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Association and path coefficient analysis in Indian mustard genotypes

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Abstract
Indian mustard is the prime oilseed crop of the country. The present investigation was carried out with 38 Indian mustard genotypes laid in RCBD. Each genotype was collected with 16 yield and attributing observations for statistical analysis. The correlation coefficients revealed that, the trait seed yield was positively associated with biological yield, economical yield and oil yield similarly, negatively associated with seeds per silique and oil content. The trait, oil yield registered positively significant association with biological yield, economical yield, seed yield and negative significant association with seeds per silique and oil content. The traits oil yield, number of primary branches per plant and biological yield registered high direct effects and could be employed in direct selection for seed yield due to high direct effects. In selection for oil yield, the traits *viz.*, seed yield, oil content, economical yield and days to 50 per cent flowering can be employed.

Keywords: Indian mustard, association, path analysis, seed yield, oil yield

Introduction

The genera Brassica belongs to family Cruciferae comprises of economically important species yielding edible roots, stems, leaves, buds, flowers and seed condiments. Utilities from the crop was earlier restricted to non-consumption purposes in world. The use of crop as an oil seed has gained importance after 1980's. The Canola council, Canada, on conducting research had developed low glucosinolates and low erusic acid varieties (Anon., 2017). Area under brassica cultivation has picked up after development of anti-nutritionless varieties that are suitable for consumption.

Indian mustard being a prime oil seed crop of the country contains oil in different forms ranging from 30 to 48 per cent (Vikram, 1979). Indian mustard occupies 70 per cent of the total rapeseed-mustard cultivated area. It is grown in an area of 57.91 lakh ha with a production of 62.8 lakh tons. On an average, the crop yields 1,083 kg ha^{-1}(Anon, 2016). In recent years, acreage in South India is picking up. In Karnataka, it is grown in an area of 0.02 lakh hectares with a production of 0.01 lakh tons. Productivity of the crop is considerably low in the state (500 kg ha^{-1}) than the average yield in the country (Anon, 2016). The probable reason for lower yield is the local cultivar being grown by vast majority of the farmers. The performance of available land races and introduced varieties are poor due to fluctuating environment and pest-disease incidence. In order to exploit and explore consumer demand, demand for its medicinal and industrial application, introduction of high grain and oil yielding varieties suitable for Southern India is indispensable. In this connection, primary step in breeding research is to collect available genetic resources in mustard, evaluation of genetic material for their yield potential and pest-disease resistance. Later, through screening procedure best performing genetic material may be used for further breeding program with the sole interest of improving productivity to national average and imparting of pest and disease resistance.

Seed yield is a complex character which depends on several morphological characters. Tools like correlation and path analysis serve as a basis for determination of direct and indirect effects of various traits (Ali *et al.*, 2003) [1]. The trait which has positive direct effect and positive correlation with seed yield is expected to influence genetic makeup of the genetic material in yield and attributes. This can be directly exploited in crop improvement program. Some other traits which have got indirect effect on seed yield could be used for crop improvement through alternative ways (Marjanovic-Jeromela *et al* 2007) [12].

Materials and Methods

The present investigation was conducted at Botanical garden, Agricultural College, Dharwad, Karnataka. The experimental material consisted of 38 Indian mustard genotypes evaluated for yield and attributing characters. The genotypes were collected from DRMR, Bharatpur (18 in number) and from BARC, Trombay (17 in number). The performance of these genotypes was compared with national check NRCHB-101 and two local checks *viz.,* Sannasaasive and Doddasaasive collected locally. The experiment was laid out in RCBD in two seasons of *Rabi* 2016 and *Rabi* 2017 in a plot size of 4.5 m × 5 m in both the seasons along with recommended agronomical practices. A spacing of 45 cm × 10 cm was maintained in the field, along with chemical control of white rust was taken up.

The observations were recorded on 16 yield and attributes. From each plot, five randomly selected plants were selected and all the observations were recorded. The average values for each genotype was used in statistical analysis. The data was recorded for the characters *viz.*, Days to 50 per cent flowering, Days to maturity, Plant height (cm), Number of primary branches per plant, Number of secondary branches per plant, Number of racemes per plant Number of siliqua per plant, Number of seeds per siliqua, Siliqua length,1000 seed weigh, Oil content (%), Economical yield (g), Biological yield per plant (g), Harvest Index (%), Seed yield (kg/ha) and Oil yield (kg ha^{-1}).

