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## DECIPHERING YIELD ARCHITECTURE IN INDIAN MUSTARD (*BRASSICA JUNCEA* L. CZERN AND COSS) USING CORRELATION AND PATH ANALYSIS APPROACH

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### ABSTRACT

Indian mustard (*Brassica juncea* L.) is a crucial oilseed crop in India, contributing significantly to the country's edible oil production. This study aimed to analyze the correlation and path coefficient relationships between seed yield and its components in 30 genotypes of Indian mustard. The study was conducted during the *Rabi* season of 2023-24 at the Instructional Farm of Sri Karan Narendra College of Agriculture, Jobner, Rajasthan, using a randomized block design with three replications. Traits evaluated included days to 50% flowering, plant height, branches per plant, siliquae per plant, siliqua length, oil content and seed yield. Correlation analysis revealed significant positive associations between seed yield and traits such as plant height, branches per plant, and oil content, suggesting their importance for breeding. Path coefficient analysis showed that branches per plant, oil content, and siliquae per plant had the highest direct positive effects on seed yield, while siliqua density and seeds per siliqua displayed negative direct effects despite positive correlations. The results emphasize the importance of these traits for improving seed yield and their potential as targets for genetic improvement in Indian mustard breeding programs.

**Keywords** : Correlation coefficient, Path coefficient, Direct effect, Indirect effect.

### Introduction

Indian mustard (*Brassica juncea* L. Czern and Coss) is one of the most significant *Rabi* oilseed crops in India, contributing considerably to the nation's edible oil requirements. Originally domesticated in China (Prain, 1898; Bailey, 1922), this crop has become integral to Indian agriculture. Commonly referred to as brown mustard, Chinese mustard, or leaf mustard, it belongs to the Brassicaceae family and is a

natural amphidiploid ( $2n=36$ ), derived from *Brassica campestris* ( $2n=20$ ) and *Brassica nigra* ( $2n=16$ ) (Nagaharu, 1935). Ranking as the second-most vital oilseed crop after soybean, mustard plays a critical role, particularly in supporting farmers in rainfed areas (Kumar *et al.*, 2008).

Mustard seeds contain 38-43% oil, rich in erucic acid (38-57%) and linoleic acid (4.7-13%), making them highly suitable for cooking and other industrial

applications (Prakash and Hinata, 1980). The crop is also valued for its use in producing soaps, lubricants, and fertilizers, while the residue serves as cattle feed (Reed, 1976). With its ability to thrive in varied climates, tolerance to rainfall between 500-4200 mm, and low water demand of 240-400 mm, mustard is well-suited for rainfed farming systems (Shekhawat *et al.*, 2012).

Improved yield and productivity depend on selecting varieties resilient to environmental stresses and possessing superior seed quality (Shekhawat *et al.*, 2012). Studying the traits contributing to yield is essential, and correlation analysis helps in identifying their interrelations. However, to understand direct and indirect effects, path coefficient analysis, introduced by Wright (1921), provides deeper insights by partitioning the correlation coefficients (Yadav *et al.*, 2021).

Considering these aspects, the present study aims to analyze the relationships between seed yield and its components to facilitate the development of high-yielding mustard varieties.

## Materials and Methods

The present investigation was conducted during the *Rabi* season of 2023-24 at the Instructional Farm of Sri Karan Narendra College of Agriculture, Jobner, Jaipur, Rajasthan. The experimental site is situated at an altitude of 450 meters above mean sea level, located at 26°5' N latitude and 75°28' E longitude within the Agro-climatic Zone III A (Semi-arid Eastern Plains) of Rajasthan. The study utilized 30 genotypes of Indian mustard (*Brassica juncea*), including released varieties, pipeline entries, and germplasm collections procured from the Directorate of Rapeseed-Mustard Research (DRMR), Bharatpur, and the Department of Genetics and Plant Breeding, S.K.N. College of Agriculture, Jobner.

The experiment was conducted in a randomized block design with three replications. Each genotype was represented by two rows in each replication, with a row length of 3 meters. The inter-row spacing was maintained at 45 cm, and the intra-plant spacing was

20 cm. Standard agronomic practices were followed throughout the crop-growing season. The traits recorded in the study include days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of siliquae per plant, siliqua length (cm), siliqua density, number of seeds per siliqua, 1000-seed weight (g), seed yield per plant (g), chlorophyll content (SPAD value) and oil content (%). Data were recorded for various traits using five randomly selected plants in each row, except for traits like days to 50% flowering, days to maturity, 1000-seed weight, and oil content, where observations were taken on a plot basis.

