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Correlation and path coefficient analysis for yields contributing parameters in indian mustard [*brassica juncea (l.*) Czern & coss.]

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ABSTRACT

Four diverse genotypes of Indian mustard (*Brassica juncea* L. Czern & Coss.) and their crosses with Ogura restorer as the background were evaluated for eleven quantitative traits during winter (Rabi) 2011–12. The mean, range, phenotypic, genotypic and environmental variance, genotypic and phenotypic coefficient of variation, heritability in broad sense and genetic advance were calculated to differentiate the contribution made by each parameter in the final seed yield. The maximum value of phenotypic coefficient of variation was observed for no. of pods on main branch (36.23) followed by oil content (31.65), siliqua density on main shoot (30.72) and the highest genotypic coefficient of variation was observed for number of pods on main branch (33.49) followed by seed yield per plant (29.18) followed by oil content (28.89). Path coefficient analysis revealed that no. of pods on main branch (5.94) had the highest direct contribution towards seed yield per plant followed by 1000-seed weight (4.14) and siliqua density on main shoot (1.82) which suggested that selection for these traits would be quite effective in improving seed yield in Indian mustard. During the course of investigations, it was observed that the mean performance of F_1's (OR x RH 406 and OR x RH 832) was better than parental genotypes for no. of primary and secondary branches, no. of seeds per siliqua and seed yield per plant.

Keywords: Brassica juncea, genetic advance, genetic variability, heritability, path analysis.

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INTRODUCTION

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is one of the most important oilseed crops of the country, and it occupies considerably large acerage among the *Brassica* group of oil seed crops At global level, rapeseed-mustard crops are grown in 53 countries spreading over the 6 continents, covering an area of 22.33 million hectare with on average production of 33.17 million tonnes and an average yield of 1468 kg/hectare ranging from 333 kg/hectare (Tazikistan) to 6667 kg/hectare (Algeria)(1).The contribution of rapeseed-mustard to the total oilseed acreage and production in India was 23.7% and 26% respectively during the year 2012-13. In India, it is predominantly cultivated in Rajasthan, U.P., M.P., Haryana, Gujarat, West Bengal, Assam and Bihar states. The yield of rapeseed-mustard was 1176 kg/ha as compared to 955 kg/ha of total oilseeds (2). Indian mustard [*Brassica juncea* (L.) Czern & Coss.] accounts for about 80 % of the 6.3 m ha area under rapeseed-mustard crops in the country. *Per capita* consumption of edible oil is likely to reach 23-43 kg by 2030 from the present level of 13.4 kg (2).

In recent years, the country produced lesser than that of our national requirement. This gap is increasing day by day as the breeding approaches for Indian mustard improvement remained confined to selection and recombination followed by selection (3). To address this challenge for a better breeding program, it should have a broad genetic base. Among CMS types of *Brassicaceae*, the CMS discovered by Ogura (1968), which is now popularly referred to by his name, has been studied most extensively and is used worldwide in F_1 breeding of *B. napus*, *B. juncea*, *B. oleracea* and *R. sativus* (4). The success of any breeding program depends upon the genetic variability engraved in the breeding material. The assessment of parameters including phenotypic and genotypic coefficients of variation, heritability in a broad sense, and genetic advance as a % of the mean is a pre-requisite for making effective selection. The existing genetic base, is not enough to meet the challenge. Yield is a complex trait, polygenic in inheritance, more prone to environmental fluctuations than ancillary traits such as branches/ plant, seeds/siliqua, main shoot length, and 1000-seed weight. Understanding the association between yield and its components is of paramount importance of making the best use of these relationships in selection (5). The path coefficient analysis helps breeders to explain direct and indirect effects, and hence been extensively used in breeding experiments in different crop species(6). The present investigation was undertaken to assess the genetic variability, trait association, and path coefficient analysis in Indian mustard and their crosses with Ogura restorer as background.

MATERIALS AND METHOD

In the present study field experiment was conducted during the year 2012-2013 in the area of oilseed section of Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, situated at latitude of $29^0$10'N, longitude of $75^0$46'E and altitude of 215.2 m above sea level in semi-tropical region of western zone of India.

Plant materials

The plant material used in present investigation comprised of *B. juncea* genotypes RH 406, RH 555, RH 749 and RH 832. In addition, crosses were attempted to get F_1 using Ogura restorer line as a female parent with the four genotypes**.**

S. No.	Crosses
1	Ogura restorer x RH 406
2	Ogura restorer x RH 555
3	Ogura restorer x RH 749
4	Ogura restorer x RH 832

Flower buds and seeds of above parents and F_1's were used for another culture and regeneration experiments.

