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Genetic variability, character association and path analysis for seed yield and component traits under two environments in Indian mustard

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Abstract

Total 50 genotypes of Indian mustard [*Brassica juncea* (L.) Czern & Coss.] collected from different parts of country to study the revealed substantial genetic variability in the material under timely sown (E_1) and late sown (E_2) environments. Genotypic and phenotypic coefficients of variance were higher for number of secondary branches/ plant and seed yield/ plant under both the environments. High heritability in both the environments was observed for days to 1st flowering, siliquae length and seed yield/ plant. Genetic advance values were high for plant height, number of siliqua on main shoot and seed yield / plant under both the environments, whereas, genetic advance as % of mean was high for seed yield / plant, 1000- seed weight, number of secondary branches / plant and siliqua length. Seed yield / plant showed a positive significant correlation with main shoot length, siliqua length, number of seeds / siliqua and 1000- seed weight in E_1, whereas in E_2 it was positively associated with plant height, main shoot length, number of siliqua on main shoot and 1000- seed weight. Days to 50% flowering showed maximum positive direct and indirect effect on seed yield under both the environments.

Key words: *Genetic variability, heritability, character association, path analysis and Indian mustard*

Introduction

Among the major oilseed crops grown in the country, rapeseed-mustard occupies a prestigious position and ranks second after groundnut both in area and production. Oilseed Brassica crops accounts for more than 22 per cent of the total acreage as compared to other oilseeds group and has been playing an increasingly important role by restlessly marching towards self-reliance in vegetable oils. Success of breeding programmes is largely dependent on the extent and nature of genetic variability, heritability and genetic advance present in the base population. Greater the diversity in the material, better are the chances for recovery of desired plant types. In general, direct selection for yield may not be effective as it is a complex trait and depends upon the component traits. Correlation studies alone do not provide the clear picture regarding the association of different traits. Path coefficient analysis makes the situation clearer and also provides relatively more realistic picture of complex situation that exists at correlation level worked out only at the genotypic level separately for morphological attributes. Therefore, keeping the above background in view, the present investigation was undertaken to study the variability, correlation and path analysis in 50 genotypes of Indian mustard under two different environments.

Materials and Methods

All the 50 genotypes collected from different parts of country were grown in a randomized block design replicated thrice under two different *i.e.* in the last week of October (E_1) and in last week of November (E_2). Each genotype was accommodated in a paired row of 4 meter length spaced 30cm apart. Three weeks after sowing, the plant-to-plant distances within rows were adjusted to 10-15 cm by thinning. The observations were recorded for different quantitative characters viz. days to 1st flowering, days to 50 % flowering, days to maturity, plant height (cm), number of primary branches / plant, number of secondary breaches / plant, main shoot length (cm), number of siliqua on main shoot, siliqua length (cm), number of seeds / siliqua, 1000-seed weight (g), seed yield / plant (g) and oil content (%) 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 and phenotypic correlation coefficients were estimated according to Al-Jibouri *et al*. (1958). The path coefficients were obtained according to Dewey and Lu (1959).

Results and discussion

Genotypic and phenotypic variances and coefficient of variation revealed substantial genetic variability in the base population. Both genotypic and phenotypic coefficients of variance were higher for number of secondary branches/plant followed by seed yield/plant under both the environments *i.e.* timely sown (E_1) and late sown (E_2) (Table 1). Similar results have also been reported by Singh *et. al*. (2008) in Indian mustard. Heritability indicates the effectiveness with which the selection of genotypes could be based on phenotypic performance. Heritability (broad sense) is helpful in providing an idea about the relative importance effects, which the selected parents would pass on to the progenies. In the present investigation, high heritability (broad sense) under both the environments was observed for days to 1st flowering, siliqua length and seed yield/plant. The characters with high heritability are inherited precisely and are important for a plant selection for

Table 1: Heritability (broad sense), genetic advance, genotypic and phenotypic coefficients of variance under normal sown (E_1) and late sown environments (E_2)

