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Studies on Inter-Relationship and Path Coefficient Analysis for Seed Yield/Plant and Qualitative Traits in Indian mustard (*Brassica juncea* L. czern and cos)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out with ten Indian mustard genotypes in biochemistry laboratory of ICAR-DRMR, Bharatpur, during 2021-22. Analysis of oil, fatty acid profiling and estimation of glucosinolate was done to study the inter-relationship and path coefficient analysis between seed yield and among all nine qualitative traits taken. It is found that the genotypic

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correlation was higher than phenotypic correlation due to genetic effect. The positive correlation of seed yield/plant is associated at both phenotypic and genotypic levels with palmitic acid, linoleic acid, oleic acid, stearic acid and linolenic acid whereas negatively associated with glucosinolate, erucic acid and eicosenoic acid. Oleic acid was positively correlated with linoleic acid. Path coefficient analysis studies revealed that the high positive direct effect on seed yield/plant was exhibited by linoleic acid, linolenic acid and stearic acid while negative direct effect by erucic acid, glucosinolate, oil and eicosenoic acid on seed yield/plant. Selection of the plants based on these traits would certainly leads to improvement in seed yield.

Keywords: Correlation coefficient; Indian mustard (Brassica juncea L. Czern and Cos); inter-relationship; path coefficient analysis; qualitative traits; seed yield/plant.

1. INTRODUCTION

Indian mustard is cultivated throughout the world. Oilseeds are the backbone of agricultural economy of India [1,2]. Since, *Brassica juncea* is the second most important oilseed crop in the country, it should be emphasized on the seed yield, quality and quantity of oil to increase the productivity through developing high yielding varieties and to provide best diet to the society. Mustard seed contains about 38% to 43% of oil and is considered to be the healthiest and nutritious cooking medium. It contains low amount of saturated fatty acids (SFAs) includes Palmitic acid, stearic acid, whereas, an appreciable amount of unsaturated fatty acids are either monounsaturated (MUPAs) i.e. erucic acid (anti- nutritional factor) and oleic acid or polyunsaturated fatty acids (PUFAs) such as omega-3- alpha- linolenic acid, omega-6- linoleic acid and Eicosenoic acid [3]. It also contains high glucosinolate content (80-125 µ moles/g) are major Sulphur components in crucifers. High concentrations in the oil cake consumption affects human and animal health. There is a greater need to reduce the glucosinolate in seed meal and erucic acid in fatty acid composition to improve the quality of mustard oil. Main thrust in breeding of Indian mustard is to enhance its seed yield along with better oil and meal quality. These important traits of Indian mustard are influenced by the environment because of their polygenic nature [4,6].

Therefore, Inter-relationship and path coefficient studies provide a better understanding of the association among qualitative characters and their direct and indirect effect on seed yield/plant, which help breeders to formulate an appropriate breeding strategy to improve a number of traits simultaneously and effectively.

2. MATERIALS AND METHODS

In the present study, ten open pollinated Indian mustard genotypes were obtained from DRMR, Bharatpur were used for the analysis of oil, fatty acid profiling and for glucosinolate estimation. The analysis of these qualitative traits was done in the biochemistry laboratory of ICAR-DRMR, Bharatpur during 2021-2022. Field trail of these 10 genotypes was conducted in the Field Experimentation Centre, SHUATS, Prayagraj. The data was recorded for 10 characters viz; Oil (%), palmitic acid(%), stearic acid (%), oleic Acid (%), linoleic acid (%), linolenic acid (%), eicosenoic acid (%), erucic acid (%), glucosinolate (µg/g) and Seed yield / plant. Oil is extraction was done by Soxhlet apparatus. Chemical used was Hexane. Fatty acid profiling was done with Gas Chromatography (Nucon Model 5765) using SP 2300 + 2310 SS columns.

