Genetic Variability and Character Association of Yield and Related Traits in Advance Breeding Lines of Indian Mustard (*Brassica juncea* L.)

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Twenty-one advance breeding lines and four check varieties, Varuna, BIO-902, Kranti and Rajat of Indian mustard (*Brassica juncea* L.) were evaluated in Randomized Complete Block design with three replications during 2001-02 and 2002-03 *rabi* season to estimate genetic parameter and study character association for 12 quantitative characters, *viz.*, plant height (cm), primary branches/plant, secondary branches/plant, main shoot length (cm), siliquae on main shoot, siliqua length (cm), seeds/siliqua, 1000-seed weight (g), oil content (%), biological yield/plant (g), seed yield/plant(g) and harvest index (%). The PCV and GCV varied from 8.8 (seeds/siliqua) to 48.0% (seed yield/ plant) and 1.4 (oil content) to 26.0% (secondary branches/plant), respectively. The higher estimate of heritability coupled with higher genetic advance for 1000-seed weight indicated that heritability could mainly be due to additive effects and selection would be effective for this trait. Seed yield / plant had positive and significant correlations with, plant height, secondary branches/plant, main shoot length, seeds/siliqua, 1000-seed weight and harvest index. Moderate to high direct positive effects of these characters except seeds/ siliqua and main shoot length on seed yield were responsible for their positive and significant association with yield. Hence these characters merit consideration in the selection programme to improve yield. The characters under investigation could explain about 71.9% of the variability in the seed yield.

Key words: *Brassica juncea*, Genetic variability, Path analysis, Correlation coefficient, Indian mustard

Indian mustard (*Brassica juncea* L.) is the major rapeseed-mustard crop in India. Hence, the improvement of productivity of this crop will go a long way in enhancing the rapeseed-mustard production in country. Seed yield is the end product of additive and / or multiplicative interaction among various factors known as yield contributing characters. Direct selection for seed yield is usually not very effective because yield being a complex character. Therefore, selection based on component characters has been suggested to improve seed yield (Grafius, 1964) in different crops. Genetic variability is prerequisite for a meaningful selection. Genetic parameters like heritability, coupled with genetic advance largely determine the success of selection. The nature and magnitude of association among yield and its components reveal the scope for correlated response to selection. Hence, basic information on genetic parameters, extent of variability and nature of association is essential in formulating appropriate selection approaches in the mustard-breeding programme. Therefore, the present study was attempted to asses the nature of variation and characters association in Indian mustard.

Materials and Methods

The experimental material consisted of 21 advanced breeding lines and four varieties, Varuna, BIO-902, Kranti and Rajat of Indian mustard. These breeding lines were derived from nine crosses viz., TERI (OE) M-08 x Bio-902 (BPR-2), TERI (OE) M-21 x Varuna (BPR-6), Shiva x Varuna (BPR-62), Pusa Basant x RLM-514 (BPR-83), (Pusa Bold x RLM-514) x Shiva (BPR-87), (RH-30 x PCR-3) x Shiva (BPR-95), RH-819 x PCR-3 (BPR-96), RL-1359 x PCR-3 (BPR-104), and YSRL-9 x PCR-3 (BPR-106). The experimental materials were sown in randomized complete block design with three replications during 2001-02 and 2002-03 *rabi* season. Each genotype was sown in five-row-plot and each row was 5 m long, spaced 30 cm apart. Plant-to-plant distance was maintained of 10-15 cm within a row by thinning. 40 kg N and 40 kg P_2O_5/ha was applied at the time of sowing and the rest of 40 kg N was applied after first irrigation. Two irrigations were given at 40 and 78 days after the sowing, respectively. Observations were recorded on five competitive randomly taken plants from each genotype in each replication on plant height (cm), primary branches/plant, secondary branches/plant, main shoot length (cm), siliquae on main shoot, siliqua length (cm), seeds/siliqua, 1000-seed weight (g), oil content (%), biological yield/plant (g), seed yield/plant (g) and harvest index (%). The genotypic (GCV) and the phenotypic (PCV) coefficients of variation, heritability and genetic advance were calculated by the formulae given by Johnson *et al.* (1955). The genotypic and phenotypic correlations were calculated as per the method of Al-Jibouri *et al.* (1958). Path coefficient analysis was done according the method of Dewey and Lu (1959).