Statistical analysis of the data was carried out using Indostat statistical package version 9.1. For the estimation of Karl pearson's simple correlation coefficients at genotypic and phenotypic levels, two seasons data was considered. The genotypic correlations were derived from combined ANOVA of RCBD as described by Gomez and Gomez (2010). Significance of correlation coefficients was tested using student's T statistics at n-2 degrees of freedom and chosen level of significance (α). Path coefficient analysis was carried out with both seed yield and oil yield as dependent characters with contributory traits as independent variables. The correlation coefficient was partitioned as direct and indirect effects as per Sewall Wright (1921) [21] and illustrated by Deway and Lu (1959) [7]. Similarly, residual effects were computed to represent the coverage of variables in explaining seed yield and oil yield.

Results and Discussion

The observations on 16 yield and attributes were used for estimation of correlation and path coefficients. The results of genotypic and phenotypic correlation coefficients are presented in Table 1.

Among the genotypes, there was significant and positive phenotypic association of seed yield with characters like number of secondary branches per plant (0.25), number of racemes per plant (0.15), number of siliqua per plant (0.24), siliqua length (0.21), biological yield (0.31), economical yield (0.47), harvest index (0.19), 1000 seed weight (0.19) and oil yield (0.99). Negative significant results were registered with days to maturity (-0.21) and oil content (-0.32).

At genotypic level, positive significant correlation of seed yield was registered with number of primary branches per plant (0.28), number of secondary branches per plant (0.54), number of racemes per plant (0.29), number of siliqua per plant (0.39), siliqua length (0.36), biological yield (0.68), economical yield (0.91) and oil yield (0.98). Negative significant results were registered by days to 50 per cent flowering (-0.33), days to maturity (-0.38), seeds per siliqua (-0.44), oil content (-0.98) and harvest index (-0.16). Similar results were reported by Gangapur (2008) [8], Belete (2011) [5], Rameeh (2011) [14], Helal *et al*. (2014) [10] and Mustafa *et al*. (2018). The results of present investigation were in contrast to Basalma (2008) [4], Belete (2011) [5] and Kumar *et al.* (2018) [6] who reported positive correlation of oil content, days to maturity and days to 50 per cent flowering respectively with seed yield.

Similarly, the trait oil yield per hectare registered significant positive phenotypic correlation with number of secondary branches per pant (0.24), number of racemes per plant (0.15), number of siliqua per raceme (0.25), siliqua length (0.21), biological yield (0.30), economical yield (0.45), harvest index (0.19), 1000 seed weight (0.19) and seed yield (0.99). Negative significant association was found with days to maturity (-0.21) and oil content (-0.25).

The genotypic coefficients of oil yield were positively significant with number of primary branches per pant (0.26), number of secondary branches per pant (0.53), number of racemes per plant (0.28), number of siliqua per raceme (0.41), siliqua length (0.34), biological yield (0.67), economical yield (0.90), 1000 seed weight (0.22) and seed yield (0.98). Negative significant association was found with days to 50 per cent flowering (-0.32), days to maturity (-0.38), seeds per siliqua (-0.44), oil content (-0.99) and harvest index (-0.15). The present findings are in accordance with results of Thiyagu *et al.* (2007) [16] in Sesamum and Marjanović-jeromela *et al.* (2007) in rapeseed genotypes. Generally, the seed yield and oil yield are positively associated while oil content and seed yield are negatively associated. Thus, it is evident in the results that traits with positive association with seed yield have positive association with oil yield, as oil content had lesser variation (38.85 % to 41.40 %) among the genotypes which is almost constant. The significant genotypic correlations can be attributed to linkage of the traits. Since most of the traits recorded were governed by QTLs, congruency of the QTLs which share some of the genes in common can also be a reason for detected association between the traits.

Path coefficients are standardized partial regression coefficients. In the present investigation, path coefficients were computed considering both seed yield and oil yield as dependent variables. Traits with significant values of correlation coefficients with dependent characters were only considered for path analysis. The results from path analysis are presented in Table 2 to Table 5. The residual values for phenotypic path coefficient with oil yield as dependent trait was 0.03, while for seed yield as dependent trait, residue was 0.0279. Genotypic path coefficients with oil yield as dependent trait registered a residual value of (R) of 0.038 and 0.042 as residual value for seed yield as dependent trait.

