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Research Article

Association studies for yield, genetic variability, heritability and genetic advance in Indian mustard (*Brassica juncea* L.)

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ABSTRACT

The study revealed highly significant differences for all the thirteen characters studied, the analysis of variance worked out for seed yield and its components in Indian mustard indicated that the mean sum of squares due to genotypes were highly significant for all the characters. Results of phenotypic correlation coefficient revealed that the seed yield/plant (g) had significant positive correlation with biological yield/plant followed by traits test weight (g), number of secondary branches/ plant and harvest index. Path coefficient analysis of different characters contributing towards seed yield/plant revealed that days to maturity, test weight, number of primary branches/plant, siliqua length, plant height biological yield/plant and number of siliqua/plant harvest index had the highest positive direct effect relationship with seed yield/plant followed by days to 50% flowering, number of secondary branches/plant, days to first flowering, number of siliquae/plant and harvest index had genotypic negative direct effect on seed yield/plant. In present investigation the high heritability was recorded for the characters seed yield/plant (77.9%), harvest index and biological yield. Genetic advance as percentage of mean was observed high for the characters number of siliqua/plant (47.638) followed by harvest index, biological yield and test weight. High heritability estimates in broad sense along with high genetic advance as percent of mean was observed for seed yield/plant, harvest index, biological yield. The high PCV and GCV were observed for number of siliqua/plant whereas, moderate PCV and GCV was recorded seed yield/plant, harvest index, biological yield and days to first flowering.

Keywords: *Brassica juncea*, genetic variability, correlation, path coefficient and heritability

INTRODUCTION

Brassica juncea is a natural amphidiploid (2n=36) derived from interspecific cross of *Brassica nigra* (2n=16) and *Brassica campestris* (2n=20) (Rout et al., 2018). Rapeseed- mustard group of oil seed crops is the second most important crop after groundnut. Indian mustard covers over 80% of the total area under rapeseed mustard crops (Rao et al., 2017; Kumar et al., 2019 & Singh et al., 2022). Mustard is the third most important source of edible oil of the world after soyabean and palm. In India it ranks second in acreage superseded by groundnut only. Mustard crop is grown both in tropical and subtropical countries Rapeseed and mustard can be cultivated in both tropical as well as temperate climates. Its growth is most vigorous in the temperature between 10°C and 30°C with an optimum temperature of around 20°C seed oil formation is optimum at a temperature of 10°C to 15°C. A crop is sensitive at a time of flowering to the high temperature as well to the frost. In India mustard is normally cultivated as a winter season crop. It requires cooler temperature for setting of seeds and

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formation of oil. Vegetable oil and fats are valuable food ingredients in human diet and contains saturated and unsaturated fatty acids and are stored in the form of oil bodies in the cell and called "oleosomes". Edible oils are the chief source of fats and proteins, fatty acids. In human body fats and oils acts as a transport medium for vitamins A, D, E and K (Reed, 1976). Vegetable oils are commonly used as a cooking medium throughout the country and also serve as important raw material for the manufacture of soap, paint, hair oil, lubricants, cosmetics etc. Mustard oil contains a high amount of selenium and magnesium, which gives it anti-inflammatory properties. It also helps in stimulating sweat glands and helps in lowering body temperature. In traditional medicines, it is used to relieve the pain associated with arthritis, muscle sprains and strains. Seed paste applied on wounds whereas paste of leaf said to heal cattle wounds (Sood et al., 2010). Various traits exhibit varying degree of associations with seed yield as well as among themselves. The correlation between traits contributing directly or indirectly to seed yield with their level of inheritance is important in the framing selection programme. So that the present study was taken to find out genetic variability available, heritability and genetic advance, the association of different characters and their contribution to define seed yield.