Results and Discussion

The analysis of variance indicated significant differences among the genotypes for all the characters except primary branches/plant, siliquae on main shoot, siliqua length and biological yield/plant. Therefore, these four characters were excluded from further analysis. The environmental effect was significant only for harvest index indicating thereby that all the genotypes had similar pattern of variability both the years for all the characters except harvest index. Interaction effect of year x genotypes was significant only for main shoot length. The results implied that the genotypes would behave differentially for this character during both the years. The range, mean, phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), heritability and genetic advance for eight quantitative characters are presented in Table 1. The wide range of mean was observed for almost all the characters. The range for plant height was 141.9 cm (BPR-6-91-53-4) to 191.9 cm (Kranti). Genotype BPR-166-24-1 had maximum number of secondary branches per plant. The main shoot length was the highest for the genotype BPR-96-3 (75.6 cm). Minimum and maximum of seeds/siliqua were recorded in the genotype BPR-166-24-1 and BPR-83, respectively (Table 1). Genotype BPR-6-91-52-3 had the highest 1000-seed weight (6.8 g). Harvest index ranged from 18.7 (PCR-18) to 29.4% (BPR-83). All the characters, in general, showed higher magnitude of PCV than GCV indicating the effect of environment on the expression of these characters. However, trend of GCV and PCV was similar. The PCV and GCV varied from 8.8 (seeds/siliqua) to 48.0% (seed yield/plant) and 1.4 (oil content) to 26.0% (secondary branches/plant), respectively. The PCV and GCV were high for secondary branches/plant, seed yield/plant and 1000-seed weight (Table 1). Sikarwar *et al.* (2000) and Mahla *et al.* (2003) reported high PCV and GCV for seed yield/plant. The rest of the characters showed low PCV and GCV. Heritability values ranged from 14.4 (seed/siliqua) to 63.0% (1000-seed weight). Heritability was relatively high only for 1000-seed weight. Similar results were also reported earlier (Sikarwar *et al.* 2000; Mahla *et al.* 2003). The characters plant height, secondary branches/plant and harvest index showed moderate heritability while, the rest of characters showed low heritability. But in previous studies, high heritability was reported for plant height, secondary branches/plant and seed yield (Sikarwar *et al.* 2000; Mahla *et al.* 2003). Moderate to low estimates of broad sense heritability indicates that improvement for these characters through simple selection would be limited. Genetic advance was high for 1000-seed weight (32.4%) and secondary branches/plant (29.5%), while the other characters showed low genetic advance. Mahla *et al.* (2003) observed high genetic advance for seed yield/plant. The higher estimates of heritability coupled with higher genetic advance for 1000-seed weight indicated that heritability could be mainly due to the additive effects and selection would be effective. The results of the present study were in conformity with earlier report of Mahla *et al.* (2003). Moderate heritability accompanied with low or medium to low genetic advance for other characters indicated the involvement of non-additive gene action in the expression of these characters and moderate heritability is expressed due to favorable influence of the environment rather than genotypes. These results were similar to the finding of Sikarwar *et al.* (2000) and Mahla *et al.* (2003).

Correlations at Phenotypic Level

Estimates of correlation coefficients presented in Table 2 revealed that plant height; secondary branches/plant,

Table 1. Range, mean, phenotypic coefficient of variability (PCV), genotypic coefficient of variability (GCV) heritability (in broad sense) and genetic advance (as percent of mean) of different characters in Indian mustard.

