Int.J.Curr.Microbiol.App.Sci (2020) Special Issue-11: 2630-2643

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Special Issue-11 pp. 2630-2643**
Journal homepage: http://www.ijcmas.com

Original Research Article

Study of Correlation and Path Coefficient Analysis in Indian Mustard (*Brassica juncea* L.)

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A B S T R A C T

The present investigation entitled "Study of correlation and path coefficient analysis in Indian mustard (*Brassica juncea* L.)" was conducted during 2010-2011. Observations of all the characters were recorded on single plant basis. Average of these selected five plants in respect of different plant characters were used for statistical analysis. In this studies, various traits were used and these are Days to 50% flowering, Days to 80% maturity, Plant height (cm), Number of primary branches per plant, Number of secondary branches per plant, Length of siliqua (cm), Number of seeds per siliqua, 1000-seed weight (g), Biological yield per plant (g), Harvest index (%), Oil content and Seed yield per plant (g). Both yield and component traits along with 12 characters were analysed including flowering and maturity. Moreover, genetic analysis of variance all the 12 traits, highest positive correlation were observed between biological yield per plant and seed yield per plant.

Keywords

Indian mustard, Correlation, Pathway coefficient analysis, Cultivar, Genotypes

Introduction

Indian mustard (*Brassica juncea* L.) ranked 2nd among all oilseed crop after soybean (*Glycine max*) which plays a key role in oil economy and trade by its significant contribution as 30 % of the total oilseed production in the country. Among the various oilseed crops grown globally, the estimated area, production and yield of rapeseed-mustard in the world was 33.57 mha, 60.56 mt and1800 kg/ha, respectively (USDA, 2011). *Brassica juncea* is a major winter oil seed crop of India occupying 6.39m ha with total production of 7.41m tones and average productivity of 1104kg/ha (Anonymous, 2010). India occupies third position among the mustard growing countries in the world in terms of production contributing 14.7% of total world production of rapeseed-mustard is very low compared to world average of 1400 kg/ha. *Brassica juncea* is a predominantly

self fertilized crop with 5-15% cross fertilization (Asthana and Singh, 1973). Cultivar improvement in *Brassica juncea* has been mostly done through different breeding methodologies to achieve maximum yield potential in this crop. Indian mustard is the second most important source of edible oil after soybean. The oil content of the seeds ranges from 35 to 48 per cent. The oil obtained is the main cooking medium in northern India and cannot be easily replaced by the any other edible oil. The seeds and oil are used as a condiment in the preparation of pickles and for flavouring curries, lubricants, hair oil and medicines. Although, the oil seed crops are cultivated throughout the regions of M.P., Rajasthan, U.P., Haryana, Gujarat, Bihar, Punjab, H.P., Orissa and W.B. In terms of area, Rajasthan is the leading state and occupies nearly 50 % of the total are and contributes in the same proportion towards the production to the national pool (Anonymous, 2010). The correlation coefficient reflects some ideas about yield and components. As we know, the analysis of correlations does not covers purpose because it is not able to affects overall traits relating to indirect effects on seed yield. In this context, a work on path correlations would be highly recognized by wright (1921) and according to him it gives real and factual analysis correlation coefficients to see both direct and indirect impacts. In lieu of the above, this paper discussed rigorously about correlation and path coefficient analysis in Indian mustard (*Brassica juncea* L.) and provides some feedbacks and research analysis to draw a attention towards a scientific cultivation and production of Indian mustard.

Materials and Methods

The present investigation entitled "Study of correlation and path coefficient analysis in Indian mustard (*Brassica juncea* L.)" was conducted during 2010-2011 at the Research Farm of Janta Vedic College, Baraut, Baghpat (U.P.).

The details of the materials and methods are given below: The material for this study consisted of 39 genotypes was obtained from the NBPGR, New Delhi.