Process of Fatty acid Estimation:

a) 35-40 seeds were grinded,
b) The mix was taken into test tube,
c) 10ml hexane added and left it for 24 hrs
d) Supernatant collected and NaOH 500µL added
e) After 45 min NaCl 700µL added
f) After 30 min readings were taken by Gas Chromatography

Glucosinolate estimation was done by spectrophotometer method at 425nm [6]. The genotypic and phenotypic correlations were calculated as per the method given by Al-Jibouri et al. [7]. Path coefficient analysis was done according to the method suggested by Wright [8] and illustrated by Dewey and Lu [9]. Knowledge of correlations and path analysis between the seed yield and quality traits is of great importance for a successful breeding programme.

3. RESULTS AND DISCUSSION

Correlation coefficient is the mutual association between various characters and determines the component characters on which the selection

Table 1. Estimation of phenotypic correlation coefficient for different traits in Indian mustard

TRAITS	Oil (%)	Palmitic acid(%)	Stearic acid (%)	Oleic Acid (%)	Linoleic acid (%)	Linolenic acid (%)	Eicosenoic acid (%)	Erucic acid (%)	Glucosinolate (µg/g)	Seed yield / plant
Oil (%)	1.0000	0.0527	0.1318	0.0114	-0.2223	0.1941	-0.3395	0.0232	0.2293	-0.0032
Palmitic acid (%)		1.0000	-0.0963	0.0571	0.3373	0.370*	-0.470*	0.0142	-0.2961	0.365*
Stearic acid (%)			1.0000	-0.2272	-0.3165	0.3130	0.470*	0.0372	-0.0146	0.2788
Oleic acid (%)				1.0000	**0.740****	0.0288	-0.1621	-0.952**	-0.588**	0.2823
Linoleic acid (%)					1.0000	-0.1126	-0.2904	-0.690**	-0.750**	0.2893
Linolenic acid (%)						1.0000	0.2106	-0.0184	-0.1520	0.0373
Eicosenoic acid (%)							1.0000	0.0220	0.1122	-0.3211
Erucic acid (%)								1.0000	**0.653****	-0.3588
Glucosinolate (ug/g)									1.0000	-0.476*
Seed yield /plant(g)										1.0000

**Significant at 5% level, **Significant at 1% level.*

Table 2. Estimation of genotypic correlation coefficient for different traits in Indian mustard

Traits	Oil (%)	Palmitic acid	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Linolenic acid (%)	Eicosenoic acid (%)	Erucic acid (%)	Glucosinolate (ug/g)	Seed yield / plant
Oil (%)	1.0000	0.389*	0.1842	0.0022	-0.1855	-0.0307	-0.668**	0.0819	0.2598	0.517*
Palmitic Acid		1.0000	-0.0592	0.0720	0.362*	0.695**	-0.679**	0.0241	-0.3532	0.363*
Stearic Acid (%)			1.0000	0.2284	-0.371*	0.545*	0.545*	0.0230	-0.0449	0.546*
Oleic Acid (%)				1.0000	0.843**	0.0801	-0.1139	-0.961**	-0.605**	0.3150
Linoleic Acid (%)					1.0000	0.2696	-0.1389	-0.772**	-0.910**	0.2292
Linolenic Acid (%)						1.0000	0.1613	-0.1289	-0.2420	0.1019
Eicosenoic Acid (%)							1.0000	-0.0396	0.0349	-0.3115
Erucic Acid (%)								1.0000	0.673**	-0.413*
Glucosinolate (ug/g)									1.0000	-0.466*
Seed yield / plant										1.0000

*Significant at 5% level, **Significant at 1% level.

