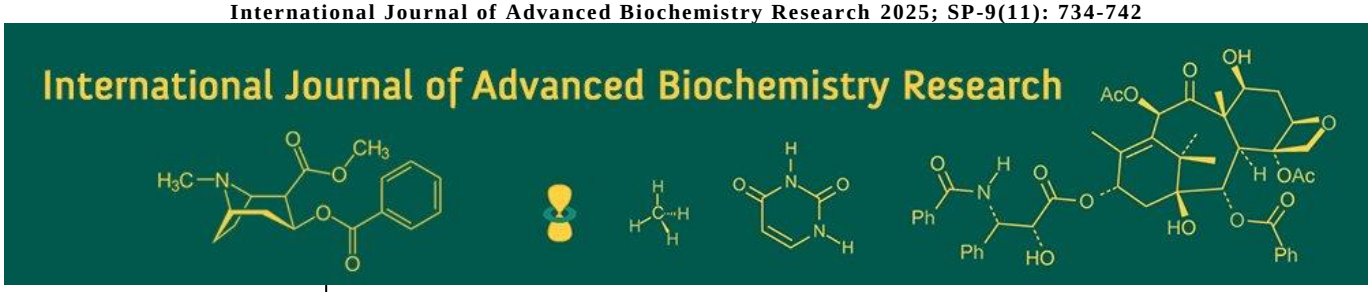

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Sandeep Kumar
Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Mahak Singh
Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

RK Yadav
Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Sarvendra Kumar
Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Lokendra Singh
Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Shweta
Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

CL Maurya
Department of seed science and technology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Corresponding Author:
Sandeep Kumar
Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Assessment of correlation and path parameters in Indian mustard (*Brassica juncea* L. czern. & coss.)

Sandeep Kumar, Mahak Singh, RK Yadav, Sarvendra Kumar, Lokendra Singh and Shweta and CL Maurya

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Abstract
The present investigation was conducted to study the correlation and path coefficient analysis for yield and its component traits in Indian mustard (*Brassica juncea* L. Czern & Coss.). The experimental material comprised ten genotypes Varuna, Rohini, Azad Mahak, NRC-DR-2, Maya, PR-21, KMR(L)17-5, Mathura Rai, Narendra Rai-4, and NDR-8501 crossed in a diallel mating design (excluding reciprocals) to obtain 45 F_1s and their corresponding F_2 generations. A total of 100 treatments (10 parents, 45 F_1s, and 45 F_2s) were evaluated in a Randomized Block Design with three replications during the Rabi season of 2024-2025 at the Oilseed Research Farm, C.S. Azad University of Agriculture and Technology, Kanpur. Observations were recorded on 18 morphological, yield, and quality traits. Correlation analysis revealed that seed yield per plant was significantly and positively associated with biological yield, harvest index, number of siliquae per plant, and number of secondary branches per plant. Path analysis indicated that biological yield and harvest index exerted the highest positive direct effects on seed yield across all generations. The results suggest that these traits, along with siliquae number and secondary branches, should be emphasized in selection programs. Simultaneous improvement for yield efficiency and seed quality may lead to the development of high-yielding, nutritionally superior mustard cultivars.

Keywords: *Brassica juncea*, correlation, path analysis, direct effect

Introduction
Oilseeds are essential agricultural commodities worldwide, providing not only edible oil but also protein-rich meals (oilcakes) for livestock, industrial raw materials, and bioenergy feedstocks. Improving the yield, quality, and stability of oilseed crops is a key component of national agricultural strategy in India, where there is still a large reliance on imported edible oil (Solvent Extractors' Association of India projects 12 million tons of mustard seed production in the 2023-24 season) (SEA, 2024) [13]. Because of its versatility in the winter (*Rabi*) season, compatibility for a variety of agroclimatic zones, and dual utility - oil for human consumption and oilcake for livestock feed and secondary uses - mustard (rapeseed-mustard complex), and *Brassica juncea* in particular, plays a crucial role.

One of India's main oilseed crops, Indian mustard (*Brassica juncea* L. Czern & Coss) is grown extensively in states like Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Punjab. It is valued for its fatty acid profile as well as its seed oil production; characteristics such as oil content, erucic acid, oleic, linoleic, and linolenic acid proportions are of industrial and nutritional significance. Certain genotypes had lower erucic acid and greater oleic acid, making them more suited for edible oil quality (Gadpayale *et al.*, 2022) [7]. Also, the recent release of a low erucic acid variety 'Raya Hisar 1706' with ~38% oil content exemplifies breeding progress aimed at improving nutritional and safety traits in *B. juncea* (Singh *et al.*, 2025) [12].

Even with its significance, Indian mustard productivity is still limited by a number of factors, such as suboptimal yield, a large genotype × environment interaction, a limited genetic base for key quality traits, and trade-offs between quality, yield, and oil content (SEA, 2024; Patel *et al.*, 2023) [13, 10]. To determine which traits most strongly contribute directly to seed yield and which traits influence yield only through other traits, breeders must have a thorough understanding of the relationships between yield and its component characters, including

plant height, number of branches, siliqua number, seeds per siliqua, 1000-seed weight, days to flowering, and maturity. Although it cannot determine whether a link is direct or mediated, correlation analysis provides an image of the relationship between qualities, both positive and negative (Meena *et al.*, 2024) [9]. Path coefficient analysis helps partition correlation coefficients into direct and indirect effects, thereby allowing breeders to target component traits with high direct effect on yield (and acceptable heritability) for selection.