Experimental details

Overall, 39 genotypes were grown Randomized Block Desing (RBD) with three replications during rabi season on dated 2nd November 2010 at Research Farm of Janta Vedic College Baraut, Baghpat (U.P.). However, the research plot was located at the western boundary of Uttar Pradesh 20°, 6N and 77°, 15E, 226.80 meters above the mean sea level. Similarly, soil of study sites was heavy loam which is situated between Ganga and Yamuna rivers including semi-arid subtropical climate. The row length was 2.5 m with row to row spacing 45 cm along with 15 cm of plant to plant distance, respectively.

Observation recorded

Five competitive plants from each plot were randomly selected from all three rows for recording data. Observations of all the characters were recorded on single plant basis except for days to flowering and days to maturity. Average of these selected five plants in respect of different plant characters were used for statistical analysis. In this studies, various tarits were used and these are Days to 50% flowering, Days to 80% maturity, Plant height (cm), Number of primary branches per plant, Number of secondary branches per plant, Length of siliqua (cm), Number of seeds per siliqua, 1000-seed weight (g), Biological yield per plant (g), Harvest index (%), Oil content and Seed yield per plant (g).

Correlation coefficient analysis

Correlated characters are of interest to find out the genetic causes of correlation through the pleiotropic action of genes, to know the level of selection for one character that will cause simultaneous change in other characters and find out correlation between character and their fitness.

Phenotypic correlation coefficients 'r(p)' for all possible pairs of characters were calculated from the already obtained variance and co-variances according to Johnson *et al.*, (1955).

The phenotypic correlations was worked out by

$$r(p) = \frac{\sigma xy(p)}{\sqrt{\sigma^2 px.\ \sigma^2 py}}$$

Where,

σxy(p) = Phenotypic co-variances between character X and Y.

σ^2px = Phenotypic variance of character X

σ^2py = Phenotypic variance of character Y

Phenotypic correlation coefficients were tested against table value of 'r' with (g-2) degrees of freedom as per the procedure described by Fisher and Yates (1936). Path coefficient analysis was carried out according to the method suggested by Dewey and Lu (1959)

Results and Discussion

Both yield and component traits along with 12 characters were analysed including flowering and maturity. Moreover, genetic analysis of variance, cluster pattern in relation to all the 12 traits, character association were judged in the studies.

Correlation coefficient analysis

Genotypic correlation coefficient

Data on genotypic correlation coefficient in Table 1, indicated that the highest positive correlation was observed between biological yield per plant and seed yield per plant (0.943) while highest negative correlation was observed between day to 50% flowering with 1000-seed weight (-0.546).

Days to 50% flowering showed positive association with day to 75% maturity (0.293), plant height (0.340), number of primary branches per plant (0.312), oil content (0.066) and seed yield per plant (0.080).While this character showed highest negative correlation with 1000-seed weight (-0.546).

Days to 75% maturity showed positive association with plant height (0.353), number of primary branches per plant (0.083), length of siliqua (0.288), 1000-seed weight (0.248), biological yield per plant (0.356), harvest index (0.042), oil content (0.011) and seed yield per plant (0.328). While this character showed negative correlation with number of seeds per siliqua (-0.316).

Plant height showed positive correlation with number of primary branches per plant (0.282), length of siliqua (0.285), 1000-seed weight (0.160), biological yield per plant (0.348), harvest index (0.028), oil content (0.347) and seed yield per plant (0.294).

Number of primary branches per plant showed positive correlation with number of secondary branches per plant (0.403), length of siliqua (0.176), number of seeds per siliqua (0.121), biological yield per plant (0.211), harvest index (0.122) and seed yield per plant (0.225).

Number of secondary branches per plant showed positive correlation with number of seeds per siliqua (0.237), biological yield per plant (0.373), harvest index (0.148), and seed yield per plant (0.376).

Length of siliqua exhibited positive correlation with number of seeds per siliqua (0.076), 1000-seed weight (0.587), biological yield per plant (0.359), harvest index (0.054), oil content (0.340) and seed yield per plant (0.357).

Number of seeds per siliqua showed positive association with biological yield per plant (0.120), and seed yield per plant (0.054). 1000-seed weight showed positive correlation with biological yield per plant (0.389), harvest index (0.272), oil content (0.011) and seed yield per plant (0.406).