Characters	Range	Mean ± SEm	PCV (%)	GCV (%)	Heritability (%)	Genetic advance (%)
Plant height (cm)	141.9–191.9	165.8±7.1	13.2	7.6	33.0	9.0
Secondary branches/plant	2.8–10.8	7.4±1.2	47.2	26.0	30.0	29.5
Main shoot length (cm)	57.0–75.6	65.9±3.1	13.2	5.8	19.5	5.3
Seeds/siliqua	12.8–15.1	13.7±13.7	8.8	3.4	14.4	2.6
1000 seed weight (g)	3.2–6.8	4.9±0.3	24.9	19.8	63.0	32.4
Oil content (%)	39.3–42.6	40.8±0.5	3.2	1.4	19.0	1.2
Seed yield /plant (g)	5.2–15.5	8.9±1.5	48.0	23.7	24.3	24.0
Harvest index (%)	18.7–29.4	24.1±1.7	21.3	12.2	33.0	14.5

main shoot length, seeds/siliqua, 1000-seed weight and harvest index had significant and positive correlations with seed yield/plant at phenotypic level. Secondary branches/plant had positive and significant correlation with seed yield/plant at phenotypic level (r=0.306**) whereas at genotypic level both were negatively associated (r = – 0.834), thereby suggesting the influence of environment on the correlation. Positive and significant correlations of plant height were observed with main shoot length, 1000-seed weight and harvest index while it had significant and negative association with secondary branches/plant (r = -0.187*). Secondary branches/plant exhibited significant and negative relationships with 1000-seed weight, oil content and harvest index but its association with seeds/siliqua was positive and significant (Table 2). The associations of seeds/siliqua were positive and significant with main shoot length, 1000-seed weight and harvest index. 1000-seed weight showed significantly positive relationships with harvest index and seeds/siliqua.

Correlations at Genotypic Level

High positive correlations of plant height were observed with main shoot length, 1000-seed weight and harvest index but its relationship with secondary branches/plant was strong and negative (r = – 1.095). Positive and high genotypic correlations of seed yield/plant were observed with plant height; secondary branches/plant, main shoot length, seeds/siliqua, 1000-seed weight and harvest index (Table 2). Mahla *et al.* (2003) also reported high positive association of seed yield with plant height. Seed yield/plant was negatively correlated with secondary branches/plant (r = –0.834 and its association with oil content was weak (r= 0.206). Secondary branches/plant, in general, had negative association with all the characters investigated in the present study. However, main shoot length showed positive correlation with 1000-seed weight, seeds/siliqua, oil content and harvest index. Seeds/siliqua had relatively weak positive correlation with oil content and harvest index. 1000-seed weight showed positive relationship with harvest index and oil content (Table 2).

In general, the pattern of associations between yield and its attributes were similar at both genotypic and phenotypic levels except for secondary branches/plant, which showed variable nature of association with seeds/siliqua and seed yield. The results suggest that g x e interaction played important role in the expression of these relationships.

Path Analysis at Phenotypic Level

Correlation coefficients generally describes association between the characters in statistical terms, they are inadequate in interpreting the cause and effect relationship. Hence, correlation coefficients between various characters are partitioned into direct and indirect relationship by path analysis considering seed yield as dependent variable and the rest of the characters as independent variables. Highly significant correlation of seed yield with plant height was due to its moderate positive direct effect and low indirect effects via secondary branches/plant and 1000-seed weight (Table 3). Secondary branches/

Table 2. Correlation coefficients at phenotypic (P) and genotypic (G) levels.

Characters		Secondary branches/plant	Main shoot length	Seeds/ siliqua	1000-seed weight	Oil content	Harvest index	Seed yield / plant
Plant height	P	-0.187*	0.444**	0.009	0.354**	0.060	0.185*	0.469**
	G	-1.095	0.670	0.021	0.952	0.159	0.880	0.725
Secondary branches/	P		-0.142	0.280**	-0.556**	-0.256**	-0.189*	0.306**
	G		-0.929	-0.086	-0.985	-0.347	-0.917	-0.834
Main shoot length	P			0.176*	0.33**	0.252**	0.097	0.358**
	G			0.664	0.810	0.362	0.687	0.673
Seeds/siliqua	P				0.6**	0.062	0.231**	0.351**
	G				0.084	0.329	0.289	0.434
1000 seed weight	P					0.102	0.498**	0.330**
	G					0.220	0.839	0.811
Oil content	P						0.040	0.006
	G						0.206	0.206
Harvest index	P							0.510**
	G							0.998