Among the genotypes, highest positive phenotypic direct effects on seed yield as dependent character were exerted by oil yield (0.9791), days to maturity (0.0034) and number of racemes per plant (0.0020). Thus, oil yield can be considered to be the primary casual factor for seed yield. In contrast, highest negative direct effects on oil yield were exerted by oil content (-0.0791) and 1000 seed weight (-0.0042). At phenotypic level, highest positive indirect effects on seed yield were exerted by oil yield through economical yield (0.4404), biological yield (0.2918) and number of siliqua per raceme (0.2408). Similarly, oil content through economical yield exerted positive indirect effects (0.0280) while, it was negatively associated with seed yield. The indirect effects were negative with seed yield by oil yield through oil content (-0.2419). Oil content exerted negative indirect effects through number of siliqua per raceme (-0.0032) and number of racemes per plant (-0.0016).

At genotypic level, positive direct effects on seed yield as dependent character were exerted by oil yield (0.9645), number of primary branches per plant (0.0444) and biological yield (0.0402). Similarly, negative direct effects were exerted by oil content (-0.0702), economical yield per plant (-0.0675) and days to 50 per cent flowering (-0.0193). Positive indirect effects were exerted on seed yield by oil yield through biological yield (0.7168), economical yield (0.3894) and number of secondary branches per plant (0.1971). While, negative indirect effects were registered by oil yield *via* oil content (-0.6549), harvest index (-0.4904) and days to maturity (-0.2417). The trait economical yield exerted negative indirect effects on seed yield *via* siliqua length (-0.0296) and oil yield (-0.0272). These results were in agreement with Gangapur (2008), Dawar *et al.* (2018) and Kumar *et al.* (2018) [11]. The results were in contrast to those by Tahira *et al.* (2014). The trait, primary branches registered positive direct effect and negative association with seed yield, the undesirable indirect effects should be nullified in order to make use of the direct effects.

In Table 4 and 5, the path coefficients with oil yield as dependent character are presented. At phenotypic level, maximum positive direct effects were exerted by seed yield (1.0264) and oil content (0.0897). While, negative direct effects were exerted by biological yield (-0.0059) and number of secondary branches per plant (-0.0033). The indirect effects were positive by seed yield through biological yield (0.6019) and 1000 seed weight (0.3211). Similarly, oil content exerted positive direct effects through number of siliqua per raceme (0.0254). Indirect effects were negative by oil content through biological yield (-0.0325) and seed yield (-0.0312).

Genotypic path coefficients reveled that high positive direct effects were exerted on oil yield by seed yield (1.0395), oil content (0.0727), economical yield (0.0494) and days to 50 per cent flowering (0.0220). The negative direct effects were exerted on oil yield by days to maturity (-0.0353), number of primary branches per plant (-0.0328) and biological yield per plant (-0.0277). Similarly, indirect effects were high and positive by seed yield *via* biological yield (0.7826), economical yield (0.4342) and 1000 seed weight (0.3620). Similarly, oil content through number of siliqua per raceme (0.0551). Economical yield exerted an indirect effect of 0.0251 on oil yield through number of primary branches per plant. Contrastingly, negative indirect effects were observed by seed yield *via* oil content (-0.7370) and harvest index (-0.5234). Oil content exerted negative indirect effects through seed yield (-0.0515) and economical yield (-0.0467). Economical yield exerted negative indirect effect of -0.0317 through oil content. These results are in agreement with Thiyagu *et al.* (2007) [] in Sesamum. Since, seed yield has maximum direct effect and close correlation coefficient, indirect selection can be practiced for oil yield. The trait oil content registered positive direct effect and negative association, thus undesirable indirect effects have to be nullified before considering the direct effect.

The rest of estimates of indirect effects were too low for consideration. Thus, path coefficient analysis of yield and attributes clearly indicated that traits *viz.*, days to 50 per cent flowering, number of siliqua per raceme, oil content were negatively related with seed yield. While, traits biological yield and oil content were in positive association with seed yield. Similarly, traits number of secondary branches per plant, siliqua length, economical yield and seed yield were in positive association with oil yield. The traits, days to maturity, number of primary branches per plant, number of racemes per plant and seeds per siliqua were negatively associated as evident by path analysis.

