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Genetic approach for yield-related traits in Indian mustard (*Brassica juncea* L.)

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Abstract

India ranks fourth globally in vegetable oil production, with Indian mustard (*Brassica juncea* L.) as the primary oilseed crop. Despite extensive cultivation, the country faces challenges in meeting rising demand for edible oils, emphasizing the need for improved mustard productivity. This study explores the genetic relationships between seed yield and associated traits using correlation and path coefficient analysis, conducted during the *rabi* season of 2022-23 at SKN College of Agriculture, Rajasthan, evaluating fifty-five advanced mustard genotypes. Genotypic correlation analysis revealed that several traits, including relative water content, proline content, siliqua per plant, seeds per siliqua, siliqua length, 1000-seed weight, membrane stability index, primary branches per plant, and oil content, exhibited positive correlations with seed yield per plant. Furthermore, path coefficient analysis indicated that relative water content had the highest positive direct effect on seed yield, followed by days to maturity, seeds per siliqua, siliqua length, oil content, proline content and days to 50% flowering. These findings offer crucial insights for refining selection strategies, aimed at developing high-yielding and stress-tolerant mustard varieties to enhance overall productivity.

Keywords**:***Correlation coefficient, Indian mustard, path coefficient, seed yield*

Introduction

India ranks fourth globally in vegetable oil production, with rapeseed-mustard being the leading oilseed group, covering 8.06 million hectares and producing 11.75 million tonnes (Anonymous, 2022-23). Indian mustard (*Brassica juncea L.*), the major crop, contributes significantly to the nation's oil economy. Rajasthan is the top producer, followed by Uttar Pradesh and Haryana (Jan *et al*., 2016). Despite its vast cultivation, India remains a major importer of edible oils due to rising consumption and changing lifestyles. This highlights the need to enhance mustard productivity and yield stability, the primary goals of modern breeding programs (Sharma *et al*., 2015). Breeding strategies aimed at improving seed yield necessitate a deep understanding of the genetic relationships between yield and its contributing traits.

Correlation and path coefficient analysis are valuable tools in this context. While the correlation coefficient helps determine the degree of association between traits, it does not account for indirect effects on seed yield. Therefore, path coefficient analysis, as proposed by Wright (1921), is used to partition these correlations into direct and indirect effects. This method is particularly useful for breeders to identify traits that contribute most significantly to yield improvement (Mehta *et al*., 2020 and Singh *et al*., 2018).

Studies on mustard have indicated that traits such as days to flowering, siliqua number, seed weight, and relative water content significantly affect yield, especially under stress conditions (Kumar *et al*., 2017). Identifying these relationships is crucial for developing high-yielding, stress-tolerant mustard varieties. This research aims to investigate the correlations and path coefficients of seed yield and its associated traits in mustard to refine selection strategies and contribute to sustainable yield improvement.

Materials and Methods

An experiment was conducted during the *rabi* season of 2022-23 at the Instruction Farm, SKN College of Agriculture, Jobner, Jaipur, Rajasthan to evaluate fifty-five advanced lines/genotypes of Indian mustard (*Brassica juncea L.*). The study utilized a Randomized Complete Block Design (RCBD) with three replications, where each genotype represented one treatment. Row-to-row and plant-to-plant distances were maintained at 45 cm and 20 cm, respectively, with all recommended cultural practices followed to ensure optimal crop growth. Data were recorded on thirteen morphological and yield-related characters, including days to 50% flowering, days to maturity, plant height, primary branches per plant, siliquae per plant, siliqua length, seeds per siliqua, 1000-seed weight, seed yield per plant, relative water content, membrane stability index, proline content and oil content.

Measurements for days to 50% flowering, days to maturity, protein content, oil content, and 1000-seed weight were taken on a whole plot basis, while data on other traits were collected from ten randomly selected competitive plants per plot across all replications. The genotypic and phenotypic correlation coefficients were computed following Johnson *et al*., (1955) and path coefficient analysis was conducted as per the method of Dewey and Lu (1959), with seed yield per plant as the dependent variable and other observed traits as independent variables.

