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Study of correlation and path coefficient among the quantitative and qualitative characters of Indian mustard [*Brassica juncea* (L.) Czern and Coss]

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Abstract

The experiment was carried out with sixty diverse genotypes of Indian mustard [*Brassica juncea* (L.) Czern & Coss.] In order to study correlation and path analysis for seventeen quantitative and qualitative traits. Association analysis between seed yield per plant and other sixteen characters revealed that seed yield per plant was significant and positively correlated with plant height ($r_g = 0.298$), number of branches per plant ($r_g = 0.192$), number of siliques per plant ($r_g = 0.163$), seeds per silique ($r_g = 0.265$), length of silique ($r_g = 0.246$), 1000-seed weight ($r_g = 0.496$), oil content ($r_g = 0.203$), linolenic acid ($r_g = 0.279$) and erucic acid ($r_g = 0.234$) at genotypic level. These yield contributing traits also possessed positive and highly significant association between themselves. The character days to flowering ($r_g = -0.282$), days to maturity ($r_g = -0.163$), stearic acid ($r_g = -0.147$), linoleic acid ($r_g = -0.168$) and eicosenoic acid ($r_g = -0.167$) was negative and significantly correlated with seed yield per plant at genotypic level. Path coefficient analysis indicated the highest positive direct effect on seed yield per plant by oil content (4.384) followed by days to flowering (3.857), linoleic acid (3.658), number of branches per plant (3.313), 1000-seed weight (3.271), length of silique (2.608), days to maturity (1.512) and stearic acid (1.263). The character oleic acid (-6.906) exerted the highest negative direct effect on seed yield per plant.

Keywords: Correlation, path analysis, seed yield and Indian mustard

1. Introduction

Oilseed *Brassicaceae* also referred to as rapeseed-mustard, an important group of oilseed crops in the world, comprise eight cultivated crops of tribe *Brassicaceae* within the family *Brassicaceae* (*Cruciferae*). It is grown for oil as well as condiment and for medicinal use. However, the largest cultivation of the crop is for edible vegetable oil production. It is the cheapest source of oil in human diet. It is also used in preparations of hair oils, soap making, in mixtures with mineral oils for lubrication and in the tanning and softening leather. It is an important *rabi* season crop extensively grown under irrigated condition. Rai is very popular among the farmers due to higher yield and greater tolerance against lodging, shattering, drought condition, heat and relative diseases as well as the saline sodic conditions. *Brassica* also performs well on neglected sites where problems like soil acidity, low available nutrient content, poor drainage, drought and soils with topographical limitations exist. Yield is a complex trait, polygenic in inheritance, more prone to environmental fluctuations than other ancillary traits such as number of branches per plant, number of seeds per silique, main shoot length and 1000-seed weight. Understanding the association between yield and its attributing characters is of paramount importance for making the best use of these relationships in selection (Sarawgi *et al.*, 1997) ^[14]. It is well known that correlation mainly does not fulfill the purpose of the researcher because it does not detect the characters having direct or indirect effects on seed yield. In such situation, path coefficient analysis developed by Wright (1921) ^[17] helps breeders to explain direct and indirect effects, hence it has been extensively used in breeding experiments in different crop species (Akbar *et al.*, 2003) ^[2]. Keeping in view the above aspects, the present investigation was undertaken to study the correlation and path analysis in a set of sixty genotypes of Indian mustard.

2. Material and Methods

Sixty genotypes of Indian mustard were sown in *rabi* season of the year 2017-18 in a Randomized Block Design with three replications at Castor-Mustard Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Each plot consisted of single row of 5.0 meter length. The inter row and intra row spacing was 45 cm and 15 cm, respectively. Standard agronomic practices were followed to raise the good crop. The characters studied were days to flowering, days to maturity, plant height (cm), number of branch per plant, number of siliqua per plant, seeds per siliqua, length of siliqua (cm), 1000-seed weight (g), seed yield per plant (g), oil content (%), palmitic acid (%), stearic acid (%), oleic acid (%), linoleic acid (%), linolenic acid (%), eicosenoic acid (%) and erucic acid (%). Five competitive plants were tagged randomly from each genotype in each replication for recording field observations for all the traits except for days to flowering and days to maturity, which were observed on plot basis. A random sample (approximately 60.0 g) of bulk seeds of each genotype from replicated samples were taken and oil content was determined in percentage through Nuclear Magnetic Resonance (NMR) Technique (Tiwari *et al.*, 1974) ^[16]. Fatty acid of the oil were determined in percentage by Gas Liquid Chromatography (Craske *et al.*, 1987) ^[14]. The replication wise mean values were used for statistical analysis. Correlation coefficient both at genotypic and phenotypic level was analysed as suggested by Johnson *et al.* (1955) ^[8]. Path coefficient as suggested by Dewey and Lu (1959) ^[5].

