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Research Article

ASSESSMENT OF GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS FOR YIELD TRAITS IN F_1 HYBRIDS OF INDIAN MUSTARD [*BRASSICA JUNCEA* (L.) CZERN & COSS.]

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Abstract Results of phenotypic correlation coefficient revealed that the seed yield/plant (g) had significant positive correlation with biological yield/plant (g) followed by traits number of primary branches/plant, plant height (cm), number of secondary branches/plant, siliqua length and number of siliquae/plant. Path coefficient analysis of different characters contributing towards seed yield/plant revealed that biological yield/plant (g) had the highest positive direct effect relationship with seed yield/plant followed by harvest index (%), siliqua length (cm), number of primary branches/plant, days to maturity, plant height (cm), number of secondary branches/plant and days to first flowering.

Key words: correlation, characters, yield, phenotype, siliqua

Introduction

Brassica juncea L. commonly known as Indian mustard is globally used as vegetable, oilseed and condiments (Saleem *et al.*, 2017). Mustard belongs to family Brassicaceae and with Brassica genus. Indian mustard is a natural amphidiploids (2n=36) of *B. rapa* (2n=20) and *B. nigra* (2n=16) (Kaur *et al.*, 2019). Mustard is the premier oilseed Brassica which covers about 85 to 90% of the total area under cultivation of all oilseed crops (Rao *et al.*, 2017). It is second most important edible oilseed crop of the India after groundnut. Mustard seed contains about 38 to 43 percent oil which is yellow fragrant and is considered to be the healthiest and nutritious cooking medium (Patel *et at.*, 2012). It is cultivated in winter season mainly in Northwest India and contributes nearly 27 per cent to edible oil pool of the country (Singh *et al.*, 2010). Inclusion of more diverse parents in hybridization programme increases the chances of obtaining maximum heterosis and gives a broad spectrum of variability in segregating generations (Kumar *et al*. 2017).

Coefficient of variation is helpful in exposing and understanding the clear picture of existing variability within the population. Heritability coupled with genetic advance would be more useful tool in predicting the resultant effect in selection of the best genotypes for seed yield and its attributing traits (Synrem *et al.*, 2014, Kumar *et al*., 2018b). Genetic diversity plays an important role in crop improvement because hybrid between lines of diverse origin generally display a great hybrid vigor than those between closely related genotypes which permits to select the genetically divergent plants to obtain the desirable recombination of the segregating generation. The assessment of parameters including phenotypic and genotypic coefficients of variation, heritability in broad sense, and genetic advance as % of mean is a pre-requisite for making effective selection (Manjunath *et al.*, 2017). An estimate of genetic advance along with heritability is helpful in assessing the reliability of character for selection (Meena *et al.*, 2017). The character showing high heritability along with low genetic advance can be improved by intermating superior genotypes of segregating population developed from combination breeding (Synrem *et al.*, 2014). The proper evaluation of important crop species helps in the identification and utilization of improved genotypes (Jan *et al.*, 2016). Identifying parental material with strong heterosis for yield and obtain genetic parameters are the important steps in the development of new cultivars. It is important to have information about the desirable parental combinations which can represent a high degree of heterotic response (Singh *et al.*, 2019). The present investigation was planned to access heritability, association between traits and defines suitable selection criteria for mustard yield improvement.

Methods and materials

The present investigation consisted eight Indigenous lines (IC-589669, IC-589670, IC-589680, IC-597879, IC-597919, IC-571648, IC-335852 and IC-338586) of Indian mustard which were provided by National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India. The experiments was conducted at Research Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, during Rabi seasons 2016-17 and 2017-18 using Randomized Block Design (RBD) with three replications. Row to plant spacing of 70×25 cm was maintained and proper plant population maintained by thinning. The recommended agricultural package of practices was followed. Observation was recorded for various yield traits on five randomly selected plants in every genotype from each replication. Line x Tester mating design using was proposed by Kempthorne (1957).

Result and Discussion

Correlation coefficient analysis

Correlation coefficient analysis is a statistical measurement, which is used to find out the degree and direction of relationship between two or more variables. Phenotypic correlation coefficients for all possible combination of characters are presented in Table 1.