Material and Methods

The basic material for the present investigation comprised ten varieties/strains of Indian mustard, namely Varuna, Rohini, Azad Mahak, NRC-DR-2, Maya, PR-21, KMR(L)17-5, Mathura Rai, Narendra Rai-4, and NDR-8501, which were obtained from the germplasm maintained at the Oilseed Section, Department of Genetics and Plant Breeding, C.S. Azad University of Agriculture and Technology, Kanpur.

All ten genotypes were crossed in a diallel mating design (excluding reciprocals) in all possible combinations to produce sufficient F_1 seeds of 45 cross combinations during 2022-2023. The mature seeds were harvested separately and stored individually. Half of the F_1 seed of each cross obtained during 2022-2023 was used to raise the crop for obtaining the source seed of the F_2 generation, and the parental lines were selfed during 2023-2024 to obtain sufficient seed. The mature seeds were harvested separately and stored properly.

In the final trial, 100 treatments (10 parents + 45 F_1s + 45 F_2s) were evaluated in a Randomized Block Design (RBD) with three replications during the *Rabi* season of 2024-2025 at the Oilseed Research Farm, C.S. Azad University of Agriculture and Technology, Kanpur-208002 (U.P.). Each parent and F_1 was planted in a single row, while each F_2 was planted in two rows of 5 m length with a row-to-row spacing of 45 cm. A plant-to-plant distance of 15 cm was maintained by thinning. All recommended agronomic practices were followed to raise a healthy crop.

Data were recorded on the following traits days to 50% flowering, days to maturity, plant height (cm), main axis height (cm), leaf area index (cm^2/m^2), chlorophyll content, number of primary branches per plant, number of secondary branches per plant, number of siliquae per plant, number of seeds per siliqua, biological yield per plant (g), 1000-seed weight (g), harvest index (%), oil content (%), seed yield per plant (g), protein content (%), tryptophan content (%), and methionine content (%).

The genotypic correlation coefficients were estimated according to the formula given by Al-Jibouri et al. (1958) [1] while path analysis was carried out using the genotypic correlation coefficient to know direct and indirect effects of the components on yield as suggested by Wright (1921) [14] and illustrated by Dewey and Lu (1957) [4].

Results and Discussion

Correlation Analysis

In the parental generation, days to 50% flowering showed a dual role, positively correlating with primary branches and methionine content, suggesting that early-flowering genotypes tend to be more branched and nutritionally enriched. However, its negative correlation with plant height, harvest index, and tryptophan indicates a trade-off with structural development and partitioning efficiency. Similar trends of contrasting associations with phenological and yield-related traits have been reported by Yadav *et al.*, (2023) [15] and Meena *et al.*, (2024) [9] in *Brassica juncea*, indicating that flowering time often exerts indirect effects on productivity through growth and partitioning behavior.

Biological yield was tightly linked to seed yield but inverselyrelated to oil content, a relationship also observed by Duluri *et al.*, (2024) [5] and Dwivedi *et al.*, (2023) [6], who noted that higher biomass does not necessarily enhance oil accumulation. Thousand-seed weight supported harvest index and oil content, while harvest index itself was positively associated with oil, linoleic acid, and seed yield, confirming its importance in efficient assimilate translocation and yield formation (Kumar *et al.*, 2022) [8].

Seed yield was positively and significantly associated with the number of secondary branches per plant, number of siliquae per plant, biological yield per plant, and harvest index. Similar trends for yield per plant were observed in the F_1 generation as well, while in the F_2 generation, only the number of secondary branches per plant, biological yield per plant, and harvest index showed significant and positive correlations with grain yield. These results corroborate the findings of Patel *et al.*, (2023) [10], Awasthi *et al.*, (2018) [2], and Choudhary *et al.*, (2023) [3], who emphasized that secondary branching, siliquae number, and harvest index are the most stable and heritable contributors to yield in Indian mustard.

Path Correlation Analysis

For the parental generation, biological yield per plant and harvest index showed high direct effects, while similar trends were observed for these characters in F_1 and F_2 generations as well. These findings are consistent with earlier reports by Meena *et al.*, (2024) [9], Dwivedi *et al.*, (2023) [6], and Duluri *et al.*, (2024) [5], all of whom demonstrated that biological yield and harvest index exert the strongest direct influence on seed yield among yield-contributing traits.

In the parental generation, days to 50% flowering had a small negative direct effect on seed yield, but its stronger indirect effects via biological yield and harvest index suggest that flowering time influences productivity more through biomass and partitioning than directly. Siliquae per plant had a positive direct effect and strong indirect contributions via biological yield and harvest index, making it a key yield component. Seeds per plant had a moderate direct effect and significant indirect effects via biological yield, reinforcing its central role. Biological yield had the strongest direct effect, dominating seed yield determination. These relationships have also been emphasized by Kumar *et al.*, (2022) [8] and Yadav *et al.*, (2023) [15], who found similar trait interdependencies in Indian mustard hybrids.