Layout of field experiment

Above parents and F_1's were sown in randomized block design in three replications with a plot size of 2 rows of 3 m length at the research area of the Oilseeds Section. All the recommended packages and practices were followed to raise a good crop to evaluate parents and F_1's. The observations were recorded on five randomly selected plants for eleven traits, Characters studied were Plant height (cm), No. primary branches per plant, No. secondary branches per plant, Main shoot length (cm), Number of siliquae on main shoot, Siliqua density on main shoot, Siliqua length (cm), Number of seeds per siliqua, 1000- seed weight (g) , Seed yield per plant (g) and Oil content (%). The phenotypic and genotypic coefficients of variation (GCV and PCV), heritability in a broad sense, genetic advance as % of mean, correlation coefficients at genotypic and phenotypic level, and path coefficient analysis computed using standard statistical methods.

RESULTS AND DISCUSSION

Wide range of variation was observed for most of the traits significant for the yield, its component traits and oil content studied in the present investigation except pod length and no. of seeds per siliqua (Table 1). This revealed that there was a considerable magnitude of variability among the different genotypes of *Brassica juncea* for all the traits except for pod length and no. of seeds per siliqua. Similar findings were reported by Synrem (7) that analysis of variance showed significant differences among the crosses for all characters under study except for length of siliqua. The high amount of genetic variability in the evaluated genotypes for the major yield contributing characters along with oil content indicated that further improvement of these traits is possible. Yadava reported similar findings pertaining to the presence of high genetic variability for different traits including seed yield/plant(8).

The assessment of heritable and non-heritable components in the total variability observed is indispensable in adapting suitable breeding procedures. The heritable portion of the overall observed variation can be ascertained by studying the components of variation such as GCV, PCV, heritability and predicted genetic advance.

In the present investigation high GCV was recorded for no. of pods on main branch, Moderate GCV was recorded for seed yield per plant, oil content, no. of secondary branches per plant, siliqua density on main shoot, 1000-seed weight, main shoot length and Pod length. Low GCV was recorded for no. of primary branches per plant, plant height and no. of seeds per siliqua (Table 2). Low PCV was recorded for plant height and no. of seeds per siliqua but it was moderate in 1000-seed weight, Pod length and no. of primary branches per plant. Highest PCV was observed for no. of pods on main branch followed by oil content, seed yield per plant, siliqua denity on main shoot, no. of secondary branches and main shoot length. This indicated that still there is the possibility of improvement of genotypes through these characters. It is interesting to note that PCV was more than GCV for all the traits studied.

The coefficient of variation doesn’t offer the full scope of heritable variation. It can be determined with greater degree of accuracy when heritability in conjunction with genetic advance is studied. This could be ascertained from heritability estimates, which include both additive and non-additive gene effects. Hence, heritability and genetic advance are important parameters to study the scope of improvement in various characters through selection. High heritability was recorded for seed yield per plant followed by 1000-seed weight, pod length, no. of pods on main branch, oil content and main shoot length. High heritability for 1000-seed weight has also been reported earlier also. (9,10) It was moderate for no. of secondary branches, plant height and siliqua density on main shoot, low for no. of primary branches and no. of seeds per siliqua. The characters with high heritability are inherited precisely and are important and more reliable for selection on the basis of phenotypic performance more reliably and could attain quick improvement within short period.(11)

The high genetic advance was observed for no. of pods on main branch, seed yield per plant and oil content. Moderate genetic advance was observed for no. of secondary branches, 1000-seed weight, main shoot length, siliqua density on main shoot and pod length. High heritability associated with high genetic advance, revealed that variation was mostly due to additive gene effects. In the present study low genetic advance was observed in no. of primary branches, plant height and no. of seeds per siliqua suggesting further improvement of genotypes for these characters though further selection would be limited until and unless new recombinations are fostered. In the present study, high heritability coupled with high genetic advance was observed for no. of pods on main branch, seed yield per plant and oil content. High value of heritability and moderate genetic advance was observed for 1000 seed weight, pod length, and main shoot length indicating that improvement in these traits could be done through selection to some extent. High heritability with high genetic advance for seed yield/plant has also been reported by Singh(2) and Kumar and Misra(12) indicating that improvement in these traits could be made by simple selection. Panse and Sukhatme(13) expressed high heritability together with high genetic advance were an indicative of additive gene effects, and high heritability associated with low genetic advance was an indication of dominance and epistatic effects. High heritability associated with low genetic advance was indication of dominance and epistatic effects. The results of present investigations are in conformity with those obtained by Singh(14); Yadava(8) and Thakral(15) in Indian mustard.

The phenotypic correlation coefficients were higher in magnitude than their respective genotypic correlation coefficients for most of the traits indicating the environmental influence on phenotypic expression. Higher estimates of phenotypic coefficient of variation (PCV) than genotypic coefficient of variation (GCV) for all the traits reflected the influence of environmental factor on these traits, similar observations were recorded by Singh(16) and Synrem(7) that maximum and minimum differences between GCV and PCV were observed for days to maturity and number of primary branches indicating the influence of environment for these traits, respectively.

