14
62	DRMR-IJ-31	179.53	0.62	57.33	0.27	41.00	0.27	4.53	0.46	7.53	0.35	125.53	0.30	12.13	0.35
63	NRCHB-101	160.80	0.40	51.87	0.23	47.00	0.55	3.53	0.25	5.87	0.20	134.07	0.34	13.47	0.66
64	DRMR-150-35	152.27	0.30	44.40	0.18	54.00	0.86	3.67	0.28	6.53	0.26	99.87	0.15	13.27	0.62
65	Pusa mustard-25(NPJ 112)	162.47	0.42	47.33	0.20	38.00	0.14	3.87	0.32	7.33	0.33	123.93	0.29	13.53	0.68
66	Pusa mustard26(NPJ 113)	164.60	0.45	56.20	0.26	37.00	0.09	3.80	0.31	6.93	0.30	127.73	0.31	12.80	0.51
67	Pusa mustard27(EJ 17)	186.20	0.69	87.27	0.50	38.00	0.14	4.40	0.43	9.20	0.49	153.60	0.45	14.20	0.83
68	CS 54	154.47	0.33	49.00	0.21	47.00	0.55	4.13	0.38	7.73	0.36	146.07	0.41	13.53	0.68
69	PHR 2	212.93	1.00	153.00	1.00	57.00	1.00	6.20	0.81	8.13	0.40	132.47	0.33	11.87	0.29
70	RL 1359	182.60	0.65	100.20	0.60	54.00	0.86	6.13	0.79	9.40	0.51	136.93	0.36	13.20	0.60
71	Kranti	153.73	0.32	52.67	0.24	42.00	0.32	2.93	0.13	3.47	0.00	113.80	0.23	14.20	0.83

Electronic Journal of Plant Breeding, 10 (4): 1482-1494 (Dec 2019) DOI: 10.5958/0975-928X.2019.00191.1
ISSN 0975-928X

Table 6. Continued (Genotypes 36 to 71)

Sl. No.	Genotypes	1000 seed weight (g)		Aphid count (% incidence)		Penetration force (kpascal)		Seed yield per plant (g)		Total of the rescaled values (L)	Ranking on the basis of the total rescaled value*
		X	Rescaled Index value (**H**) = (X-Min)/(Max-Min)	X	Rescaled Index value (**I**) = (Max-X)/(Max-Min)	X	Rescaled Index value (**J**) = (X-Min)/(Max-Min)	X	Rescaled Index value (**K**) = (X-Min)/(Max-Min)	**L**=(A+B+C+D+E+F+G+H +I+J+K)	
36	DRMR-15-16	4.47	0.33	8.09	0.82	117.52	0.48	13.18	0.81	5.32	**31**
37	NPJ-198	5.57	0.49	8.80	0.79	85.45	0.26	11.97	0.71	5.57	**22**
38	JMM-927-RC	4.97	0.40	7.39	0.86	61.97	0.10	10.42	0.59	5.39	**27**
39	DRMR-15-47	5.07	0.42	6.93	0.88	121.43	0.51	12.27	0.74	6.03	**7**
40	RGN-389	5.17	0.43	7.78	0.84	61.22	0.10	13.70	0.85	6.27	**3**
41	RAURD-214	4.93	0.40	7.05	0.87	80.85	0.23	15.50	1.00	6.27	**4**
42	DRMR-15-14	4.50	0.33	4.35	1.00	97.78	0.35	8.01	0.39	5.78	**14**
43	DRMR-4001	4.27	0.30	4.43	1.00	93.25	0.32	7.00	0.31	5.04	**40**
44	RGN-384	4.93	0.40	7.90	0.83	87.43	0.28	10.17	0.57	5.47	**26**
45	NPJ-197	3.77	0.23	6.78	0.89	71.02	0.17	9.95	0.55	5.14	**36**
46	RB-81	4.67	0.36	6.41	0.90	46.93	0.00	8.75	0.45	4.42	**59**
47	NPJ-200	4.27	0.30	7.87	0.83	82.30	0.24	9.05	0.48	3.71	**70**
48	DRMR-15-9	4.53	0.34	9.58	0.75	72.38	0.17	6.21	0.25	4.42	**60**
49	KMR-L-15-6	5.37	0.46	12.00	0.64	55.28	0.06	11.49	0.67	4.90	**46**
50	PRD-2013-9	4.47	0.33	6.59	0.89	52.60	0.04	10.29	0.58	6.62	**1**
51	DRMRIJ-15-66	4.07	0.27	9.14	0.77	82.93	0.25	8.87	0.46	5.17	**34**
52	RH-1368	3.97	0.26	10.38	0.71	51.67	0.03	10.13	0.56	4.43	**58**
53	RH-1325	5.07	0.42	10.72	0.70	54.77	0.05	8.53	0.43	4.90	**46**
54	RGN-386	4.77	0.37	10.10	0.73	51.67	0.03	9.89	0.54	5.61	**17**
55	RNWR-09-3	8.83	0.97	16.62	0.42	51.67	0.03	10.94	0.63	5.86	**10**
56	PRD-2013-2	4.07	0.27	9.79	0.74	105.13	0.40	11.47	0.67	4.94	**43**
57	RH-749	5.30	0.45	19.34	0.29	96.62	0.34	7.00	0.31	3.73	**68**
58	GIRIRAJ	5.50	0.48	10.43	0.71	96.22	0.34	8.01	0.39	4.26	**64**
59	RH-406	5.10	0.42	9.29	0.77	139.52	0.64	11.30	0.66	5.15	**35**
60	NRCHB-101	6.20	0.58	15.74	0.46	95.68	0.33	7.29	0.33	5.30	**33**
61	RGIN-73	5.80	0.52	18.14	0.35	101.38	0.37	9.92	0.55	4.51	**55**
62	DRMR-IJ-31	5.10	0.42	15.90	0.45	136.98	0.62	10.85	0.62	4.73	**51**
63	NRCHB-101	5.30	0.45	13.77	0.55	98.03	0.35	9.17	0.49	4.48	**56**
64	DRMR-150-35	5.70	0.51	12.49	0.61	121.27	0.51	11.14	0.65	4.93	**44**
65	Pusa mustard-25(NPJ 112)	6.20	0.58	12.05	0.64	116.57	0.48	5.86	0.22	4.28	**63**
66	Pusa mustard26(NPJ 113)	3.90	0.25	17.30	0.39	147.98	0.69	5.23	0.17	3.71	**69**
67	Pusa mustard27(EJ 17)	3.50	0.19	9.31	0.76	100.35	0.37	5.01	0.15	5.00	**41**
68	CS 54	5.32	0.45	14.31	0.53	72.33	0.17	6.38	0.26	4.33	**61**
69	PHR 2	2.20	0.00	11.13	0.68	60.85	0.10	3.19	0.00	5.61	**18**
70	RL 1359	5.30	0.45	8.77	0.79	98.23	0.35	5.69	0.20	6.17	**5**
71	Kranti	5.60	0.49	10.03	0.73	115.05	0.47	5.94	0.22	3.98	**67**

X=Mean performance of the trait; *Ranking has been done in descending order taking the highest rescaled value as 1 (first rank) followed by other lower rescaled values from rank 2 onwards. The formulas for the index value (rescaled value) are the same for all the traits except in case of "Aphid Count" where this trait was negatively associated with yield

https://ejplantbreeding.org