Biological yield per plant exhibited positive correlation with harvest index (0.163), oil content (0.046) and seed yield per plant (0.943).

Harvest index showed positive correlation with seed yield per plant (0.443). While this character showed negative correlation with oil content (-0.339).

Oil content showed negative correlation with seed yield per plant (-0.065).

Phenotypic correlation coefficient

Results on phenotypic correlation coefficient between different characters of Indian mustard are summarized in Table 2. The data revealed that the highest positive and highly significant correlation was recorded between biological yield per plant and seed yield per plant (0.937) and highest negative but highly significant correlation between day to 50% per cent flowering and 1000-seed weight (-0.542). Estimating the value of correlation coefficient among other characters observed that days to 50% flowering had positive and significant correlation with plant height (0.338). Thus, day to 50% flowering showed negative but highly significant association with 1000-seed weight (-0.542).Days to 75% maturity showed positive and significant association with biological yield per plant (0.348), plant height (0.345) and seed yield per plant (0.322).

Plant height showed positive and significant association with biological yield per plant (0.348) and oil content (0.346).Number of primary branches per plant exhibited positive and significant correlation with number of secondary branches per plant (0.395).Number of secondary branches per plant showed positive and significant correlation with biological yield per plant (0.372) and seed yield per plant (0.372).Length of siliqua showed positive and highly significant correlation with 1000-seed weight (0.579), biological yield per plant (0.355), seed yield per plant (0.349) and oil content (0.336).Number of seeds per siliqua showed positive correlation with biological yield per plant (0.119), and seed yield per plant (0.055). While this character was not significant.1000-seed weight showed positive and significant correlation with seed yield per plant (0.403) and biological yield per plant (0.388).Biological yield per plant showed positive and highly significant correlation with seed yield per plant (0.937). Harvest index exhibited positive and significant correlation with seed yield per plant (0.443). However, harvest index showed negative and significant association with oil content (-0.314).Oil content showed positive and significant correlation with plant height (0.346) and length of siliqua (0.336). Although, oil content showed negative but significant correlation with harvest index (-0.314).Seed yield per plant showed positive and highly significant correlation with

biological yield per plant (0.937). While this character had positive and significant correlation with harvest index (0.443), 1000-seed weight (0.403), length of siliqua (0.349) number of secondary branches per plant (0.372) and day to 75% maturity (0.372).

Path analysis

For path analysis seed yield per plant was considered as the dependent variable while the remaining characters were considered as independent variables. The estimates of genotypic path coefficient represents the direct and indirect effects of various characters were furnished in Table 3 and Table 4, respectively.