MATERIALS AND METHODS

The present research was carried out at the experimental farm Research Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib during *Rabi* season of 2018-19. A set of thirty eight genotypes *viz.* IC447111, IC589690, RH119, Ashriwad, Kanti, Basanti, Geeta, Maya, Kranti, CS-54, IC571649, IC571668, IC571678, IC338586, IC339953, IC342777, IC355856, IC335858, IC-597919, IC-598692, IC-571649, IC-405232, IC-571630, GEETA, BASANTI, BR-40, Jawahar mustard, Narinder rye, IC599679, IC598692, IC597879, IC589662, IC589669, IC589670, IC589680, IC589686, Durgamani, Jagannath were grown in Randomized Block Design with three replications. The data were recorded on ten randomly selected plants eg. days to first flowering, days to 50% flowering, number of primary branches/plant, number of secondary branches/plant, plant height (cm), number of siliquae/plant, siliqua length (cm), days to maturity, number of seeds/siliqua, biological yield/plant, seed yield/plant, harvest index (%) and test weight (g) were recorded on five competitive plants randomly selected from each plot while flowering was recorded on row basis. Analysis of variance was calculated using MS Excel software using MSTAT-C software. The genotypic (GCV) and phenotypic (PCV) coefficient of variation was computed by Burton. Heritability and genetic advance were determined as described by many researchers. The data collected for all quantitative characters were subjected to analysis of variance according to the method recommended by Panse & Sukhatme (1967), coefficient of variation by Burton & De Vane (1953), estimation of heritability by Hanson et al. (1956), genetic advance by Johnson et al. (1955), correlation coefficient by Searle (1961) and path coefficient analysis by Dewey & Lu (1965).

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance revealed significant differences for all traits studied. Variance due to genotype was highly significant for all the thirteen traits indicating the presence of sufficient variability in the genotypes selected for this study. The estimates of genetic variability parameters showed that phenotypic variance is greater than genotypic variance indicating the influence of environment on the expression of the trait (Table 1).

Genetic variability parameters

The estimates of genetic variability parameters for all the traits were worked out and Phenotypic coefficient of variation (PCV), genotypic coefficient of variation

Table 1: Analysis of variance (ANOVA) for yield and yield attributing traits in 38 genotypes of Mustard

Source of variation	d.f.	Mean sum of squares					
		Days to 50% flowering	No. of primary branches	No. of secondary branches	Plant height	No. of siliquae per plant	Siliqua length
Replication	2	5.429824	3.528509*	25.638510	134.408700	3785.351000	0.969488
Treatment	37	48.206970	2.985095**	151.518266**	771.979542**	60754.445543**	0.882576**
Error	74	9.871266	1.105941	48.642833	154.452916	5246.296982	0.435095

Table 1 conti.....

Source of variation	d.f.	Mean sum of squares					
		No. of seeds per siliquae	Days to maturity	Biological yield	Seed yield	Harvesting index	Test weight
Replication	2	0.144934	67.956140	686.529200	2.407001	31.687250	7.471401
Treatment	37	6.390985**	415.989569**	3733.749449	127.940320**	192.416823**	23.552051**
Error	74	1.641916	65.739924	359.845567	11.440109	17.893967	6.450187

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

(GCV), heritability in broad sense, genetic advance and genetic advance as per cent mean were estimated for all the characters under study and presented in Table 2. Among the yield attributes maximum PCV and GCV were depicted by test weight (57.376 and 39.300) followed by number of siliquae per plant (52.732 and 46.545) and number of secondary branches/plant (38.978 and 25.064). Similar findings were reported by Kumar et al. (2017) and Raliya *et al.* (2018). Genetic advance is the improvement of mean genotypic values of selected plants over parental population under each cycle of selection. Allard (1960) indicated that high genetic advance coupled with high heritability offers most suitable conditions to decide the criteria of selection. According to Singh (2001), heritability values greater than 80% are very high, values from 60-79% are moderately high, values from 40-59% are medium and values less than 40% are low. The high heritability was recorded highest on the number of siliquae per plant (77.9%) with genetic advance and an expected genetic advance over percentage of mean of (247.332 and 316.969%), followed by seed yield per plant (77.2%) with genetic advance and an expected genetic advance over percentage of mean of (11.282 and 14.459%) and harvest index (76.5%) with genetic advance and an expected genetic advance over percentage of mean of (13.740 and 17.609%). Similar findings were reported by Singh et al. (2011) & Singh et al. (2022).