Correlation coefficients showed highly significant positive correlation of seed yield with days to 50% flowering at phenotypic level. Thus, it can be inferred that by improving these traits through selection either alone or in combination, will result in improvement of yield in mustard.

Days to first flowering showed highly significant positive correlation with days to 50% flowering (0.7674). Number of primary branches showed highly significant positive correlation with number of secondary branches/plant (0.3380), plant height (0.4375), biological yield/plant (0.4037), seed yield/plant (0.5743) and test weight (0.2370). Number of secondary branches showed highly significant positive correlation with plant height (g) (0.3127), number of siliquae/plant (0.2737), biological yield/plant (0.2881), seed yield/plant (0.3823) and test weight (0.3026). Plant height estimated significant positive correlation with number of siliquae/plant (0.3489), siliqua length (0.2946), number of seeds/siliqua (0.3608), biological yield/plant (0.3870) and seed yield/plant (0.5034). Number of siliquae/plant estimated significant positive correlation with siliqua length (0.3313), number of seeds/siliqua (0.4746), seed yield/plant (0.2454) and test weight (0.2657). Siliqua length in showed significant positive correlation with number of seeds/siliqua (0.4548) and seed yield/plant (0.2584). Biological yield/plant showed highly significant positive correlation with seed yield/plant (0.6312). Seed yield/plant showed highly significant positive correlation with harvest index (0.2902) and test weight (0.3421).

Highly significant negative correlation for yield components was observed. The days to first flowering showed highly significantly negative correlation with number of seeds/siliqua (-0.2954). Days to 50% flowering showed significantly negative correlation with number of seeds/siliqua (-0.2638). Plant height estimated significantly negative correlation with days to maturity (-0.2883). Number of siliquae/plant showed significantly negative correlation with days to maturity (-0.2406). The siliqua length estimated significantly negative correlation with days to maturity (-0.3447). Biological yield/plant showed significantly negative correlation with harvest index (-0.4659).Our results agree with the previous correlation recorded by Gupta *et al*. (2018).

Path analysis

Path coefficient method given by Dewey and Lu (1959) has been used to estimate the magnitude and direction of direct and indirect effects of various yields and its contributing characters. Correlation coefficients along with path coefficients together provide more reliable information which can be effectively predicted in crop improvement programme. If the correlation between yield and a character is due to direct effect of a character, it reveals true relationship between them and direct selection for this trait will be rewarding for yield improvement. However, if the correlation coefficient is mainly due to indirect effects of the character through another component trait, indirect selection through such trait will be effective in yield improvement. The present results of phenotypic and genotypic path coefficient of yield and yield contributing characters discussed here under which were presented in Table 2.

Direct effect at phenotypic level

The data revealed that biological yield/plant (0.8451) had the highest positive direct effect on seed yield/plant followed by harvest index (0.6735), siliqua length (0.1309), number of primary branches/plant (0.1090), days to maturity (0.0988), plant height (0.0752), number of secondary branches/plant (0.0625), days to first flowering (0.0238), test weight (0.0046) at phenotypic level whereas, number of seeds/siliqua (-0.0914) followed by days to 50% flowering (-0.0201), number of siliquae/plant (-0.0141) had at phenotypic negative direct effect on yield/plant. Similar results have been found by Mekonnen *et al*. (2014) and Kumar *et al*. (2016).

Indirect effects at phenotypic level

Days to first flowering had positive phenotypic indirect effects via days to 50% flowering (0.0183), days to maturity (0.0017), harvest index (0.0038) while negative indirect effect through number of primary branches/plant (-0.0040), number of secondary branches/plant (-0.0001), plant height (-0.0049), number of siliquae/plant (-0.0052),

Table 1. Phenotypic correlation analysis showing effects of thirteen characters on seed component in Indian mustard (*Brassica juncea* L.)