Genotypic path analysis

The results of path analysis at genotypic level are present in Table 3. The partitioning of genotypic correlation between seed yield per plant and days to 50% flowering (0.080) was positive. The direct effect of this character was (0.025). The positive association due to indirect effect of this character via number of secondary branches per plant (0.001), number of seeds per siliqua (0.004) and 1000-seed weight (0.042). The negative indirect effect was found through day to 75% maturity (-0.008), plant height (-0.019), number of primary branches per plant (-0.004), length of siliqua (-0.026), biological yield per plant (-0.046), harvest index (-0.046), and oil content (-0.002).Days to 75% maturity showed positive genotypic correlation between days to 75% maturity and seed yield per plant (0.328) but direct effect of this character on seed yield per plant was negative (-0.028). The positive indirect effect due to day to 50% flowering (0.007), number of secondary branches per plant (0.001), length of siliqua (0.028), number of seeds per siliqua (0.020), biological yield per plant (0.331), harvest index (0.013) and oil content (0.001). The negative indirect effect was found through plant height (-0.002), number of primary branches per plant (-0.001) and 1000-seed weight (-0.022).Plant height showed positive genotypic correlation between plant height and seed yield per plant (0.294) but direct effect of this character on seed yield per plant was negative (-0.055). The positive indirect effect due to days to 50% flowering (0.009), number of secondary branches per plant (0.001), length of siliqua (0.027), number of seeds per siliqua (0.016), biological yield per plant (0.324) and harvest index (0.008). The negative indirect effect was due to days to 75% maturity (-0.010), number of primary branches per plant (-0.003), 1000-seed weight (-0.012) and oil content (-0.009).Number of primary branches per plant showed positive genotypic correlation between seed yield per plant and number of primary branches per plant (0.225). The direct effect of this character on seed yield per plant was negative (-0.011). The positive indirect effect due to days to 50% flowering (0.008), number of secondary branches per plant (0.001), length of siliqua (0.017), 1000-seed weight (0.004), biological yield per plant (0.196), harvest index (0.036), and oil content (0.001). The negative indirect effect due to days to 75% maturity (-0.002), plant height (-0.016) and number of seeds per siliqua (-0.008).Number of secondary branches per plant showed positive genotype correlation between number of secondary branches per plant and seed yield per plant (0.376) but direct effect of this character on seed yield per plant was positive (0.001). The positive indirect effect due to days to 75% maturity (0.005), plant height (0.008), 1000-seed weight (0.002), biological yield per plant (0.347), harvest index (0.044), and oil content (0.001). The negative indirect was found through days to 50% flowering (-0.004), number of primary branches per plant (-0.005), length of siliqua (-0.008) and number of seeds per siliqua (-0.015).Length of siliqua showed positive

correlation (0.357) with seed yield per plant. The direct effect of this character on seed yield was also positive (0.095). The positive indirect effect due to number of secondary branches per plant (0.001), biological yield per plant (0.338), and harvest index (0.017).

The negative indirect was found through days to 50% flowering (-0.007), days to 75% maturity (-0.008), plant height (-0.016), number of primary branches per plant (-0.002), number of seeds per siliqua (-0.005), 1000-seed weight (-0.045) and oil content (-0.003).

Number of seeds per sliqua positive correlation (0.054) with seed yield per plant but direct effect of this character on seed yield per plant was negative (-0.063). The positive indirect effect due to days to 75% maturity (0.009), plant height (0.014), number of secondary branches per plant (0.001), length of siliqua (0.007), 1000-seed weight (0.016), biological yield per plant (0.112) and oil content (0.002). This character showed negative indirect effect via. days to 50% flowering (-0.002), number of primary branches per plant (-0.001) and harvest index (-0.041).1000-seed weight showed positive correlation with seed yield per plant (0.406), and direct effect of this character on seed yield per plant was negative (-0.076). 1000-seed weight showed positive indirect effect via. number of primary branches per plant (0.001), number of secondary branches per plant (0.001), length of siliqua (0.056), number of seeds per siliqua (0.014), biological yield per plant (0.362), harvest index (0.081) and oil content (0.001).

This character showed negative indirect effect via. days to 50% flowering (-0.014),days to 75% maturity (-0.008) and plant height (-0.009).Biological yield per plant showed positive correlation with seed yield per plant (0.943), and the direct effect of this character on seed yield per plant was also positive (0.931). Biological yield per plant showed positive indirect effect via. number of secondary branches per plant (0.001), length of siliqua (0.034) and harvest index (0.048).

This character showed negative indirect effect via. days to 50% flowering (-0.001), days to 75% maturity (-0.010), plant height (-0.019), number of primary branches per plant (-0.002), number of seeds per siliqua (-0.008), 1000-seed weight (-0.032) and oil content (-0.001). Harvest index showed positive correlation with seed yield per plant (0.443) and the direct effect of this character on seed yield per plant was also positive (0.298). Harvest index showed positive indirect effect through number of secondary branches per plant (0.001), length of siliqua (0.006), number of seeds per siliqua (0.009), biological yield per plant (0.151) and oil content (0.008). This character showed negative indirect effect via. days to 50% flowering (-0.004), days to 75% maturity (-0.001), plant height (-0.002), number of primary branches per plant (-0.001), and 1000-seed weight (-0.021).Oil content showed negative correlation with seed yield per plant (-0.065).