Correlation and path coefficient analysis

In this study, genotypic correlation coefficients (Table 3) were higher in magnitude than phenotypic correlation coefficient (Table 4) for most of the traits indicating the depression of phenotypic expression by environmental influence. To estimate the association between two characters, correlation coefficient at phenotypic and genotypic levels were worked out in all possible combinations among yield components. Days to first flowering showed highly significant positive correlation with days to 50% flowering (0.7005) followed by days

Table 2: Estimates of different genetic parameters of variation for 13 traits among the genotypes

Characters	General mean	GCV	PCV	Heritability (%)	Genetic advancement 5 %	Genetic advancement 1 %	Gen advancement as % of mean 5%	Genetic advancement as % of mean 1%	Exp mean next generation
Days to first flowering	40.895	9.901	12.283	65	6.723	8.616	16.440	21.069	47.618
Days to (50%) flowering	55.009	6.498	8.652	56	5.531	7.088	10.055	12.886	60.540
No. of primary branches/plant	5.828	13.580	22.583	36	0.980	1.256	16.822	21.558	6.808
No. of secondary branches/plant	23.364	25.064	38.978	41	7.757	9.941	33.200	42.548	31.121
Plant height (cm)	174.266	8.233	10.892	57	22.339	28.629	12.819	16.429	196.605
No. of siliqua/plant	292.244	46.545	52.732	77	247.332	316.969	84.632	108.460	539.576
Siliqua length (cm)	4.767	8.101	16.034	25	0.402	0.515	8.433	10.807	5.169
No. of seeds/siliqua	14.780	8.513	12.150	49	1.816	2.327	12.286	15.745	16.596
Days to maturity	136.456	7.918	9.900	64	17.803	22.816	13.047	16.721	154.260
Biological yield (g)	106.055	31.621	36.329	75	60.130	77.060	56.697	72.661	166.185
Seed yield/plant (g)	21.597	28.854	32.830	77	11.282	14.459	52.240	66.949	32.880
Harvest index (%)	22.377	34.085	38.976	76	13.740	17.609	61.403	78.692	36.117
Test weight	6.075	39.300	57.376	46	3.369	4.317	55.452	71.064	9.444

Table 3: Estimates of genotypic correlation coefficients between different characters in Indian mustard

Character	Days to first flower-ing	Days to 50% flower-ing	No. of primary branches	No. of secondary branches	Plant height (cm)	No. of silique per plant	Siliqua length (cm)	No. of seeds per silique	Days to maturity	Biological yield per plant (g)	Harvest index (%)	Test weight (g)	Seed yield (g)
Days to first flowering	**1.0000**	0.6422	0.1988	-0.0038	-0.2265	-0.0817	-0.0002	0.2841	0.2471	-0.1086	0.1592	0.3321	0.1179
Days to 50% flowering		**1.0000**	0.1368	0.0405	0.0324	-0.0878	-0.0968	0.2675	0.1845	-0.0847	0.1393	0.2686	0.0930
No. of primary branches			**1.0000**	0.5100	0.0950	-0.3441	-0.4033	0.3374	0.1788	0.1765	0.3159	-0.4913	0.7481
No. of secondary branches				**1.0000**	0.3616	0.0540	-0.2120	0.3704	0.0783	0.3428	-0.2467	-0.3522	0.2716
Plant height (cm)					**1.0000**	0.0727	0.1790	0.1816	-0.2589	0.3708	-0.3245	-0.1396	0.1868
No. of silique per plant						**1.0000**	-0.0927	-.1021	0.0405	-0.4042	-0.2287	0.4939	-0.7623
Siliqua length (cm)							**1.0000**	-0.4112	-0.2451	0.1196	-0.3172	0.5004	-0.1575
No. of seeds per siliqua								**1.0000**	0.4315	-0.0439	0.0997	-0.4069	0.2542
Days to maturity									**1.0000**	-0.3002	0.3838	-0.0693	0.0458
Biological yield / plant (g)										**1.0000**	-0.6723	-0.4115	0.4153
Harvest index (%)											**1.0000**	0.0632	0.2989
Test weight (g)												**1.0000**	0.5745