3. Results and Discussion

The correlation coefficients between seed yield and its sixteen component characters as well as among themselves were estimated at genotypic and phenotypic levels (Table 1 & 2). In general, the values of genotypic correlation were slightly higher than their phenotypic counterpart. Higher genotypic correlations than phenotypic ones might be due to modifying or masking effect of environment in the expression of these characters under study. Johnson *et al.* (1955) ^[8] also reported that higher genotypic correlation than phenotypic correlation indicated an inherent association between various characters. In few cases, the phenotypic correlation was slightly higher than their genotypic counterpart, which implied that the non-genetic causes inflated the values of genotypic correlation because of the influence of the environmental factors. In the present investigations, seed yield per plant was found to be significant and positively correlated with plant height, number of branches per plant, number of siliquae per plant, seeds per siliqua, length of siliqua, 1000-seed weight, linolenic acid and erucic acid at both genotypic and phenotypic levels, while oil content at genotypic level (Table 1 & 2). The trait, days to flowering and oleic acid were found to be highly significant and negatively correlated with seed yield per plant at both the levels, while days to maturity, stearic acid, linoleic acid, and eicosenoic acid showed significant negative correlation with seed yield per plant at genotypic level only. Palmitic acid was found negatively and non-significantly correlated at both levels. The trait days to flowering exhibited highly significant and positive correlation with plant height at both the levels. It showed the highly significant and negative correlation with number of branches per plant, seeds per siliqua, length of siliqua at genotypic and phenotypic level. Day to maturity showed highly significant and negative correlation with 1000-seed weight at both the levels. It showed significant and positive correlation with plant height at genotypic level. Plant

height showed non-significant and positive correlation with number of branches per plant, number of siliquae per plant, seeds per siliqua and length of siliqua. It showed significant and positive correlation with 1000-seed weight at genotypic level only. The character number of siliquae per plant exhibited highly significant and negative correlation with length of siliqua at both levels and 1000-seed weight at genotypic level. Seeds per siliqua had highly significant and positive correlation with length of siliqua at both the levels. Length of siliqua had highly significant and positive correlation with 1000-seed weight at both levels.

The quality trait oil content showed significant and negative correlation with palmitic acid and eicosenoic acid at genotypic level. It showed significant and positive correlation with stearic acid at genotypic level. Palmitic acid showed highly significant and positive correlation with stearic acid, oleic acid, linoleic acid and eicosenoic acid at both levels. It also showed highly significant and negative correlation with linolenic acid and erucic acid at both the levels. Stearic acid exhibited highly significant and positive correlation with oleic acid and linoleic acid at both levels. It showed highly significant and negative correlation with linolenic acid and erucic acid at both levels. The trait oleic acid showed highly significant negative correlation with linolenic acid and erucic acid at both levels. It showed highly significant and positive correlation with linoleic acid at genotypic and phenotypic level. Linoleic acid exhibited highly significant and negative correlation with linolenic acid and erucic acid at both levels. Linolenic acid showed the highly significant and positive correlation with erucic acid, while eicosenoic acid exhibited highly significant and negative correlation with erucic acid at both levels.

The results of present study are in conformation with the earlier findings of Bineeta Devi (2018) ^[3], Kumar *et al.* (2016) ^[9] and Lodhi *et al.* (2014) ^[10] for plant height, Akbari *et al.* (2015) ^[1] and Lodhi *et al.* (2014) ^[10] for number of branches per plant, Bineeta Devi (2018) ^[3], Kumar *et al.* (2016) ^[9] and Akbari *et al.* (2015) ^[1] for seeds per siliqua, Roy *et al.* (2018) ^[13] and Lodhi *et al.* (2014) ^[10] for length of siliqua, Roy *et al.* (2018) ^[13], Akbari *et al.* (2015) ^[1] and Lodhi *et al.* (2014) ^[10] for 1000-seed weight, Rout *et al.* (2018) ^[12] and Kumar *et al.* (2016) ^[9] for days to flowering, Sushil Kumar (2013) ^[15] and Islam *et al.* (2009) ^[7] for palmitic acid, stearic acid and oleic acid and Sushil Kumar (2013) ^[15] for oil content, linoleic acid, linolenic acid and eicosenoic acid at only genotypic or both the levels.