Characters	Environment	Heritab-ilitybs (%)	Genetic advance (% mean)	Genotypic coefficient of variance	Phenotypic coefficient of variance
Days to 1st flowering	E_1	89.9	11.4	11.5	12.1
	E_2	90.8	3.0	4.4	4.7
Days to 50% flowering	E_1	82.6	10.5	10.1	11.1
	E_2	86.7	2.8	3.7	4.0
Days to maturity	E_1	86.6	9.6	3.5	3.8
	E_2	78.8	4.5	1.8	2.1
Plant height (cm)	E_1	72.1	33.5	10.0	11.8
	E_2	81.1	28.8	9.2	10.2
No. of primary branches/plants	E_1	42.3	1.2	15.4	23.6
	E_2	63.4	1.0	12.4	15.5
No. of secondary branches/plant	E_1	31.9	3.6	26.7	47.3
	E_2	73.9	2.9	18.4	21.3
Main shoot length (cm)	E_1	17.1	2.9	4.9	12.1
	E_2	79.9	12.9	13.1	14.5
No. of siliquae on main shoot	E_1	47.9	7.9	11.7	17.1
	E_2	57.2	7.1	12.2	16.1
Siliquae length (cm)	E_1	85.7	1.1	14.2	15.3
	E_2	89.1	1.1	14.9	15.7
No. of seeds/siliqua	E_1	59.8	1.6	8.7	14.2
	E_2	73.5	1.8	9.8	11.5
1000- seed weight (g)	E_1	94.9	1.7	16.9	17.4
	E_2	89.8	1.1	12.2	13.0
Seed yield/ plant (g)	E_1	85.6	7.3	18.6	20.1
	E_2	87.6	5.0	18.1	19.3
Oil content (%)	E_1	79.0	1.6	2.2	2.5
	E_2	71.2	1.2	2.0	2.4

such characters on phenotypic performance more reliably and could attain quick improvement within short period. Similar results of high heritability have also been reported by Singh *et. al*. (2008) in Indian mustard. Genetic advance values were high for plant height, number of siliqua on main shoot and seed yield/plant for both the environments, whereas, genetic advance as % of mean were high for seed yield/plant, 1000-seed weight, number of secondary branches/plant and siliqua length in both E_1 and E_2. Heritability estimates coupled with genetic advance are more helpful than heritability alone in predicting the progress from the selected better individuals. However, there are limitations of using broad sense heritability as it includes both additive and non-additive gene effects. It is therefore necessary to estimate the broad sense heritability in conjunction with the genetic advance. In the present investigation, seed yield / plant showed high estimates of heritability coupled with genetic advance which indicates that selection would be effective for the improvement of these traits.

In the present study the magnitude of genotypic correlation coefficients were found to be higher than their corresponding phenotypic coefficients which indicated a strong inherent association between various characters studied and the phenotypic expression of these traits was less under the influence of environment. Oil content showed significant positive association with No. of primary branches/plant in E_1, whereas, in E_2 it was correlated positively with No. of seeds/siliqua and negatively with No. of primary branches/plant (Table 2). Seed yield / plant was found to be positively and significantly associated with number of seeds / siliqua, 1000- seed weight and siliqua length and negatively correlated with days to 1st flowering and days to 50% flowering in E_1, whereas, in E_2 it was positively and significantly correlated with plant height, main shoot length and number of siliquae on main shoot. 1000-seed weight had positive relationship with main shoot length and siliqua length in E_1, whereas in E_2 it was associated positively with siliqua length only. For majority of the traits it had negative correlation under both E_1 and E_2. No. of seeds/siliqua was positively correlated with No. of primary and secondary branches/plant and main shoot length in E_1 and with No. of primary branches/ plant and main shoot length in E_2. On the other hand siliqua length and main shoot length had direct positive relationship under both the environments. Similarly, No. of siliqua on main shoot was positively associated with majority of component traits in both the environments. Srivastava and Singh (2002) also reported significant association of main shoot length with seed yield in Indian mustard. Days to 1st flowering showed positive correlation with days to 50% flowering and negative correlation with seed yield / plant in $E_{1.}$ In $E_{2,}$ days to flowering showed positive significant relationship with days to 50% flowering, days to maturity while it exhibited negative correlation with 1000-seed weight and siliqua length. Days to maturity showed positive correlation with plant height, number of primary branches / plant. These results are in confirmation with those obtained by Verma *et. al*. (2008) and Singh *et. al*. 2008.