Table 3. Direct and indirect effects of qualitative traits on seed yield (phenotypic)

Traits	Oil (%)	Palmitic Acid	Stearic Acid (%)	Oleic Acid (%)	Linoleic Acid (%)	Linolenic Acid (%)	Eicosenoic Acid (%)	Erucic Acid (%)	Glucosinolate (ug/g)	Seed yield / plant
Oil (%)	-0.1749	-0.0092	-0.0231	-0.0020	0.0389	-0.0339	0.0594	-0.0041	-0.0401	-0.0032
Palmitic Acid	-0.0110	-0.2092	0.0201	-0.0119	-0.0705	-0.0774	0.0983	-0.0030	0.0619	0.365*
Stearic Acid (%)	0.0100	-0.0073	0.0758	-0.0172	-0.0240	0.0237	0.0356	0.0028	-0.0011	0.2788
Oleic Acid (%)	-0.0150	-0.0751	0.2987	-1.3150	-0.9733	-0.0379	0.2131	1.2516	0.7737	0.2823
Linoleic Acid (%)	-0.1203	0.1825	-0.1713	0.4005	0.5411	-0.0609	-0.1571	-0.3732	-0.4058	0.2893
Linolenic Acid (%)	0.1032	0.1967	0.1665	0.0153	-0.0599	0.5319	0.1120	-0.0098	-0.0809	0.0373
Eicosenoic Acid (%)	0.0142	0.0197	-0.0197	0.0068	0.0122	-0.0088	-0.0419	-0.0009	-0.0047	-0.3211
Erucic Acid (%)	-0.0288	-0.0177	-0.0462	1.1819	0.8564	0.0228	-0.0273	-1.2418	-0.8114	-0.3588
Glucosinolate (ug/g)	-0.0647	0.0836	0.0041	0.1661	0.2117	0.0429	-0.0317	-0.1844	-0.2823	-0.476*
Seed yield/plant	-0.0032	0.365*	0.2788	0.2823	0.2893	0.0373	-0.3211	-0.3588	-0.476*	1.0000
Partial R^2	0.0006	-0.0763	0.0211	-0.3712	0.1566	0.0198	0.0135	0.4456	0.1343	

**Significant at 5% level, **Significant at 1% level.*

Table 4. Direct and indirect effect of qualitative traits on seed yield (genotypic)

Traits	Oil (%)	Palmitic Acid	Stearic Acid (%)	Oleic Acid (%)	Linoleic Acid (%)	Linolenic Acid (%)	Eicosenoic Acid (%)	Erucic Acid (%)	Glucosinolate (ug/g)	Seed yield /plant
Oil (%)	-0.1528	-0.0594	-0.0282	-0.0003	0.0284	0.0047	0.1021	-0.0125	-0.0397	0.517*
Palmitic Acid	-0.0809	-0.2082	0.0123	-0.0150	-0.0753	-0.1447	0.1414	-0.0050	0.0735	0.363*
Stearic Acid (%)	0.0190	-0.0061	0.1032	-0.0236	-0.0383	0.0562	0.0562	0.0024	-0.0046	0.546*
Oleic Acid (%)	-0.0038	-0.1242	0.3938	-1.7244	-1.4544	-0.1381	0.1964	1.6571	1.0431	0.3150
Linoleic Acid (%)	-0.1040	0.2026	-0.2080	0.4725	0.5603	0.1510	-0.0778	-0.4326	-0.5096	0.2292
Linolenic Acid (%)	-0.0132	0.2981	0.2338	0.0343	0.1156	0.4289	0.0692	-0.0553	-0.1038	0.1019
Eicosenoic Acid (%)	0.0332	0.0337	-0.0271	0.0057	0.0069	-0.0080	-0.0497	0.0020	-0.0017	-0.3115
Erucic Acid (%)	-0.1300	-0.0382	-0.0365	1.5255	1.2258	0.2046	0.0629	-1.5875	-1.0677	-0.413*
Glucosinolate (ug/g)	-0.0791	0.1076	0.0137	0.1842	0.2770	0.0737	-0.0106	-0.2048	-0.3046	-0.466*
Seed yield per plant	0.517*	0.363*	0.546*	0.3150	0.2292	0.1019	-0.3115	-0.413*	-0.466*	1.0000
Partial R^2	-0.0791	-0.0756	0.0563	-0.5432	0.1284	0.0437	0.0155	0.6557	0.1418	

**Significant at 5% level, **Significant at 1% level.*

can be based on improvement in yield. Path coefficient analysis is to assist partition of correlation coefficients into direct and indirect effects of independent variables on dependant variables. The correlation coefficient values do not reveal the true pattern of association between independent and dependent variables. It solely considers the variables magnitude and direction. The standard partial regression coefficient or path coefficient analysis, divides the correlation coefficient into measures of direct and indirect effects of independent factors on dependent factors. When the deciding component features are correlated, this approach is even more significant for understanding the genetic makeup of a dependent trait.