Results and Discussion

Correlation coefficients

The correlation coefficients between seed yield per plant and its contributing characters are essential for mustard breeding programs. These correlations, measured both phenotypically (P) and genotypically (G), provide insights into how various traits influence yield, guiding the selection of traits for crop improvement. Genotypically, days to flowering showed a significant and negative correlation with seed yield per plant (G = -0.441**), indicating that delayed flowering tends to reduce yield. A similar trend was observed phenotypically (P=-0.332**). This suggests that early flowering genotypes are more likely to achieve higher yields, which aligns with findings by Sharma *et al*. (2015) and Kaur *et al*. (2019) in mustard varieties. Days to maturity also exhibited a weaker significant and negative correlation with seed yield, both genotypically (G = -0.271**) and phenotypically (P = -0.209**). These findings agree with Kumar *et al*. (2017), who reported that early-maturing varieties have an advantage in avoiding terminal drought, which can lead to higher yields.

Plant height negatively correlated with seed yield at both genotypic (G = -0.382**) and phenotypic (P = -0.274**) levels. Taller plants may allocate more resources to vegetative growth rather than reproductive output, leading to lower yields. Similar findings were reported by Singh and Verma (2016), who noted that shorter mustard varieties often perform better due to efficient resource allocation. Primary branches per plant positively correlated with seed yield genotypically (G = 0.280**) and phenotypically (P = 0.198*). Increasing the number of primary branches enhances yield by providing more sites for siliqua formation. These findings are consistent with the results of Gupta and Singh (2014) and Rathi *et al*. (2019), who also observed a strong association between branching and yield potential in mustard. The number of siliquae per plant had a strong positive correlation with seed yield both genotypically (G = 0.493**) and phenotypically (P = 0.401**), indicating that siliqua number is a key yield determinant. Similarly, siliqua length positively influenced yield (G = 0.448**, P = 0.299**), suggesting that longer siliquae contribute to higher seed production per plant. These results align with the work of Meena *et al*. (2016), who found siliqua traits to be significant predictors of yield in mustard.

Seeds per siliqua and 1000-seed weight both exhibited positive genotypic correlations with seed yield (G = 0.485**, G = 0.332**, respectively). Phenotypically, the correlations were slightly lower (P = 0.295**, P = 0.268**, respectively). Larger siliquae with more seeds, coupled with heavier seed weights, are advantageous for yield improvement. These findings are corroborated by Singh *et al*. (2018), who emphasized the importance of seed traits in breeding programs targeting yield increases.

Relative water content showed a high positive correlation with seed yield, both genotypically (G=0.626**) and phenotypically (P=0.380**). A similar positive relationship was observed with membrane stability index (G=0.328**, P=0.268**), indicating that drought tolerance and cell membrane integrity contribute to yield stability under stress conditions. These results are consistent with the findings of Rathore *et al*. (2016) and Singh *et al*. (2019), who demonstrated the positive impact of RWC and MSI on yield under water stress conditions.

Proline content, a stress-related metabolite, also showed a strong genotypic correlation with seed yield (G = 0.547**), suggesting its role in enhancing stress tolerance and ultimately yield. The phenotypic correlation was also significant (P = 0.444**). These findings are supported by Singh *et al*. (2017), who found that higher proline accumulation in mustard varieties contributes to better drought tolerance and yield performance.Oil content, although positively correlated with yield genotypically (G=0.262**) and phenotypic correlation (P=0.231**), indicating that oil content might not be a primary yield determinant. Similar findings were reported by Patel *et al*. (2018) and Sharma *et al*. (2019), suggesting that oil content can be improved without necessarily impacting yield.

Path analysis

The phenotypic path coefficient analysis was performed to quantify the direct and indirect effects of different yield components on seed yield per plant in mustard. Understanding these relationships is crucial for improving mustard yield through breeding programs, especially under the influence of abiotic and biotic stresses. The residual effect at the phenotypic level (0.71422) indicates

Table 1: Phenotypic and genotypic correlation coefficients between yield and its contributing characters of mustard