Conclusion

Hence, the traits *viz.*, oil yield, number of primary branches per plant and biological yield can be employed in direct selection for seed yield. The traits *viz.*, seed yield, oil content, economical yield and days to 50 per cent flowering can be employed for direct selection for oil yield as dependent characters. For indirect selection of seed yield as dependent character, biological yield can be employed which exerted highest indirect effect through oil yield. Similarly, traits *viz.*, biological yield, economic yield, test weight, siliqua length and number of secondary branches per plant can be employed in indirect selection for oil yield through seed yield.

Table 1: Association between yield and yield attributes in the genotypes of Indian mustard.

		Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of primary branches/plant	No. of secondary branches/plant	No. of racemes/plant	No. of siliqua/raceme	Siliqua length (cm)	Seeds/siliqua (No.)	Oil content (%)	Biological yield (g)	Economic yield (g)	Harvest index (%)	1,000-seed weight (g)	Seed yield (kg/ha)	Oil yield (kg/ha)
Days to 50 % flowering	rg	1															
	rp	1															
Days to maturity	rg	0.88**	1														
	rp	0.42**	1														
Plant height (cm)	rg	0.04	0.07	1													
	rp	0.25**	0.23**	1													
No. of primary branches/plant	rg	-0.35**	-0.32**	0.32**	1												
	rp	-0.04	-0.24**	0.22**	1												
No. of secondary branches/plant	rg	-0.75**	-0.53**	0.31**	0.99**	1											
	rp	-0.09	-0.28**	0.28**	0.70**	1											
No. of racemes/plant	rg	-0.40**	-0.39**	0.37**	0.90**	0.92**	1										
	rp	-0.13	-0.24**	0.19**	0.69**	0.81**	1										
No. of siliqua/raceme	rg	0.45**	0.12**	0.54**	0.34**	0.38**	0.40**	1									
	rp	0.06	0.01	0.39**	0.36**	0.42**	0.37**	1									
Siliqua length (cm)	rg	-0.35**	-0.36**	-0.29**	-0.15	0.09	0.03	-0.19*	1								
	rp	-0.15*	-0.17*	-0.14 *	0.05	0.13	0.11	0.01	1								
Days to 50 % flowering	rg	-0.30**	-0.37**	0.06	-0.08	-0.16**	-0.14*	-0.24*	0.1	1							
	rp	-0.02	-0.23**	0.04	0.07	-0.05	-0.1	-0.08	0.05	1							
Seeds/siliqua (No.)	rg	0.67**	0.50**	-0.05	-0.44**	-0.63**	-0.35**	-0.14*	-0.76**	0.43**	1						
	rp	-0.05	0.07	0.05	0.08	-0.06	0.02	0.04	-0.15*	0.13	1						
Oil content (%)	rg	-0.42**	-0.53**	-0.40**	0.69**	0.64**	0.46**	0.1	0.27**	-0.16*	-0.72**	1					
	rp	-0.05	-0.20**	-0.16*	0.26**	0.34**	0.23**	0.13	0.22**	-0.11	-0.22	1					
Biological yield (g)	rg	0.15*	-0.22**	-0.02	0.27**	0.50**	0.16	0.23**	0.35**	-0.61**	-0.99**	0.65**	1				
	rp	-0.1	-0.14*	-0.12	-0.13	0.1	0.09	-0.08	0.28**	0.01	-0.35	0.25**	1				
Economic yield (g)	rg	0.49**	0.40**	0.41**	-0.68**	-0.45**	-0.49**	-0.15*	-0.15*	-0.29**	0.1	-0.75**	-0.08	1			
	rp	-0.07	-0.05	-0.01	-0.11	-0.02	-0.1	0.13	-0.1	-0.03	-0.13*	0.01	0.11	1			
Harvest index (%)	rg	-0.39**	0.20**	-0.08	-0.33**	-0.12	-0.27**	0.11	-0.20**	-0.35**	-0.25**	-0.02	0.19**	0.23**	1		
	rp	-0.07	-0.05	-0.01	-0.11	-0.02	-0.1	0.13	-0.1	-0.03	-0.13*	0.01	0.11	0.04	1		
1,000-seed weight (g)	rg	-0.33**	-0.38**	-0.11	0.28**	0.54**	0.29**	0.39**	0.36**	-0.44**	-0.98**	0.68**	0.91**	-0.16*	0.02	1	
	rp	-0.11	-0.21**	-0.03	0.07	0.25**	0.15*	0.24**	0.21**	-0.09	-0.32**	0.31**	0.47**	0.19**	0.19**	1	
Seed yield (kg/ha)	rg	-0.32**	-0.38**	-0.11	0.26**	0.53**	0.28**	0.41**	0.34**	-0.44**	-0.99**	0.67**	0.90**	-0.15*	0.22**	0.98**	1
	rp	-0.12	-0.21**	-0.02	0.08	0.24**	0.15*	0.25**	0.21**	-0.08	-0.25**	0.30**	0.45**	0.19**	0.19**	0.99**	1