Statistical analysis was performed to estimate the correlation and path coefficient among seed yield and its components. Correlation analysis was conducted at both genotypic and phenotypic levels to measure the association among traits using the formulas suggested by Dewey and Lu (1959). The significance of the correlation coefficients was tested using the t-test, as described by Fisher and Yates (1963). Path coefficient analysis was then used to partition the correlation coefficients into direct and indirect effects, allowing for the estimation of the contributions of independent traits to seed yield. Residual effects were also calculated to identify traits with significant direct and indirect impacts on seed yield.

## Results and Discussion

### Correlation Coefficient Analysis

The present study utilized correlation and path coefficient analysis to explore the interrelationships among various traits and their influence on seed yield in Indian mustard. Correlation analysis reveals the degree of association between traits and is an essential tool for identifying key factors influencing seed yield. The results of this analysis provide valuable insights into the complex interactions of traits that contribute to yield. As noted in earlier studies, many economically significant traits are interlinked, often due to genetic factors such as pleiotropy or genetic linkage (Singh *et al.*, 2013; Kumar *et al.*, 2016; Rajeev *et al.*, 2016).

**Table 1:** Genotypic and phenotypic correlation coefficients between yield and its contributing traits of Indian mustard

Traits		Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Branches per plant	Siliquae per plant	Siliqua length (cm)	Siliqua density	Seed per siliqua	1000-seed weight (g)	Seed yield per plant (g)	Chlorophyll content (SPAD)	Oil content (%)
Days to 50 per cent flowering	$r_g$	1.000	0.449**	0.546**	-0.186	0.291**	-0.074	-0.028	0.239*	-0.168	0.245*	-0.332**	0.293**
	$r_p$	1.000	0.362**	0.473**	-0.095	0.271**	-0.072	-0.022	0.147	-0.093	0.216*	-0.317**	0.271**
Days to maturity	$r_g$		1.000	-0.114	-0.065	-0.078	-0.078	-0.168	0.035	-0.127	-0.191	-0.298**	-0.031
	$r_p$		1.000	-0.039	-0.072	-0.053	-0.112	-0.014	0.090	-0.057	-0.199	-0.232*	-0.043
Plant height (cm)	$r_g$			1.000	0.194	0.777**	0.281**	0.486**	0.443**	0.148	0.684**	0.021	0.372**
	$r_p$			1.000	0.211*	0.690**	0.101	0.204	0.252*	0.014	0.583**	0.041	0.237*

Traits		Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Branches per plant	Siliquae per plant	Siliqua length (cm)	Siliqua density	Seed per siliqua	1000-seed weight (g)	Seed yield per plant (g)	Chlorophyll content (SPAD)	Oil content (%)
Branches per plant	r <sub>g</sub>				1.000	0.441**	0.105	0.566**	-0.055	-0.190	0.409**	0.503**	0.046
	r <sub>p</sub>				1.000	0.326**	0.018	0.380**	0.051	-0.023	0.347**	0.377**	0.083
Siliquae per plant	r <sub>g</sub>					1.000	0.284**	0.435**	0.345**	0.143	0.841**	0.087	0.432**
	r <sub>p</sub>					1.000	0.163	0.196	0.179	0.072	0.796**	0.080	0.365**
Siliqua length (cm)	r <sub>g</sub>						1.000	0.112	0.569**	0.504**	0.017	-0.357**	0.037
	r <sub>p</sub>						1.000	-0.053	0.189	0.044	0.010	-0.197	0.068
Siliqua density	r <sub>g</sub>							1.000	0.410**	0.529**	0.416**	0.419**	0.021
	r <sub>p</sub>							1.000	0.021	0.220*	0.146	0.164	-0.062
Seed per siliqua	r <sub>g</sub>								1.000	0.570**	0.007	-0.230*	0.033
	r <sub>p</sub>								1.000	0.127	0.042	-0.093	0.002
1000-seed weight (g)	r <sub>g</sub>									1.000	0.193	-0.168	-0.007
	r <sub>p</sub>									1.000	0.060	-0.155	0.072
Seed yield per plant (g)	r <sub>g</sub>										1.000	0.161	0.468**
	r <sub>p</sub>										1.000	0.174	0.401**
Chlorophyll content (SPAD)	r <sub>g</sub>											1.000	0.111
	r <sub>p</sub>											1.000	0.102
Oil content (%)	r <sub>g</sub>												1.000
	r <sub>p</sub>												1.000

\*, \*\* Significant at 5 per cent and 1 per cent level of significance, respectively

In Table 1, the genotypic correlation coefficients, which eliminate the influence of environmental factors, were consistently higher than the phenotypic correlation coefficients. This suggests that the phenotypic correlation coefficients observed in the present study were influenced by environmental factors, reinforcing the importance of distinguishing between genetic and environmental correlations in breeding programs. These findings align with the work of Yadav *et al.* (2021), who emphasized the significance of understanding both genetic and environmental correlations in breeding strategies.

