



Genetic variability and trait association studies in Indian mustard (*Brassica juncea*)

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ABSTRACT

Thirty released varieties of Indian mustard [*Brassica juncea* (L.) Czern and Coss.] were evaluated during winter (*rabi*) 2006–07 and 2007–08 under irrigated and rainfed environments. Analysis of variance on 14 quantitative traits was carried out and pooled analysis over the environments was conducted. The mean, range, phenotypic, genotypic and environmental variance, genotypic and phenotypic coefficient of variation, heritability in broad sense and genetic advance were calculated. Path coefficient analysis was carried out using correlation coefficients to know the yield- contributing traits having true associations with seed yield. Improvement in seed yield can be achieved by selection using the correlation and path analysis data generated in this study. 1 000-seed weight was positively correlated with siliqua length. 1 000-seed weight and total siliquae/plant also had higher phenotypic and genotypic direct effects on seed yield/plant, revealing that indirect selection for these traits would be effective in improving seed yield. The high heritability coupled with high genetic advance for 1 000-seed weight would also be of great use for indirect selection for improvement in seed yield. The material used in the study is of diverse nature and can be used in the breeding programme for development of improved genotypes in mustard.

Key words: *Brassica juncea*, Correlation, Heritability, Path analysis, Variability

Oleiferous *Brassicaceae*, collectively known as rapeseed-mustard are important oilseed crops of India and stand second after soybean in production among the eight annual edible oilseeds cultivated in our country. Among the four oleiferous *Brassica* species, major area is under *Brassica juncea* which contributes about 80% of the total rapeseed-mustard production in the country. All these four oleiferous *Brassicaceae* are cultivated in about 6.18 million ha with 7.36 million tons production of oilseed (AICRP-RM 2009) contributing about 26.8% and 24.7% of the total oilseed production and hectareage, respectively in the country with the average productivity of 1 190 kg/ha. The current productivity level of 1 190 kg/ha in India is far below than that of the developed countries (2 500–3 000 kg/ha) as well as the world average of about 1900 kg/ha. Though, we have the varieties with high

yield potential (2 000–2 500 kg/ha), yet there is a wide fluctuation in area, production and productivity of this crop. This fluctuation is mainly due to its cultivation on marginal lands either rainfed or with limited irrigation facilities and non-availability of biotic and abiotic stress-resistant/tolerant varieties for different mustard growing regions of the country.

The success of any breeding programme in general and improvement of specific trait through selection in particular, totally depends upon the genetic variability present in the available germplasm of a particular crop. For the success of the crop improvement programme, the characters for which variability is present, it should be highly heritable as progress due to selection depends on heritability, selection intensity and genetic advance of the character. Heritability and genetic advance estimates for different targeted traits help the breeder to apply appropriate breeding methodology in the crop improvement programme. Main thrust in any crop improvement programme is to enhance yield. As an established fact, yield is a complex trait and is dependent on many other ancillary characters which are mostly inherited quantitatively. The different morphological traits vary in their relationship with yield in terms of their nature as well as magnitude, though they show a continuous variation and are influenced by environment. The components which have high

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heritability and positive correlation with yield can be used in the indirect selection for yield and act as an alternate mode of selection for yield improvement. When the indirect associations become complex, path coefficient analysis is the most effective mean to find out direct and indirect causes of association among the different variables. Path coefficient analysis can discriminate between the realistic (genetic effects) and inflated (environmental effects) correlations. Hence, the knowledge of direct and indirect effects of different components on yield is of prime importance in selection of high yielding genotypes. Keeping the above facts in view, the present investigation was undertaken by involving some popularly cultivated and newly developed varieties of Indian mustard.

MATERIALS AND METHODS

The experiments were conducted at the experimental farm. Indian Agricultural Research Institute, New Delhi during *rabi* 2006–07 and 2007–08 under rainfed and irrigated situations. The material for present study consisted of 30 popular varieties of *B. juncea* from six states with wider adaptability in areas of their recommendation. There were five varieties from Rajasthan (RN 393, RGN 13, RGN 48, RGN 73, NRCDR 02), four from Punjab (RLM 619, PBR 91, PBR 97, PBR 210), ten from Haryana (Laxmi, RH 30, RH 819, RH 781, Geeta, Swarnjyoti, Vasundhra, PCR 7, CS 52, CS 54), four from UP (Kranti, Varuna, Vardan, Rohini), five from Delhi (Pusa Bold, Pusa Jagannath, Pusa Karishma, Pusa Jaikisan, Pusa Barani) and two from Gujarat (GM 1, GM 2).

