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Genetic variability, interrelation and path analysis for yield & yield characters in Indian mustard (*Brassica juncea* L.)

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Abstract

An investigation was undertaken to study the genetic variability, heritability, genetic advance and association of 13 characters Indian mustard (*Brassica juncea* L.) including number of biological yields, number of siliquae/plants, days to first flowering and days to 50% flowering. Analysis of variance estimates of all the characters were found highly significant. Coefficient of variation for genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were found high for the following traits *i.e.,* primary branches per plant, 1000- seed weight, no. of seeds per siliqua and seed yield per plant. All the characters showing higher heritability except biological yield per plant, no. of siliquae/ plant show higher genetic advance. Highest value of GCV and PCV were recorded for 1000 seed weight (35.32 and 35.48) followed by biological yield (30.71 and 30.93), seed yield/plant (30.05 and 30.32), harvest index % (28.70 and 29.38). Correlation study revealed that that seed yield had significant and positive correlation with 1000 seed weight (0.71 G & 0.70 P), harvest index (0.48 G & 0.49 P), biological yield (0.53 G & 0.52 P), no. of siliquae per plant (0.46 G & 0.45 P) and number of primary branches (0.21G & 0.21P) at genotypic and phenotypic levels. These components play an important role in a crop for best selecting of genotypes for making rapid improvement in yield and other desirable characters as well as to select the potential parent for hybridization programmes.

Keywords: *Correlation, heritability, Indian mustard, path analysis, seed yield, variability*

Introduction

Indian mustard [*Brassica juncea* (L) Czern & Coss.] is an amphidiploids species that originated through the interspecific hybridization of B. *rapa* and B. *nigra* (UN, 1935). 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). Mustard seed contains about 38 to 43 % oil which is yellow fragrant and is considered to be the healthiest and nutritious cooking medium (Patel *et al.,* 2012; Kumar *et al.,* 2017). It includes of some carefully vital species which yield edible roots, stems, leaves, buds, flowers and seed as condiment. Therefore, it is necessary to know the various components of the yield and its mutual correlation with other independent traits. In order to incorporate desirable characters to maximize economic yields, the information nature and extent of genetic variability present in a population for desirable characters, their association and relative contribution to yield constitutes the basic requirement. The election would be more efficient if based on some components which are less sensitive to environment. 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 work was conducted at Research Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, during winter 2020-21 using Randomized Block Design (RBD) with three replications with 40 genotypes and the genotypes were replicated thrice. The forty genotypes were IC589686, IC405235, IC589690, IC447111, IC571630, IC355856, IC571627, IC571661, IC571630, IC589686, IC571662, IC311734, IC571697, IC589680, IC589670, IC597919, IC335858, IC538719, IC571678, IC571648, IC317528, IC401516, IC311734, IC393232, IC597879, IC589690, IC424414, IC1976789, IC335852, IC571655, IC589681, IC571649, IC339953, IC571668, IC589662, IC589669, IC598692, IC599679, IC342777, and IC335856 of the experiment. Crop was grown in single row of 3 meter spaced at 30 cm apart. The distance between plant to plant 15 cm was maintained by thinning. All the recommended cultural practices were adopted and the observations were recorded on five competitive plants from each replication viz., days to first flowering, days to 50% flowering, number of primary branches/plants, number of secondary branches/plants, plant height (cm), number of siliquae/plants, siliqua length (cm), days to maturity, number of seeds/siliquae, 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. The data collected for all quantitative characters were subjected to analysis of variance according to the method recommended by Panse and Sukhatme (1967), coefficient of variation by Burton and 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 Deway and 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).

Heritability and genetic advance

Among the yield attributes maximum PCV and GCV was depicted by 1000 seed weight followed by biological yield and seed yield/plant while minimum by days to maturity (Table 2). The high values of PCV and GCV indicating that selection may be effective on these traits. The maximum PCV and GCV recorded for test weight (35.5 and 35.3). A close correspondence between the phenotypic and genotypic variance for all the characters indicating stable expression of attributes and absence of high environmental influence. Corroborative results also were reported by Kumar *et al.* (2017) and Raliya *et al.* (2018). The highest heritability (%) was recorded for 1000 seed weight (99.1) followed by biological yield (98.6), seed yield (98.2), number of siliquae/plant (96.0) and no. of secondary branches (95.5). Similar findings were reported by Yadava *et al.* (2011). The higher genetic advance as percentage of mean observed for the 1000-seed weight (72.4) followed biological yield, seed yield, harvest index