Seed yield per plant exhibited significant and positive correlations with several traits, including days to 50% flowering, plant height, branches per plant, siliquae per plant, and oil content, at both genotypic and phenotypic levels. These results are consistent with previous reports by Singh *et al.* (2013), Kumar *et al.* (2016), and Chaudhary *et al.* (2023), who also found strong positive correlations between seed yield and these traits in Indian mustard. Specifically, plant height showed a robust positive correlation with days to 50% flowering, siliquae per plant, and seed yield per plant, confirming the observations made by Pandey (2018), Gupta *et al.* (2022), and Lavanya *et al.* (2022).

The trait days to 50% flowering was positively correlated with other important traits such as days to maturity, plant height and oil content, suggesting that early-flowering genotypes may possess favorable growth and yield attributes. This finding aligns with the results of Singh *et al.* (2013) and Kumar *et al.* (2016), who suggested that early-flowering plants are more likely to exhibit better overall performance in

terms of growth and yield. Additionally, branches per plant showed strong positive associations with siliquae per plant, siliqua density, and seed yield per plant, further supporting the findings of Singh *et al.* (2017) and Tantuwai *et al.* (2018), who highlighted the importance of branching for enhancing seed yield. The significant positive relationship between oil content and several traits, including days to 50% flowering, plant height, and seed yield per plant, aligns with the findings of Mekonnen *et al.* (2014), emphasizing oil content as a key economic trait in mustard breeding.

These positive associations among traits suggest that simultaneous improvement of these traits through selection could lead to increased seed yield in Indian mustard, making these traits essential targets for breeding programs aimed at enhancing productivity.

### Path Coefficient Analysis

While correlation analysis provides valuable insights into trait associations, it does not differentiate between direct and indirect effects on seed yield. To address this limitation, path coefficient analysis was employed to determine the direct and indirect contributions of various traits to seed yield. Path analysis, as introduced by Wright (1921), offers a deeper understanding of causal relationships between traits and their collective impact on seed yield, which is crucial for improving complex traits such as seed yield.

The path coefficient analysis revealed that traits such as branches per plant, oil content, siliquae per plant, plant height, and days to 50% flowering exhibited the highest positive direct effects on seed

yield per plant. These results are in agreement with the findings of Rout *et al.* (2018), Yadav *et al.* (2023) and Saini *et al.* (2023), who similarly identified these traits as key determinants of seed yield in mustard genotypes.

