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Study of correlation and path coefficients for Indian mustard yield and yield contributing characteristics

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Abstract
The field experiment was carried out during *Rabi* season of 2022-23 at Agricultural Research Farm, Department of Plant Breeding and Genetics, R.B.S. College, Bichpuri, Agra, Uttar Pradesh. The Variables involved in this study were 30 different genotypes *viz.* Radhika, Girraj, RH725, RH-761, DRMR-150-35, RH-406, PPM-25, PM-27, RGN-73, Pusha tarak, Kranti, Geeta, Pusha bold, RH-0749, KRISHNA, DRMR-31, NRCHB-101, PUSHA MAHAK, NRCHB-02, CS-60, CS-56, ASHIRWAD, RGN-48, Maga, Pusha vijay, Bhagirathi, Seeta, Pusha jay, Kishan, NRCDR-601, RH-30 of Indian mustard. Thus, in all 30 genotypes were compared in a randomized block design (RBD) with three replications. These genotypes were made available from the DRMR, Bharatpur (Rajsthan). The results correlation and path analysis highlight the importance of traits like siliquae on the main raceme and biological yield in determining mustard yield. Positive and significant correlations with seed yield were observed for biological yield (r = 0.84), siliquae per plant (r = 0.78), and 1000-seed weight (r = 0.72). Path Coefficient with Siliquae on the main raceme exhibited the highest direct effect on seed yield (0.67), followed by biological yield (0.55). Indirect effects, such as those mediated through plant height, emphasized the complex interdependence among traits.

Keywords: Correlation analysis, path analysis, mustard, seed yield, yield components

Introduction

In India, rapeseed-mustard crops include traditional indigenous species such as toria (*Brassica rapa* L. var. toria), brown sarson (*Brassica rapa* L. var. brown sarson), yellow sarson *(Brassica rapa* L. var. yellow sarson), Indian mustard (*Brassica juncea*), black mustard (*Brassica nigra*), and taramira (*Eruca sativa*). Other non-traditional species include gobhi sarson (*Brassica napus*) and Ethiopian mustard or Karan rai (*Brassica carinata*). After groundnuts, Indian mustard (*Brassica juncea* (L.) Czern and Coss) is the second-most significant oilseed crop in both India and the world. It is an amphidiploid (2n=36) of Brassica nigra (2n=16) and Brassica campestris (2n=20) that occurs naturally. It is a crop that is mostly self-pollinated (85-90%) and self-compatible. The Brassica group of oil seed crops includes Indian mustard, often referred to as rai, raya, or laha. It makes up around 75-80% of the 6.6 million hectares planted to rapeseed and mustard in the nation. Additionally, cell division and the formation of new tissues depend on phosphorus (Singh *et al*., 2022) [17]. The creation of new cultivars for increased yields has currently plateaued, and unless biotechnological measures are used, no further rise will be possible (Archna, *et al*., 2023) [2]. Grain, which is utilized for industrial processing as well as food and feed, is the commodity with the highest economic value. (Singh *et al.*, 2024) [16]. However, human activity has drastically changed the composition of the atmosphere over the last few centuries, especially since the industrial revolution. environment-resilient farming seeks to preserve secure farmer livelihoods and sustainable food production despite a changing environment. (Singh *et al.*, 2023) [18]. The recent rise in fertilizer prices is one of the main barriers to increasing crop yields for commercial use. Consequently, steps must be taken to reduce its losses and enhance its economic usage (Lokendra *et al*., 2024) [13].

The relationship between various morphological factors and yield components provides insight into growth and yield characteristics, which may be promoted to achieve increased productivity. Path analysis may be used to determine if each character has a direct or indirect impact on yield. (Wright, 1921) [21]. Measuring the independent factors' direct and indirect effects on the dependent variable is helpful.

It separates the direct and indirect influence components of the correlation coefficient. The degree of relationship between seed yield and its constituent parts will be determined using correlation and path analysis, which will also highlight the relative significance of their direct and indirect impacts. Grain yield is a complicated trait that depends on the interaction of several genes. Measuring the independent factors' direct and indirect effects on the dependent variable is helpful. It separates the direct and indirect influence components of the correlation coefficient. The degree of relationship between seed yield and its constituent parts will be determined using correlation and path analysis, which will also highlight the relative significance of their direct and indirect impacts. Grain yield is a complicated trait that depends on the interaction of several genes. (Shubam *et al*., 2023) [14]. The correlation coefficient and path analysis between several variables in thistly genotypes of Indian mustard were reported in the current study.