In the F_1 hybrids, days to 50% flowering had a small positive direct effect, but its negative indirect effects via biological yield and harvest index reduced its overall contribution. Siliquae per plant had a modest direct effect and strong indirect effects via biological yield, reinforcing its reproductive value. Biological yield was the most influential trait with a direct effect, dominating seed yield determination. Harvest index had the strongest direct effect, with additional indirect contributions, findings consistent with those reported by Dwivedi *et al.*, (2023) [6] and Meena *et al.*, (2024) [9].

In the F_2 generation, days to 50% flowering had a small negative direct effect, with strong negative indirect effects via biological yield and positive ones via harvest index, indicating a complex influence. Harvest index had the strongest direct effect, confirming its central role. Oil content, protein, tryptophan, and methionine had small direct effects, with methionine showing the most positive influence. Erucic acid and linoleic acid had minor direct effects, with linoleic acid showing offsetting indirect contributions. Comparable findings have been reported by Awasthi *et al.*, (2018) [2] and Duluri *et al.*, (2024) [5], who observed minor direct but notable indirect effects of quality traits on yield, mediated through yield components such as biological yield and harvest index.

Table 1: Phenotypic correlation coefficients in parents for 20 characters in 10 x 10 diallel cross in Indian mustard (*Brassica juncea* L.) for agronomic traits:

Parent/Hybrids	Days of 50(%) flowering	Days to maturity	Plant height (cm)	Length of main raceme (cm)	Leaf area index	Chlorophyll content (mg/g)	Number of primary branches/Plant	Number of secondary branches/Plant	Number of siliquae/Plant	Number of seeds/Plant	Biological yield/Plant	1000-seed weight (g)	Harvest index (%)	Oil content (%)	Protein (%)	Tryptophan content (%)	Methionine content (%)	Erucic acid	Linoleic acid content (%)	Seed yield/Plant
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1 **	0.2445	-0.724 **	0.15	0.0833	0.2257	0.5419 **	0.3375	0.1918	0.1982	-0.1887	-0.1453	-0.4221 *	0.0798	-0.1934	-0.5582 **	0.4078 *	-0.1875	-0.0736	-0.3145
2		1 **	0.0328	0.1773	0.1753	-0.1968	0.2353	0.146	-0.2359	0.3501	-0.0581	0.2507	-0.126	0.0975	-0.3337	-0.0519	0.5236 **	-0.1672	0.2365	-0.0851
3			1 **	-0.3396	0.2204	0.0715	-0.3297	-0.1973	-0.0657	0.2651	0.1731	-0.1451	0.2712	-0.432 *	0.1148	0.3826 *	-0.1164	0.1074	0.4876 **	0.2465
4				1 **	-0.4414 *	-0.2209	0.4209 *	0.6023 **	0.2327	0.1289	0.451 *	0.1879	-0.316	-0.2187	-0.346	-0.0803	-0.1995	-0.4721 **	-0.2841	0.286
5					1 **	0.0432	-0.1202	-0.5758 **	0.0645	0.2347	-0.3448	-0.0731	0.1313	0.1281	-0.3157	0.1294	0.5708 **	-0.0257	0.5552 **	-0.2633
6						1 **	0.1225	0.2549	0.2264	0.3228	0.0252	-0.5873 **	0.0849	-0.2305	0.0609	-0.3416	-0.1087	0.2512	0.2919	0.0486
7							1 **	0.544 **	0.3811 *	0.4747 **	0.1816	0.095	-0.1143	-0.1263	-0.3394	-0.3426	0.0918	-0.3691 *	-0.026	0.1133
8								1 **	0.4473 *	0.466 **	0.5833 **	-0.0104	-0.238	-0.4889 **	-0.1767	-0.4046 *	-0.2448	-0.25	-0.0636	0.4283 *
9									1 **	0.474 **	0.6965 **	0.1534	0.3238	-0.4102 *	-0.3776 *	-0.2785	-0.0594	-0.0197	0.2906	0.7127 **
10										1 **	0.2685	-0.061	0.1148	-0.2583	-0.526 **	-0.4401 *	-0.043	-0.2398	0.5328 **	0.2628
11											1 **	0.116	0.1784	-0.5124 **	-0.2781	0.1565	-0.1274	0.1658	0.0706	0.9373 **
12												1 **	0.3667 *	0.2133	-0.0949	-0.0207	0.0452	-0.274	-0.1176	0.231
13													1 **	0.1709	-0.0964	0.0687	-0.1287	0.431 *	0.3127	0.5081 **
14														1 **	-0.0764	-0.0245	0.0627	0.2504	-0.2537	-0.3942 *
15															1 **	0.0705	-0.2016	0.2103	-0.1905	-0.2707
16																1 **	0.3347	0.3407	-0.2082	0.1722
17																	1 **	0.1613	0.1222	-0.1465
18																		1 **	0.0377	0.2998
19																			1 **	0.1652
20																				1 **

