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Research Note

Correlation and path analysis in F_2, F_3 and biparent crosses of mustard

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Abstract
The genetic study of F_2 crosses in mustard was undertaken with a view to identify the potential F_2 crosses for their use in individual plants selection. Three F_2 crosses were C-I (Varuna X RH-819), C-II (Ashirwad X RH-819) and C-III (ACN-9 X Geeta) raised during *rabi* 2012-13 and data were recorded on six characters i.e. days to first flower, days to maturity, plant height, number of primary branches per plant, number of siliqua per plant and seed yield per plant. The correlation studies at genotypic level revealed positive significant association of seed yield per plant with number of siliqua per plant and with number of primary branches per plant in all the crosses studied and with plant height in some cases. The study on path analysis indicated the significance of number of siliqua per plant and number of primary branches per plant as the promising characters to increase seed yield per plant either directly or indirectly.
Key words:
Mustard, Correlation co-efficient, Path co-efficient analysis

Indian mustard (*Brassica juncea*) called as 'rai', 'raya' or 'laha' is an important oil seed crop belonging to *Brassicae* group. The important breeding programme in mustard is oriented to develop new varieties with high yield potential, wider adaptability, disease resistance and high oil content. Selection based on multiple traits is always better than selection based on yield alone. As we know that yield is a quantitative character controlled by many genes, therefore an adequate knowledge about the magnitude and degree of association of yield with its attributing characters is of great significance to the breeders, through which they can clearly understand the strength of correlated traits, when they have to exercise selection for simultaneous improvement of more than one character.

Success of selection in plant breeding also depends on the choice of initial genetic variation, which may result in high expected genetic gain. Unless the amount of genetic gain is measured as per cent of mean and is substantial, the heritability alone cannot depict the possible improvement of a character achievable through selection. In addition to all these, genetic recombinations may be measured phenotypically through an alteration in relationship among quantitative characters. It is well established that, intermating in early segregating generations cause shifts in the genetic correlations in self-pollinated crops (Yunus and Paroda, 1982). Hence, correlation co-efficient has been the most frequently used statistical tool to identify these changes due to biparental mating. Further, in a breeding programme, selection based on the knowledge and the direction of association between yield and its attributes is very useful in identifying key characters, which can be exploited to achieve maximum improvement in yield.

The experiment comprising of F_2, F_3 and BIP generations in three crosses i.e C-I (Varuna X RH-819), C-II (Ashirwad X RH-819) and C-III (ACN-9 X Geeta) of mustard was conducted with the objective , to asses inter-relationships and path co-efficients during *rabi* 2012-13 in randomized complete block design with two replications. Each replication consisted of 15 rows for F_2, 10 rows of F_3 and BIP generations in each cross. The observations were recorded on 250 plants from F_2, 100 plants from F_3 and BIP generations in each cross for the following six characters. i.e. days to first flower, days to maturity, plant height (cm), number of primary branches per plant, number of siliqua per plant and seed yield per plant. The data recorded were subjected to the statistical and biometrical analysis. Correlation coefficients between yield and yield contributing characters were estimated as per the procedure suggested by Sharma (1998) and path co-efficient analysis was carried out using the simple correlation co-efficient to know the direct and indirect effects of the yield components on seed yield as suggested by Wright (1921) and illustrated by Dewey and Lu (1959).

The knowledge of interrelationship of plant characters with seed yield and among themselves also help the breeders in improvement of a complex character like seed yield for which direct selection is not much effective. Recombination in segregating generation leads to formation of new pattern of association of linked characters, hence the genotypic correlation co-efficient of different characters with seed yield per plant were estimated and presented in Table 1.