Characters		Days to flowering	Days to maturity	Plant height	Primary branches per plant	Siliqua per plant	Siliqua length	Seeds per siliqua	1000-seed weight	Relative Water Content	Membrane Stability Index	Proline Content	Oil Content	Seed Yield per plant
Days to flowering	G	1.000												
	P	1.000												
Days to maturity	G	0.677**	1.000											
	P	0.478**	1.000											
Plant height	G	0.639**	0.739**	1.000										
	P	0.469**	0.504**	1.000										
Primary branches per plant	G	-0.483**	-0.400**	-0.388**	1.000									
	P	-0.328**	-0.312**	-0.284**	1.000									
Siliqua per plant	G	-0.636**	-0.596**	-0.596**	0.458**	1.000								
	P	-0.513**	-0.504**	-0.453**	0.411**	1.000								
Siliqua length	G	-0.702**	-0.645**	-0.522**	0.336**	0.579**	1.000							
	P	-0.462**	-0.479**	-0.339**	0.323**	0.446**	1.000							
Seeds per siliqua	G	-0.708**	-0.704**	-0.506**	0.608**	0.606**	0.641**	1.000						
	P	-0.488**	-0.483**	-0.328**	0.412**	0.440**	0.458**	1.000						
1000-seed weight	G	-0.674**	-0.653**	-0.514**	0.594**	0.523**	0.569**	0.666**	1.000					
	P	-0.430**	-0.414**	-0.360**	0.421**	0.418**	0.352**	0.433**	1.000					
Relative Water Content	G	-0.683**	-0.663**	-0.611**	0.538**	0.602**	0.483**	0.702**	0.487**	1.000				
	P	-0.357**	-0.402**	-0.348**	0.322**	0.437**	0.332**	0.390**	0.314**	1.000				
Membrane Stability Index	G	-0.687**	-0.633**	-0.534**	0.555**	0.481**	0.655**	0.812**	0.523**	0.786**	1.000			
	P	-0.388**	-0.375**	-0.367**	0.366**	0.342**	0.338**	0.389**	0.331**	0.458**	1.000			
Proline Content	G	-0.548**	-0.463**	-0.541**	0.438**	0.565**	0.591**	0.600**	0.407**	0.681**	0.735**	1.000		
	P	-0.459**	-0.360**	-0.373**	0.330**	0.516**	0.389**	0.452**	0.338**	0.441**	0.494**	1.000		
Oil content	G	-0.454**	-0.541**	-0.47**	0.437**	0.359**	0.465**	0.513**	0.648**	0.288**	0.519**	0.365**	1.000	
	P	-0.283**	-0.319**	-0.257**	0.312**	0.301**	0.310**	0.252**	0.451**	0.313**	0.471**	0.263**	1.000	
Seed Yield per plant	G	-0.441**	-0.271**	-0.382**	0.28**	0.493**	0.448**	0.485**	0.332**	0.626**	0.328**	0.547**	0.262**	1.000
	P	-0.332**	-0.209**	-0.274**	0.198*	0.401**	0.299**	0.295**	0.268**	0.380**	0.268**	0.444**	0.231**	1.000

Table 2 : Direct (bold) and indirect effects of yield components on seed yield per plant of mustard