But direct effect of this character on seed yield was negative (-0.025). This character showed positive indirect effect via. days to 50% flowering (0.002), days to 75% maturity (0.001), number of primary branches per plant (0.001), number of secondary branches per plant (0.001), length of siliqua (0.032), number of seeds per siliqua (0.004), and biological yield per plant (0.042). This character showed negative indirect effect via. plant height (-0.019), 1000-seed weight (-0.001) and harvest index (-0.101).

Table.1

S.No.	Genotypes	S.No.	Genotypes	S.No.	Genotypes
1	IC9841	14	IC363942	27	IC399857
2	IC10965	15	IC366460	28	IC399853
3	IC10967	16	IC375924	29	IC399854
4	IC10977	17	IC375925	30	IC399877
5	IC11765	18	IC399788	31	IC399878
6	IC320641	19	IC399795	32	IC417020
7	IC320648	20	IC399797	33	IC426336
8	IC329705	21	IC399808	34	IC426357
9	IC335854	22	IC399841	35	IC446900
10	IC347949	23	IC399816	36	IC491257
11	IC360723	24	IC399826	37	IC491283
12	IC360749	25	IC399839	38	IC491313
13	IC360770	26	IC399840	39	IC491330

Table.2 Genotypic correlation for 12 characters of Indian mustard

S. N0.	Characters	Day of 50% flowering	Day to 75% maturity	Plant height (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	Length of siliqua (cm)	No. of seeds/ siliqua	1000 seed Wt. (g)	Biological yield /plant (g)	Harvest index (%)	Oil content (%)	Seed yield / plant
1.	Day of 50%flowering	-	0.293	0.340	0.312	-0.145	-0.274	-0.066	-0.546	-0.050	-0.154	0.066	0.080
2.	Day to 75%maturity		-	0.353	0.083	-0.161	0.288	-0.316	0.284	0.356	0.042	0.011	0.328
3.	Plant height (cm)			-	0.282	-0.136	0.285	-0.254	0.160	0.348	0.028	0.347	0.294
4.	No. of primary branches/plant				-	0.403	0.176	0.121	-0.048	0.211	0.122	-0.033	0.225
5.	No. of secondary branches / plant					-	-0.088	0.237	-0.031	0.373	0.148	-0.060	0.376
6.	Length of siliqua (cm)						-	0.076	0.587	0.359	0.054	0.340	0.357
7.	No. of seeds/siliqua							-	-0.216	0.120	-0.136	-0.062	0.054
8.	1000-seed weight. (g)								-	0.389	0.272	0.011	0.406
9.	Biological yield/plant(g)									-	0.163	0.046	0.943
10.	Harvest index (%)										-	-0.339	0.443
11.	Oil content (%)											-	-0.065
12.	Seed yield / plant												-

Table.3 Phenotypic correlation for 12 characters of Indian mustard

S.N.	Characters	Day of 50% flowering	Day to 75% maturity	Plant height (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	Length of siliqua (cm)	No. of seeds/ siliqua	1000-seed Wt. (g)	Biological yield /plant (g)	Harvest index (%)	Oil content (%)	Seed yield/ plant
1.	Day of 50%flowering	-	0.282	0.338*	.294	-0.145	-0.270	-0.061	-0.542**	-0.050	-0.147	0.065	-0.079
2.	Day to 75%maturity		-	0.345*	0.080	-0.155	0.275	-0.301	0.275	0.348*	0.047	0.010	0.322*
3.	Plant height (cm)			-	0..275	-0.132	0.283	-0.246	0.159	0.348*	0.026	0.346*	0.293
4.	No. of primary branches/plant				-	0.395*	0.174	0.131	-0.047	0.204	0.115	-0.035	0.216
5.	No. of secondary branches / plant					-	0.083	0.240	-0.032	0.372*	0.137	-0.059	0.372*
6.	Length of siliqua (cm)						-	0.077	0.579**	0.355*	0.045	0.336*	0.349*
7.	No. of seeds/siliqua							-	-0.213	0.119	-0.125	-0.062	0.055
8.	1000-seed weight. (g)								-	0.388*	0.254	0.011	0.403**
9.	Biological yield /plant (g)									-	0.150	0.045	0.937**
10.	Harvest index (%)										-	-0.314*	0.443**
11.	Oil content (%)											-	-0.064
12.	Seed yield / plant												-