While reviewing, the studies on correlation, it was observed that strength and direction of correlation in different character combination depends on the nature of the experimental material and environmental condition in which they have been studied. The correlation studies at genotypic level carried out in F_2, F_3 and BIP in the existing agroclimatic situation of Nagpur revealed positive significant association of seed yield per plant with number of siliqua per plant in all the generations and all the crosses studied and with number of primary branches per plant in all the crosses and in all the generations except BIP of C-I and C-II. Plant height was also associated with seed yield per plant in some cases. This indicates that an increase in any one of these three characters especially number of siliqua per plant and number of primary branches per plant can result in increase in the seed yield of mustard. Hence, it is stressed that more emphasis should be given for number of siliqua per plant and number of primary branches per plant as they showed very high degree of positive association with seed yield per plant. Similar results of positive significant correlation of number of siliqua per plant, number of primary branches per plant with seed yield per plant were also reported by Patel *et al*. (2000), Badsra and Choudhary (2001), Mahla *et al*. (2003) and Kardam and Singh (2005) in mustard.

Correlation studies indicates association pattern of the different component traits with seed yield per plant. It simply represents the overall influence of particular trait on target traits without revealing the cause and effect relationship. The knowledge of direct and indirect influence of yield contributing characters is of prime importance in selecting high yielding genotypes. Path coefficient analysis indicates only the manual association of various contributing characters with seed yield per plant. The combination of characters for path coefficient analysis was chosen based on two criteria (I) The magnitude of correlation coefficients of different characters with seed yield plant and (II) the residual factor. In order to obtain developmental relations, the cause and effect relationship between yield and yield contributing parameters were studied in mustard through path co-efficient analysis. The results on the estimates of direct and indirect effect of different characters on seed yield per plant are presented crosswise.

Path analysis studies carried out in F_2, F_3 and BIP of three crosses (Table 2, Table 3 and Table 4) revealed that seed yield per plant was highly influenced by number of siliqua per plant followed by number of primary branches per plant in all the crosses and their contribution was more in BIP and F_3 than F_2 in C-I and C-III, whereas in C-II, BIP and F_3 negative direct effect was recorded by number of per siliqua plant. However number of siliqua per plant had contributed to seed yield per plant in these cases indirectly through number of primary branches per plant and plant height. Similar to this results direct effect of number of siliqua per plant on seed yield was also reported by Patel *et al*. (2000), Badsra and Choudhary (2001), Singh (2004), Kardam and Singh (2005) in mustard. Number of primary branches per plant was found to be the next significant character contributing towards seed yield per plant which had changed its direction from positive to negative direct effect from one generation to another i.e it was positive in case of F_2 of all the three crosses and has become negative in F_3 and BIP in one or the other cross. The varying magnitude of direct and indirect effect of characters towards seed yield per plant were observed in this study. Such varying magnitude of direct and indirect effect was also recorded by Gangappa. (2001), Naik *et al*. (2009). This study on path analysis indicated the significance number of siliqua per plant and number of primary branches per plant as the promising characters to increase seed yield per plant either directly or indirectly.

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Table 1. Simple correlation coefficient for different characters with seed yield per plant

Characters	C-I			C-II			C-III		
	F_2	F_3	BIP	F_2	F_3	BIP	F_2	F_3	BIP
Days to first flower	- 0.1321	- 0.05287	- 0.2969**	0.1861*	- 0.9230**	0.4375**	- 0.0193	- 0.1404	- 0.0139
Days to maturity	- 0.7654**	0.05243	0.3405**	0.0753	- 0.1307	- 0.1992	0.1629**	0.3694**	0.4829**
Plant height	- 0.9855**	0.7922**	- 0.0055	0.9136**	0.9278**	0.9916**	0.9798**	- 0.8805**	- 0.8121**
Number of primary branches per plant	0.9138**	0.9918**	- 0.1022	0.9938**	0.7554**	0.1309	0.9456**	0.9093**	0.9882**
Number of siliqua per plant	0.9998**	0.9510**	0.7489**	0.9811**	0.9999**	0.9527**	0.9999**	0.8746**	0.9335**

, * = significant at 5% and 1% level respectively.

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Table 2. Estimates of direct and indirect effects of different traits on seed yield plant^{-1} in F_2, F_3 and BIP of C-I.