Table 1: Analysis of variance for 13 characters for yield and yield traits in 40 genotypes of Indian mustard

Source of variation	DF	Days to First flowering	Days to 50% flowering	Days to maturity	No. of primary branches	No. of secondary branches	Plant height (cm)	No. of siliquae per plant
Replication	2	9.05	22.64	8.33	0.19	2.12	0.34	544.00
Treatment	39	299.44**	321.57**	271.55**	1.56**	55.88**	580.25**	9679.35**
Error	78	7.49	9.74	7.57	0.05	0.86	46.00	131.48

Source of variation	DF	Siliquae length (cm)	No. of seed/ siliquae	Biological yield (g)	1000 seed weight (g)	Harvest index (%)	Seed yield (g)
Replication	2	0.003	0.23	2.75	0.02	0.21	0.60
Treatment	39	0.424**	11.96**	6122.86**	8.28**	141.79**	306.19**
Error	78	0.025	0.31	29.16	0.03	2.23	1.86

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

and number of siliquae/plants. Similar findings were reported by Singh *et al.* (2011).

Correlation and path 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. Days to first flowering showed highly Significant positive phenotypic correlation coefficient with no. of primary branches (0.595) followed by days to 50% flowering (0.589), no. of secondary branches (0.414) and plant height (0.290). Days to 50% flowering showed highly significant positive correlation with days to first flowering (0.589) are followed by no. of primary branches (0.418), no. of secondary branches (0.272) and plant height (0.235). Number of primary branches showed highly significant correlation with no. of secondary branches (0.659) is followed by days to first flowering (0.595), biological yield (0.494), days to 50% flowering (0.418), no. of siliquae/plant (0.271), plant height (0.235) and seed yield (0.211).Plant height showed highly positive correlation with days to first flowering (0.290) are followed by no. of seed/siliquae (0.244), days to maturity (0.241), days to 50% flowering (0.235) and no. of primary branches (0.235) at phenotypic level. Number of siliqua/plants showed highly significant correlation with biological yield (0.567) is followed by seed yield (0.458), no. of secondary branches (0.338), no. of primary branches (0.271) and seed weight (0.219) at phenotypic level. Siliqua length showed highly significant correlation with no. of seed/siliquae (0.581) while negative correlation with no. of primary branches (-0.384), no of secondary branches (-0.384), days to first flowering (-0.373) and days to 50% flowering (-0.257) at phenotypic level. Biological yield/plant showed highly significant correlation with no. of siliquae/plant (0.567) is followed by seed yield (0.522.), no. of primary branches (0.494), no. of secondary branches (0.397), seed weight (0.292) and no. of siliquae/plant (0.219)). Index showed highly positive significant correlation with seed yield (0.493) is followed by seed weight (0.455). Seed yield/plant showed highly positive significant correlation with seed weight (0.703) are followed by biological yield (0.522), harvest index (0.493), no. of siliquae/plant (0.458) and no. of primary branches (0.211). 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) and Rout *et al*. (2019) in which HI shows highly significant and positive correlation with seed yield/ plant and siliquae/ plant. The grain yield, in most of the crops, is referred to as super character which results from multiplicative interaction of several other characters that are termed as yield components.

Table 2: Estimates of range, grand mean, genotypic and phenotypic coefficient of variation, heritability and genetic advance for 13 characters in Indian mustard

Genotypes	Mean	Min	Max	Heritability (%)	GA	GA% mean	GCV (%)	PCV (%)	% Cont
Days to First flowering	50.21	36.70	69.07	92.85	19.58	39.00	19.65	20.39	9.63
Days to 50% flowering	65.21	49.17	85.53	91.43	20.08	30.79	15.63	16.35	10.50
Days to maturity	138.05	117.73	160.83	92.08	18.54	13.43	6.79	7.08	9.74
No. of primary branches / plant	5.47	3.90	7.30	90.85	1.39	25.48	12.97	13.61	10.79
No. of secondary branches / plant	23.41	14.60	31.83	95.51	8.62	36.83	18.29	18.72	5.85
Plant height (cm)	186.79	157.53	220.15	79.47	24.51	13.12	7.14	8.01	9.05
No. of siliquae per plant	278.92	172.20	436.77	96.03	113.89	40.83	20.23	20.64	6.49
Siliquae length (cm)	3.94	3.30	5.67	84.44	0.69	17.55	9.27	10.09	9.91
No. of seed/siliquae	13.95	11.50	23.80	92.62	3.91	28.01	14.13	14.68	8.78
Biological yield (g)	146.76	68.00	317.30	98.58	92.18	62.81	30.71	30.93	5.33
1000 seed weight (g)	4.70	2.06	8.14	99.10	3.40	72.44	35.32	35.48	4.52
Harvest index (%)	23.77	11.88	43.75	95.42	13.72	57.75	28.70	29.38	3.77
Seed yield / plant (g)	33.52	15.15	54.70	98.20	20.56	61.34	30.05	30.32	5.66