Seed yield is a complex character being affected by so many factors, it might not be possible to include all the characters. If the genetic correlation is high, the two characters can be regarded as being substantially the same and if there are no special circumstances affecting the heritability or the intensity of the selection, it will make little difference in which environment the selection is carried out (Falconer, 1981) ^[6]. In selection programme, when fewer variables are considered, correlation study can serve the purpose. However, when the number of variables increases the situation become complex. "Path analysis" a method developed by Wright (1921) ^[17] is very efficient in this situation. Dewey and Lu (1959) ^[5] employed this method in plants to dissent angle the direct and indirect influences of component on seed yield. The analysis of correlation co-efficient together with information on path co-efficient helps considerably in identification of suitable characters for proper weightage to be given during selection. Seed yield is the result of direct and indirect effects of several yield contributing characters. To know the contribution of

various characters towards seed yield, the significant genotypic correlation of different traits with seed yield were partitioned into their direct and indirect effects (Table 3 & Fig. 1). The perusal of results revealed that the direct effect of days to flowering on seed yield per plant was positive while indirect effect *via* seeds per siliqua was positive. The trait days to maturity had significant and negative correlation with seed yield per plant due to its very high and positive direct effect and positive and high indirect effect *via* oil content. Plant height possessed positive and highly significant association with seed yield per plant, which was due to its high and negative direct effect, while it showed positive and high indirect effect *via* days to flowering, number of branch per plant, 1000-seed weight and oleic acid. Number of branches per plant exhibited high and positive genotypic correlation with seed yield per plant. The direct effect of number of branches per plant on seed yield was very high and positive. The high and positive indirect effect *via* oil content, while, positive and low indirect effect *via* oleic acid. Number of siliquae per plant had positive and significant association with seed yield due to its very high and negative direct effect and positive and high indirect effect *via* number of branches per plant and oleic acid. The direct effect of seeds per siliqua on seed yield per plant was negative, but it contributed indirectly towards seed yield per plant *via* length of siliqua, oil content, oleic acid and 1000-seed weight. Length of siliqua had positive and highly significant correlation with seed yield per plant due to its very high and positive direct effect on seed yield per plant. The positive and high indirect effect *via* 1000-seed weight, oleic acid and number of siliquae per plant. The direct effect of 1000-seed weight on seed yield per plant was positive and it exhibited high positive indirect effect *via* oleic acid and length of siliqua.

Oil content exhibited highly significant and positive genotypic correlation with seed yield per plant. The direct effect on seed yield was very high and positive, while indirect effect *via* plant height and number of branches per plant were found positive. The direct effect of palmitic acid on seed yield per plant was very high and negative. The indirect effect of this trait on seed yield per plant *via* stearic acid, linoleic acid, erucic acid and linolenic acid were positive. The direct effect of stearic acid on seed yield was very high and positive. While, indirect effect of this character *via* linoleic acid, erucic acid, oil content and linolenic acid were found positive. The

direct effect oleic acid on seed yield was very high and negative, but it contributed indirectly towards seed yield per plant *via* stearic acid, linoleic acid, erucic acid, oil content and linolenic acid. Linoleic acid exhibited very high and positive direct effect on seed yield per plant. The indirect effect of this character on seed yield per plant *via* stearic acid, erucic acid and linolenic acid were found high and positive. The direct effect of linolenic acid on seed yield per plant was high and negative, while high and positive indirect effect *via* 1000-seed weight, oleic acid, number of branches per plant and length of siliqua. The direct effect of eicosenoic acid on seed yield per plant was negligible and negative. This trait possessed high and positive indirect effect *via* linoleic acid and erucic acid. The direct effect erucic acid on seed yield per plant was very high and negative. This trait possessed high and negative indirect effects *via* stearic acid and linoleic acid and linolenic acid, while negative and low indirect effect *via* seeds per siliqua and oil content.