Table 2: Phenotypic path coefficients with seed yield as a dependent character in Indian Must ard.

	Days to maturity	No. of secondary branches/plant	No. of racemes/plant	No. of siliqua /raceme	Siliqua length (cm)	Oil content (%)	Biological yield (g)	Economic yield (g)	1,000- seed weight (g)	Oil yield (kg/ha)	r_p with Seed yield
Days to maturity	0.0034	-0.0010	-0.0008	0.0000	-0.0006	0.0003	-0.0007	-0.0005	-0.0002	-0.0007	-0.2132
No. of secondary branches/ plant	-0.0003	0.0010	0.0008	0.0004	0.0001	-0.0001	0.0003	0.0001	0.0000	0.0002	0.2453
No. of racemes/plant	-0.0005	0.0016	0.0020	0.0007	0.0002	0.0000	0.0005	0.0002	-0.0002	0.0003	0.1481
No. of siliqua/raceme	0.0000	-0.0007	-0.0006	-0.0017	0.0000	-0.0001	-0.0002	0.0001	-0.0002	-0.0004	0.2371
Siliqua length (cm)	0.0002	-0.0002	-0.0001	0.0000	-0.0012	0.0002	-0.0003	-0.0003	0.0001	-0.0003	0.2132
Oil content (%)	-0.0059	0.0050	-0.0016	-0.0032	0.0122	-0.0791	0.0174	0.0280	0.0104	0.0195	-0.3196
Biological yield (g)	-0.0004	0.0008	0.0006	0.0003	0.0005	-0.0005	0.0023	0.0006	0.0000	0.0007	0.3106
Economic yield (g)	0.0003	-0.0002	-0.0002	0.0002	-0.0006	0.0008	-0.0005	-0.0022	-0.0002	-0.0010	0.4659
1,000-seed weight (g)	0.0002	0.0001	0.0004	-0.0005	0.0004	0.0005	-0.0001	-0.0005	-0.0042	-0.0008	0.1917
Oil yield (kg/ha)	-0.2102	0.2389	0.1477	0.2408	0.2021	-0.2417	0.2918	0.4404	0.1862	0.9791	0.9967

Residual effect = 0.0279; Diagonal values indicate direct effects of traits with seed yield

Table 3: Genotypic path coefficients with seed yield as dependent character in Indian mustard