Path analysis

Path analysis allows researchers to study direct and indirect effects simultaneously with multiple independent and dependent variables (Valenzuela and Bachmann, 2017). When an independent variable has a direct effect on a dependent variable, it is called a direct effect.

When an independent variable influences a dependent variable through a mediating variable, it is called an indirect effect (Baron and Kenny, 1986). Direct and indirect effects of 13 traits on seed yield/plant at phenotypic level using path coefficient analysis presented in Table 5 and Table 6.The direct effects data showed that harvest index (0.87) had the highest positive direct effect on seed yield per plant followed by number of biological yield (0.87), plant height (0.11), seed weight (0.08), no. of secondary branches (0.05), number of primary branches (0.01), siliqua length (-0.01), days to 50% flowering (0.002) at phenotypic effects, whereas number of siliqua/plant (-0.03), days to first flowering(-0.03), days to maturity (-0.0034), number of seeds/siliquae (-0.002) had a phenotypic negative direct effect on yield per plant. The indirect effects of days to first flowering had very low negative indirect effects via harvest index (-0.07), seed weight (-0.003), no. of siliquae/plant (-0.003), days to maturity (-0.001) and while, positive indirect effects through biological yield (0.09), plant height (0.03), no. of secondary branches (0.02), seed yield (0.05), no. of primary branches (0.004), siliqua length (0.002), days to 50% flowering (0.001), no. of seeds/siliqua (0.0001).Days to 50% flowering had very low negative indirect effects via harvest index (-0.15), days to first flowering (-0.014), seed weight (-0.013), seed yield (-0.10) while, positive indirect effects through biological yield (0.03), plant height (0.03), no. of secondary branches (0.01), no. of primary branches (0.003), siliqua length (0.001), no. of siliqua/plant (0.001), days to maturity (0.0006).No. of secondary branches had very low positive indirect effects via biological yield (0.3444), plant height (0.0128), seed yield (0.125), no. of primary branches (0.0047), siliquae length (0.0018), days to 50% flowering (0.0005), no. of seeds/siliqua (0.0003), while, negative indirect effects through harvest index (-0.2578), seed weight (-0.0137), days to first flowering (-0.0101), no. of siliqua/plant (-0.0089), days to maturity (-0.0007).Days to maturity had very low negative indirect effects via harvest index (-0.1202), days to first flowering (-0.0020), no. of siliqua/plant (-0.0015), no. of seeds/siliqua (-0.0004), seed weight (-0.0003), siliqua length (-0.0003), days to 50% flowering (-0.0003), while, positive indirect effects through biological yield (0.0971), plant height (0.0271), no. of secondary branches (0.0102), no. of primary branches (0.0011), seed

Table 3: Estimates of Genotypic correlation coefficients thirteen different characters in Indian mustard.

Characters	Days to First flowering	Days to 50% flowering	Days to maturity	Primary branches	Secondary branches	Plant height (cm)	No. of siliquae per plant	Siliquae length (cm)	No. of seed/ siliquae	Biological yield (g)	1000 seed weight (g)	Harvest index (%)	Seed yield/ plant (g)
Days to First flowering	1.00	0.60*	0.08	0.64**	0.44**	0.33**	0.13	-0.43**	-0.07	0.10	-0.04	-0.07	0.06
Days to 50% flowering		1.00	-0.16	0.45**	0.29**	0.26**	-0.04	-0.28**	-0.007	0.04	-0.17	-0.18*	-0.10
Days to maturity			1.00	0.17	0.20*	0.28**	0.06	0.05	0.22*	0.11	-0.006	-0.14	0.01
Primary branches/plant				1.00	0.76**	0.24**	0.31**	-0.46**	-0.30**	0.53**	-0.05	-0.35**	0.21*
Secondary branches/plant					1.00	0.18*	0.34**	-0.41**	-0.18*	0.41**	-0.18	-0.29**	0.14
Plant height (cm)						1.00	0.13	-0.02	0.31**	0.06	-0.10	-0.15	0.04
No. of siliquae per plant							1.00	-0.08	-0.17	0.58**	0.23*	-0.07	0.46**
Siliquae length (cm)								1.00	0.72**	-0.05	0.12	0.08	0.03
No. of seed/siliquae									1.00	-0.11	-0.10	-0.16	-0.22*
Biological yield (g)										1.00	0.29*	-0.43**	0.54**
1000 seed weight (g)											1.00	0.47**	0.72**
Harvest index (%)												1.00	0.48**
Seed yield (g)													1.00

