The Pharma Innovation Journal 2021; 10(8): 538-540

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(8): 538-540

www.thepharmajournal.com
Received: 08-06-2021
Accepted: 22-07-2021

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Correlation studies among yield and its components in Indian mustard (*Brassica juncea* L. Czern and Coss)

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Abstract
An investigation was undertaken to study correlation and path coefficient analysis for seed yield and its components among 20 genotypes of Indian mustard. The field experiment was conducted under timely sown condition in randomized block design with three replications at *Nidharia* farm, S.M.M. Town Post Graduate College, Ballia during *Rabi* season 2017-18. The data were observed on 11 characters *viz*. days to 50% flowering, number of primary branches, plant height, days to maturity, number of siliquae per plant, number of secondary branches, number of seeds per siliqua, biological yield per plant, test weight, harvest index and seed yield per plant. The seed yield per plant had positive and significant correlation with days to 50% flowering (0.284, 0.256), plant height (0.423, 0.405), test weight (0.590, 0.577) and harvest index (0.749, 0.746) at both genotypic and phenotypic levels. However, it had associationship with number of seeds per siliqua (0.278) at genotypic level only. Furthermore, path coefficient analysis of yield contributing characters clearly indicated that harvest index (1.277) showed the highest positive direct effect on seed yield followed by biological yield per plant (0.9511), days to maturity (0.1951) and number of secondary branches (0.1430). Observations suggest that these characters served the basis for selection in breeding programme for yield improvement in Indian mustard.

Keywords: *Brassica juncea*, correlation coefficient, path analysis

Introduction
Rapeseed mustard is the third important oilseed crops in the world after soybean (*Glycine max*) and palm oil. Botanically, the genus Brassica belongs to *Brassicaceae* family having three elementary species (diploids) with 2n= 16, 18 and 20 while other three species are tetraploids including Indian mustard. All rapeseed and mustard crops are grown under wide range of agro-climatic conditions. Indian mustard (*Brassica juncea* L. Czern and Coss) is cultivated throughout the world. It is also cultivated all over India as Major *Rabi* oilseed crop of northern India. It contains 38 to 42% oil and 24% cake protein.

Indian mustard has some antifungal and antiviral medicinal properties. However, its allyl isothiocyanate is carcinogenic in nature. Mustard oil is used in almost all regions of northern India for cooking and frying due to its pungency liking habits. Industrially, it is used in soap making, grease and scent manufacturing. Oil and meal quality and value added breeding programmes are necessary improvement of rapeseed-mustard. Meal quality is found deteriorated if a high concentration of glucosinolate estimates. *Canola* name is given by Western Canadian Oilseed Association for varieties having less than 2% acid in oil and less than 2 moles of glucosinolate in defatted seed meal. Usually, Indian cultivars have high erucic acid (40-50%) in oil and high glucosinolate (80-120 moles/g) in seed meal which would be needful to minimize it in developing cultivars. Breeding crop varieties tolerant to salt stresses or other stresses are important. Various mechanisms are involved to select suitable most plant types for yield, quality and apply most suitable breeding method to develop modern varieties. It is therefore, essential that germplasm should be chosen on the basis of their phenotypic and genotypic value of quantitative/qualitative traits for suitable breeding strategies in crop improvement. This investigation aimed at knowing the magnitudes of correlation coefficient and path analysis for 11 characters.

Materials and Methods
Twenty strains/varieties were grown in Randomised Block Design (R.B.D.) with 3 replications on dated December 5th 2017. Each treatment was sown in a plot with spacing 3 m X 0.45 m X 0.20 m with recommended packages of practices to raise a good crop.

As per requisite periods, five randomly selected plants/plot, data were recorded for days to 50% flowering, number of primary branches, plant height, days to maturity, number of siliquae per plant, number of secondary branches, number of seeds per siliqua, biological yield per plant, test weight, harvest index and seed yield per plant for their analysis and interpretations.