	Days to 50 per cent flowering	Days to maturity	Number of primary braches per plant	Number of secondary branches per plant	Number of racemes per plant	Number of siliqua per raceme	Siliqua length (cm)	Number of seeds per siliqua	Oil content (%)	Biological yield (g)	Economical yield (g)	Harvest index (%)	Oil yield (kg/ha)	r_g with Seed yield
Days to 50 per cent flowering	-0.0193	-0.0106	-0.0006	0.0055	0.0043	0.0024	0.0051	0.0009	0.0033	0.0032	0.0038	0.0006	0.0036	-0.1594
Days to maturity	0.0142	0.0258	-0.0065	-0.0107	-0.0098	-0.0014	-0.0049	-0.0122	0.0013	-0.0097	-0.0049	0.0080	-0.0065	-0.2389
Number of primary braches per plant	0.0014	-0.0112	0.0444	0.0373	0.0329	0.0112	0.0015	0.0065	0.0007	0.0166	0.0226	-0.0068	-0.0024	-0.0504
Number of secondary branches per plant	0.0039	0.0056	-0.0113	-0.0135	-0.0087	-0.0030	-0.0007	0.0006	0.0012	-0.0076	-0.0052	0.0067	-0.0028	0.2096
Number of racemes per plant	-0.0008	-0.0013	0.0026	0.0023	0.0035	0.0007	0.0000	-0.0005	0.0005	0.0004	0.0004	-0.0007	-0.0006	-0.1606
Number of siliqua per raceme	0.0026	0.0011	-0.0052	-0.0045	-0.0042	-0.0204	0.0101	0.0007	-0.0155	0.0039	0.0072	0.0071	0.0018	-0.1341
Siliqua length (cm)	0.0009	0.0006	-0.0001	-0.0002	0.0000	0.0016	-0.0032	-0.0008	0.0013	-0.0012	-0.0014	0.0003	-0.0006	0.1912
Number of seeds per siliqua	-0.0005	-0.0051	0.0016	-0.0005	-0.0014	-0.0004	0.0027	0.0107	0.0035	-0.0013	0.0001	0.0012	-0.0024	-0.235
Oil content (%)	0.0121	-0.0036	-0.0012	0.0060	-0.0107	-0.0532	0.0278	-0.0232	-0.0702	0.0435	0.0451	-0.0066	0.0476	-0.709
Biological yield (g)	-0.0066	-0.0151	0.0150	0.0226	0.0047	-0.0078	0.0153	-0.0049	-0.0249	0.0402	0.0265	-0.0252	0.0299	0.7529
Economical yield (g)	0.0132	0.0129	-0.0343	-0.0259	-0.0073	0.0237	-0.0296	-0.0007	0.0434	-0.0445	-0.0675	-0.0095	-0.0272	0.4177
Harvest index (%)	-0.0004	0.0037	-0.0018	-0.0059	-0.0025	-0.0041	-0.0011	0.0013	0.0011	-0.0075	0.0017	0.0119	-0.0061	-0.5035
Oil yield (kg/ha)	-0.1801	-0.2417	-0.0531	0.1971	-0.1614	-0.0835	0.1682	-0.2135	-0.6549	0.7168	0.3894	-0.4904	0.9645	0.9990

Residual effect = 0.042; Diagonal values indicate direct effects of traits with seed yield

Table 4: Phenotypic path coefficients with oil yield as dependent character in Indian mustard

	Days to maturity	No. of secondary branches/plant	No. of racemes/plant	No. of siliqua/raceme	Siliqua length (cm)	Oil content (%)	Biological yield (g)	Economic yield (g)	1,000-seed weight (g)	Seed yield (kg/ha)	r_p with Oil yield
Days to maturity	-0.0032	0.0008	0.0005	0.0000	0.0003	-0.0001	0.0007	0.0004	0.0001	0.0005	-0.1638
No. of secondary branches/plant	0.0008	-0.0033	-0.0024	-0.001	-0.0002	0.0000	-0.0011	-0.0004	0.0002	-0.0005	0.1541
No. of racemes/plant	0.0005	-0.0023	-0.0032	-0.0009	-0.0002	-0.0005	-0.0005	-0.0002	0.0007	0.0001	-0.0221
No. of siliqua/raceme	-0.0001	0.0025	0.0024	0.0082	-0.0009	0.0023	-0.0003	-0.0022	0.0003	0.0000	0.0306
Siliqua length (cm)	-0.0004	0.0003	0.0003	-0.0005	0.0045	-0.0005	0.0016	0.0009	-0.0004	0.0005	0.0953
Oil content (%)	0.0018	0.001	0.0127	0.0254	-0.0106	0.0897	-0.0325	-0.029	-0.0134	-0.0312	-0.2667
Biological yield (g)	0.0012	-0.0019	-0.0009	0.0002	-0.0021	0.0021	-0.0059	-0.0025	-0.0006	-0.0034	0.5673
Economic yield (g)	-0.0009	0.0007	0.0004	-0.0018	0.0012	-0.0021	0.0028	0.0065	0.0007	0.0018	0.258
1,000-seed weight (g)	-0.0002	-0.0004	-0.0012	0.0002	-0.0005	-0.0008	0.0006	0.0006	0.0057	0.0018	0.3144
Seed yield (kg/ha)	-0.1635	0.1569	-0.0305	0.0008	0.1037	-0.3568	0.6019	0.284	0.3211	1.0264	0.9959

Residual effect =0.03; Diagonal values indicate direct effects of traits with oil yield

Table 5: Genotypic path coefficients with oil yield as dependent character in Indian mustard.