Characters	Days to 50% Flowering	Primary Branches/ Plant	Secondary Branches/ Plant	Plant Height (cm)	No. of Siliquae/ Plant	Siliqua Length (cm)	No. of Seeds/ Siliqua	Days to Maturity	Biological Yield/ Plant (g)	Seed Yield/ Plant (g)	Harvest Index (%)	Test Weight (g)
Days to First Flowering	0.7674**	-0.1661	-0.0043	-0.2045	-0.2197	-0.1510	-0.2954*	0.0718	-0.1986	-0.0675	0.1616	-0.1471
Days to 50% Flowering	1.0000	-0.1943	-0.0799	-0.1998	-0.1645	-0.0787	-0.2638*	0.1694	-0.1664	-0.0777	0.1098	-0.1865
Primary Branches/ Plant		1.0000	0.3380**	0.4365**	0.1810	0.0630	0.0992	-0.0697	0.4037**	0.5743**	0.1180	0.2370*
Secondary branches/plant			1.0000	0.3127**	0.2737*	0.1742	0.1630	-0.1342	0.2881*	0.3823**	0.0332	0.3026**
Plant Height (cm)				1.0000	0.3489**	0.2946*	0.3608**	-0.2883*	0.3870**	0.5034**	0.0916	0.2257
No. of Siliquae/Plant					1.0000	0.3313**	0.4746**	-0.2406*	0.1964	0.2454*	0.0817	0.2657*
Siliqua Length (cm)						1.0000	0.4548**	-0.3447**	0.1068	0.2584*	0.1185	-0.0413
No. of Seeds/ Siliqua							1.0000	-0.2095	0.0225	0.1582	0.2251	0.0912
Days to Maturity								1.0000	0.0027	-0.0140	-0.0788	-0.0175
Biological Yield/ Plant (g)									1.0000	0.6312**	-0.4659**	0.1766
Seed Yield/ Plant (g)										1.0000	0.2902*	0.3421**
Harvest Index (%)											1.0000	0.2160

Table 2. Path coefficient analysis showing the direct and indirect effect of twelve characters on seed yield at phenotypic level in Indian mustard (*Brassica juncea* L.

Character	Days to First Flowering	Days to 50% Flowering	Primary Branches/ Plant	Secondary Branches/ Plant	Plant Height (cm)	No. of Siliquae/ Plant	Siliqua Length (cm)	No. of Seeds/ Siliqua	Days to Maturity	Biological Yield/ Plant (g)	Harvest Index (%)
Days to First Flowering	0.0238	0.0183	-0.0040	-0.0001	-0.0049	-0.0052	-0.0036	-0.0070	0.0017	-0.0047	0.0038
Days to 50% Flowering	-0.0154	-0.0201	0.0039	0.0016	0.0040	0.0033	0.0016	0.0053	-0.0034	0.0033	-0.0022
Primary Branches/ Plant	-0.0181	-0.0212	0.1090	0.0368	0.0476	0.0197	0.0069	0.0108	-0.0076	0.0440	0.0129
Secondary Branches/ Plant	-0.0003	-0.0050	0.0211	0.0625	0.0195	0.0171	0.0109	0.0102	-0.0084	0.0180	0.0021
Plant Height (cm)	-0.0154	-0.0150	0.0328	0.0235	0.0752	0.0262	0.0221	0.0271	-0.0217	0.0291	0.0069
No. of Siliquae/Plant	0.0031	0.0023	-0.0026	-0.0039	-0.0049	-0.0141	-0.0047	-0.0067	0.0034	-0.0028	-0.0012
Siliqua Length (cm)	-0.0198	-0.0103	0.0082	0.0228	0.0386	0.0434	0.1309	0.0595	-0.0451	0.0140	0.0155
No. of Seeds/ Siliqua	0.0270	0.0241	-0.0091	-0.0149	-0.0330	-0.0434	-0.0416	-0.0914	0.0191	-0.0021	-0.0206
Days to Maturity	0.0071	0.0167	-0.0069	-0.0133	-0.0285	-0.0238	-0.0340	-0.0207	0.0988	0.0003	-0.0078
Biological Yield/ Plant (g)	-0.1678	-0.1406	0.3412	0.2435	0.3270	0.1660	0.0903	0.0190	0.0023	0.8451	-0.3938
Harvest index (%)	0.1089	0.0739	0.0795	0.0223	0.0617	0.0550	0.0798	0.1516	-0.0531	-0.3138	0.6735
Test weight (g)	-0.0007	-0.0009	0.0011	0.0014	0.0010	0.0012	-0.0002	0.0004	-0.0001	0.0008	0.0010
Seed Yield/ Plant (g)	-0.0675	-0.0777	0.5743	0.3823	0.5034	0.2454	0.2584	0.1582	-0.0140	0.6312	0.2902