During both the years, trials were laid out in randomized block design with three replications with plot size of 7.5 m². Row to row and plant to plant distance was kept at 30 and 10 cm, respectively. The data was recorded on fourteen characters, viz days to 50% flowering, days to maturity, plant height (cm), point to the first branch (cm), number of primary

branches/plant, number of secondary branches/plant, length of main shoot (cm), number of siliquae on main shoot, point to first siliqua on main shoot (cm), siliqua length (cm), number of seeds/plant, 1 000-seed weight (g), total siliquae/plant and seed yield/plant (g). Except days to 50% flowering and days to maturity, where, data were recorded on plot basis, data on rest of the morphological traits was recorded on randomly selected ten competitive plants in the middle three rows of each plot in all the three replications. The recommended package of practices was followed to raise a good crop.

Analysis of variance was performed following the standard procedures. The phenotypic and genotypic coefficients of variation (PCV, GCV) were computed as per method described by Burton (1954) and the correlation coefficients at genotypic and phenotypic level were computed according to Johnson *et al.* (1955). Path coefficient analysis was done by using correlation coefficients as suggested by Dewey and Lu (1959). In the present investigation, path coefficient analysis was carried out by taking seed yield/plant as dependent variable and other observed traits as independent variables in each of the environments and also for the pooled data.

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences for individual as well as pooled data amongst genotypes for all the fourteen characters studied. Variance due to genotype was highly significant for all the fourteen characters indicating the presence of sufficient variability in the genotypes selected for this study. High magnitude of variability has been reported in Indian mustard germplasm and varieties for various characters by many workers for days to 50% flowering, days to maturity, plant height, total siliquae/plant and seed yield (Kumar and Misra 2007). The reason for high magnitude of variability in the present study may be due the fact that the genotypes selected were developed in different breeding

Table 1 Estimates of different genetic parameters of variation over four environments (pooled)

Character	Mean	Range	PCV	GCV	h ²	GA as per cent of mean
Days to 50% flowering	53.26	46.08–61.50	5.59	5.08	0.827	9.52
Days to maturity	141.02	132.67–148.08	2.40	2.24	0.878	4.33
Plant height (cm)	197.60	179.00–214.33	4.32	3.90	0.816	9.62
Point to first branch (cm)	39.65	19.08–62.75	26.46	24.81	0.879	36.17
No. of primary branches/plant	5.72	4.92–6.99	10.90	7.38	0.459	10.31
No. of secondary branches/plant	16.31	12.45–20.69	15.37	11.19	0.530	16.74
Length of main shoot (cm)	75.06	61.65–89.67	9.95	9.07	0.832	17.05
No. of siliquae on main shoot	45.64	38.67–52.83	7.91	6.20	0.616	10.04
Point to first siliqua (cm)	6.55	3.15–10.52	23.29	19.67	0.713	34.20
Siliqua length (cm)	3.84	3.23–4.71	9.79	9.21	0.885	17.71
No. of seeds/siliqua	13.44	10.73–15.82	7.43	6.85	0.851	13.02
1 000-seed weight (g)	4.63	3.32–5.79	18.31	18.00	0.966	36.50
Total no. of siliquae/plant	247.76	212.26–293.25	11.38	7.49	0.433	10.25
Seed yield/plant (g)	24.41	14.96–33.37	18.93	16.44	0.754	29.41

programmes representing different agro-climatic conditions of the country. Phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the observed characters (Table 1). High PCV and GCV were observed for point to first branch, seed yield/plant, point to first siliqua, number of secondary branches/plant and 1000-seed weight. These characters have been reported as main yield contributing traits (Kardam and Singh 2005). Similar findings pertaining to presence of high genetic variability were reported for different traits including seed yield/plant (Singh 2004). Results revealed presence of high amount of genetic variability in the evaluated genotypes for the major yield-contributing characters along with seed yield which indicated that further improvement for these traits is possible.

Thousand seed weight and point to first branch exhibited high heritability (Table 1). High heritability for 1 000-seed weight has been reported earlier also (Mahla *et al.* 2003, Singh 2004). High heritability for different traits under study, viz days to flowering, plant height and total siliquae/plant (Singh 2004, Kumar and Misra 2007) has been reported earlier also. Genetic advance as per cent of mean was higher for 1 000-seed weight, point to first branch and point to first siliqua indicating that selection for these traits would be effective for the improvement. Similar findings related to high genetic advance as per cent of mean have been reported by earlier workers for various traits (Singh 2004, Kumar and Misra 2007, Mahla *et al.* 2003). High heritability with high genetic advance for seed yield/plant has also been reported (Singh 2004, Kumar and Misra 2007), which supports the results of the present investigation.

Correlation coefficients were estimated between seed yield and other traits under study indicated that seed yield was positively associated with 1 000-seed weight and siliqua length at phenotypic level (Table 2). 1 000-seed weight was positively correlated with siliqua length. Positive correlation of 1000-seed weight and siliqua length with seed yield has been reported in the earlier studies in *B. juncea* (Singh 2004). Hence, selection for these traits would also help in improving the seed yield in this crop.