*, ** Significant at 5% and 1% level of probability

plant had a strong positive direct effect (0.6397) in building its positive association with yield, which was partially neutralized, by low negative indirect effects via rest of the characters. Satyavathi *et al.* (2000) and Mahla *et al.* (2003) also reported that the number of branches/plant is an important character contributing directly to seed/yield. Low positive direct and indirect effects of main shoot length and seeds/siliqua were the cause of their positive and significant association with seed yield (Table 3). Moderate positive direct effect and low indirect effects via harvest index and oil content resulted in positive and significant association between 1000-seed weight and seed yield. Gupta and Thakur (2000) also reported that 1000- seed weight had significant positive correlation and positive direct effects on seed yield in karan rai (*Brassica carinata).* Harvest index also showed highly significant correlation with seed yield due its moderate positive direct effect (0.3666). The characters together could explain 71.9% of the variability in the seed yield. Further, in the present study, direct positive effects of plant height, secondary branches/ plant, main shoot length, 1000-seed weight and harvest index were observed on seed yield (Table 3). Therefore, selection based on plant height, secondary branches/ plant, main shoot length, 1000-seed weight and harvest index should bring forth the desired improvement in seed yield in Indian mustard.

Path Analysis at Genotypic Level

Strong negative direct effect (–1.0247) of plant height and its negative indirect effects via secondary branches/ plant and seeds/siliqua were neutralized by equally strong positive indirect effect via harvest index (1.5007) and moderate positive effects through main shoot length and 1000-seed weight, resulting into positive association between plant height and seed yield. High negative indirect effect of secondary branches/plant through harvest index and moderate indirect effects via 1000-seed weight and main shoot length was the cause of its negative association with seed yield. Nevertheless, secondary branches /plant had moderate positive direct effect on seed yield (Table 3). Similarly, positive association between main shoot length and seed yield was the result of its moderate direct effect and strong indirect effect via harvest index, which were partly negated, by indirect effects via seeds/siliqua (-0.2077). Although, seeds/siliqua had negative direct effects which were compensated by positive indirect effects via rest of the characters (Table 3). Direct and indirect positive effects of 1000-seed weight and via harvest index were the main reasons for its positive association with seed yield. The correlation between harvest index and seed yield was due to its strong positive direct effect. The study revealed that harvest index is the major component in building associations of seed yield with other yield contributing characters as it had high direct as well as indirect effects through them.

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Table 3. Path analysis at phenotypic (P) and genotypic (G) level taking yield as dependent variable (direct effects in bold).

S. No.	Characters		Plant height	Secondary branches/plant	Main shoot length (cm)	Seeds/ siliqua	1000 seed weight	Oil content	Harvest index	Seed yield / plant
1	Plant height	P	**0.329**	0.1194	0.0543	0.0007	0.1222	0.0038	0.0678	0.4594
		G	**-1.0247**	-0.4719	0.2696	-0.0067	0.4548	0.0032	1.5007	0.7249
2	Secondary branches/plant	P		**0.6397**	-0.0173	0.0218	-0.1917	-0.0165	-0.0693	0.3050
		G		**0.4309**	-0.3735	0.0268	-0.4707	-0.0069	-1.5632	-0.8343
3	Main shoot length	P			**0.1222**	0.0137	0.1140	0.0162	0.0355	0.3576
		G			**0.4031**	-0.2077	0.3870	0.0072	1.1720	0.6733
4	Seeds/siliqua	P				**0.0778**	-0.0194	0.0040	0.0845	0.3506
		G				**-0.3129**	0.0400	0.0065	0.4922	0.4339
5	1000 seed weight	P					**0.3443**	0.0065	0.1826	0.3301
		G					**0.4777**	0.0044	1.4298	0.8112
6	Oil content	P						**0.0643**	0.0146	0.0052
		G						**0.0199**	0.3506	0.2062
7	Harvest index	P							**0.3666**	0.5103
		G							**1.7047**	0.9983

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