C- I	Characters	Simple correlation	Direct effect	% Direct effect	Total indirect effect	% Indirect effect	Major contributing characters with their percentage
F_2	Days to first flower	- 0.1321	- 0.2463	186.45	0.1142	- 86.45	-
	Days to maturity	- 0.7654**	- 0.5361	70.04	- 0.2292	29.95	Number of primary branches plant^{-1}(43.96), Number of siliqua plant^{-1} (36.51)
	Plant height	- 0.9855**	- 0.7379	74.87	- 0.2475	25.12	Number of siliqua plant^{-1} (27.98), Number of primary branches plant^{-1}(21.94)
	Number of primary branches plant^{-1}	0.9138**	0.3699	40.48	0.5439	59.51	Days to maturity (53.36), Plant height(47.21)
	Number of siliqua plant^{-1}	0.9998**	0.3692	36.92	0.6306	63.07	Plant height (55.12), Days to maturity (40.59)
F_3	Days to first flower	- 0.0528	0.2263	- 428.07	- 0.2792	528.07	Plant height (272.35), Number of siliqua plant^{-1} (157.48), Days to maturity (71.61), Number of primary branches plant^{-1}(26.56)
	Days to maturity	0.0524	0.1807	344.65	- 0.1282	- 244.65	-
	Plant height	0.7922	- 0.4661	- 58.83	1.2583	158.83	Number of siliqua plant^{-1} (132.10), Number of primary branches plant^{-1}(11.50)
	Number of primary branches plant^{-1}	0.9918**	- 0.0932	- 9.40	1.0851	109.40	Number of siliqua plant^{-1} (55.23), Plant height (45.91)
	Number of siliqua plant^{-1}	0.9510**	1.3532	142.29	- 0.4022	- 42.29	-
BIP	Days to first flower	- 0.2969**	- 0.4691	157.96	0.1721	- 57.96	-
	Days to maturity	0.3405**	- 0.4375	- 128.46	- 0.0969	- 28.46	-
	Plant height	- 0.0055	0.5355	9592.71	0.5299	- 9492.71	-
	Number of primary branches plant^{-1}	- 0.1022	0.1939	- 189.58	- 0.2961	289.58	Plant height (164.48), Days to maturity (147.20), Days to first flower (42.71)
	Number of siliqua plant^{-1}	0.7489**	0.7533	100.58	- 0.0044	- 0.58	-

Table 3. Estimates of direct and indirect effect of different traits on seed yield plant^{-1} in F_2, F_3 and BIP of C- II.

C-II	Characters	Simple correlation	Direct effect	% direct effect	Total indirect effect	% indiret effect	Major contributing characters with their percentage
F_2	Days to first flower	0.1861*	- 0.0141	- 7.57	0.2002	107.57	Number of primary branches plant^{-1} (58.58), Number of siliqua plant^{-1} (46.57), Days to maturity(13.09)
	Days to maturity	0.0753	- 0.0365	- 48.48	0.1119	148.48	Number of primary branches plant^{-I}(102.72), Number of siliqua plant^{-1} (48.53), Days to first flower(12.47)
	Plant height	0.9136**	- 0.1256	- 13.75	1.0393	113.75	Number of primary branches plant^{-1} (65.01), Number of siliqua plant^{-1} (49.34)
	Number of primary branches plant^{-1}	0.9938**	0.6633	66.73	0.3305	33.26	Number of siliqua plant^{-1} (45.24)
	Number of siliqua plant^{-1}	0.9811**	0.4508	45.95	0.5302	54.04	Number of primary branches plant^{-1} 67.43)
F_3	Days to first flower	- 0.9230**	- 0.7130	77.24	- 0.2100	22.75	Plant height (63.35), Number of primary branches plant^{-1} (15.85)
	Days to maturity	- 0.1307	0.0851	- 65.12	- 0.2159	165.12	Days to first flower (170.18), Plant height (37.91), Number of primary branches plant^{-1} (11.39)
	Plant height	0.9278**	0.6953	74.94	0.2324	25.05	Days to first flower (64.62), Number of primary branches plant^{-1} (18.81)
	Number of primary branches plant^{-1}	0.7554**	0.2077	27.50	0.5476	72.49	Plant height (77.35), Days to first flower (66.47)
	Number of siliqua plant^{-1}	0.9999**	- 0.5391	- 53.91	1.5391	153.91	Plant height (69.10), Days to first flower (65.40), Number of primary branches plant^{-1} (20.53)
BIP	Days to first flower	0.4375**	0.1899	43.41	0.2475	56.58	Plant height (1121.25), Number of primary branches plant^{-1} (30.98)
	Days to maturity	- 0.1992	1.2195	- 612.18	- 1.4187	712.18	Plant height (1959.14), Number of primary branches plant^{-1} (46.56), Days to first flower (44.46)
	Plant height	0.9916**	10.703	1079.33	- 9.7115	- 979.33	-
	Number of primary branches plant^{-1}	0.1309	0.2869	219.15	- 0.1560	- 199.15	-
	Number of siliqua plant^{-1}	0.9527**	- 9.6877	- 1016.80	10.640	1116.80	Plant height (1114.22), Number of primary branches per plant (29.10)