In the present investigation, oil content showed highest direct effect followed by days to flowering, linoleic acid, number of branches per plant, 1000-seed weight, length of siliqua, days to maturity and stearic acid. The positive direct effect of days to flowering, days to maturity, number of branches per plant, length of siliqua on seed yield per plant were also reported by Rout *et al.* (2018) ^[12] and Rathod *et al.* (2013) ^[11], while positive direct effect of 1000-seed weight and oil content on seed yield per plant were also recorded by Roy *et al.* (2018) ^[13]. The negative direct effects were recorded for oleic acid followed by erucic acid, seeds per siliqua, number of siliquae per plant, plant height, linolenic acid, palmitic acid and eicosenoic acid. The negative direct effect of plant height on seed yield per plant was also noticed by Rout *et al.* (2018) ^[12] and Rathod *et al.* (2013) ^[11].

4. Conclusion

In the present investigation of interrelationship, it can be presumed that for improving seed yield in *Brassica juncea*, an ideal plant type would be early flowering and maturity, more number of branches, number of siliquae per plant, 1000-seed weight with bold seed, high oil content, lenoleic acid, oleic acid, low erucic acid. Hence, these characters could be utilized as selection criteria for improving seed yield in Indian mustard.

Table 1: Genotypic (r_g) and phenotypic (r_p) correlation coefficient of seed yield with quantitative characters in Indian mustard [*Brassica juncea* (L.) Czern and Coss]

Character		Days to maturity	Plant height	Number of branch per plant	Number of siliqua per plant	Seeds per siliqua	Length of siliqua	1000-seed weight	Seed yield per plant
Days to flowering	r_g	-0.028	0.360**	-0.275**	-0.144	-0.436**	-0.374**	-0.011	-0.282**
	r_p	0.260**	0.222**	-0.199**	-0.073	-0.332**	-0.270**	-0.020	-0.232**
Days to maturity	r_g		0.165*	-0.103	-0.114	-0.038	-0.049	-0.346**	-0.163*
	r_p		0.116	-0.001	0.023	-0.055	-0.067	-0.197**	-0.141
Plant height	r_g			0.104	0.044	0.034	0.071	0.178*	0.298**
	r_p			0.129	0.151*	0.039	0.047	0.145	0.200**
Number of branch per plant	r_g				1.000**	-0.038	-0.212**	-0.202**	0.192**
	r_p				0.682**	0.045	-0.122	-0.133	0.197**
Number of siliqua per plant	r_g					-0.108	-0.444**	-0.205**	0.163*
	r_p					0.054	-0.122	-0.092	0.170*
Seeds per siliqua	r_g						0.608**	0.127	0.265**
	r_p						0.509**	0.074	0.154*
Length of siliqua	r_g							0.343**	0.246**
	r_p							0.253**	0.155*
1000-seed weight	r_g								0.496**
	r_p								0.390**

* 0.05% level and ** 0.01% level.

Table 2: Genotypic (r_g) and phenotypic (r_p) correlation coefficient of seed yield with qualitative characters in Indian mustard [*Brassica juncea* (L.) Czern and Coss]

Character		Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	Eicosenoic acid	Erucic acid	Seed yield per plant
Oil content	r_g	-0.156*	0.164*	0.142	-0.114	-0.022	-0.184*	-0.036	0.203**
	r_p	-0.110	0.111	0.080	-0.054	-0.030	-0.122	-0.022	0.082
Palmitic acid	r_g		0.877**	0.740**	0.876**	-0.530**	0.293**	-0.855**	-0.086
	r_p		0.849**	0.725**	0.827**	-0.479**	0.279**	-0.835**	-0.036
Stearic acid	r_g			0.887**	0.856**	-0.594**	0.100	-0.916**	-0.147*
	r_p			0.871**	0.806**	-0.549**	0.097	-0.898**	-0.123
Oleic acid	r_g				0.820**	-0.644**	0.047	-0.963**	-0.263**
	r_p				0.787**	-0.594**	0.045	-0.954**	-0.211**
Linoleic acid	r_g					-0.742**	0.116	-0.897**	-0.168*
	r_p					-0.662**	0.100	-0.856**	-0.131
Linolenic acid	r_g						-0.021	0.576**	0.279**
	r_p						-0.018	0.521**	0.207**
Eicosenoic acid	r_g							-0.217**	-0.167*
	r_p							-0.211**	-0.134
Erucic acid	r_g								0.234**
	r_p								0.181*

* 0.05% level and ** 0.01% level.