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

Table.4 Genotypic path for 12 characters of Indian mustard

S.N.	Characters	Day of 50%flowering	Day to 75%maturity	Plant height (cm)	No. of primary branches/ plant	No. of secondary branches / plant	Length of siliqua (cm)	No. of seeds/ siliqua	1000 seed Wt. (g)	Biological yield /plant (g)	Harvest index (%)	Oil content (%)	r values with seed yield/ plant
1.	Day of 50% flowering	**0.025**	-0.008	-0.019	-0.004	0.001	-0.026	0.004	0.042	-0.046	-0.046	-0.002	0.080
2.	Day to 75%maturity	0.007	**-0.028**	-0.002	-0.001	0.001	0.028	0.020	-0.022	0.331	0.013	0.001	0.328
3.	Plant height (cm)	0.009	-0.010	**-0.055**	-0.003	0.001	0.027	0.016	-0.012	0.324	0.008	-0.009	0.294
4.	No. of primary branches / plant	0.008	-0.002	-0.016	**-0.011**	0.001	0.017	-0.008	0.004	0.196	0.036	0.001	0.225
5.	No. of secondary branches / plant	-0.004	0.005	0.008	-0.005	**0.001**	-0.008	-0.015	0.002	0.347	0.044	0.001	0.376
6.	Length of siliqua (cm)	-0.007	-0.008	-0.016	-0.002	0.001	**0.095**	-0.005	-0.045	0.338	0.017	-0.003	0.357
7.	No. of seeds/siliqua	-0.002	0.009	0.014	-0.001	0.001	0.007	**-0.063**	0.016	0.112	-0.041	0.002	0.054
8.	1000-seed weight (g)	-0.014	-0.008	-0.009	0.001	0.001	0.056	0.014	**-0.076**	0.362	0.081	0.001	0.406
9.	Biological yield /plant (g)	-0.001	-0.010	-0.019	-0.002	0.001	0.034	-0.008	-0.032	**0.931**	0.048	-0.001	0.943
10.	Harvest index (%)	-0.004	-0.001	-0.002	-0.001	0.001	0.006	0.009	-0.021	0.151	**0.298**	0.008	0.443
11.	Oil content (%)	0.002	0.001	-0.019	0.001	0.001	0.032	0.004	-0.001	0.042	-0.101	**-0.025**	-0.065

Residual effect = 0.0190

Table.5 Phenotypic path for 12 characters of Indian mustard

S.N.	Characters	Day of 50% flowering	Day to 75% maturity	Plant height (cm)	No. of primary branches/ plant	No. of secondary branches / plant	Length of siliqua	No. of seeds/siliqua	1000 - seed Wt. (g)	Biological yield /plant (g)	Harvest index (%)	Oil content (%)	r values with seed yield/ plant
1.	Day of 50%flowering	**0.026**	-0.007	-0.018	-0.003	0.001	-0.025	0.004	0.037	-0.046	-0.046	-0.002	-0.079
2.	Day to 75%maturity	0.007	**-0.025**	-0.018	-0.001	0.001	0.025	0.017	-0.019	0.321	0.015	0.001	0.322**
3.	Plant height (cm)	0.009	-0.004	**-0.053**	-0.003	0.001	0.026	0.014	-0.011	0.321	0.008	-0.009	0.293
4.	No. of primary branches/plant	0.008	-0.002	-0.015	**-0.012**	0.001	0.016	-0.008	0.003	0.118	0.036	0.001	0.216
5.	No. of secondary branches / plant	-0.004	0.004	0.007	-0.005	**0.002**	-0.008	-0.014	0.002	0.343	0.042	0.001	0.372**
6.	Length of siliqua	-0.007	-0.007	-0.015	-0.002	0.001	**0.091**	-0.004	-0.040	0.328	0.014	-0.009	0.349
7.	No. of seeds/siliqua	-0.002	0.007	0.013	-0.002	0.001	0.007	**-0.058**	0.015	0.110	-0.039	0.002	0.055
8.	1000-seed weight(g)	-0.014	-0.007	-0.008	0.001	0.001	0.053	0.012	**-0.069**	0.353	0.0.79	0.001	0.403**
9.	Biological yield /plant(g)	-0.001	-0.009	-0.018	-0.002	0.001	0.032	-0.007	-0.027	**0.923**	0.047	-0.001	0.937**
10.	Harvest index (%)	-0.004	-0.001	-0.001	-0.001	0.001	0.004	0.007	-0.017	0.139	**0.310**	0.008	0.443**
11.	Oil content (%)	0.002	0.001	-0.018	0.001	0.001	0.031	0.004	-0.001	0.042	-0.097	**-0025**	-0.064