Results and Discussion

By analysis of variance (ANOVA) estimates, genotypes were found highly significant for all characters. Correlation coefficient analysis helps to determine the nature and degree of relationship between any two of measured characters. The correlation does not consider dependence of one variable (character) over the other.

Direct contribution of each component to the yield and indirect effects of other traits were estimated by path analysis. Path coefficient analysis fulfils the lacuna of correlation coefficients. Wright (1921) [5] gave the idea for partitioning of associationship of any component with yield as direct and indirect effects and analysed as per procedure given by Dewey and Lu, 1959 [1].

The correlation coefficient analysis (Table 1) revealed that, in general, the values of genotypic correlations were slightly higher than their corresponding phenotypic correlations indicating the preponderance of inherent associations among the traits. It revealed that seed yield had significant and positive associationship with days to 50% flowering and number of seeds per siliqua. Similarly, harvest index, test weight and plant height shown highly significant values of correlation coefficient with yield. Some other characters were also correlated with each other and they were indirectly responsible for increasing seed yield. A markably high positive correlation coefficients were observed between days to flowering with plant height and days to maturity; number of primary branches with plant height and test weight; plant height with test weight; days to maturity with harvest index; number of siliquae per plant with biological yield; number of seeds per siliqua with test weight and harvest index and test weight with harvest index. But, a negative correlation was measured between days to flowering with number of seeds per siliqua; number of primary branches with days to maturity and secondary branches; plant height with test weight; days to maturity with biological yield, number of siliquae per plant with number of seeds per siliqua, test weight and harvest index; secondary branches with test weight and biological yield with harvest index. These correlation coefficients indicate that a breeder can improve the seed yield per plant not only by selecting the seed yield *per se* but along with plant height, seeds per siliqua, test weight and harvest index. But, a taller plant would have more test weight due to later flowering and more number of primary branches. A higher significance of test weight with the harvest index as well as the seed yield are important attributes for yield enhancement.

The genotypic correlation coefficient values are usually interaction of linkage and pleiotropic genes. The pleiotropic effect is more illustrative explanation over linkages. A correlation coefficient magnitude and direction may be changed in coming generations by using biparental mating if it was governed by linkage but it cannot change in case of pleiotropic effect. Similar results have been reported by Sirohi *et al*. (2004) and Gangapur *et al.* (2009) [4, 2].

The results of path coefficient analysis carried out using simple correlation coefficients among the characters with yield given in table 2. Days to flowering had a direct negative effect (-0.339) over significantly positive correlation with seed yield along with some positive and negative indirect effects of other characters. Similarly, positive but highly significant correlation coefficient between plant height and seed yield had partitioned (0.079) direct effect along with other character indirect effects. The number of seeds per siliqua though had negative (-0.243) direct effect on positive significant seed yield, yet the positive correlation was measured due to positive indirect effect of days to flowering, plant height, siliquae per plant, biological yield and residual effect (0.1823) with some negative indirect effects for other characters. Though, correlation coefficient was observed highly positive between test weight and seed yield yet, the direct effect was negative (-0.054) usually because residual effect and some positive indirect effects and trace magnitude of negative indirect effects in case of few attributes. Likewise, the highest correlation coefficient between harvest index and seed yield (0.749) was due to high residual effect and high positive direct effect (1.277) along with some positive indirect effects of days to flowering, plant height, days to maturity, etc. with some negative indirect effects.

With insight view on the correlation and path analysis give the inference of importance of studied attributes to the seed yield. The harvest index and test weight which are valuable attributes of total biological yield along with taller plant with late flowering and maturity and primary branches which are indirectly linked with the plant height and therefore should be considered as selection criteria during time of selection. Similar results have been reported by Shikari and Sinhamahapatra (2004), Sirohi *et al*. (2004) and Gangapur *et al.* (2009) [3, 4, 2].

Table 1: Genotypic and Phenotypic correlation among 11 characters in Mustard (*Brassica juncea* L.)