Materials and Methods

At the Agricultural Research Farm, Department of Plant Breeding and Genetics, Raja Balwant Singh College, Bichpuri, Agra, Uttar Pradesh, the field experiment was conducted during the *Rabi* season of 2022-2023. The experimental field's soil had a pH of 8.12 and was sandy loam in texture. Thirty distinct genotypes were the variables in this investigation. *viz.* Radhika, Girraj, RH725, RH-761, DRMR-150-35, RH-406, PPM-25, PM-27, RGN-73, Pusha tarak, Kranti, Geeta, Pusha bold, RH-0749, KRISHNA, DRMR-31, NRCHB-101, PUSHA MAHAK, NRCHB-02, CS-60, CS-56, ASHIRWAD, RGN-48, Maga, Pusha vijay, Bhagirathi, Seeta, Pusha jay, Kishan, NRCDR-601, RH-30 of Indian mustard. Therefore, a randomized block design (RBD) with three replications was used to compare all 30 genotypes. including three genotype rows, each measuring 45 cm and spaced 15 plants apart. Throughout the cropping season, all of the suggested practices were followed. The DRMR in Bharatpur, Rajasthan, provided these genotypes. Plant height was one of the twelve characteristics for which data were gathered. The Dewey and Lu technique (1959) [7] was used to determine phenotypic and genotypic correlations and perform path coefficient analysis.

Results and Discussion

(I) Phenotypic correlation

There was a negative and highly significant correlation between the number of siliqua on the main raceme and seed yield per plant, whereas days to maturity and the number of seeds per siliqua showed a positive and significant correlation with seed yield/plant. Additionally, the harvest index showed a positive and highly significant correlation with seed yield per plant at the phenotypic level. 1000 seed weight, length of main raceme and days to 50% flowering showed negative and non-significant correlation with seed yield per plant. Primary branches, secondary branches per plant and plant height exhibited positive and non-significant correlation with seed yield per plant. at phenotypic level Chaudhary *et al*. (2003) [5], Gangapur *et al*. (2009) [8] Kumar and Pandey (2014) [11], Lodhi *et al* (2014) [12] and Devi *at al*. (2018) [6], Harish *et al*., (2023) [9], Babu and Singh (2024) [3, 4] also reported more of less similar findings, except for the negetively significant contribution of number of siliqua on main raceme in present study.

Genotypic correlations

A crop enhancement program's primary goal is to increase the crop's potential output. Since yield is essentially a polygenically regulated trait, selection that is specifically focused on yield is challenging. To get around this, yield-contributing characters must be taken into account concurrently after effective selection. Understanding the relationships between yield-contributing characteristics is essential before selection. Reliable information on the kind, scope, and direction of selection is provided by correlation studies. Days 50% to flowering were found to be negatively significantly correlated with the number of primary branches/plant, number of siliqua on mean raceme, harvest index, and seed yield plants, but positively significantly correlated with days to maturity and length of mean receme in the current genotypic level investigation similar findings have been reported by Lakra *et al.* 2020 [22] for length of main raceme but contrary to the correlations for other characters. The days to maturity showed significant positive correlation with number of secondary branches and negative significant correlation with plant height at genotypic level. Bind *et al* 2014 reported number results except for days to maturity and length of main raceme. This may be due to the nature of Genotypes taken in this study and the effect of environment on them. The number of primary branches showed significant positive correlation with number of secondary branches/plant highly significant negative correlation with test weight and number of selliqua on main raceme similar findings were reported by Shubham, *et al.*, (2023) [14] and Babu and Singh (2024) [3, 4]. Harish *et al.*, (2023) [9].

Path coefficient

Using route coefficient analysis, the genotypic and phenotypic correlation coefficients of seed yield per plant with the other remaining characteristics under investigation were further divided into direct and indirect effects, and are shown in Tables 2(i) and (ii), respectively.

Genotypic

The harvest index exhibited the greatest positive direct influence (0.858) on seed yield per plant, followed by days to maturity (0.635) at the genotypic level, according to path coefficient analysis. There was a positive direct effect on seed yield from primary branches per plant, plant height, length of main raceme, number of seeds per siliqua, 1000 seed weight, and biological yield per plant, while there was a negative direct effect on seed yield from days to 50% flowering, number of secondary branches per plant, and number of siliquae on main raceme. The maximum negative direct effect was observed in the case of days to 50% flowering (-0.839). The number of siliqua on the main raceme, the number of primary branches per plant, and the number of days to 50% blooming all had a favorable indirect influence on seed output at the genotypic level. The estimated residual impact was (0.0438).