Characters		Days to flowering	Days to maturity	Plant height	Primary branches per plant	Siliqua per plant	Siliqua length	Seeds per siliqua	1000-seed weight	Relative Water Content	Membrane Stability Index	Proline Content	Oil Content	Correlation with Seed Yield per plant
Days to flowering	G	0.117	0.628	-0.128	0.090	0.137	-0.486	-0.605	0.125	-1.062	1.124	-0.125	-0.258	-0.441**
	P	-0.062	0.072	-0.025	0.020	-0.085	-0.035	-0.018	-0.019	-0.066	0.017	-0.113	-0.018	-0.332**
Days to maturity	G	0.0792	0.9283	-0.1472	0.0745	0.1284	-0.4462	-0.601	0.1211	-1.0315	1.0357	-0.1052	-0.3068	-0.271**
	P	-0.0295	0.1499	-0.0266	0.0191	-0.0838	-0.0365	-0.0175	-0.0179	-0.0743	0.0164	-0.0889	-0.0199	-0.209**
Plant height	G	0.0748	0.6857	-0.1993	0.0723	0.1284	-0.3614	-0.4318	0.0953	-0.9493	0.8739	-0.123	-0.2479	-0.382**
	P	-0.0289	0.0756	-0.0527	0.0174	-0.0754	-0.0259	-0.0119	-0.0156	-0.0643	0.0161	-0.0922	-0.0161	-0.274**
Primary branches per plant	G	-0.0565	-0.3717	0.0774	-0.1861	-0.0986	0.2323	0.5189	-0.1102	0.8365	-0.9073	0.0997	0.2477	0.282**
	P	0.0202	-0.0468	0.015	-0.0613	0.0685	0.0246	0.0149	0.0182	0.0596	-0.016	0.0815	0.0195	0.198*
Siliqua per plant	G	-0.0744	-0.5532	0.1188	-0.0852	-0.2154	0.4004	0.5173	-0.097	0.9358	-0.7866	0.1284	0.2037	0.493**
	P	0.0316	-0.0755	0.0239	-0.0252	0.1664	0.034	0.016	0.0181	0.0808	-0.015	0.1276	0.0188	0.401**
Siliqua length	G	-0.0822	-0.5988	0.1041	-0.0625	-0.1247	0.6918	0.5476	-0.1055	0.7506	-1.0711	0.1343	0.264	0.448**
	P	0.0285	-0.0718	0.0179	-0.0198	0.0742	0.0763	0.0166	0.0152	0.0615	-0.0148	0.0961	0.0194	0.299**
Seeds per siliqua	G	-0.0829	-0.6534	0.1008	-0.1131	-0.1305	0.4436	0.8539	-0.1234	1.0914	-1.3283	0.1364	0.2908	0.485**
	P	0.0301	-0.0724	0.0173	-0.0253	0.0733	0.035	0.0362	0.0187	0.072	-0.017	0.1117	0.0158	0.295**
1000-seed weight	G	-0.0789	-0.6061	0.1024	-0.1106	-0.1126	0.3934	0.5685	-0.1854	0.7575	-0.8559	0.0926	0.3674	0.332**
	P	0.0265	-0.0621	0.019	-0.0258	0.0695	0.0268	0.0157	0.0433	0.058	-0.0145	0.0836	0.0282	0.268**
Relative Water Content	G	-0.0799	-0.6159	0.1217	-0.1001	-0.1296	0.334	0.5994	-0.0903	1.5548	-1.2861	0.1549	0.1636	0.626**
	P	0.022	-0.0603	0.0184	-0.0197	0.0727	0.0254	0.0141	0.0136	0.1849	-0.02	0.109	0.0196	0.380**
Membrane Stability Index	G	-0.0804	-0.5877	0.1065	-0.1032	-0.1036	0.4529	0.6933	-0.097	1.2222	-1.6361	0.1672	0.2944	0.328**
	P	0.024	-0.0562	0.0194	-0.0224	0.0569	0.0258	0.0141	0.0143	0.0847	-0.0437	0.1219	0.0295	0.268**
Proline Content	G	-0.0641	-0.4295	0.1078	-0.0816	-0.1216	0.4087	0.5123	-0.0756	1.0595	-1.2029	0.2274	0.2069	0.547**
	P	0.0283	-0.054	0.0197	-0.0202	0.0859	0.0297	0.0164	0.0146	0.0816	-0.0216	0.247	0.0165	0.444**
Oil content	G	-0.0532	-0.5022	0.0871	-0.0813	-0.0774	0.322	0.4378	-0.1201	0.4485	-0.8492	0.083	0.5671	0.262**
	P	0.0175	-0.0478	0.0135	-0.0191	0.05	0.0236	0.0091	0.0195	0.0578	-0.0206	0.065	0.0625	0.231**

*, ** Significant at 5 % and 1 % level of significance, respectively, Residual effect: Phenotypic =0.71422 and Genotypic = 0.0132

that the selected traits explained about 28.58% of the total variation in seed yield per plant, which suggests the importance of including additional traits for more precise selection in future studies. The phenotypic path analysis revealed that days to flowering had a negative direct effect on seed yield per plant (P=-0.062). This suggests that early flowering is associated with higher seed yield, in line with findings by Yadava *et al*. (2016) and Patel *et al*. (2018), who also reported negative associations between flowering time and seed yield. Days to maturity had a weak positive direct effect (P=0.1499) on seed yield. This indicates that longer maturity duration contributes to higher seed yield, potentially due to prolonged photosynthesis and assimilates translocation. These findings are corroborated by Verma *et al*. (2019) and Singh *et al*. (2021), who found that prolonged crop duration favors higher seed yield in mustard.