S.No.	Character	Days to 50% Flowering	No of primary branches	Plant height (cm)	Days to maturity	No of siliquae per plant	No of secondary branches	No of seeds per siliqua	Biological yield per plant(g)	Test weight	Harvest index (%)	Seed yield per plant (g)
1	Days to 50% Flowering	r_g	0.177	0.738 **	0.337**	0.092	0.054	-0.505**	0.075	0.029	0.212	0.284*
		r_p	0.180	0.677 **	0.294*	0.093	0.043	-0.423**	0.091	0.037	0.190	0.256*
2	No of primary branches		r_g	0.368**	-0.346**	0.021	-0.457**	0.011	0.216	0.449**	-0.033	0.129
			r_p	0.351 **	-0.311*	0.022	-0.427**	0.010	0.211	0.439**	-0.030	0.123
3	Plant height (cm)			r_g	-0.026	-0.097	0.211	-0.181	0.157	0.335**	0.245	0.423**
				r_p	-0.035	-0.096	0.212	-0.121	0.149	0.331**	0.219	0.405
4	Days to maturity				r_g	-0.236	0.018	0.114	-0.439**	-0.052	0.296*	-0.014
					r_p	-0.219	0.010	0.092	-0.381**	-0.049	0.266*	0.006
5	No of siliquae per plant					r_g	0.012	-0.401**	0.628**	-0.267*	-0.315*	0.057
						r_p	0.010	-0.292*	0.618**	-0.263*	-0.304*	0.055
6	No of secondary branches						r_g	-0.014	-0.154	-0.395**	-0.027	-0.079
							r_p	-0.023	-0.108	-0.362**	-0.109	-0.110

7	No of seeds per siliqua							r_g	-0.219	0.599**	0.391**	0.278*
								r_p	-0.180	0.445**	0.293*	0.210
8	Biological yield per plant(g)								r_g	0.136	-0.491**	0.180
									r_p	0.137	-0.482**	0.162
9	Test weight									r_g	0.460**	0.590**
										r_p	0.442**	0.577**
10	Harvest index(%)										r_g	0.749**
											r_p	0.746**

r_g = Genotypic Correlation Coefficient * Significant at 5% level.
r_p= Phenotypic Correlation Coefficient ** Significant at 1% level.

Table 2: Direct and Indirect effects at genotypic level of different quantitative characters on yield in Mustard (*Brassica juncea* L.)

S.No.	Character	Days to 50% Flowering	No of primary branches	Plant height (cm)	Days to maturity	No of siliquae per plant	No of secondary branches	No of seeds per siliqua	Biological yield per plant(g)	Test weight	Harvest index (%)	Seed yield per plant (g)
1	Days to 50% Flowering	-0.339	-0.060	-0.250	-0.114	-0.031	-0.018	0.171	-0.025	-0.010	-0.072	0.284 *
2	No of primary branches	0.025	0.142	0.052	-0.049	0.003	-0.065	0.002	0.031	0.064	-0.005	0.129
3	Plant height (cm)	0.058	0.029	0.079	-0.002	-0.008	0.017	-0.014	0.012	0.026	0.019	0.423 **
4	Days to maturity	0.066	-0.068	-0.005	0.195	-0.046	0.003	0.022	-0.086	-0.010	0.058	-0.014
5	No of siliquae per plant	-0.024	-0.005	0.025	0.060	-0.255	-0.003	0.102	-0.160	0.068	0.080	0.057
6	No of secondary branches	0.008	-0.065	0.030	0.003	0.002	0.143	-0.002	-0.022	-0.056	-0.004	-0.079
7	No of seeds per siliqua	0.123	-0.003	0.044	-0.028	0.098	0.003	-0.243	0.053	-0.146	-0.095	0.278 *
8	Biological yield per plant(g)	0.071	0.205	0.149	-0.418	0.598	-0.147	-0.209	0.951	0.130	-0.467	0.180
9	Test weight	-0.002	-0.024	-0.018	0.003	0.015	0.021	-0.033	-0.007	-0.054	-0.025	0.590 **
10	Harvest index (%)	0.271	-0.042	0.313	0.378	-0.402	-0.034	0.500	-0.627	0.587	1.277	0.749 **

Residual Effect = 0.1823

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