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Table 4. Estimates of direct and indirect effect of different traits on seed yield plant^{-1} in F_2, F_3 and BIP of C-III.

C-III	Character	Simple correlation	Direct effect	% Direct effect	Total indirect effect	% Indirect effect	Major contributing characters with their percentage
F_2	Days to first flower	- 0.0193	0.0373	- 192.68	- 0.0567	292.68	Number of primary branches plant^{-1} (202.83) Plant height (79.19)
	Days to maturity	0.1629**	- 0.0138	-8.49	0.1767	108.49	Plant height (61.83), Number of primary branches plant^{-1} (28.89), Number of siliqua plant^{-1}(17.62)
	Plant height	0.9798**	0.5780	58.99	0.4017	41.00	Number of primary branches plant^{-1} (24.04) Number of siliqua plant^{-1} (18.28)
	Number of primary branches plant^{-1}	0.9456**	0.2630	27.81	0.6826	72.18	Number of primary branches plant^{-1} (27.81) Number of siliqua plant^{-1}(17.30)
	Number of siliqua plant^{-1}	0.9999**	0.1730	17.30	0.8269	82.69	Plant height (56.67) Number of primary branches plant^{-1} (26.29)
F_3	Days to first flower	- 0.1407	- 1.1244	800.81	0.9840	- 700.81	-
	Days to maturity	-0.3694**	- 1.5112	409.02	1.1417	- 309.03	-
	Plant height	-0.8804**	- 0.3355	38.11	- 0.5449	61.88	Number of primary branches plant^{-1} (103.80) Days to maturity (46.83) Number of siliqua plant^{-1}(29.58)
	Number of primary branches plant^{-1}	0.9093**	1.2032	132.32	- 0.2939	- 32.32	-
	Number of siliqua plant^{-1}	0.8746**	0.2678	30.62	0.6067	69.37	Days to first flower (94.81), Days to maturity (72.24), Plant height (37.30)
BIP	Days to first flower	- 0.0139	0.0068	- 49.24	- 0.0207	149.24	Number of siliqua plant^{-1}(201.70)
	Days to maturity	0.4829**	0.1313	27.18	0.3516	72.81	Number of siliqua plant^{-1}(113.47)
	Plant height	-0.8121**	0.0952	- 11.72	- 0.9073	111.72	Number of siliqua plant^{-1}(201.70)
	Number of primary branches plant^{-1}	0.9882**	- 0.1005	- 10.17	1.0887	110.17	Number of siliqua plant^{-1}(105.19) Days to maturity (13.22)
	Number of siliqua plant^{-1}	0.9335**	1.0533	112.83	- 0.1198	- 12.83	-