	Days to 50 per cent flowering	Days to maturity	Number of primary braches per plant	Number of secondary branches per plant	Number of racemes per plant	Number of siliqua per raceme	Siliqua length (cm)	Number of seeds per siliqua	Oil content (%)	Biological yield (g)	Economical yield (g)	Harvest index (%)	1000-seed weight (g)	Seed yield (kg/ha)	r_g with Oil yield
Days to 50 per cent flowering	0.0220	0.0121	0.0007	-0.0063	-0.0049	-0.0028	-0.0059	-0.0010	-0.0038	-0.0036	-0.0043	-0.0070	-0.0050	-0.0035	-0.1867
Days to maturity	-0.0195	-0.0353	0.0089	0.0147	0.0134	0.0019	0.0067	0.0167	-0.0018	0.0132	0.0067	-0.0110	0.0016	0.0084	-0.2506
Number of primary braches per plant	-0.0010	0.0083	-0.0328	-0.0275	-0.0243	-0.0083	-0.0011	-0.0048	-0.0005	-0.0123	-0.0166	0.0050	0.0176	0.0017	-0.0551
Number of secondary branches per plant	-0.0037	-0.0054	0.0109	0.0130	0.0083	0.0029	0.0007	-0.0006	-0.0011	0.0073	0.0050	-0.0065	-0.0027	0.0027	0.2043
Number of racemes per plant	0.0032	0.0055	-0.0107	-0.0093	-0.0145	-0.0030	-0.0002	0.0019	-0.0022	-0.0017	-0.0016	0.0030	0.0082	0.0023	-0.1673
Number of siliqua per raceme	-0.0031	-0.0013	0.0062	0.0054	0.0051	0.0244	-0.0120	-0.0009	0.0185	-0.0047	-0.0086	-0.0085	-0.0065	-0.0033	-0.0866
Siliqua length (cm)	-0.0027	-0.0020	0.0004	0.0006	0.0001	-0.0051	0.0103	0.0026	-0.0041	0.0039	0.0045	-0.0010	-0.0012	0.0020	0.1744
Number of seeds per siliqua	0.0009	0.0093	-0.0029	0.0009	0.0026	0.0007	-0.0049	-0.0197	-0.0065	0.0024	-0.0002	-0.0022	0.0018	0.0046	-0.2213
Oil content (%)	-0.0125	0.0037	0.0012	-0.0063	0.0111	0.0551	-0.0288	0.0241	0.0727	-0.0450	-0.0467	0.0069	-0.0249	-0.0515	-0.6789
Biological yield (g)	0.0046	0.0104	-0.0104	-0.0156	-0.0032	0.0053	-0.0105	0.0034	0.0171	-0.0277	-0.0183	0.0174	-0.0047	-0.0208	0.7432
Economical yield (g)	-0.0096	-0.0094	0.0251	0.0190	0.0053	-0.0173	0.0217	0.0005	-0.0317	0.0325	0.0494	0.0070	0.0089	0.0206	0.4037
Harvest index (%)	-0.0002	0.0017	-0.0008	-0.0026	-0.0011	-0.0018	-0.0005	0.0006	0.0005	-0.0033	0.0007	0.0053	-0.0003	-0.0027	-0.5084
1000-seed weight (g)	0.0007	0.0001	0.0016	0.0006	0.0017	0.0008	0.0003	0.0003	0.0010	-0.0005	-0.0005	0.0002	-0.0030	-0.0010	0.352
Seed yield (kg/ha)	-0.1657	-0.2483	-0.0524	0.2179	-0.1669	-0.1394	0.1987	-0.2443	-0.7370	0.7826	0.4342	-0.5234	0.3620	1.0395	0.9990

Residual effect =0.038; Diagonal values indicate direct effects of traits with oil yield

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