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

Table 2: Phenotypic correlation coefficients in F_1 for 20 characters in 10 x 10 diallel cross in Indian mustard (*Brassica juncea* L.) in agronomic traits:

Parent/Hybrids	Days of 50(%) flowering	Days to maturity	Plant height (cm)	Length of main raceme (cm)	Leaf area index	Chlorophyll content (mg/g)	Number of primary branches/Plant	Number of secondary branches/Plant	Number of siliquae/Plant	Number of seeds/Plant	Biological yield/Plant	1000-seed weight (g)	Harvest index (%)	Oil content (%)	Protein (%)	Tryptophan content (%)	Methionine content (%)	Erucic acid	Linoleic acid content (%)	Seed yield/Plant
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1 **	0.2788 **	-0.4133 **	-0.0347	0.195 *	0.1162	0.2909 **	-0.013	-0.093	-0.1041	-0.2522 **	0.1092	0.0338	-0.0041	0.08	0.0705	0.0704	-0.0181	-0.1433	-0.1916 *
2		1 **	0.0768	0.0404	0.0245	-0.0749	0.3138 **	0.0338	-0.1999 *	0.3579 **	-0.1369	0.3538 **	-0.0249	0.0939	0.0758	0.0896	0.1911 *	0.1426	0.1563	-0.1222
3			1 **	-0.0578	-0.1578	-0.1238	-0.0638	-0.066	0.0787	0.1398	0.2352 **	-0.0319	-0.1422	0.1752 *	-0.1767 *	-0.0183	-0.1979 *	-0.0611	0.0572	0.0871
4				1 **	-0.0031	-0.0689	0.2967 **	0.4984 **	0.0831	0.1861 *	0.3398 **	0.0458	0.0282	-0.1669	0.0962	0.0983	0.0256	0.13	0.1234	0.3531 **
5					1 **	0.0042	0.0904	-0.1047	-0.029	-0.1153	-0.1878 *	-0.1105	-0.0496	0.0904	-0.0084	0.0496	-0.0045	-0.0596	-0.1988 *	-0.2407 **
6						1 **	0.0588	0.0568	0.1339	0.1317	-0.1474	-0.3143 **	0.138	0.0602	-0.1539	0.0543	-0.029	-0.0568	0.1623	-0.0003
7							1 **	0.3911 **	0.0295	0.4587 **	0.0267	0.1615	-0.0427	0.0427	0.1559	0.1815 *	0.1842 *	0.1306	0.2314 **	-0.0006
8								1 **	0.1332	0.2976 **	0.3366 **	0.0862	0.1271	-0.2772 **	0.2809 **	-0.0129	0.2299 **	0.2157 *	0.0428	0.4931 **
9									1 **	0.1149	0.4045 **	0.1172	-0.1233	-0.0311	-0.1089	-0.0734	0.0024	-0.1013	-0.1076	0.2675 **
10										1 **	0.1962 *	0.126	-0.0424	0.1363	-0.1339	0.0511	0.1375	-0.0311	0.3229 **	0.1696 *
11											1 **	0.1723 *	-0.5592 **	-0.1456	0.0008	-0.1152	-0.0656	0.0152	-0.0019	0.3767 **
12												1 **	-0.1763 *	0.1075	-0.0809	0.0524	0.1807 *	0.0949	0.0535	0.0068
13													1 **	0.0086	-0.077	0.1682	0.1551	0.0928	0.0659	0.5447 **
14														1 **	-0.342 **	-0.0791	-0.0756	-0.2172 *	0.3161 **	-0.1297
15															1 **	0.0462	0.0789	0.247 **	-0.1397	-0.0906
16																1 **	0.3719 **	0.1905 *	0.0203	0.0799
17																	1 **	0.0971	0.1026	0.1524
18																		1 **	-0.1108	0.1227
19																			1 **	0.0893
20																				1 **

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

Table 3: Phenotypic correlation coefficients in F_2 for 20 characters in 10 x 10 diallel cross in Indian mustard (*Brassica juncea* L.) in agronomic traits:

Parent/Hybrids	Days of 50(%) flowering	Days to maturity	Plant height (cm)	Length of main raceme (cm)	Leaf area index	Chlorophyll content (mg/g)	Number of primary branches/Plant	Number of secondary branches/Plant	Number of siliquae/Plant	Number of seeds/Plant	Biological yield/Plant	1000-seed weight (g)	Harvest index (%)	Oil content (%)	Protein (%)	Tryptophan content (%)	Methionine content (%)	Erucic acid	Linoleic acid content (%)	Seed yield/Plant
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1 **	0.0427	-0.3502 **	0.0786	0.2217 **	-0.0114	0.1019	-0.3072 **	-0.0081	-0.1308	-0.3226 **	-0.1232	0.1897 *	0.1213	0.0031	0.0643	0.1026	0.0347	0.0672	-0.0972
2		1 **	0.0441	0.3262 **	-0.0882	-0.0913	0.2969 **	0.2653 **	-0.3011 **	0.4024 **	0.1147	0.2754 **	0.0239	0.1171	-0.0757	0.144	0.0206	-0.0414	0.0545	0.1349
3			1 **	-0.0113	-0.1966 *	0.077	-0.0672	0.2228 **	-0.1314	-0.0133	0.0291	-0.0056	0.074	-0.1494	-0.1057	0.0537	-0.1492	0.0077	-0.1397	0.0968
4				1 **	-0.0785	-0.028	0.0015	0.2374 **	-0.0509	0.2049 *	0.154	0.1304	-0.0019	0.19 *	-0.212 *	0.0562	-0.0111	-0.114	-0.0892	0.1533
5					1 **	-0.0516	0.1197	-0.1427	0.1608	-0.1292	-0.2523 **	-0.2101 *	-0.074	-0.1028	-0.0183	0.0496	-0.0045	0.1814 *	-0.244 **	-0.3331 **
6						1 **	0.104	0.0491	0.0608	0.1745 *	-0.024	-0.1714 *	0.0012	-0.0658	0.0794	0.0922	-0.1289	-0.0104	0.0597	-0.0379
7							1 **	0.385 **	-0.0623	0.3056 **	0.0821	0.2117 *	-0.0631	0.0847	-0.082	0.1595	0.2313 **	0.0936	-0.0444	0.0254
8								1 **	-0.03	0.1637	0.417 **	0.2247 **	-0.0433	0.1477	-0.207 *	-0.0621	0.1635	-0.0583	-0.1228	0.3913 **
9									1 **	-0.1064	0.2211 **	0.0402	-0.1273	0.0777	0.0635	-0.0577	-0.1028	0.0998	0.1873 *	0.0448
10										1 **	0.0402	0.2182 *	-0.0504	0.0057	0.0456	0.1081	0.1635	0.0981	-0.0019	-0.007
11											1 **	0.3843 **	-0.6178 **	0.0522	-0.0537	-0.2753 **	-0.2037 *	-0.1202	0.2244 **	0.2367 **
12												1 **	-0.274 **	-0.1291	0.1412	-0.1571	0.0254	0.0865	0.23 **	0.0616
13													1 **	0.1047	-0.1068	0.2944 **	0.3074 **	0.0549	-0.2662 **	0.6021 **
14														1 **	-0.4058 **	0.0433	0.0227	-0.2827 **	0.1077	0.1454
15															1 **	-0.1553	0.0238	0.183 *	0.1138	-0.1227
16																1 **	0.3719 **	0.0334	-0.1663	0.0601
17																	1 **	0.0868	-0.1488	0.2276 **
18																		1 **	-0.0683	-0.0302
19																			1 **	-0.1323
20																				1 **

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

Table 4: Phenotypic path coefficients parent for 20 characters in 10 x 10 diallel cross in Indian mustard (*Brassica juncea* L.) for agronomic traits:

Parent/ Hybrids	Days of 50(%) flowering	Days to maturity	Plant height (cm)	Length of main raceme (cm)	Leaf area index	Chlorophyll content (mg/g)	Number of primary branches/Plant	Number of secondary branches/Plant	Number of siliquae/Plant	Number of seeds/Plant	Biological yield/Plant	1000-seed weight (g)	Harvest index (%)	Oil content (%)	Protein (%)	Tryptophan content (%)	Methionine content (%)	Erucic acid	Linoleic acid content (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	**-0.042**	0.003	0.023	-0.001	-0.005	-0.002	-0.013	0.002	0.004	0.001	-0.163	0.008	-0.167	0.001	-0.003	-0.001	0.029	0.011	0.000
2	-0.010	**0.014**	-0.001	-0.001	-0.011	0.001	-0.005	0.001	-0.005	0.002	-0.050	-0.014	-0.050	0.001	-0.005	0.000	0.037	0.010	0.001
3	0.030	0.000	**-0.032**	0.003	-0.013	-0.001	0.008	-0.001	-0.001	0.002	0.150	0.008	0.108	-0.004	0.002	0.001	-0.008	-0.006	0.002
4	-0.006	0.003	0.011	**-0.008**	0.027	0.002	-0.010	0.004	0.005	0.001	0.390	-0.011	-0.125	-0.002	-0.005	0.000	-0.014	0.028	-0.001
5	-0.003	0.002	-0.007	0.004	**-0.061**	0.000	0.003	-0.003	0.001	0.001	-0.299	0.004	0.052	0.001	-0.004	0.000	0.041	0.002	0.003
6	-0.009	-0.003	-0.002	0.002	-0.003	**-0.007**	-0.003	0.002	0.005	0.002	0.022	0.033	0.034	-0.002	0.001	-0.001	-0.008	-0.015	0.001
7	-0.023	0.003	0.010	-0.004	0.007	-0.001	**-0.023**	0.003	0.008	0.003	0.157	-0.005	-0.045	-0.001	-0.005	-0.001	0.007	0.022	0.000
8	-0.014	0.002	0.006	-0.005	0.035	-0.002	-0.013	**0.006**	0.009	0.003	0.505	0.001	-0.094	-0.004	-0.002	-0.001	-0.017	0.015	0.000
9	-0.008	-0.003	0.002	-0.002	-0.004	-0.002	-0.009	0.003	**0.021**	0.003	0.603	-0.009	0.128	-0.004	-0.005	0.000	-0.004	0.001	0.001
10	-0.008	0.005	-0.008	-0.001	-0.014	-0.002	-0.011	0.003	0.010	**0.006**	0.232	0.003	0.046	-0.002	-0.007	-0.001	-0.003	0.014	0.003
11	0.008	-0.001	-0.005	-0.004	0.021	0.000	-0.004	0.004	0.015	0.002	**0.865**	-0.007	0.071	-0.004	-0.004	0.000	-0.009	-0.010	0.000
12	0.006	0.004	0.005	-0.002	0.004	0.004	-0.002	0.000	0.003	0.000	0.101	**-0.056**	0.146	0.002	-0.001	0.000	0.003	0.016	-0.001
13	0.018	-0.002	-0.009	0.003	-0.008	-0.001	0.003	-0.001	0.007	0.001	0.154	-0.021	**0.397**	0.001	-0.001	0.000	-0.009	-0.025	0.002
14	-0.003	0.001	0.014	0.002	-0.008	0.002	0.003	-0.003	-0.009	-0.002	-0.443	-0.012	0.068	**0.009**	-0.001	0.000	0.005	-0.015	-0.001
15	0.008	-0.005	-0.004	0.003	0.019	0.000	0.008	-0.001	-0.008	-0.003	-0.241	0.005	-0.038	-0.001	**0.014**	0.000	-0.014	-0.012	-0.001
16	0.023	-0.001	-0.012	0.001	-0.008	0.002	0.008	-0.002	-0.006	-0.003	0.135	0.001	0.027	0.000	0.001	**0.002**	0.024	-0.020	-0.001
17	-0.017	0.007	0.004	0.002	-0.035	0.001	-0.002	-0.001	-0.001	0.000	-0.110	-0.002	-0.051	0.001	-0.003	0.001	**0.072**	-0.009	0.001
18	0.008	-0.002	-0.003	0.004	0.002	-0.002	0.009	-0.002	0.000	-0.001	0.144	0.015	0.171	0.002	0.003	0.001	0.012	**-0.058**	0.000
19	0.003	0.003	-0.015	0.002	-0.034	-0.002	0.001	0.000	0.006	0.003	0.061	0.007	0.124	-0.002	-0.003	0.000	0.009	-0.002	**0.005**

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

Table 5: Phenotypic path coefficients F1 for 20 characters in 10 x 10 diallel cross in Indian mustard (*Brassica juncea* L.) in agronomic traits:

Parent/ Hybrids	Days of 50(%) flowering	Days to maturity	Plant height (cm)	Length of main raceme (cm)	Leaf area index	Chlorophyll content (mg/g)	Number of primary branches/Plant	Number of secondary branches/Plant	Number of siliquae/Plant	Number of seeds/Plant	Biological yield/Plant	1000-seed weight (g)	Harvest index (%)	Oil content (%)	Protein (%)	Tryptophan content (%)	Methionine content (%)	Erucic acid	Linoleic acid content (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0.0291	0.0059	-0.0103	0.0011	0.0015	-0.0013	-0.0027	-0.0004	-0.0007	-0.0002	-0.2492	0.0006	0.0369	0.0000	-0.0012	-0.0004	0.0029	-0.0001	-0.0033
2	0.0081	0.0212	0.0019	-0.0012	0.0002	0.0008	-0.0029	0.0011	-0.0015	0.0005	-0.1353	0.0021	-0.0272	-0.0006	-0.0011	-0.0005	0.0078	0.0008	0.0036
3	-0.0120	0.0016	0.0249	0.0018	-0.0012	0.0013	0.0006	-0.0021	0.0006	0.0002	0.2324	-0.0002	-0.1553	-0.0011	0.0026	0.0001	-0.0081	-0.0004	0.0013
4	-0.0010	0.0009	-0.0014	-0.0308	0.0000	0.0007	-0.0028	0.0161	0.0006	0.0003	0.3358	0.0003	0.0308	0.0011	-0.0014	-0.0006	0.0011	0.0007	0.0029
5	0.0057	0.0005	-0.0039	0.0001	0.0078	-0.0001	-0.0008	-0.0034	-0.0002	-0.0002	-0.1856	-0.0006	-0.0542	-0.0006	0.0001	-0.0003	0.0000	-0.0004	-0.0046
6	0.0034	-0.0016	-0.0031	0.0021	0.0000	-0.0108	-0.0006	0.0018	0.0010	0.0002	-0.1456	-0.0018	0.1507	-0.0004	0.0023	-0.0003	-0.0012	-0.0003	0.0038
7	0.0085	0.0067	-0.0016	-0.0091	0.0007	-0.0006	-0.0094	0.0126	0.0002	0.0007	0.0265	0.0009	-0.0465	-0.0003	-0.0023	-0.0011	0.0075	0.0008	0.0054
8	-0.0004	0.0007	-0.0016	-0.0153	-0.0008	-0.0006	-0.0037	0.0322	0.0010	0.0005	0.3326	0.0005	0.1388	0.0018	-0.0042	0.0001	0.0094	0.0012	0.0010
9	-0.0027	-0.0043	0.0020	-0.0026	-0.0002	-0.0015	-0.0003	0.0043	0.0074	0.0002	0.3998	0.0007	-0.1347	0.0002	0.0016	0.0004	0.0001	-0.0006	-0.0025
10	-0.0030	0.0076	0.0035	-0.0057	-0.0009	-0.0014	-0.0043	0.0096	0.0009	0.0015	0.1939	0.0007	-0.0463	-0.0009	0.0020	-0.0003	0.0056	-0.0002	0.0075
11	-0.0073	-0.0029	0.0059	-0.0105	-0.0015	0.0016	-0.0003	0.0108	0.0030	0.0003	0.9882	0.0010	-0.6107	0.0009	0.0000	0.0007	-0.0027	0.0001	0.0000
12	0.0032	0.0075	-0.0008	-0.0014	-0.0009	0.0034	-0.0015	0.0028	0.0009	0.0002	0.1705	0.0058	-0.1924	-0.0007	0.0012	-0.0003	0.0074	0.0005	0.0012
13	0.0010	-0.0005	-0.0035	-0.0009	-0.0004	-0.0015	0.0004	0.0041	-0.0009	-0.0001	-0.5526	-0.0010	1.0921	-0.0001	0.0012	-0.0010	0.0063	0.0005	0.0015
14	-0.0001	0.0020	0.0044	0.0051	0.0007	-0.0007	-0.0004	-0.0089	-0.0002	0.0002	-0.1439	0.0006	0.0094	-0.0065	0.0051	0.0005	-0.0031	-0.0012	0.0073
15	0.0023	0.0016	-0.0044	-0.0030	-0.0001	0.0017	-0.0015	0.0091	-0.0008	-0.0002	0.0008	-0.0005	-0.0841	0.0022	-0.0149	-0.0003	0.0032	0.0014	-0.0032
16	0.0020	0.0019	-0.0005	-0.0030	0.0004	-0.0006	-0.0017	-0.0004	-0.0005	0.0001	-0.1141	0.0003	0.1839	0.0005	-0.0007	-0.0057	0.0153	0.0011	0.0005
17	0.0021	0.0041	-0.0049	-0.0008	0.0000	0.0003	-0.0017	0.0074	0.0000	0.0002	-0.0648	0.0010	0.1693	0.0005	-0.0012	-0.0021	0.0409	0.0006	0.0024
18	-0.0005	0.0030	-0.0015	-0.0040	-0.0005	0.0006	-0.0012	0.0069	-0.0008	-0.0001	0.0151	0.0006	0.1014	0.0014	-0.0037	-0.0011	0.0040	0.0057	-0.0026
19	-0.0042	0.0033	0.0014	-0.0038	-0.0015	-0.0018	-0.0022	0.0014	-0.0008	0.0005	-0.0019	0.0003	0.0720	-0.0020	0.0021	-0.0001	0.0042	-0.0006	0.0231
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*, ** significant at 5% and 1% level, respectively

Table 6: Phenotypic path coefficients F2 for 20 characters in 10 x 10 diallel cross in Indian mustard (*Brassica juncea* L.) in agronomic traits:

Parent/ Hybrids	Days of 50(%) flowering	Days to maturity	Plant height (cm)	Length of main raceme (cm)	Leaf area index	Chlorophyll content (mg/g)	Number of primary branches/Plant	Number of secondary branches/Plant	Number of siliquae/Plant	Number of seeds/Plant	Biological yield/Plant	1000-seed weight (g)	Harvest index (%)	Oil content (%)	Protein (%)	Tryptophan content (%)	Methionine content (%)	Erucic acid	Linoleic acid content (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	-0.0099	-0.0007	0.0075	0.0015	0.0000	0.0002	0.0012	-0.0110	0.0002	-0.0001	-0.3158	0.0011	0.2284	-0.0016	0.0002	-0.0023	0.0052	0.0003	-0.0016
2	-0.0004	-0.0169	-0.0009	0.0061	0.0000	0.0012	0.0036	0.0095	0.0055	0.0002	0.1124	-0.0025	0.0288	-0.0015	-0.0046	-0.0051	0.0011	-0.0003	-0.0013
3	0.0035	-0.0007	-0.0213	-0.0002	0.0000	-0.0010	-0.0008	0.0080	0.0024	0.0000	0.0285	0.0001	0.0891	0.0019	-0.0064	-0.0019	-0.0076	0.0001	0.0032
4	-0.0008	-0.0055	0.0002	0.0186	0.0000	0.0004	0.0000	0.0085	0.0009	0.0001	0.1507	-0.0012	-0.0023	-0.0025	-0.0127	-0.0020	-0.0006	-0.0008	0.0021
5	-0.0022	0.0015	0.0042	-0.0015	-0.0002	0.0007	0.0015	-0.0051	-0.0029	-0.0001	-0.2469	0.0019	-0.0891	0.0013	-0.0011	-0.0016	0.0000	0.0013	0.0057
6	0.0001	0.0015	-0.0016	-0.0005	0.0000	-0.0132	0.0013	0.0018	-0.0011	0.0001	-0.0235	0.0015	0.0014	0.0009	0.0048	-0.0032	-0.0066	-0.0001	-0.0014
7	-0.0010	-0.0050	0.0014	0.0000	0.0000	-0.0014	0.0121	0.0138	0.0011	0.0002	0.0804	-0.0019	-0.0761	-0.0011	-0.0049	-0.0057	0.0118	0.0007	0.0010
8	0.0030	-0.0045	-0.0047	0.0044	0.0000	-0.0007	0.0047	0.0358	0.0006	0.0001	0.4082	-0.0020	-0.0521	-0.0019	-0.0124	0.0022	0.0084	-0.0004	0.0029
9	0.0001	0.0051	0.0028	-0.0010	0.0000	-0.0008	-0.0008	-0.0011	-0.0182	-0.0001	0.2164	-0.0004	-0.1533	-0.0010	0.0038	0.0020	-0.0053	0.0007	-0.0044
10	0.0013	-0.0068	0.0003	0.0038	0.0000	-0.0023	0.0037	0.0059	0.0019	0.0005	0.0394	-0.0019	-0.0607	-0.0001	0.0027	-0.0038	0.0083	0.0007	0.0000
11	0.0032	-0.0019	-0.0006	0.0029	0.0001	0.0003	0.0010	0.0149	-0.0040	0.0000	0.9788	-0.0034	-0.7437	-0.0007	-0.0032	0.0097	-0.0104	-0.0009	-0.0052
12	0.0012	-0.0046	0.0001	0.0024	0.0000	0.0023	0.0026	0.0081	-0.0007	0.0001	0.3760	-0.0089	-0.3297	0.0017	0.0085	0.0057	0.0013	0.0006	-0.0053
13	-0.0019	-0.0004	-0.0016	0.0000	0.0000	0.0000	-0.0008	-0.0016	0.0023	0.0000	-0.6046	0.0024	1.2040	-0.0014	-0.0064	-0.0104	0.0157	0.0004	0.0062
14	-0.0012	-0.0020	0.0032	0.0035	0.0000	0.0009	0.0010	0.0053	-0.0014	0.0000	0.0511	0.0012	0.1261	-0.0130	-0.0244	-0.0015	0.0011	-0.0021	-0.0025
15	0.0000	0.0013	0.0023	-0.0040	0.0000	-0.0011	-0.0010	-0.0074	-0.0012	0.0000	-0.0526	-0.0013	-0.1286	0.0053	0.0601	0.0055	0.0013	0.0013	-0.0026
16	-0.0006	-0.0024	-0.0012	0.0011	0.0000	-0.0012	0.0020	-0.0022	0.0011	0.0001	-0.2700	0.0014	0.3553	-0.0006	-0.0093	-0.0351	0.0190	0.0002	0.0039
17	-0.0010	-0.0004	0.0032	-0.0002	0.0000	0.0017	0.0028	0.0059	0.0019	0.0001	-0.1997	-0.0002	0.3704	-0.0003	0.0015	-0.0131	0.0510	0.0006	0.0035
18	-0.0003	0.0007	-0.0002	-0.0021	0.0000	0.0001	0.0011	-0.0021	-0.0018	0.0001	-0.1177	-0.0008	0.0660	0.0037	0.0110	-0.0012	0.0044	0.0073	0.0016
19	-0.0007	-0.0009	0.0030	-0.0017	0.0001	-0.0008	-0.0005	-0.0044	-0.0034	0.0000	0.2196	-0.0020	-0.3205	-0.0014	0.0068	0.0059	-0.0076	-0.0005	-0.0232
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*, ** significant at 5% and 1% level, respectively

Conclusion

The present study on correlation and path coefficient analysis in Indian mustard (*Brassica juncea* L. Czern & Coss.) revealed that seed yield is a complex trait governed by several interrelated components. Biological yield per plant and harvest index exhibited the highest positive direct effects across all generations, confirming their pivotal role in determining yield potential. The number of secondary branches per plant and siliquae per plant also showed strong positive associations with seed yield, making them effective selection criteria. Days to 50% flowering and certain quality traits such as oil and amino acids influenced yield mainly through indirect effects. The stability of these associations across parental, F_1, and F_2 generations suggests strong genetic control. Therefore, selection emphasizing biological yield, harvest index, and siliquae number would enhance yield improvement. Furthermore, the indirect but positive contribution of methionine and linoleic acid indicates potential for nutritional enhancement. Hence, simultaneous improvement in yield efficiency and quality traits can accelerate the development of high-yielding, nutritionally enriched *Brassica juncea* cultivars adaptable to diverse environments.

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