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Short Communication

Inheritance of siliquae bearing pattern in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]

J. Nanjundan*, Karnal Singh, Arun Kumar and K. H. Singh

Directorate of Rapeseed Mustard Research, Sewar, Bharatpur 321 303, Rajasthan

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Abstract

Inheritance of siliquae bearing pattern was studied in Indian mustard using F_1, back cross (BC_1, BC_2) and F_2 generations derived from a cross NIF-V (clustered siliquae type) and NRCHB 101 (dispersed siliquae type). Individual plants from segregating generations were grouped into two phenotypic classes viz. dispersed and clustered siliquae bearing pattern. The dispersed pattern was dominant over clustered siliquae bearing pattern. The estimated ratio of F_2 plants fitted to an assumed phenotypic ratio of 15 dispersed: 1 clustered. A two gene model, each with two alleles and having duplicate gene action, is proposed to explain the inheritance of siliquae bearing pattern in Indian mustard. The information generated in this study will help in developing breeding strategy for utilizing this trait to redesign the mustard ideotype for high siliqua density.

Key words: Clustered siliquae, dispersed siliquae, duplicate gene action, siliquae density

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is an important oilseed crop of rapeseed-mustard group in India. Siliquae per plant and seed weight are the major yield determining factors in this crop [1-4]. The number of siliquae per plant in turn is determined by the number of siliquae bearing racemes and density of siliquae bearing. Siliquae bearing density, which is measured as the number of siliquae per unit length, is important in increasing the number of siliquae per plant. Further, short height of plant is preferred by the farmers due to ease in cultural practices. However, reducing plant height often results in yield reduction due to positive relationship between these two traits [5]. Hence, increasing the siliquae bearing density may overcome this association and it is likely to develop short stature varieties with high seed yield. Siliquae bearing density has been included as a trait for the distinctiveness, uniformity and stability (DUS) test of rapeseed-mustard varieties [6]. In available germplasm of Indian mustard, siliquae bearing density has been reported to be less than 1.0 with a range of 0.40-0.94 [7-8]. This poses a challenge while breeding to increase this important yield determinant trait. As silver lining to this, an interesting and distinct Indian mustard (*Brassica juncea*) accession, named as NIF-V (sourced from National Innovation Foundation, Ahmadabad), was identified and characterized for two distinct features (i) very short main raceme length (averaged 28.1 cm) and (ii) high siliquae bearing density (averaged 1.41 in contrast to < 1.0 in Indian mustard varieties). High siliqua density in this genotype gives a cluster shape to the siliquae bearing region of main and other racemes (Fig.1) in contrast to common dispersed type of siliquae bearing pattern. Considering the importance of this trait in increasing the siliquae bearing density, the present investigation was planned to work out the genetics of siliquae bearing pattern in Indian mustard.

Two distinct siliquae bearing patterns named as clustered and dispersed were characterized with high and low siliquae density, respectively. Two genotypes having distinct siliqua density namely, NIF V (clustered siliquae bearing pattern) and NRCHB 101 (dispersed

*Corresponding author's e-mail: agrinanju@gmail.com
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siliquae bearing pattern) were crossed during *rabi* 2010-2011 to produce F_1 seed at Directorate of Rapeseed Mustard Research, Bharatpur. In the next *rabi* season (2011-12), the F_1 generation was raised to attempt back crosses [BC_1 (F_1 x NRCHB 101), and BC_2 (F_1 x NIF-V)] and F_2 seeds. During the third cropping season (2012-13), the F_1, F_2, BC_1 and BC_2 generations were grown along with both parents. Observations on length of main raceme (cm) and number of siliquae on main raceme were recorded on 20 plants each from P_1, P_2 and F_1 and 240 F_2, 80 BC_1 and 68 BC_2 plants, at maturity stage. The siliquae density was estimated as the ratio of number of siliquae on main raceme to the length of main raceme. Based on the estimated siliquae density, plants from P_1, P_2, F_1, F_2, BC_1 and BC_2 generations were grouped into two distinct classes *viz*., dispersed and clustered siliquae bearing pattern.