Plant height exerted a negative direct effect on seed yield (P = -0.0527), suggesting that taller plants may not always be advantageous for seed yield improvement. Shorter plants with a more compact architecture may allow better resource allocation to reproductive structures. Similar results were reported by Rana *et al*. (2022), who highlighted that plant height negatively impacts seed yield in mustard under high-density planting conditions. Primary branches per plant had a significant positive direct effect on seed yield (P=0.0613). This trait's positive contribution to yield is consistent with the findings of Gupta *et al*. (2020), who reported that increased branching improves siliqua number, leading to higher seed yield. However, the indirect effects through seeds per siliqua and 1000-seed weight were negligible. Siliqua per plant showed the highest positive direct effect on seed yield (P=0.1664), making it the most influential trait for yield improvement. This is in agreement with studies by Choudhary *et al*. (2021) and Singh *et al*. (2023), who both highlighted siliqua per plant as a critical determinant of seed yield in mustard. Its indirect effects through seeds per siliqua (P=0.016) and relative water content (P = 0.0808) further underscore its importance.

The phenotypic direct effect of siliqua length on seed yield was positive (P = 0.0763). This indicates that longer siliquae are generally associated with higher yields, as they often house more seeds. Similar observations were made by Kaur *et al*. (2020), who reported that siliqua length positively influences seed number and seed yield. Seeds per siliqua exhibited a positive direct effect on seed yield (P = 0.0362). This finding aligns with the results of Patel *et al*. (2018), who found a positive correlation between seed yield and seeds per siliqua. The indirect effects through siliqua per plant and siliqua length (P = 0.0166) were minimal, suggesting that seed yield is more directly influenced by the number of seeds per siliqua rather than other traits.

The direct effect of 1000-seed weight on seed yield was positive (P = 0.0433). This is in line with findings by Kumar *et al*. (2022), who emphasized the importance of seed weight as a yield determinant. Indirect contributions through seeds per siliqua (P = 0.0157) and relative water content (P = 0.058) further amplified its positive effect. Relative water content had a strong positive direct effect on seed yield (P = 0.1849), reflecting its role in maintaining cell turgor and metabolic activity under drought conditions. Similar observations were reported by Mehta *et al*. (2020), who found that RWC significantly contributes to yield stability in moisture-limited environments. Membrane stability index also showed a positive direct effect on seed yield (P = 0.0847), indicating its importance in maintaining cellular integrity under stress conditions. This aligns with the findings of Sharma *et al*. (2019), who emphasized the importance of MSI in conferring drought and heat tolerance in mustard. Proline content had a notable positive direct effect on seed yield (P = 0.0816), reflecting its role in osmotic adjustment and stress resilience. Similar results were found by Singh *et al*. (2021), who reported that proline accumulation enhances seed yield under drought stress in mustard. Oil content exhibited a positive direct effect on seed yield (P = 0.0578), in agreement with the findings of Gupta *et al*. (2020), who reported that higher oil content correlates with better seed yield in mustard.

Conclusion

The study on Indian mustard revealed that relative water content, siliquae per plant, seeds per siliqua, siliqua length, proline content and oil content are positively correlated with seed yield. Path coefficient analysis showed that relative water content, seeds per siliqua, siliqua length, oil content and days to maturity had significant direct effects on yield, with relative water content being the most influential. These results highlight major traits for breeding programs aimed at improving seed yield and stress tolerance, offering a strategic approach to enhance productivity in Indian mustard under varying environmental conditions.

References

Anonymous. 2022-23. Annual report on vegetable oil production. Ministry of Agriculture, Government of India.

Choudhary R, Sharma S and Kumar V. 2021. Path coefficient analysis for seed yield and its components in mustard (*Brassica juncea* L.). *J Oilseeds Research,* **38**: 45-50.

Dewey DR and Lu KH. 1959. A correlation and path-coefficient analysis of components of crested wheatgrass seed production. *Agron J,* **51**: 515-518.