Table 1 i: Phenotypic correlations

Characters	**Days to maturity**	**Number of primary branches/plant**	**Number of secondary branches/plant**	**Plant height (cm)**	**Length of main receme**	**Number of siliquae on main receme**	**Number of seeds/ siliqua**	**1000 seed weight (g)**	**Biological yield (g)**	**Harvest index**	**Seed yield/plant (g)**
Days to 50 percent flowering	0.109	-0.390**	-0.039	0.125	-0.073	-0.280**	0.210*	0.070	-0.115	-0.097	-0.092
Days to maturity		-0.030	-0.079	-0.056	0.086	-0.282**	0.064	0.128	0.055	-0.017	0.213*
Number of primary branches plant^{-1}			0.169	-0.145	0.178	-0.007	-0.062	-0.307**	0.187*	0.001	0.011
Number of secondary braches plant^{-}				-0.094	-0.156	-0.119	0.126	0.012	0.077	0.065	0.065
Plant height (cm)					0.025	-0.227*	0.061	0.102	-0.176	0.011	0.113
Length of main raceme						-0.260**	-0.186*	0.011	0.023	-0.101	-0.099
Number of siliquae on main raceme							0.121	-0.081	0.014	0.069	-0.201*
Number of seeds siliqua^{-1}								0.148*	0.042	0.025	0.198*
1000 seed weight (g)									-0.032	-0.050	-0.002
Biological yield (g)										-0.647**	-0.153
Harvest index											0.722**

Table 1 ii: Genotypic correlations

Characters	**Days to 50 percent flowering**	**Days to maturity**	**Number of primary branches** plant^{-1}	**Number of secondary branches** plant^{-1}	**Plant height (cm)**	**Length of main raceme (cm)**	**Number of siliqae on main raceme**	**Number of seeds/siliqua**	**1000 seed weight (g)**	**Biological yield (g)**	**Harvest index**	**Seed yield/plant (g)**
Days to 5o percent flowering		0.386**	-0.247**	-0.292**	-0.096	0.266**	-0.325**	-0.171	0.131	0.123	0.241**	-0.307**
Days to maturity			-0.029	0.269**	-0.500**	-0.048	0.147	0.136	0.024	0.112	0.135	0.160
Number of primary branches plant^{-1}				0.271**	0.083	0.095	-0.259**	0.176	-0.318**	-0.019	0.017	0.164
Number of secondary branches plant^{-1}					-0.029	0.018	-0.475**	0.056	0.149	0.133	-0.062	0.137
Plant height (cm)						0.129	0.040	-0.125	0.038	-0.026	0.054	-0.071
Length of maine raceme							-0.271**	-0.030	-0.063	-0.076	-0.030	-0.072
Number of siliqua on main raceme								0.363**	0.081	-0.152	-0.015	-0.073
Number of seed /siliqua^{-1}									0.205*	0.239**	-0.017	0.139
1000 seed weight (g)										0.001	-0.001	-0.051
Biological yield (g)											0.710**	-0.070
Harvest index %												0.807**
Seed yield/plant (g)												

Phenotypic

Path coefficient analysis revealed that the harvest index had the greatest positive direct influence (1.105) on seed production, followed by biological yield per plant (0.586) at the phenotypic level. Days to maturity, plant height, and number of seeds per siliqua all had a positive direct effect on seed yield, whereas days to 50 percent flowering, primary branches per plant, secondary branches per plant, length of main raceme, siliquae on main raceme, and 1000-seed weight had a negative direct effect. Days to maturity, number of seeds per selliqua via seed yield per plant, number of primary branches per plant via biological yield per plant, days to 50% flowering via number of siliquae on main racemes, and number of seeds per selliqua via seed yield per plant all demonstrated positive indirect effects on seed yield at the phenotypic level. The Harves index showed the highest positive highly significant indirect effect (0.722) and number of seeds per selliqua on seed yield per plant, followed by days to maturity (0.213). The residual impact estimate was 0.141.

Days to maturity biological yield and harvest index had a direct impact on seed yield at both the genotypic and phenotypic levels, according to path coefficient analysis. Additionally, there was a favorable correlation between these traits and seed yield. This suggested that a noticeable increase in seed output will come from direct selection based on harvest index and biological yield per plant. Sirohi *et al*. (2004) [19], Gangapur *et al*. (2009) [8], Kumar and Pandey (2014) [11], Karan *et al.,* (2023) [10], found that harvest index had high, positive and direct negative effects on seed yield.