Table 3: Path coefficient analysis showing direct (bold) and indirect effects of different traits on seed yield per plant in Indian mustard [*Brassica juncea* (L.) Czern and Coss]

Characters	DF	DM	PH	NBPP	NSPP	SPS	LS	TW	OC	PA	SA	OA	LA	LLA	ESA	EA	Genotypic correlation with Y
DF	3.857	-0.043	-0.356	-0.914	0.147	0.546	-0.977	-0.038	-2.564	-0.018	-0.116	-0.088	0.180	0.097	-0.001	0.005	-0.282**
DM	-0.110	1.512	-0.164	-0.341	0.116	0.048	-0.129	-1.132	0.309	0.032	-0.067	-0.007	-0.218	-0.076	-0.002	0.068	-0.163*
PH	1.392	0.251	-0.987	0.345	-0.045	-0.043	0.186	0.585	-1.560	-0.037	-0.149	0.720	-0.153	-0.130	-0.002	-0.074	0.298**
NBPP	-1.064	-0.156	-0.103	3.313	-1.043	0.048	-0.555	-0.662	0.495	-0.012	0.036	0.144	-0.167	-0.115	0.000	0.032	0.192**
NSPP	-0.558	-0.172	-0.044	3.400	-1.016	0.135	-1.160	-0.672	0.045	0.001	-0.021	0.640	-0.153	-0.120	0.001	-0.145	0.163*
SPS	-1.683	-0.058	-0.034	-0.127	0.110	-1.252	1.587	0.418	1.014	0.065	-0.223	1.123	-0.173	-0.048	0.001	-0.455	0.265**
LS	-1.445	-0.075	-0.070	-0.705	0.452	-0.762	2.608	1.123	-0.358	0.055	-0.245	1.032	-0.748	-0.148	0.001	-0.468	0.246*
TW	-0.045	-0.523	-0.177	-0.670	0.209	-0.160	0.896	3.271	-1.638	0.104	-0.577	2.462	-1.316	-0.213	0.002	-1.129	0.496**
OC	-2.256	0.106	0.351	0.374	-0.011	-0.290	-0.213	-1.223	4.384	0.050	0.208	-0.986	-0.419	0.013	0.002	0.112	0.203**
PA	0.212	-0.150	-0.115	0.123	0.004	0.257	-0.449	-1.066	-0.687	-0.318	1.108	-5.115	3.206	0.306	-0.004	2.603	-0.086
SA	-0.355	-0.080	0.117	0.093	0.017	0.222	-0.505	-1.494	0.722	-0.279	1.263	-6.130	3.134	0.342	-0.001	2.789	-0.147*
OA	0.049	0.002	0.103	-0.069	0.094	0.204	-0.390	-1.166	0.626	-0.236	1.121	-6.906	3.001	0.371	-0.001	2.933	-0.263**
LA	0.190	-0.090	0.041	-0.151	0.042	0.059	-0.533	-1.177	-0.502	-0.279	1.082	-5.665	3.658	0.427	-0.001	2.731	-0.168*
LLA	-0.649	0.200	-0.222	0.661	-0.212	-0.104	0.671	1.207	-0.101	0.169	-0.751	4.453	-2.715	-0.576	0.000	-1.754	0.279**
ESA	0.297	0.254	-0.198	0.011	0.116	0.131	-0.180	-0.582	-0.806	-0.093	0.126	-0.330	0.424	0.012	-0.012	0.663	-0.167*
EA	-0.007	-0.034	-0.024	-0.035	-0.048	-0.187	0.401	1.213	-0.161	0.272	-1.157	6.655	-3.282	-0.332	0.003	-3.044	0.234**

* 0.05% level and ** 0.01% level, respectively. Residual effect = 0.832

Note: Bold diagonal value indicate direct effect

DF = Days to flowering

DM = Days to Maturity

PH = Plant height

NBPP = Number of branch per plant

NSPP = Number of siliqua per plant

SPS = Seeds per siliqua

LS = Length of siliqua

TW = 1000-seed weight

OC = Oil content

PA = Palmitic acid

SA = Stearic acid

OA = Oleic acid

LA = Linoleic acid

LLA = Linolenic acid

ESA = Eicosenoic acid

EA = Erucic acid

Y = Seed yield per plant

Fig 1: Path diagram indicating direct and indirect effect of components of seed yield in Indian mustard [*Brassica juncea* (L.) Czern and Coss]

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