Residual effect = 0.228

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

Phenotypic path analysis

The result of the path analysis at phenotypic level is presented in Table 5.

Days to 50% flowering showed negative phenotypic correlation with seed yield per plant (-0.079) and the direct effect of this character was also positive (0.026). This character showed positive indirect effect via. number of secondary branches per plant (0.001), number of seeds per siliqua (0.004) and 1000-seed weight (0.037). Days to 50% flowering showed negative indirect effect via. days to 75% maturity (-0.007), plant height (-0.018), number of primary branches per plant (-0.003), length of siliqua (-0.025), biological yield per plant (-0.046), harvest index (-0.046) and oil content (-0.002).Days to 75% maturity showed positive and significant correlation with seed yield per plant (0.322) but the direct effect of this character was negative (-0.025). This character showed positive indirect effect via. days to 50% flowering (0.007), number of secondary branches per plant (0.001), length of siliqua (0.025), number of seeds per siliqua (0.017), biological yield per plant (0.321), harvest index (0.015) and oil content (0.001). Days to 75% maturity showed negative indirect effect via. plant height (-0.018), number of primary branches per plant (-0.001) and 1000-seed weight (-0.019).Plant height showed positive correlation with seed yield per plant (0.293) but the direct effect of this character on seed yield per plant was negative (-0.053). This character showed positive indirect effect on seed yield per plant via. days to 50% flowering (0.009), number of secondary branches per plant (0.001), length of siliqua (0.026), number of seeds per siliqua (0.014), biological yield per plant (0.321) and harvest index (0.008). Plant height had negative indirect effect on seed yield per plant via. days to 75% maturity (-0.004), number of primary branches per plant (-0.003), 1000-seed weight (-0.011) and oil content (-0.009).Number of primary branches per plant showed positive correlation with seed yield per plant (0.216) but the direct effect of this character was negative (-0.012). This character showed positive indirect effect via. days to 50% flowering (0.008), number of secondary branches per plant (0.001), length of siliqua (0.016), 1000-seed weight (0.003), biological yield per plant (0.118), harvest index (0.036) and oil content (0.001). This character showed negative indirect effect via. days to 75% maturity (-0.002), plant height (-0.015) and number of seeds per siliqua (-0.008).Number of secondary branches per plant showed positive and significant correlation with seed yield per plant (0.372) and direct effect of this character on seed yield per plant was also positive (0.002). This character showed positive indirect effect via. days to 75% maturity (0.004), plant height (0.007), 1000-seed weight (0.002), biological yield per plant (0.343), harvest index (0.042) and oil content (0.001). Number of secondary branches per plant showed negative indirect effect via. days to 50% flowering (-0.004), number of primary branches per plant (-0.005), length of siliqua (-0.008) and number of seeds per siliqua (-0.014).Length of siliqua showed positive and significant correlation with seed yield per plant (0.349) and direct effect of this character was also positive (0.091). Length of siliqua showed positive indirect effect on seed yield per plant through number of secondary branches per plant (0.001), biological yield per plant (0.328) and harvest index (0.014). This character showed negative indirect effect via. days to 50% flowering (-0.007), days to 75% maturity (-0.007), plant height (-0.015), number of primary branches per plant (-0.002), number of seeds per siliqua (-0.004), 1000-seed weight (-0.040) and oil content (-0.009).Number of seeds per siliqua showed positive correlation with seed yield per plant (0.055) and direct effect of this character was

