International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(10): 815-817
www.biochemjournal.com
Received: 07-07-2024
Accepted: 12-08-2024

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Genetic architecture of oil content and seed yield in biparental progenies of Indian mustard [*Brassica juncea* (L.) Czern and Coss]

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DOI: https://doi.org/10.33545/26174693.2024.v8.i10k.2613

Abstract
The genetic architecture of oil content and seed yield per plant was studied in two sets of each biparental progenies (BIPs) of RH-725 x Urvashi (cross I), DRMRIJ-31 (Giriraj) x Urvashi (cross II) and PM - 27 x Urvashi (cross III) in Indian mustard [*Brassica juncea* (L.) Czern and Coss] developed through NCD II. The study was conducted at Agricultural Research Station (ARS), Ummedganj-Kota and College of Agriculture, Ummedganj-Kota during *Rabi*, 2022-23 and 2023-24. The result reported that the variance due to male x female interaction was found to be prevalent in both oil content and seed yield per plant in the BIPs of all the three crosses. The dominance variance was solely responsible for variance in oil content in the BIPs of cross I and seed yield per plant in the BIPs of cross III, in the rest both additive variance and dominance variance played a significant role; however, the dominance part was found to be more impactful. Additionally, average degree of dominance and dominance ratio exposed the non-additive gene effect in the expression of oil content in seed yield per plant in all the three BIPs. Hence, the selection for these traits would not be effective selection therefore the selection should be practiced at advanced segregating generations.

Keywords: Genetic variance, average degree of dominance, biparental progenies, Indian mustard [*Brassica juncea* (L.) Czern and Coss]

Introduction
Brassica spp. plays an important role in the Indian economy by providing edible oils, vegetables, condiments and animal feed. Indian mustard [*Brassica juncea* (L.) Czern and Coss] commonly known as rai, raya or laha, belongs to family *Cruciferae* (*Brassicaceae*). It covers a large area among the *Brassica* group of oilseed crops and contributes more than 85% to the total rapeseed-mustard production in the country.

Despite great success, the need and opportunities for further improvement in oil content and the creation of new mustard varieties are still a major task due to constantly changing growing conditions and the lack of suitable varieties for these conditions. Therefore, to mitigate the oil constraints of Indian mustard so as to meet the increasing demand for vegetable oil, the F_2 generation of Indian mustard were subjected to biparental mating.

The biparental approach enlarges the spectrum of variation for diverse traits by releasing the latent variability. Further, it provides the most precise estimates of additive and dominance components of genetic variance besides those of heritability and mean degree of dominance. Therefore, it facilitates suitable breeding methodologies for rapid population improvement.

Henceforth, the six sets of biparental progenies were discussed for changes in oil content and seed yield per plant with respect to three different F_2 generations of Indian mustard [*Brassica juncea* (L.) Czern and Coss] in this paper.

Materials and Methods
The experiment was carried out in the College of Agriculture, Ummedganj-Kota and ARS, Ummedganj-Kota (Agriculture University, Kota) during *Rabi* 2022-23 and 2023-24. The two sets of biparental progenies (BIPs) in each F_2 generations of RH-725 x Urvashi (cross I), DRMRIJ-31 (Giriraj) x Urvashi (cross II) and PM - 27 x Urvashi (cross III) were obtained through North Carolina Design II (NCD II). The oil content in the BIPs were estimated through NIR at GBPUA&T, Pantnagar whereas seed yield per plant was measured at

research field of ARS, Ummedganj-Kota. All the recommended package and practices for raising the crop was followed during the investigation. The statistical analysis was carried out as per the NCD II model of biparental progenies for the evaluation of variance due to males, variance due to females, variance due to males x females interaction, additive variance, dominance variance, dominance ratio and average degree of dominance. Since in the present study, number of males and number of females in each sets were equal, therefore the variance due to males and variance due to females were also equal.

Results and Discussion

Understanding the estimates of variance components in biparental progenies is pivotal for unravelling the genetic architecture underlying traits. By dissecting genetic variance into categories such as variance due to males, females, and their interaction, researchers gain crucial insights into how traits are inherited. These insights are invaluable for selective breeding programs aimed at enhancing desirable traits in Indian mustard. Moreover, knowledge of additive and dominance variance helps in predicting the response to selection accurately, guiding breeders towards more effective strategies. Moreover, variance components also shed light on gene interactions, particularly those influenced by the sex of the parent, offering a deeper understanding of inheritance patterns. The estimates of variance components and average degree of dominance in biparental progenies for all three crosses are depicted in table 1.

The estimates of variances due to males x females interaction were greater than variance due to males or females for both oil content and seed yield in all the three crosses. This underscores the importance of considering both parents in breeding strategies for these traits.

Additionally, both additive variance and dominance variance was significant for both the characters in all the three crosses. However, it was also observed that the oil content reported negative additive variance in cross I. Similarly, seed yield per plant showed negative variance for additive variance in cross III. Robinson *et al.* (1952) [3] pointed out that the true values of negative estimates were either near to zero or small positive value, and that the negative result from sampling error. Similar findings were also reported by Zeina, 2002 [7] in cotton and Manickavelu *et al.*, 2006 [5] in rice.

Notably, the negative additive variance recorded for oil content (among BIPs of RH 725 x Urvashi) presents a conundrum, potentially implying that the selection of parents with high oil content may not lead straightforwardly to progeny with enhanced oil content traits. Similar conclusion can be drawn from seed yield per plant for BIPs of PM 27 x Urvashi. This negative aspect demands further studies to elucidate the mechanisms behind the negative additive variance for these traits.