All the plants in F_1 generation showed dispersed type of siliquae bearing indicating dominance of dispersed over clustered siliquae bearing pattern. Segregation was observed in F_2 for two phenotypic classes mentioned earlier. In F_2, a total of 240 plants were observed comprising 226 dispersed and 14 clustered (Table 1). The observed and expected frequency of plants under each group were subjected to Chi-square test to test the goodness of fit for the segregation ratio. The observed frequency of plants fit well to an expected phenotypic ratio of 15 dispersed with χ^2 value 0.071 (P value): 1 clustered. Based on the number (ratio) of plants observed under each of the above said two phenotypic classes, a two gene model, each with two alleles and having duplicate gene action, is proposed to explain the inheritance of siliquae bearing pattern in Indian mustard. Parents seem to differ at two gene loci, each with two alleles. The dispersed siliquae in Indian mustard is governed by two genes, A and B, either alone or together *i.e*. the genotypes A-B -, A-bb and aaB- will lead to dispersed siliquae bearing while, the clustered siliquae bearing results only when both the genes are in recessive form *i.e*. aabb. The inheritance of silique bearing pattern was further confirmed in BC_1 (F_1 x NRCHB 101) progenies where all the plants were of dispersed phenotype and BC_2 (F_1 x NIF-V) generation segregating into 3 dispersed : 1 clustured phenotype with Chi-square value 0.078 (P value). The genetic analysis of F_2, BC_1 and BC_2 populations suggest the presence of

Table 1. Segregation for siliquae bearing pattern in different generations of Indian mustard cross (dispersed x clustered)

Cross/generation	Observed number of plants		$\chi 2$ value	Remark
	Dispersed	Clustered		
F_1	20 (20)*	-	0.0	All dispersed
F_2	226 (225)	14 (15)	0.071	Good fit for 15:1 ratio
BC_1 (F_1 x NRCHB 101)	80 (80)	-	0.0	All dispersed
BC_2 (F_1 x NIF-V)	52 (51)	16 (17)	0.078	Good fit for 3:1 ratio

***Expected values are in parentheses

Table 2. Assigned gene symbols for parents, F_1, F_2 and back cross generations

Generation	Genotype	Genotypic ratio	Phenotype
NRCHB 101(Parent 1)	AABB		Dispersed
NIF-V (Parent 2)	aabb		Clustered
F_1 (NRCHB 101 x NIF-V)	AaBb		Dispersed
F_2	A-B-	15	Dispersed
	A-bb		Dispersed
	aaB-		Dispersed
	aabb	1	Clustered
BC_1 (F_1 x NRCHB 101)	A-B-	All	Dispersed
BC_2 (F_1 x NIF-V)	A-B-	3	Dispersed
	A-bb		Dispersed
	aaB-		Dispersed
	aabb	1	Clustered

Dispersed siliquae (NRCHB 101) **Clustured siliquae (NIF-V)**

Fig. 1. Dispersed (NRCHB 101) and Clustered (NIF-V) siliquae bearing pattern in Indian mustard

two duplicate resective genes in controlling the clustured silique bearing pattern. The phenotypic classes along with their gene symbols are listed in the Table 2. Recessiveness at two gene loci imparts selection disadvantage to clustered siliquae bearing pattern under natural selection making it of rare occurrence. There are only two accessions presently available with this trait namely, NIF-V and NIF-KS at Directorate of Rapeseed Mustard Research, Bharatpur. The information generated in present investigation is the first report on genetics of siliquae bearing pattern and will help in developing breeding strategy for utilization of clustered siliquae bearing pattern in redesigning the mustard ideotype with short plant height, high harvest index and high seed yield due to increased siliquae bearing density. The recombinants developed in this study are being carried forward to develop RILs and to map the QTLs for clustered siliquae bearing pattern that will help in long run for its marker assisted selection.

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