negative (-0.058). This character showed positive indirect effect on seed yield per plant through days to 75% maturity (0.007), plant height (0.013), number of secondary branches per plant (0.001), length of siliqua (0.007), 1000-seed weight (0.015), biological yield per plant (0.110) and oil content (0.002). This character showed negative indirect effect via. days to 50% flowering (-0.002), number of primary branches per plant (-0.002) and harvest index (-0.039).1000-seed weight showed positive and highly significant correlation with seed yield per plant (0.403) while the direct effect of this character was negative (-0.069). This character showed positive indirect effect on seed yield per plant through number of primary branches per plant (0.001), number of secondary branches per plant (0.001), length of siliqua (0.053), number of seeds per siliqua (0.012), biological yield per plant (0.353), harvest index (0.079) and oil content (0.001). This character showed negative indirect effect via. days to 50% flowering (-0.014), days to 75% maturity (-0.007) and plant height (-0.008).Biological yield per plant exhibited positive and highly significant correlation with seed yield per plant (0.937) and the direct effect of this character was also positive (0.923). This character showed positive indirect effect through number of secondary branches per plant (0.001), length of siliqua (0.032) and harvest index (0.047). Biological yield per plant exhibited negative indirect effect via. days to 50% flowering (-0.001), days to 75% maturity (-0.009), plant height (-0.018), number of primary branches per plant (-0.002), number of seeds per siliqua (-0.007), 1000-seed weight (-0.027) and oil content (-0.001). Harvest index showed positive and highly significant correlation with seed yield per plant (0.443) and direct effect of this character was also positive (0.310). Harvest index showed positive indirect effect on seed yield per plant via. number of secondary branches per plant (0.001), length of siliqua (0.004), number of seeds per siliqua (0.007), biological yield per plant (0.139) and oil content (0.008). Harvest index showed negative indirect effect via. days to 50% flowering (-0.004), days to 75% maturity (-0.001), plant height (-0.001), number of primary branches per plant (-0.001) and 1000-seed weight (-0.017).Oil content showed negative correlation with seed yield per plant (-0.064) but the direct effect of this character on seed yield per plant was negative (-0.025). Oil content showed positive indirect effect on seed yield per plant via. days to 50% flowering (0.002), days to 75% maturity (0.001), number of primary branches per plant (0.001), number of secondary branches per plant (0.001), length of siliqua (0.031), number of seeds per siliqua (0.004) and biological yield per plant (0.042). This character showed negative indirect effect on seed yield per plant through plant height (-0.018), 1000-seed weight (-0.001) and harvest index (-0.097).

The estimates of genotypic correlation were higher than their corresponding phenotypic correlation. Seed yield per plant also showed positive and highly significant association with days to 75% maturity, number of secondary branches per plant, length of siliqua, 1000-seed weight, biological yield per plant and harvest index. However, days to 50% flowering showed positive and significant correlation with plant height. While, this character showed negative correlation with 1000-seed weight. However, oil content revealed positive and significant correlation with seed yield per plant. While this character showed negative correlation with oil content. The path coefficient analysis at phenotypic level revealed that biological yield per plant had the highest positive direct effect on seed yield per plant followed by harvest index, length of siliqua, days to 50% flowering and number of secondary branches per plant. At genotypic level, biological yield

per plant had the highest direct effect on seed yield per plant followed by harvest index, length of siliqua, days to 50% flowering and number secondary branches per plant. 1000-seed weight showed negative direct effect on seed yield per plant at both genotypic and phenotypic level.

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