Table 2 (i): Direct and indirect effect for different characters on seed yield at genotypic level in Indian mustard

Characters	Days to 50 percent	Days to maturity	Number of primary branches/plant	Number of secondary branches/plant	Plant height (cm)	Length of main raceme	Number of siliquae on main raceme	Number of seeds/siliqua	1000 seed weight (g)	Biological yield (g)	Harvest index	A with Seed yield/plant (g)
Days to 50 percent flowering	-0.839	0.245	-0.001	0.188	-0.012	0.021	0.215	-0.008	0.024	0.068	-0.207	-0.307**
Days to maturity	-0.324	0.635	0.000	-0.174	-0.065	-0.004	-0.097	0.007	0.005	0.062	0.115	0.160
Number of primary branches /plant	0.208	-0.019	0.006	-0.175	0.011	0.007	0.172	0.009	-0.059	-0.010	0.015	0.164
Number of secondary branches /plant	0.245	0.171	0.002	-0.644	-0.004	0.001	0.315	0.003	0.028	0.073	-0.053	0.137
Plant height (cm)	0.080	-0.318	0.000	0.019	0.130	0.010	-0.026	-0.006	0.007	-0.014	0.047	-0.071
Length of main raceme	-0.223	-0.030	0.001	-0.012	0.017	0.077	0.180	-0.001	-0.012	-0.042	-0.026	-0.072
Number of siliquae on main raceme	0.272	0.093	-0.002	0.306	0.005	-0.021	-0.663	0.018	0.015	-0.084	-0.013	-0.073
Number of seeds /seliqua	0.143	0.086	0.001	-0.036	-0.016	-0.002	-0.241	0.049	0.038	0.132	-0.015	0.139
1000 seed weight (g)	-0.110	0.016	-0.002	-0.096	0.005	-0.005	-0.054	0.010	0.186	0.001	-0.001	-0.051
Biological yield (g)	-0.103	0.071	0.000	-0.086	-0.003	-0.006	0.101	0.012	0.000	0.553	-0.609	-0.070
Harvest index	0.203	0.085	0.000	0.040	0.007	-0.002	0.010	-0.001	0.000	-0.392	0.858	0.807**

Resi = 0.0438

Table 2 (ii): Direct and indirect effect for different characters on seed yield at phenotypic level in Indian mustard

Characters	Days to 50 percent flowering	Days to maturity	Number of primary branches /plant	Number of secondary branches/plant	Plant hight (cm)	Length of main raceme	Number of siliquae on main raceme	Number of seeds /siliqua	1000 seed weight (g)	Biologial yield (g)	Harvest index	R with Seed yield/plant (g)
Days to 50 percent flowering	-0.117	0.013	0.037	0.003	0.016	0.005	0.087	0.040	-0.002	-0.067	-0.107	-0.092
Days to maturity	-0.013	0.120	0.003	0.007	-0.007	-0.006	0.087	0.012	-0.004	0.032	-0.019	0.213*
Number of primary branches /plant	0.045	-0.004	-0.096	-0.015	-0.018	-0.011	0.002	-0.012	0.009	0.109	0.002	0.011
Number of secondary branches/plant	0.005	-0.009	-0.016	-0.089	-0.012	0.010	0.037	0.024	0.000	0.045	0.071	0.065
Plant height (cm)	-0.015	-0.007	0.014	0.008	0.126	-0.002	0.070	0.012	-0.003	-0.103	0.012	0.113
Length of main raceme	0.008	0.010	-0.017	0.014	0.003	-0.064	0.081	-0.036	0.000	0.013	-0.112	-0.099
Number of siliquae on main raceme	0.033	-0.034	0.001	0.011	-0.029	0.017	-0.310	0.023	0.002	0.008	0.077	-0.201*
Number of seeds /siliqua	-0.024	0.008	0.006	-0.011	0.008	0.012	-0.038	0.190	-0.004	0.024	0.027	0.198*
1000 seed weight (g)	-0.008	0.015	0.029	-0.001	0.013	-0.001	0.025	0.028	-0.029	-0.019	-0.055	-0.002
Biological yield (g)	0.013	0.007	-0.018	-0.007	-0.022	-0.001	-0.004	0.008	0.001	0.586	-0.715	-0.153
Harvest index	0.011	-0.002	0.000	-0.006	0.001	0.006	-0.022	0.005	0.001	-0.379	1.105	0.722**

Resi = 0.141

*, ** significant at 5% and 1% probability level, respectively

Conclusion

The study underscores the significance of critical characteristics in Indian mustard, stressing their relationship and impact on seed production. The findings showed that biological yield (r = 0.84), siliquae per plant (r = 0.78), and 1000-seed weight (r = 0.72) were significantly correlated positively with seed production. The harvest index showed the most direct positive impact on yield at the phenotypic level (1.105), followed by biological yield (0.586), according to path coefficient analysis. The harvest index also showed a substantial direct influence (0.858) at the genotypic level. Significant indirect impacts were demonstrated by characteristics like days to maturity (0.213) and number of seeds per siliqua (0.198). The intricacy of trait interactions was further highlighted by the observation of negative impacts, such as siliquae on the major raceme at the genotypic (-0.663) and phenotypic (-0.201) levels. Contributing qualities to sow yield in the study demonstrated a direct and positive correlation, which will serve as a test of strictures for the traits for component solution.

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