Seed yield, the end products of interactions of many factors, is known to be a complex trait. It is determined by several interwoven and mutually exclusive traits. Correlation studies provide information on the nature and extent of association between any two pairs of metric characters. Moreover, an understanding of the interaction of characters among themselves and with the environment has been of great use in enhancing the performance of a genotype. No. of primary branches (0.49^{**}) and no. of secondary branches (0.41^{*}) exhibited a positive correlation with seed yield per plant and negative correlation with main shoot length (-0.62^{**}) and pod length (-0.51^{**}) (Table 3). Oil content exhibited positive correlation with main shoot length and no. of pods on main branch and negative correlation with plant height and 1000 seed weight. Similar results were also obtained by Somu(17) and Srivastava and Singh(18). Correlation between different characters of plant could arise due to linkage, pleiotropy and developmentally influenced relationships. In the present investigation in general, the genotypic correlation coefficient values were higher than the phenotypic values as earlier reported by Subhashchandra *et al*.(19) Riaz-Ud-din *et al*.(20) and Iftikhar *et al.*(21). This indicated that strong intrinsic and inherent associations were somewhat masked at phenotypic level due to environmental effects.

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

Table 1: Mean Squares for various traits in different genotypes of Indian mustard

Source of variation	DF	Mean Squares										
		Plant height (cm)	No. of primary branches	No. of secondary branches	Main shoot length (cm)	No. of pods on main branch	Pod length (cm)	No. of seeds/siliqua	1000-seed weight (g)	Siliqua density on main shoot	Seed yield per plant (g)	Oil conten (%)
Replication	2	5.017	0.51	2.52	54.95	12.15	0.03	0.17	0.90	1.50	0.50	5.45
Genotypes	8	686.22**	2.21*	39.17**	662.51**	543.13**	0.71	1.82	3.29*	7.80**	19.61**	115.19*
Error	26	96.44	0.88	3.32	55.11	29.14	0.13	0.06	2.08	0.22	0.81	11.03

***, ** significant at P=0.05 and 0.01, respectively.**

Table 2: Estimates of mean performance, range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance (GA) in different genotypes of Indian mustard

Traits	Mean ± S.E (m)	Range	GCV (%)	PCV (%)	h^2(bs) (%)	GA as % of mean
Plant height (cm)	212.73 ± 8.04	181.11-233.00	6.63	8.09	67.21	11.20
No. of primary branches per plant	6.43 ± 0.76	5.56-8.33	10.36	17.89	33.56	12.37
No. of secondary branches per plant	13.58 ± 1.48	6.22-19.34	25.45	28.77	78.23	46.37
Main shoot length (cm)	65.41 ± 6.06	45-87.55	21.75	24.53	83.31	39.73
No. of pods on main branch	39.07 ± 4.40	24.44-65.11	33.49	36.23	85.46	63.79
Pod length (cm)	4.50 ± 0.19	3.61- 5.83	17.09	17.90	91.08	33.59
No. of seeds/siliqua	13.36 ± 1.17	11.78-14.78	4.764	11.81	16.27	3.95
1000-seed weight (g)	7.04 ± 0.38	3.95-10.31	22.59	23.54	92.12	44.68
Siliqua density on main shoot	1.84 ± 0.29	1.27-2.83	23.85	30.72	60.25	38.14
Seed yield per plant (g)	12.47 ± 0.9	9.51-16.48	29.18	30.38	92.27	57.75
Oil content (%)	23.16 ± 2.44	18-39.83	28.89	31.65	83.31	54.32

Table 3: Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients of parents and their F1 crosses for seed yield and yield components in Indian mustard

	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	Main shoot length (cm)	No. of pods on main branch	Pod length (cm)	No. of seeds/ siliqua	1000-seed weight (g)	Siliqua density on main shoot	Seed yield per plant (g)	Oil content (%)
Plant height (cm)		-0.05	-0.37*	-0.35	-0.29	0.27	-0.48**	0.34	-0.01	0.17	-0.65**