Correlation alone often gives misleading results when more characters are involved in the correlation study. It is apparent that many of the characters are correlated because of a mutual association, positive or negative, with other characters. As more variables are considered in the correlation tables, their indirect associations become more complex, less obvious and somewhat perplexing. Under such circumstances, the path coefficient analysis provides an effective means of separating direct and indirect cause of association and permits critical examination of the specific forces acting to produce a given correlation and measures the relative importance of each casual factor. In the present study, days to 50% flowering had the maximum direct effects on seed yield/plant followed by siliquae on main shoot, number of seeds / siliqua, 1000-seed weight and oil content in E_1,(Table3) whereas in E_2 days to 50% flowering followed by number of primary and secondary branches / plant, main shoot length, siliquae on main shoot, number of seeds / siliquae and 1000-seed weight had the positive direct effects on seed yield which clearly indicated importance of these traits in direct selection for improvement of seed yield in Indian mustard. The findings of the present investigation are supported by Srivastava and Singh (2002), Panth *et. al*. (2002)

Table 2: Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients between different characters of Indian mustard under normal sown (E_1) and late sown environments (E_2)

Character	Environment	Days to 1st Flower-ing	Days to 50% flower-ing	Days to maturity	Plant height (cm)	No. of primary branches /plant	No. of secondary branches /plant	Main shoot length (cm)	No. of siliquae on main shoot	Siliqua length (cm)	No. of seeds / siliqua	1000 -seed weight (g)	Seed yield plant (g)	Oil content (%)
Days to 1st flowering	E_1	1.00	0.99**	0.28	0.20	0.06	0.26	-0.64	-0.01	-0.18	-0.29	-0.42**	-0.51**	-0.27
	E_2	1.00	0.99**	0.37**	0.13	-0.03	0.27	-0.16	-0.01	-0.35*	-0.14	-0.34*	-0.04	-0.25
Days to 50% flowering	E_1	0.97**	1.00	0.31*	0.21	0.06	0.24	-0.68**	-0.02	-0.19	-0.31	-0.42	-0.54**	-0.25
	E_2	0.95**	1.00	0.40**	0.17	-0.04	0.26	-0.18	-0.01	-0.32*	-0.17	-0.34*	-0.07	-0.30*