In the present investigation, It is found that the genotypic correlation was higher than phenotypic correlation due to genetic effect. Johnson et al. [10] also reported that higher genotypic correlation than phenotypic correlation indicated an inherent association between various characters. Similar results have been reported by Sirohi et al. [11].

Inter-relationship/correlation coefficient analysis: Phenotypic correlation coefficient analysis revealed that palmitic acid (0.365*) showed positive significant association with seed yield/plant while linoleic acid (0.2893), oleic acid (0.2823), stearic acid (0.2788) and linolenic acid (0.0373) showed positive non- significant association with seed yield/plant. Glucosinolate (-0.476*) showed negative significant association with seed yield/plant where as erucic acid (-0.3588), eicosenoic acid (-0.3211) and oil (-0.032) showed negative non- significant association with seed yield/plant. Genotypic correlation coefficient analysis revealed that stearic acid (0.546*), oil (0.517*) and palmitic acid (0.363*) showed positive significant association with seed yield/plant while oleic acid (0.3150), linoleic acid (0.2292) and linolenic acid (0.1019) showed positive non- significant association with seed yield/plant. Glucosinolate (-0.466*) and erucic acid (-0.413*) showed negative significant association with seed yield/plant where as eicosenoic acid (-0.115) showed negative non- significant association with seed yield/plant. It was found that erucic acid and oleic acid were negatively correlated. Hence an increase in the level of oleic acid, (Tables 1&2), would result in the reduction of erucic acid content. This negative relationship between erucic and oleic acid has also been reported earlier by Zhou and Liu. [12], Singh et al. [13], Meena [14], Kumar [15]. Linoleic acid exhibited significant but negative correlation with erucic acid. Similar pattern of correlation among these traits have also been reported by Singh et al. [13], Kumar et al. [15], Meena et al. [16].

Path coefficient analysis: Path coefficient analysis at phenotypic level revealed that linoleic acid (0.5411), linolenic acid (0.5319) and stearic acid (0.0758) had direct positive effect on seed yield/plant, where as oleic acid (-1.3150), erucic acid (-1.2418), glucosinolate (-0.2823), palmitic acid (-0.2092), oil (-0.1749) and eicosenoic acid (-0.0419) showed negative direct effect on seed yield/plant. Path coefficient analysis at genotypic level, revealed that the linoleic acid (0.5603), linolenic acid (0.4089) and stearic acid (0.1032) had a direct positive effect on seed yield/plant while oleic acid (-1.7244), erucic acid (-1.5875), glucosinolate (-0.3046), palmitic acid (-0.2082), oil (-0.1528) and eicosenoic acid (-0.0497) showed negative direct effect on seed yield/plant. Saiyad et al., [17] also reported that negative direct effects on seed yield/plant were recorded for erucic acid.

4. CONCLUSION

At both the levels, Seed yield/plant showed positive association with oleic acid and linoleic acid while it showed negative association with glucosinolate and erucic acid. Seed yield/plant showed positive association with oil content at genotypic level. Similar findings were also reported by Singh et al. (2011) indicating that environment played an important role in their expression as these are the major yield attributing traits.

Path Coefficient analysis at phenotypic and genotypic levels, showed that linoleic acid, linolenic acid and stearic acid had positive direct effect on seed yield/plant, thereby improvement of these traits through various breeding programmes enhances the seed yield of the plant. As erucic acid and glucosinolate had negative direct effect on seed yield/plant, reducing of these traits which is one of the important breeding objective can be achieved through different breeding technologies which also increases the seed yield/plant.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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