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

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

Characters	Days to First flowering	Days to 50% flowering	Days to maturity	Primary branches	Secondary branches	Plant height (cm)	No. of siliquae per plant	Siliquae length (cm)	No. of seed/ siliquae	Biological yield (g)	1000 seed weight (g)	Harvest index (%)	Seed yield/ plant (g)
Days to First flowering	1.00	0.58**	0.08	0.59**	0.41**	0.29**	0.11	-0.37**	-0.07	0.10	-0.04	-0.07	0.05
Days to 50% flowering		1.00	-0.16	0.42**	0.27**	0.23**	-0.04	-0.26**	-0.001	0.04	-0.16	-0.17	-0.09
Days to maturity			1.00	0.15	0.19*	0.24**	0.06	0.06	0.19*	0.11	-0.004	-0.14	0.007
Primary branches/plant				1.00	0.66**	0.23**	0.27**	-0.38**	-0.27**	0.49**	-0.06	-0.30**	0.21*
Secondary branches/plant					1.00	0.11	0.34**	-0.38**	-0.16	0.39**	-0.17	-0.29**	0.12
Plant height (cm)						1.00	0.07	0.03	0.24**	0.07	-0.09	-0.15	0.03
No. of siliquae per plant							1.00	-0.11	-0.15	0.56**	0.22*	-0.06	0.46**
Siliquae length (cm)								1.00	0.58**	-0.04	0.12	0.07	0.02
No. of seed/siliquae									1.00	-0.11	-0.10	-0.13	-0.20*
Biological yield (g)										1.00	0.29**	-0.44**	0.52**
1000 seed weight (g)											1.00	0.45**	0.70**
Harvest index (%)												1.00	0.493**
Seed yield (g)													1.00

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

Table 5: Direct and indirect effect of different characters on seed yield per plant at genotypic level in Indian mustard

Characters	Days to First flowering	Days to 50% flowering	Days to maturity	Primary branches	Secondary branches	Plant height (cm)	No. of siliquae per plant	Siliquae length (cm)	No. of seed/ siliquae	Biological yield (g)	1000 seed weight (g)	Harvest index (%)	R with Seed yield/ plant (g)
Days to First flowering	**-0.02**	-0.01	0.00	0.02	0.02	0.05	-0.01	-0.02	0.00	0.09	0.00	-0.06	0.06
Days to 50% flowering	-0.01	**-0.01**	0.00	0.01	0.01	0.04	0.00	-0.02	0.00	0.03	-0.01	-0.16	-0.1
Days to maturity	0.00	0.00	**-0.01**	0.00	0.01	0.04	0.00	0.00	-0.01	0.10	0.00	-0.12	0.01
Primary branches/plant	-0.01	0.00	0.00	**0.03**	0.03	0.04	-0.02	-0.02	0.02	0.46	0.00	-0.30	0.21*
Secondary branches/plant	-0.01	0.00	0.00	0.02	**0.04**	0.03	-0.02	-0.02	0.01	0.36	-0.01	-0.25	0.14
Plant height (cm)	-0.01	0.00	0.00	0.01	0.01	**0.15**	-0.01	0.00	-0.02	0.06	-0.01	-0.13	0.04
No. of siliquae per plant	0.00	0.00	0.00	0.01	0.01	0.02	**-0.06**	0.00	0.01	0.51	0.02	-0.06	0.46**
Siliquae length (cm)	0.01	0.00	0.00	-0.01	-0.02	0.00	0.00	**0.05**	-0.04	-0.04	0.01	0.07	0.03
No. of seed/siliquae	0.00	0.00	0.00	-0.01	-0.01	0.05	0.01	0.04	**-0.06**	-0.10	-0.01	-0.13	-0.22*
Biological yield (g)	0.00	0.00	0.00	0.01	0.02	0.01	-0.03	0.00	0.01	**0.87**	0.02	-0.37	0.54**
1000 seed weight (g)	0.00	0.00	0.00	0.00	-0.01	-0.02	-0.01	0.01	0.01	0.26	**0.08**	0.40	0.72**
Harvest index (%)	0.00	0.00	0.00	-0.01	-0.01	-0.02	0.00	0.00	0.01	-0.38	0.04	**0.85**	0.48**