Moreover, the magnitude of additive variance was less than dominant variance for seed yield per plant (4.46 ** $\hat{\sigma}_A^2$, 5.34 ** $\hat{\sigma}_D^2$) in cross I; oil content (0.34 ** $\hat{\sigma}_A^2$, 7.15 ** $\hat{\sigma}_D^2$) and seed yield per plant (4.46 ** $\hat{\sigma}_A^2$, 5.34 ** $\hat{\sigma}_D^2$) in cross II; and oil content (1.23 ** $\hat{\sigma}_A^2$, 7.83 ** $\hat{\sigma}_D^2$) in cross III. The dominance variance was predominant and thereby they were governed by non-additive genetic factor. The results are in accordance with Abdel-Moneam *et al.* (2015) [1], Zeina (2002) [7], Manickavelu *et al.* (2006) [5], Mahalingam *et al.* (2011) [4] and Patil *et al.* (2018) [6]. Normally dominance variance is associated with heterozygosity and also it is not fixable, therefore, selection for these traits is not effective (Manickavelu *et al.*, 2006) [5].

Meena *et al.* (2017) [8] also attempted biparental mating in Indian mustard according to NCD II and observed a higher magnitude of additive genetic variance in Poorbijaya x NRCDR-2 and Poorbijaya x DRMRIJ 31 crosses, whereas in Poorbijaya x Varuna cross, a higher magnitude of dominance variance was observed for five characters. This finding supports the different outcomes for additive and dominance variances among the three crosses under study.

The dominance ratios provided further insights into the genetic architecture. The dominance ratio reported that the seed yield per plant (1.20) in cross I; oil content (20.85) and seed yield per plant (19.19) in cross II; and oil content (6.38) in cross III were having recessive alleles as the magnitude exceeds the value 1.0 (one). The dominance ratio for oil content was found to be negative. Therefore, it was not shown in the table. The results of average degree of dominance reported that the presence of over dominance was reported in seed yield per plant (1.36) in cross I; oil content (2.59) and seed yield per plant (2.57) in cross II; and oil content (2.22) in cross III. Since, additive variance was found negative oil content in cross I and seed yield per plant in cross III, the dominance ratio as well as degree of dominance was not estimated.

The presence of over-dominance in these characters was confirmed from the estimates of degree of dominance which were greater than one. This indicates that non-additive gene effects predominantly influenced the inheritance of the above characters in all the three crosses. Similar to these results the presence of overdominance and predominant influence of dominant gene effects for yield in pearl millet. The non-additive gene effects contributing to the expression of characters is a function of an interaction of alleles which influences the characters. In BIPs, this provides a better scope for the reshuffling of alleles concerned, which would certainly help in the better exploitation of non-additive gene effects and hence results in the increase in mean performance. It is also attributed to the creation of more genetic variability by breakage of undesirable linkage which otherwise conceal the genetic variations in the F_2 generations as reported by Koli *et al.*, 2012 [9]. The results of the present study are in agreement with earlier reports on safflower (Naik *et al.*, 2009) [10], chickpea (Kampli *et al.*, 2002) [11] and rice (Singh, 2015) [12].

Table 1: Estimates of variance, dominance ratio and average degree of dominance for oil content and seed yield per plant in biparental progenies of RH-725 x Urvashi (cross I), DRMRIJ-31 (Giriraj) x Urvashi (cross II) and PM - 27 x Urvashi (cross III) in Indian mustard [*Brassica juncea* (L.) Czern and Coss].

Characters	$\hat{\sigma}^2_m = \hat{\sigma}^2_f$	$\hat{\sigma}^2_{mf}$	$\hat{\sigma}^2_A$	$\hat{\sigma}^2_D$	DR	$\bar{a}$
RH-725 x Urvashi (cross I)						
Oil content (%)	-0.18	2.00	-0.73 **	8.02 **	#	#
Seed yield per plant (g)	1.12	1.33	4.46 **	5.34 **	1.20	1.36
DRMRIJ-31 (Giriraj) x Urvashi (cross II)						
Oil content (%)	0.09	1.79	0.34 **	7.15 **	20.85	2.59
Seed yield per plant (g)	0.19	3.69	0.77 **	14.77 **	19.19	2.57
PM - 27 x Urvashi (cross III)						
Oil content (%)	0.31	1.96	1.23 **	7.83 **	6.38	2.22
Seed yield per plant (g)	-0.14	2.37	-0.57 **	9.48 **	#	#

*, ** significance at 5% and 1% level; # Not estimated due to the negative values of either additive or dominance variance.
Where, $\hat{\sigma}^2_m$ = variance due to males; $\hat{\sigma}^2_f$ = variance due to females; $\hat{\sigma}^2_{mf}$ = variance due to males x females interaction; $\hat{\sigma}^2_A$ = additive variance; $\hat{\sigma}^2_D$ = dominance variance; DR = dominance ratio; $\bar{a}$ = average degree of dominance.

Conclusion

The variance due to male x female interaction was found to be prevalent in both oil content and seed yield per plant in the BIPs of all the three crosses. The dominance variance was solely responsible for variance in oil content in the BIPs of cross I and seed yield per plant in the BIPs of cross III, in the rest both additive variance and dominance variance played a significant role; however, the dominance part was found to be more impactful. Additionally, average degree of dominance and dominance ratio exposed the non-additive gene effect in the expression of oil content in seed yield per plant in all the three biparental progenies. Hence, the selection for these traits would not be effective selection therefore the selection should be practiced at advanced segregating generations.

Acknowledgement

The authors expresses the special note of thanks to Dr. (Mrs.) Usha Pant, Mustard Breeder and Programme Coordinator, AICRP-Rapeseed-mustard, GBPUA&T, Pantnagar for providing necessary help in oil estimation through NIR (Near-infrared spectroscopy).

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