Results of path coefficient indicated that 1 000-seed weight, total siliquae/plant, secondary branches/plant and point to first siliqua exhibited positive phenotypic and genotypic direct effects on seed yield/plant (Table 3). Phenotypic direct effect of siliqua length on seed yield/plant is positive, however, its genotypic direct effect was reported negative. It is quite evident that the positive correlation between seed yield/plant and siliqua length was mainly due to 1 000-seed weight and total siliquae/plant. The phenotypic direct effect of secondary branches/plant and point to first siliqua are positive but low, therefore, direct selection for these traits may not help in yield improvement. Alternatively, 1 000-seed weight and total siliquae/plant had higher phenotypic and genotypic direct effects on seed yield/plant, thus, the correlation coefficient between seed yield and these

Table 2 Phenotypic (above diagonal) and genotypic (below diagonal) correlations (pooled)

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	Point to first branch (cm)	Primary branches/plant	Secondary branches/plant	Length of main shoot (cm)	Siliquae on main shoot	Point to first siliqua (cm)	Siliqua length (cm)	Seeds/siliqua	1 000-seed weight (g)	Total siliquae/plant	Seed yield/plant (g)
Days to 50% flowering	1.000	0.578**	0.463**	0.445**	0.135	-0.278	-0.325	0.018	-0.120	-0.358	-0.296	-0.297	0.002	-0.225
Days to maturity	0.669	1.000	0.356	0.196	0.114	-0.008	-0.332	-0.010	-0.097	-0.181	-0.339	0.162	-0.064	0.097
Plant height (cm)	0.589	0.398	1.000	0.724**	0.056	-0.373	-0.088	0.395*	0.240	-0.124	-0.405*	-0.138	0.020	0.051
Point to first branch (cm)	0.520	0.214	0.864	1.000	0.242	-0.230	-0.261	0.313	-0.271	0.111	-0.138	-0.125	0.169	-0.038
Primary branches/plant	0.265	0.147	0.021	0.417	1.000	0.275	-0.059	0.002	-0.245	0.084	0.092	-0.039	0.175	0.135
Secondary branches/plant	-0.423	-0.059	-0.571	-0.337	0.504	1.000	-0.026	-0.057	-0.125	0.060	-0.007	0.120	0.072	0.125
Length of main shoot (cm)	-0.414	-0.365	-0.096	-0.300	-0.087	-0.039	1.000	0.253	0.407*	0.024	0.160	0.065	-0.106	-0.040
Siliqua on main shoot	0.032	-0.042	0.544	0.450	0.069	-0.008	0.305	1.000	0.080	0.050	-0.211	0.059	0.203	0.163
Point to first siliqua (cm)	-0.183	-0.105	0.299	-0.351	-0.418	-0.214	0.480	0.076	1.000	-0.182	-0.027	-0.125	-0.126	0.039
Siliqua length (cm)	-0.409	-0.214	-0.168	0.129	0.143	0.090	0.183	0.091	-0.244	1.000	0.295	0.364*	0.247	0.414*
Seeds/siliqua	-0.358	-0.403	-0.515	-0.151	0.125	-0.034	0.183	-0.302	-0.038	0.308	1.000	-0.047	0.055	0.033
1000-seed weight (g)	-0.325	0.172	-0.153	-0.139	-0.058	0.159	0.077	0.084	-0.141	0.400	-0.045	1.000	-0.152	0.509**
Total sil./plant	-0.034	-0.110	-0.014	0.271	0.352	0.144	-0.170	0.431	-0.245	0.376	0.132	-0.228	1.000	0.207
Seed yield/plant (g)	-0.260	0.127	0.040	-0.045	0.237	0.176	-0.061	0.194	-0.013	0.486	0.028	0.612	0.335	1.000

*P = 0.05, **P = 0.01

Table 3 Phenotypic and genotypic direct (main diagonals) and indirect path coefficients (pooled)