Bold figure shows direct effect and normal value shows indirect effect; *, ** significant at 5 % and 1 % level, respectively; Residual effect = 0.0544

Table 6: Direct and indirect effect of different characters on seed yield per plant at phenotypic level in Indian mustard

Characters	Days to First flowering	Days to 50% flowering	Days to maturity	Primary branches	Secondary branches	Plant height (cm)	No. of siliquae per plant	Siliquae length (cm)	No. of seed/ siliquae	Biological yield (g)	1000 seed weight (g)	Harvest index (%)	R with Seed yield/ plant (g)
Days to First flowering	**-0.024**	0.001	-0.0003	0.004	0.022	0.032	-0.003	0.002	0.0001	0.089	-0.003	-0.066	0.05
Days to 50% flowering	-0.014	**0.002**	0.0006	0.003	0.014	0.026	0.001	0.001	0.000	0.032	-0.013	-0.146	-0.09
Days to maturity	-0.002	-0.0003	**-0.004**	0.001	0.010	0.027	-0.002	-0.0003	-0.0004	0.097	-0.0003	-0.120	0.007
Primary branches/plant	-0.014	0.0008	-0.0005	**0.007**	0.034	0.026	-0.007	0.002	0.0005	0.428	-0.004	-0.262	0.21*
Secondary branches/plant	-0.010	0.0005	-0.0007	0.005	**0.052**	0.013	-0.009	0.002	0.0003	0.344	-0.014	-0.257	0.13
Plant height (cm)	-0.007	0.0004	-0.0009	0.002	0.006	**0.113**	-0.002	-0.0002	-0.0005	0.059	-0.007	-0.127	0.03
No. of siliquae per plant	-0.003	-0.0001	-0.0002	0.002	0.017	0.007	**-0.026**	0.0005	0.0003	0.492	0.017	-0.050	0.46**
Siliquae length (cm)	0.009	-0.0005	-0.0002	-0.003	-0.020	0.004	0.003	**-0.005**	-0.001	-0.032	0.009	0.060	0.03
No. of seed/siliquae	0.002	0.000	-0.0007	-0.002	-0.008	0.027	0.004	-0.003	**-0.002**	-0.102	-0.008	-0.112	-0.20*
Biological yield (g)	-0.003	0.0001	-0.0004	0.003	0.021	0.008	-0.015	0.0002	0.0002	**0.867**	0.024	-0.383	0.52**
1000 seed weight (g)	0.001	-0.0003	0.000	-0.0004	-0.009	-0.011	-0.006	-0.0006	0.0002	0.253	**0.080**	0.395	0.70**
Harvest index (%)	0.002	-0.0003	0.0005	-0.002	-0.015	-0.016	0.002	-0.0003	0.0003	-0.382	0.036	**0.869**	0.49**

Bold figure shows direct effect and normal value shows indirect effect; *, ** significant at 5 % and 1 % level, respectively; Residual effect = 0.0642

yield (0.007). At phenotypic level, harvest index had 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 also reported by Tahira *et al.* (2011), Bind *et al*. (2014) and Devi, 2018. Direct effect of any character on seed yield gives an idea about effective selection of trait that can be made to bring improvement in breeding programme. The indirect effect indicates the inter relationship of component characters towards contributes to yield.

Conclusion

From the present investigation, it can be concluded seed yield had significant was observation recorded for genotypic coefficient of variation exhibited that, the seed yield/ plant had a significant positive correlation with 1000 seed weight. Correlation study revealed that that seed yield had significant and positive correlation with 1000 seed weight (0.71G & 0.70P), harvest index (0.48G & 0.49P), biological yield (0.53G & 0.52P), no. of siliquae per plant (0.46G & 0.45P) and number of primary branches (0.21G & 0.21P) at genotypic and phenotypic levels. For highest value of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were recorded for 1000 seed weight (g) (35.3 and 35.5) followed by biological yield (30.71 and 30.9), seed yield/plant (30.05 and 30.3), harvest index % (28.7 and 29.4). Thus, these above said attributes can serve as marker characters for seed yield improvement in mustard. Therefore, more emphasis should be given to these components while making the selection for higher seed yield 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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