No. of primary branches per plant	-0.35		0.58**	-0.35	-0.14	-0.40*	-0.08	-0.27	-0.13	0.28	-0.21
No. of secondary branches per plant	-0.49**	0.67**		-0.25	-0.24	-0.71**	-0.20	-0.27	0.16	0.35	0.15
Main shoot length (cm)	-0.54**	-0.66**	-0.44*		0.62**	0.44*	0.17	0.11	0.15	-0.52**	0.52**
No. of pods on main branch	-0.55**	-0.15	-0.25	0.68**		-0.01	0.21	-0.58**	-0.65**	-0.24	0.62**
Pod length (cm)	0.39*	-0.59**	-0.76**	0.58**	0.03		0.12	0.68**	0.27	-0.46*	-0.23
No. of seeds/siliqua	-0.56**	0.16	-0.45*	0.66**	1.01**	0.03		-0.14	-0.19	-0.07	0.22
1000-seed weight (g)	0.47**	-0.44*	-0.35	0.10	-0.60**	0.76**	-0.53**		0.73**	-0.06	-0.46*
Siliqua density on main shoot	0.11	-0.50**	0.04	0.08	-0.73**	0.45*	-0.72**	0.83**		-0.18	-0.20
Seed yield per plant (g)	0.19	0.49**	0.41*	-0.62**	-0.28	-0.51**	-0.32	-0.06	-0.23		-0.24
Oil content (%)	-0.68**	-0.34	0.15	0.64**	0.79**	-0.28	0.19	-0.54**	-0.34	-0.29	

***, **Significance at 5% and 1% levels of respectively.**

Table 4: Path coefficients of different seed yield and yield contributing characters in Indian mustard.

	Plant height (cm)	No. of No. of primary branches per plant	No. of secondary branches per plant	Main shoot length (cm)	No. of pods on main branch	Pod length (cm)	No. of seeds/siliqua	1000-Seed weight (g)	Siliqua density on main shoot	Oil content (%)	Total correlation to seed yield per plant (g)
Plant height (cm)	**0.14**	0.02	-0.28	2.62	-3.24	-0.48	-0.37	1.96	0.19	-0.36	0.20
No. of primary branches per plant	-0.05	**-0.04**	0.39	3.20	-0.89	0.72	0.11	-1.84	-0.92	-0.18	0.50
No. of secondary branches per plant	-0.07	-0.03	**0.58**	2.14	-1.52	0.92	-0.30	-1.46	0.07	0.08	0.42
Main shoot length (cm)	-0.08	0.03	-0.26	**-4.85**	4.03	-0.70	0.44	0.41	0.01	0.34	-0.62
No. of pods on main branch	-0.08	0.01	-0.15	-3.29	**5.94**	-0.01	0.67	-2.47	-1.32	0.41	-0.29
Pod length (cm)	0.06	0.03	-0.44	-2.81	0.03	**-1.21**	0.02	3.17	0.81	-0.15	-0.51
No. of Seeds/Siliqua	-0.08	-0.01	-0.26	-3.23	6.02	-0.03	**0.66**	-2.19	-1.31	0.10	-0.32
1000-Seed weight (g)	0.07	0.02	-0.20	-0.48	-3.55	-0.93	-0.35	**4.14**	1.51	-0.28	-0.06
Siliqua density on main shoot	0.01	0.02	0.02	-0.04	-4.32	-0.54	-0.47	3.45	**1.82**	-0.18	-0.23
Oil content (%)	-0.10	0.01	0.09	-3.13	4.70	0.35	0.13	-2.25	-0.61	**0.52**	-0.29

Residual effect -0.13

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. It can discriminate between the real (genetic effects) and inflated (environmental effects) correlations. Low residual effect (-0.13) in path coefficient analysis indicated a high contribution of independent traits to the dependent trait (grain yield) as shown in table 4. Among the traits studied, no. of pods on main branch (5.94) exhibited highest positive direct effect on yield followed by 1000-seed weight (4.14), siliqua density on main shoot (1.82), no. of seeds per siliqua (0.66), no. of secondary branches (0.58), oil content (0.52) and plant height (0.14) exhibited positive direct effect on yield. So, direct selection of genotypes for grain yield through these traits may be effective. Such positive association of seed yield/ plant with secondary branches/ plant, number of seeds/ siliqua was also observed by Singh(14) However, seed yield negatively and significantly correlated with oil content was reported by Thakral(15). The variation in the findings of different studies could be ascribed to differences in the environment, and also due to different material used. 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 program for improvement of seed yield.

CONCLUSION

All the genotypes and their F_1's were evaluated for yield, its component traits and oil contents. ANOVA indicated that mean sum of squares due to genotypes were significant for the traits studied except pod length and no. of seeds per siliqua indicating the presence of sufficient variability in the plant material. The maximum value of phenotypic coefficient of variation was observed for Pods on main branch followed by oil content and siliqua density on main shoot and the highest genotypic coefficient of variation was observed to be for pods on main branch followed by seed yield per plant and for oil content. Phenotypic correlation coefficients were higher in magnitude than their respective genotypic correlation coefficients for most of the traits indicating the environmental influence on phenotypic expression. No. of primary branches and no. of secondary branches exhibited positive correlation with seed yield per plant and negative correlation with main shoot length and pod length. Among the traits studied, no. of pods on main branch exhibited positive direct effect on yield followed by 1000-seed weight, siliqua density on main shoot, number of seeds per siliqua, no. of secondary branches, oil content and plant height exhibited positive direct effect on yield.

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