Character	Path	Days to 50% flowering	Days to maturity	Plant height (cm)	Point to first branch (cm)	Primary branches/plant	Secondary branches/plant	Length of main shoot (cm)	Siliquae shoot on main shoot (cm)	Point to first siliqua (cm)	Siliqua length (cm)	Seeds/siliqua	1 000-seed weight (g)	Total siliquae/plant	Correlation with seed-yield plant
Days to 50% flowering	P	-0.034	-0.016	0.240	-0.209	0.020	-0.022	0.066	0.002	-0.004	-0.083	-0.042	-0.142	0.000	-0.225
	G	0.540	-0.160	-0.180	0.398	-0.076	-0.192	-0.087	-0.021	-0.133	0.017	0.047	-0.379	-0.033	-0.260
Days to maturity	P	-0.020	-0.028	0.184	-0.092	0.017	-0.001	0.068	-0.001	-0.003	-0.042	-0.049	0.077	-0.014	0.097
	G	0.361	-0.240	-0.122	0.163	-0.042	-0.027	-0.077	0.027	-0.076	0.009	0.053	0.201	-0.104	0.127
Plant height	P	-0.016	-0.010	0.517	-0.339	0.008	-0.029	0.018	0.042	0.008	-0.029	-0.058	-0.066	0.004	0.051
	G	0.318	-0.095	-0.306	0.661	-0.006	-0.260	-0.020	-0.352	0.217	0.007	0.067	-0.178	-0.013	0.040
Point to first branch	P	-0.015	-0.006	0.374	-0.469	0.036	-0.018	0.053	0.033	-0.010	0.026	-0.020	-0.060	0.036	-0.038
	G	0.281	-0.051	-0.264	0.765	-0.121	-0.153	-0.063	-0.291	-0.255	-0.005	0.020	-0.162	0.255	-0.045
Primary branches/plant	P	-0.005	-0.003	0.029	-0.114	0.151	0.022	0.012	0.000	-0.009	0.020	0.013	-0.018	0.037	0.135
	G	0.143	-0.035	-0.006	0.319	-0.289	0.229	-0.018	-0.045	-0.303	-0.006	-0.016	-0.068	0.332	0.237
Secondary branches/plant	P	0.010	0.000	-0.193	0.108	0.041	0.078	0.005	-0.006	-0.004	0.014	-0.001	0.058	0.015	0.125
	G	-0.228	0.014	0.175	-0.258	-0.145	0.455	-0.008	0.005	-0.155	-0.004	0.005	0.185	0.136	0.176
Length of main shoot	P	0.011	0.009	-0.046	0.122	-0.009	-0.002	-0.204	0.027	0.014	0.006	0.023	0.031	-0.022	-0.040
	G	-0.223	0.087	0.029	-0.229	0.025	-0.018	0.211	-0.197	0.348	-0.001	-0.024	0.090	-0.160	-0.061
Siliquae on main shoot	P	-0.001	0.000	0.204	-0.147	0.000	-0.004	-0.052	0.107	0.003	0.012	-0.030	0.028	0.043	0.163
	G	0.017	0.010	-0.167	0.344	-0.020	-0.004	0.064	-0.646	0.055	-0.004	0.039	0.098	0.407	0.194
Point to first siliqua	P	0.004	0.003	0.124	0.127	-0.037	-0.010	-0.083	0.009	0.035	-0.042	-0.004	-0.060	-0.027	0.039
	G	-0.099	0.025	-0.092	-0.269	0.121	-0.097	0.101	-0.049	0.725	0.010	0.005	-0.165	-0.231	-0.013
Siliqua length	P	0.012	0.005	-0.064	-0.052	0.013	0.005	-0.005	0.005	-0.006	0.233	0.042	0.174	0.052	0.414
	G	-0.221	0.051	0.052	0.099	-0.041	0.041	0.003	-0.059	-0.177	-0.042	-0.040	0.467	0.355	0.486
Seeds/siliqua	P	0.010	0.010	-0.210	0.065	0.014	-0.001	-0.033	-0.023	-0.001	0.069	0.143	-0.022	0.012	0.033
	G	-0.193	0.097	0.158	-0.116	-0.036	-0.016	0.039	0.195	-0.027	-0.013	-0.131	-0.052	0.124	0.028
1000-seed weight	P	0.010	-0.005	-0.072	0.058	-0.006	0.009	-0.013	0.006	-0.004	0.085	-0.007	0.479	-0.032	0.509
	G	-0.176	-0.041	0.047	-0.106	0.017	0.072	0.016	-0.054	-0.103	-0.017	0.006	1.165	-0.214	0.612
Total siliquae/plant	P	0.000	0.002	0.010	-0.079	0.026	0.006	0.022	0.022	-0.004	0.058	0.008	-0.073	0.211	0.207
	G	-0.019	0.026	0.004	0.207	-0.102	0.066	-0.036	-0.279	-0.177	-0.016	-0.017	-0.265	0.942	0.335

two traits is real one, revealing that indirect selection for these traits would be effective in improving seed yield. High heritability along with high genetic advance was also reported for 1 000-seed weight, thus, indirect selection for 1 000-seed weight will be most effective for the improvement in seed yield. These findings are in accordance with the earlier reports (Agarwal and Nair 2003, Kardam and Singh 2005) where direct positive effect of 1000-seed weight to the seed yield/plant has been reported in *B. juncea*. Thus, the material studied is of diverse nature and information emanated would help in designing the selection methodology which can further be used in the breeding programme for improvement of seed yield.

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