Days to maturity	E_1	0.25	0.27	1.00	0.44**	0.48**	0.39**	-0.13	0.37**	0.01	0.28	-0.19	0.18	0.17
	E_2	0.32*	0.34*	1.00	0.11	0.07	0.30*	0.18	0.29*	-0.00	0.01	-0.01	0.13	-0.07
Plant height (cm)	E_1	0.17	0.17	0.36**	1.00	0.83**	0.79**	-0.46*	0.88**	-0.29	0.17	-0.50**	0.21	0.27
	E_2	0.10	0.14	0.08	1.00	0.76**	0.74**	-0.16	0.39**	-0.28*	0.20	-0.50**	0.38**	0.03
No. of primary	E_1	0.06	0.05	0.30*	0.57**	1.00	1.03**	-0.63	0.84**	-0.30*	0.35*	-0.34*	0.05	0.33*
branches/plant	E_2	-0.03	-0.04	0.01	0.53**	1.00	0.63**	-0.22	0.25	-0.03	0.44**	0.33**	0.25	0.04
No of secondary	E_1	0.18	0.14	0.21	0.58**	0.64**	1.00	-0.82	0.77**	-0.54**	0.34*	-0.53**	0.06	0.17
branches/plant	E_2	0.23	0.19	0.22	0.59**	0.45**	1.00	-0.05	0.35*	0.35*	0.21**	-0.38*	0.23	0.08
Main shoot length (cm)	E_1	-0.19	-0.17	-0.07	-0.05	-0.20	-0.02	1.00	0.40*	0.82	0.37**	0.34*	0.28*	-0.11
	E_2	-0.16	-0.16	0.09	-0.11	-0.12	0.01	1.00	0.48**	0.43**	0.23	0.26	0.35*	0.01
No. of siliquae on	E_1	0.05	0.05	0.27	0.72**	0.41**	0.46**	0.19	1.00	0.39*	0.27	-0.45**	0.17	0.19
main shoot	E_2	-0.05	-0.06	0.10	0.38**	0.15	0.29*	0.45**	1.00	0.12	0.50**	-0.09	0.45**	0.21
Siliqua length (cm)	E_1	-0.17	-0.15	0.01	-0.22	-0.23	-0.28	0.30*	-0.26	1.00	0.28*	0.42**	0.31*	-0.11
	E_2	-0.31*	-0.29*	-0.01	-0.22	-0.01	-0.29*	0.35*	0.10	1.00	0.35**	0.47**	-0.15	0.05
No. of seeds/siliqua	E_1	-0.24	-0.25	0.17	0.14	0.25	0.23	0.20	0.14	0.23	1.00	0.13	0.51**	0.05
	E_2	-0.12	-0.14	0.06	0.20	0.30	0.16	0.18	0.32*	0.32*	1.00	0.20	0.12	0.33*
1000- seed weight (g)	E_1	0.39	-0.38**	-0.16	-0.40**	-0.21	-0.26	0.14	0.32*	0.39**	0.10	1.00	0.32*	-0.02
	E_2	-0.28	-0.28	0.01	-0.42**	-0.22	-0.30	0.22	-0.03	0.42**	0.19	1.00	-0.28*	0.22
Seed yield / plant (g)	E_1	-0.43**	-0.42**	0.17	-0.06	0.05	-0.08	0.10	0.12	-0.01	0.39**	0.29**	1.00	0.23
	E_2	0.03	0.05	0.10	0.24	0.04	0.17	0.30	0.28*	-0.10	-0.01	-0.01	1.00	0.15
Oil Content %		-0.27	-0.25	0.17	0.21	0.21	0.13	-0.07	0.15	-0.09	0.07	-0.02	0.16	1.00
		0.23	-0.22	-0.05	0.05	-0.01	0.08	0.03	0.15	0.02	0.27	0.19	0.06	1.00

*, ** P = 0.05 and 0.01, respectively

Table 3: **Direct (diagonal) and indirect (off diagonal) effects of different yield components and oil content at genotypic level on seed yield in Indian mustard under normal sown (E_1) and late sown environments (E_2)**