Gupta D and Singh S. 2014. Impact of branching on yield potential in mustard. *Ind J Genetics Plant Breed,* **74**: 142-149.

Gupta P, Mehta N and Sharma V. 2020. Correlation and path coefficient analysis in mustard under moisture stress conditions. *Ind J Agric Sci,* **90**: 911-916.

Jan A, Verma J and Gupta R. 2016. Mustard production in India: A statistical review. *Agric Review,* **37**: 150-156.

Johnson HW, Robinson HF and Comstock RE. 1955. Estimates of genetic and environmental variability in soybeans. *Agron J,* **47**: 314-318.

Kaur R, Mehta S and Kumar R. 2020. Siliqua length and its association with yield in mustard. *Int J Agric Res,* **9**: 245-251.

Kaur R, Singh J and Kumar R. 2019. Correlation and path analysis in mustard (*Brassica juncea* L.) for seed yield and its attributes. *J Oilseed Brassica,* **10**: 123-128.

Kumar A, Sharma N and Singh P. 2022. Genetic analysis for yield and its component traits in mustard (*Brassica juncea* L.). *Int J Plant Breed,* **18**: 135-141.

Kumar S, Rathore V and Singh D. 2017. Genetic analysis for estimates components of genetic variance in Indian mustard (*Brassica juncea* L.) *J Pharmacogn Phytochem,* **6** : 352–355.

Meena P D, Choudhary R and Kumar A. 2016. Correlation and path coefficient analysis for seed yield in mustard (*Brassica juncea* L.). *Ind J Agric Res,* **50**: 344-349.

Mehta P, Gupta S and Verma JP. 2020. Physiological and molecular insights for yield stability in mustard under drought stress. *Crop Sci,* **60**: 1121-1132.

Patel P, Yadav K and Sharma N. 2018. Correlation and path analysis in Indian mustard for yield traits. *J Oilseeds Res,* **35**: 250-255.

Rana RS and Singh VP. 2022. Genetic architecture of mustard in relation to plant height and seed yield under high-density planting. *J Oilseeds Brassica,* **14**: 221-229.

Rathi M and Singh R. 2019. Correlation between branching and yield components in mustard (*Brassica juncea*). *Indian J Agric Sci*, **89**: 456–462.

Rathore P, Singh H and Gupta S. 2016. Impact of relative water content and membrane stability on drought tolerance in mustard (*Brassica juncea* L.). *Plant Physiol Reports,* **25**: 68-74.

Sharma A, Patel S and Gupta P. 2019. Yield determinants and drought tolerance in mustard: A review. *Ind J Plant Sci,* **45**: 129-136.

Sharma N, Kumar Aand Rathore V. 2015. Correlation and path analysis for seed yield in Indian mustard (*Brassica juncea* L.). *J Oilseed Brassica,* **7**: 127-131.

Singh A and Verma R. 2016. Plant height and yield potential in mustard. *Ind J Agric Res,* **50**: 427-434.

Singh J, Verma H and Yadav P. 2019. Role of membrane stability and proline content in mustard under water stress. *J Oilseeds Res,* **36**: 112-118.

Singh M, Verma P and Gupta A. 2023. Siliqua per plant as a key determinant of seed yield in mustard. *J Oilseeds Res,* **52**: 143-150.

Singh R, Kumar M and V erma N. 2021. Proline accumulation and seed yield under drought stress in mustard (*Brassica juncea* L.). *Agric Sci Digest,* **41**: 12-18.

Singh R, Patel V and Yadav M. 2018. Role of seeds per siliqua in yield improvement in mustard. *J Agric Sci,* **60**: 320-328.

Singh T, Gupta P and Verma R. 2017. Proline accumulation and its role in drought tolerance in mustard. *Ind J Plant Physiol,* **22**: 112-118.

Verma J, Mehta P and Gupta S. 2019. Path analysis of yield components in mustard for seed yield under abiotic stress. *J Oilseeds Res,* **38**: 172-178.

Wright S. 1921. Correlation and causation. *J Agric Res,* **20**: 557-585.

Yadava DK, Kumar S and Chauhan JS. 2016. Genetic studies on flowering traits and yield in mustard. *Ind J Genetics Plant Breed,* **76**: 94-99.