to maturity (0.1843) and test weight (0.2426). Days to 50% flowering showed significant positive correlation with test weight (0.2006). Number of primary branches showed highly significant positive correlation with number of secondary branches (0.3710), number of seeds per siliqua (0.3183) and number of siliquae/plant (0.4525). Number of secondary branches showed highly significant positive correlation with number of seed/siliqua (0.3086) and biological yield (0.2792) at phenotypic level. Genotypic correlation coefficients positively and significantly associated with Days to first flowering showed highly positive correlation with days to 50% flowering (0.6422) followed by Days to 50% flowering showed highly positive correlation with test weight (0.2686). Number of primary branches showed highly positive correlation with number of secondary branches (0.5100). Number of secondary branches showed highly positive correlation with number of seeds per siliquae (0.3704). Plant height showed highly positive correlation with biological yield/plant (0.3708). Number of siliquae/ plant showed highly positive correlation with siliquae length test weight (0.4939). Siliqua length showed highly positive correlation with test weight (0.5004). Number of seeds/siliquae showed positive correlation with days to maturity (0.4315). Days to maturity showed positive correlation with harvest index (0.3838). Harvest index showed highly positive correlation with test weight (0.0632) at both phenotypic and genotypic levels respectively. Thus, these above said attributes can serve as marker characters for seed yield improvement in mustard. Similar findings were also reported by Shweta et al. (2014); Lodhi et al. (2014); Singh et al. (2014); Sirohi et al. (2015); Kumar et al. (2016); Kumar et al. (2017); Rout et al. (2019) & Singh et al. (2022).

Path coefficient (direct and indirect effects)

The Path coefficient analysis measures the direct influence of one variable upon the other and permits separation of partitioning of total correlation into direct and indirect effect provide actual information on contribution of characters and thus from the basis for selection to improve the yield. In the present experiment, highest positive direct effect on seed yield per plant at phenotypic level. The path coefficients analysis was carried out according to the method proposed by Dewey and Lu (1959). In the present (Table 5 & 6) experiment, highest positive direct effect on seed yield per plant at phenotypic level was exerted by days to 50% flowering (0.0154) followed by test weight (0.0053), days to maturity (0.0040), harvest index (0.0028), number of primary branches (0.0022), number of seeds per siliqua (0.0019), biological yield (-0.0021), siliqua length (0.0012) and while, negative indirect effects through biological yield (-0.0021), plant height (-0.0020), number of siliqua per plant (-0.0018). However, the highest positive direct effect on seed yield per plant at genotypic level was exhibited by plant height had positive indirect contribution through biological yield (0.0121), number of secondary branches (0.0082), number of seeds /siliqua (0.0076), number of primary branches (0.0031), number of siliqua per plant (0.0018), siliquae length (0.0017), days to 50% flowering (0.0010), but it had negative effects via harvest index (-0.0095), days to maturity (-0.0073), days to first flowering (-0.0042), test weight (-0.0018). Number of siliqua per plant had positive indirect effects via biological yield/plant (0.456), harvest index (0.0186), number of primary branches (0.0168), days to 50% flowering (0.0106), days to first flowering (0.0104), siliqua length (0.0044) while, negative indirect effects recorded through test weight (-0.0394), number of secondary branches (-0.0267), days to maturity (-0.0079) and plant height (-0.0050) and number of seeds per siliqua (-0.0048). However, the highest positive direct effect on Biological yield (g) exhibited positive indirect effects through number of secondary branches/plant (0.2512) followed by plant height (0.2338), number of primary branches (0.1136), siliqua length (0.0675), while, negative indirect effects recorded through harvest index (-0.5934), number of siliqua per plant (-0.3170), days to maturity (-0.01397), test weight (-0.1325) and days to first flowering (-0.0840), days to 50% flowering (-0.0509), number of seeds per siliqua (-0.0053). Direct and indirect effects of thirteen characters on seed yield at phenotypic

Table 4: Estimates of phenotypic correlation coefficients between different characters in Indian mustard