Character	Environment	Days to 1st Flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches /plant	No. of secondary branches /plant	Main shoot length (cm)	No. of siliquae on main shoot	Siliqua length (cm)	No. of seeds / siliqua	1000 -seed weight (g)	Oil content (%)	rG
Days to 1st flowering	E_1	**-1.57**	1.68	0.04	-0.20	-0.01	-0.79	-0.13	-0.01	0.06	-0.01	-0.09	-0.07	-0.51
	E_2	**-16.21**	16.64	-0.29	-0.18	-0.04	0.06	-0.23	-0.01	0.55	-0.01	-0.11	-0.21	-0.04
Days to 50% flowering	E_1	-1.57	**1.69**	0.04	-0.21	-0.01	-0.07	-0.13	-0.02	0.06	-0.15	-0.09	-0.06	-0.54**
	E_2	-16.15	**16.71**	-0.31	-0.21	-0.05	0.06	-0.24	-0.01	0.50	-0.01	-0.11	-0.25	-0.07
Days to maturity	E_1	-0.45	0.52	**0.14**	-0.44	-0.02	-0.12	-0.02	0.43	-0.01	0.14	-0.04	0.04	0.18
	E_2	-6.05	6.72	**-0.78**	-0.15	0.09	0.07	-0.24	0.06	0.01	0.00	-0.00	-0.06	0.13
Plant height (cm)	E_1	-0.32	0.36	0.06	**-0.98**	-0.03	-0.24	-0.09	1.01	0.10	0.08	-0.10	0.07	-0.08
	E_2	-2.22	2.63	-0.09	**-1.34**	0.99	0.17	-0.22	0.08	0.44	0.01	-0.16	0.03	0.38**
No. of primary	E_1	-0.09	0.11	0.07	-0.82	**-0.04**	-0.31	-0.13	0.97	0.10	0.17	-0.07	0.08	0.05
branches/plant	E_2	0.58	-0.68	-0.05	-1.30	**1.30**	0.15	-0.31	0.05	0.05	0.01	-0.10	0.03	0.25
No of secondary	E_1	-0.41	0.41	0.05	-0.79	-0.79	**-0.04**	-0.16	0.88	0.18	0.01	-0.11	0.04	-0.06
branches/plant	E_2	-4.44	4.34	-0.23	-0.99	-0.99	**0.82**	0.08	0.07	0.54	0.01	-0.12	0.07	0.23
Main shoot length (cm)	E_1	1.01	-1.15	-0.02	0.46	0.46	0.02	**0.20**	-0.47	-0.28	0.19	0.07	-0.03	0.29*
	E_2	2.74	-3.04	-0.14	-0.55	-0.55	-0.29	**1.36**	0.10	-0.67	0.01	0.08	0.01	0.35*
No. of siliquae on	E_1	0.01	-0.04	0.05	-0.87	-0.87	-0.03	-0.08	1.15	0.13	0.13	-0.09	0.05	0.17
main shoot	E_2	0.28	-0.31	-0.23	0.22	0.32	0.08	0.65	0.21	-0.19	0.02	-0.03	0.17	0.45**
Siliqua length (cm)	E_1	0.29	-0.32	0.00	0.28	0.01	0.16	0.16	-0.45	**-0.34**	0.14	0.09	-0.03	0.32*
	E_2	5.72	-5.40	0.01	0.38	-0.04	-0.08	0.59	0.02	**-1.56**	0.01	0.15	0.04	-0.15
No. of Seeds/siliqua	E_1	0.46	-0.52	0.04	-0.17	-0.01	-0.10	0.07	0.31	-0.10	**0.50**	0.02	0.01	0.53
	E_2	2.35	-2.94	-0.01	-0.27	-0.57	0.05	0.32	0.10	-0.55	**0.04**	0.06	0.28	0.12
1000- seed weight (g)	E_1	0.66	-0.71	-0.03	0.49	0.01	0.16	0.06	-0.57	-0.14	0.06	**0.21**	-0.01	0.26
	E_2	5.51	-5.81	0.01	0.69	-0.43	-0.09	0.35	-0.02	-0.73	0.01	**0.32**	0.18	0.28
Oil Content %	E_1	0.43	-0.43	0.02	-0.26	-0.01	-0.05	-023	0.24	0.04	0.02	-0.01	**0.26**	0.23
	E_2	4.18	-5.02	0.06	-0.05	0.06	0.02	0.01	0.04	-0.08	0.01	0.07	**0.84**	0.15

E_1 Residual effect= 0.346, E_2 Residual effect= 0.112

and Marjanovic *et. al*. (2007). Maximum indirect positive effects were exhibited by days to 50% flowering and siliquae length in E_1 and by days to 50% flowering in E2 which indicated that these characters should also be taken care of while selecting plants for higher seed yield.

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