**Table 2:** Direct and indirect effects of various traits on seed yield per plant

Traits		Days to 50 % flowering	Days to maturity	Plant height (cm)	Branches per plant	Siliquae per plant	Siliqua length (cm)	Siliqua density	Seed per siliqua	1000-seed weight (g)	Chlorophyll content (SPAD)	Oil content (%)	Correlation coefficient with seed yield per plant (g)
Days to 50 per cent flowering	G	<b>0.205</b>	-0.057	-0.709	0.324	0.491	-0.074	-0.067	-0.215	0.241	0.050	0.055	0.245*
	P	<b>0.050</b>	-0.059	0.032	-0.010	0.188	0.008	0.001	-0.011	-0.002	-0.007	0.027	0.216*
Days to maturity	G	0.092	<b>-0.128</b>	0.148	0.112	-0.132	-0.078	-0.396	-0.031	0.182	0.045	-0.005	-0.191
	P	0.018	<b>-0.165</b>	-0.002	-0.008	-0.036	0.013	0.0007	-0.006	-0.001	-0.005	-0.004	-0.199
Plant height (cm)	G	0.112	0.014	<b>-1.299</b>	-0.339	1.310	0.282	1.147	-0.400	-0.212	-0.003	0.070	0.684**
	P	0.023	0.006	<b>0.068</b>	0.023	0.478	-0.012	-0.011	-0.019	0.0004	0.001	0.024	0.583**
Branches per plant	G	-0.038	0.008	-0.252	<b>-1.748</b>	0.743	0.105	1.337	0.049	0.272	-0.076	0.008	0.409**
	P	-0.004	0.011	0.014	<b>0.110</b>	0.226	-0.002	-0.021	-0.003	-0.0007	0.009	0.008	0.347**
Siliquae per plant	G	0.059	0.010	-1.010	-0.770	<b>1.686</b>	0.284	1.027	-0.311	-0.204	-0.013	0.081	0.841**
	P	0.013	0.008	0.047	0.036	<b>0.693</b>	-0.019	-0.011	-0.013	0.002	0.001	0.037	0.796**
Siliqua length (cm)	G	-0.015	0.010	-0.365	-0.183	0.478	<b>1.004</b>	0.265	-0.514	-0.723	0.054	0.007	0.017
	P	-0.003	0.018	0.006	0.002	0.113	<b>-0.119</b>	0.003	-0.014	0.001	-0.004	0.006	0.010
Siliqua density	G	-0.005	0.021	-0.631	-0.988	0.733	0.112	<b>2.363</b>	-0.370	-0.759	-0.063	0.003	0.416**
	P	-0.001	0.002	0.013	0.041	0.136	0.006	<b>-0.057</b>	-0.001	0.006	0.004	-0.006	0.146
Seed per siliqua	G	0.049	-0.004	-0.575	0.095	0.580	0.571	0.970	<b>-0.902</b>	-0.818	0.034	0.006	0.007
	P	0.007	-0.014	0.017	0.005	0.124	-0.022	-0.001	<b>-0.075</b>	0.004	-0.002	0.0001	0.042
1000-seed weight (g)	G	-0.034	0.016	-0.192	0.331	0.240	0.506	1.251	-0.514	<b>-1.435</b>	0.025	-0.001	0.193
	P	-0.004	0.009	0.0009	-0.002	0.049	-0.005	-0.012	-0.009	<b>0.031</b>	-0.003	0.007	0.060
Chlorophyll content (SPAD)	G	-0.068	0.038	-0.027	-0.879	0.147	-0.358	0.990	0.207	0.240	<b>-0.151</b>	0.020	0.161
	P	-0.016	0.038	0.002	0.041	0.055	0.023	-0.009	0.007	-0.004	<b>0.024</b>	0.010	0.174
Oil content (%)	G	0.060	0.003	-0.483	-0.079	0.727	0.037	0.048	-0.029	0.009	-0.016	<b>0.189</b>	0.468**
	P	0.013	0.007	0.016	0.009	0.253	-0.008	0.003	-0.0001	0.002	0.002	<b>0.101</b>	0.401**

\*, \*\* Significant at 5 per cent and 1 per cent level of significance, respectively. Residual Effect: Genotypic = 0.331 and Phenotypic = 0.291

Interestingly, traits such as siliqua density, seeds per siliqua and siliqua length displayed positive correlations with seed yield per plant; however, their direct effects were negative. This paradox may be attributed to the indirect effects of these traits on other yield components, which ultimately contribute to higher seed yield. These findings align with those of Ray *et al.* (2014), who emphasized the importance of indirect effects in shaping overall seed yield. The presence of such indirect effects highlights the complexity of trait interactions and the necessity for breeders to consider not only direct effects but also the broader network of trait relationships.

The direct positive effect of oil content on seed yield was further substantiated by Mekonnen *et al.* (2014) and Chaudhary *et al.* (2023), who highlighted oil content as an economically significant trait in oilseed crops. The significant role of oil content in seed yield improvement underscores its importance as a target for genetic enhancement in Indian mustard. The low residual effect observed in the path analysis suggests that the traits included in the study effectively explain most of the variation in seed yield, confirming their relevance for genetic improvement.

Furthermore, traits such as days to 50% flowering, plant height and 1000-seed weight were found to have direct positive effects on seed yield, consistent with previous studies by Singh *et al.* (2013) and Dawar *et al.* (2018), who stressed the importance of these traits in improving seed yield in Indian mustard. The identification of traits with both direct and indirect effects provides valuable insights for breeders, suggesting that targeting these traits simultaneously could lead to greater genetic gains and improvements in seed yield.

Overall, the findings of the present study highlight the importance of understanding both the direct and indirect effects of various traits on seed yield. By utilizing both correlation and path coefficient analyses, breeders can gain a more comprehensive understanding of trait relationships and use this information to design more effective breeding strategies aimed at enhancing seed yield in Indian mustard.

## Conclusion

This study highlights the significance of correlation and path coefficient analyses in identifying key traits influencing seed yield in Indian mustard.

Traits such as plant height, branches per plant, siliquae per plant, days to 50% flowering, and oil content showed strong positive correlations with seed yield, indicating their potential for genetic improvement. Path analysis revealed that branches per plant, oil content, and siliquae per plant had the highest direct positive effects on seed yield, while traits like siliqua density showed positive correlations but negative direct effects, suggesting complex trait interactions. These findings emphasize the importance of these traits for developing effective breeding strategies aimed at improving seed yield in Indian mustard.

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