Character	Days to first flowering	Days to 50% flowering	No. of primary branches	No. of secondary branches	Plant height (cm)	No. of silique per plant	Siliqua length (cm)	No. of seeds per silique	Days to maturity	Biological yield per plant (g)	Harvest index (%)	Test weight (g)	Seed yield (g)
Days to first flowering	**1.0000**	0.7005**	-0.1014	0.0004	-0.0908	-0.0800	0.0563	0.0870	0.1843*	-0.0934	0.1253	0.2426**	0.0662
Days to 50% flowering		**1.0000**	0.0219	0.0419	0.0204	-0.0821	-0.0371	0.0488	0.1615	-0.0566	0.0851	0.2006*	0.0603
No. of primary branches			**1.0000**	0.3710**	0.0663	-0.1299	-0.0709	0.3183**	0.0381	0.1263	0.1530	-0.2085*	0.4018
No. of secondary branches				**1.0000**	0.1763	0.2064*	-0.0335	0.3086**	0.0723	0.2792**	-0.1944*	-0.1177	0.2238
Plant height (cm)					**1.0000**	0.0390	0.0368	0.1633	-0.1564	0.2599**	-0.2034*	-0.0394	0.1277
No. of silique per plant						**1.0000**	-0.0338	0.0373	0.0607	-0.3523**	-0.1437	0.3041**	-0.5726
Silique length (cm)							**1.0000**	-0.0940	-0.1051	0.0750	-0.1828	0.2504**	-0.0693
No. of seeds per siliqua								**1.0000**	0.2131*	-0.0059	0.0615	-0.2260*	0.1833
Days to maturity									**1.0000**	-0.1552	0.2393*	-0.0040	0.1184
Biological yield / plant (g)										**1.0000**	-0.6595**	-0.1472	0.4273
Harvest index (%)											**1.0000**	-0.0926	0.2851
Test weight (g)												**1.0000**	**-0.3348**

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

Table 5: Path coefficient analysis showing direct and indirect effect of thirteen characters on seed yield at genotypic level

Character	Days to first flowering	Days to 50% flowering	No. of primary branches	No. of secondary branches	Plant height (cm)	No. of silique per plant	Siliqua length (cm)	No. of seeds per silique	Days to maturity	Biological yield per plant (g)	Harvest index (%)	Test weight (g)
Days to first flowering	0.0310	0.0199	0.0062	-0.0001	-0.0070	-0.0025	0.0000	0.0088	0.0077	-0.0034	0.0049	0.0103
Days to 50% flowering	-0.1669	-0.2599	-0.0356	-0.0105	-0.0084	0.0228	0.0252	-0.0695	-0.0480	0.0220	-0.0362	-0.0698
No. of primary branches	0.1166	0.0802	0.5866	0.2991	0.0557	-0.2019	-0.2366	0.1979	0.1049	0.1035	0.1853	-0.2882
No. of secondary branches	0.0001	-0.0008	-0.0101	-0.0197	-0.0071	-0.0011	0.0042	-0.0073	-0.0015	-0.0068	0.0049	0.0070
Plant height (cm)	-0.0915	0.0131	0.0384	0.1461	0.4041	0.0294	0.0723	0.0734	-0.1046	0.1499	-0.1311	-0.0564
No. of siliquae per plant	0.0872	0.0937	0.3671	-0.0576	-0.0775	-1.0668	0.0989	0.1089	-0.0432	0.4312	0.2439	-0.5268
Siliqua length (cm)	0.0001	0.0426	0.1773	0.0932	-0.0787	0.0408	-0.4396	0.1807	0.1078	-0.0526	0.1394	-0.2200
No. of seeds per siliquae	-0.0255	-0.0240	-0.0302	-0.0332	-0.0163	0.0092	0.0369	-0.0897	-0.0387	0.0039	-0.0089	0.0365
Days to maturity	0.0395	0.0295	0.0286	0.0125	-0.0414	0.0065	-0.0392	0.0690	0.1600	-0.0480	0.0614	-0.0111
Biological yield / plant (g)	0.0237	0.0185	-0.0385	-0.0748	-0.0809	0.0882	-0.0261	0.0096	0.0655	-0.2183	0.1467	0.0898
Harvest index (%)	-0.0544	-0.0476	-0.1079	0.0843	0.1108	0.0781	0.1083	-0.0341	-0.1311	0.2296	-0.3415	-0.0216
Test weight (g)	0.1580	0.1278	-0.2338	-0.1676	-0.0665	0.2350	0.2381	-0.1936	-0.0330	-0.1958	0.0301	0.4759
Seed yield per plant (g)	0.1179	0.0930	0.7481	0.2716	0.1868	-0.7623	-0.1575	0.2542	0.0458	0.4153	0.2989	-0.5745

Table 6: Path coefficient analysis showing direct and indirect effect of thirteen characters on seed yield at phenotypic level

Character	Days to first flowering	Days to 50% flowering	No. of primary branches	No. of secondary branches	Plant height (cm)	No. of silique per plant	Siliqua length (cm)	No. of seeds per silique	Days to maturity	Biological yield per plant (g)	Harvest index (%)	Test weight (g)
Days to first flowering	**0.0220**	0.0154	0.0022	0.0000	-0.0020	-0.0018	0.0012	0.0019	0.0040	-0.0021	0.0028	0.0053
Days to 50% flowering	0.0061	**0.0088**	0.0002	0.0004	0.0002	-0.0007	-0.0003	0.0004	0.0014	-0.0005	0.0007	0.0018
No. of primary branches	0.0064	0.0014	**0.0633**	0.0234	0.0042	-0.0082	-0.0045	0.0202	0.0024	0.0080	0.0097	-0.0132
No. of secondary branches	0.0000	0.0046	0.0405	**0.1093**	0.0193	0.0226	-0.0037	0.0337	0.0079	0.0305	-0.0212	-0.0129
Plant height (cm)	-0.0042	0.0010	0.0031	0.0082	**0.0467**	0.0018	0.0017	0.0076	-0.0073	0.0121	-0.0095	-0.0018
No. of silique per plant	0.0104	0.0106	0.0168	-0.0267	-0.0050	**-0.1294**	0.0044	-0.0048	-0.0079	0.0456	0.0186	-0.0394
Silique length (cm)	0.0027	-0.0018	-0.0034	-0.0016	0.0018	-0.0016	**0.0479**	-0.0045	-0.0050	0.0036	-0.0087	0.0120
No. of seeds per siliquae	0.0051	0.0028	0.0185	0.0179	0.0095	0.0022	-0.0055	**0.0581**	0.0124	-0.0003	0.0036	-0.0131
Days to maturity	0.0078	0.0069	0.0016	0.0031	-0.0066	0.0026	-0.0045	0.0090	**0.0424**	-0.0066	0.0102	-0.0002
Biological yield / plant (g)	-0.0840	-0.0509	0.1136	0.2512	0.2338	-0.3170	0.0675	-0.0053	-0.1397	**0.8997**	-0.5934	-0.1325
Harvest index	0.1086	0.0738	0.1326	-0.1686	-0.1763	-0.1246	-0.1584	0.0533	0.2074	-0.5717	**0.8669**	-0.0803
Test weight (g)	-0.0147	-0.0122	0.0126	0.0071	0.0024	-0.0184	-0.0152	0.0137	0.0002	0.0089	0.0056	**-0.0606**
Seed yield/plant	0.0662	0.0603	0.4018	0.2238	0.1277	-0.5726	-0.0693	0.1833	0.1184	0.4273	0.2851	-0.3348

level using path coefficient analysis are presented in Table 3. The data revealed that number of primary branches (0.5866) had the highest positive direct effect on seed yield per plant followed by test weight (0.4759), plant height (0.4041), days to maturity (0.1600) and days to first flowering (0.0310) at phenotypic effects, whereas number of siliquae per plant (-1.0668), siliqua length (-0.3415), harvest index (-0.3415), days to 50% flowering (-0.2599), biological yield (-0.2183), number of seeds/ siliquae (-0.0897) and number of secondary branches (-0.0197) had a genotypic negative direct effect on yield per plant. At phenotypic level harvest index displayed maximum order of direct positive effect on seed yield/ plant followed by biological yield/ plant, number of siliquae/ plant and number of primary branches/ plant. Similar results were observed by Verma et al. (2008); Maurya et al. (2013); Ikbal et al. (2014); Kumar et al. (2017); Kumar et al. (2018) & Singh et al. (2022)

CONCLUSION

From the present investigation, it concludes that the seed yield was found significant to the genotypic coefficient of variation, there was a significant positive correlation with 1000 seeds of seeds/ plant. coefficient analysis of different characters contributing towards seed yield/ plant revealed that biological yield/ plant had the highest positive direct effect followed by days to 50% flowering, number of primary branches/ plant and harvest index. Thus, these above said attributes can serve as marker characters for seed yield improvement in mustard. However, a study of correlation alone is not enough to provide an exact picture of the relative importance of direct and indirect influences of each of the component traits on seed yield.

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