Table 3. Estimates of different genetic parameters of variation for 13 traits among parents and crosses.

Characters	Mean	Coefficient of Variation %		h² (Broad Sense) (%)	Genetic Advancement 5%	Genetic Advancement 1%	Gen.Adv as % of Mean 5%	Gen.Adv as % of Mean 1%	Exp Mean next Generation
		Genotypic	Phenotypic						
Days to First Flowering	45.01	5.72	7.44	59	4.07	5.22	9.05	11.60	49.09
Days to 50% Flowering	56.64	3.61	5.56	42	2.73	3.50	4.82	6.18	59.37
Primary Branches/ Plant	6.09	15.55	22.08	50	1.37	1.76	22.55	28.91	7.46
Secondary Branches/ Plant	14.38	19.61	23.78	68	4.79	6.14	33.30	42.68	19.16
Plant Height (cm)	177.62	4.86	6.80	51	12.70	16.28	7.15	9.16	190.33
No. of Siliquae/Plant	398.21	25.49	27.36	87	194.74	249.57	48.90	62.67	592.95
Siliqua Length (cm)	4.18	5.09	8.42	37	0.26	0.34	6.34	8.13	4.44
No. of Seeds/ Siliqua	11.39	7.10	9.40	57	1.26	1.61	11.05	14.16	12.65
Days to Maturity	147.93	1.84	2.32	63	4.44	5.69	3.00	3.85	152.37
Biological Yield/ Plant (g)	132.76	22.29	30.98	52	43.86	56.21	33.04	42.34	176.63
Seed Yield/ Plant (g)	33.89	23.51	26.51	79	14.56	18.66	42.96	55.05	48.45
Harvest Index (%)	26.47	15.39	19.61	62	6.59	8.44	24.89	31.89	33.05
Test Weight (g)	3.35	11.75	19.45	36	0.49	0.63	14.62	18.73	3.84

siliqua length (-0.0036), number of seeds/siliqua (-0.0070), biological yield/plant (-0.0047), test weight (-0.0035).

Days to 50% flowering had positive indirect effects *via* number of primary branches/plant (0.0039), number of secondary branches/plant (0.0016), plant height (0.0040), number of siliquae/plant (0.0033), siliqua length (0.0016), number of seeds/siliqua (0.0053), biological yield/plant (0.0033) and test weight (0.0037) while negative indirect effect through days to first flowering (-0.0154), days to maturity (-0.0034) and harvest index (-0.0022).

Number of primary branches/plant had positive indirect effect via number of secondary branches/plant (0.0368), plant height (0.0476), number of siliquae/plant (0.0197), siliqua length (0.0069), number of seeds/siliqua (0.0108), biological yield/plant (0.0440), harvest index (0.0129) and test weight (0.0258) while negative indirect effect through days to first flowering (-0.0181), days to 50% flowering (-0.0212) and days to maturity (-0.0076).

Number of secondary branches/plant had positive indirect effect number of primary branches/plant (0.0211), plant height (0.0195), number of siliquae/plant (0.0171), siliqua length (0.0109), number of seeds/siliqua (0.0102) , biological yield/plant (0.0180), harvest index (0.0021) and test weight (0.0189) while negative indirect effect through days to first flowering (-0.0003), days to 50% flowering (-0.0050) and days to maturity (-0.0084).

Plant height had positive indirect effect via number of primary branches/plant (0.0328), number of secondary branches/plant (0.0235), number of siliquae/plant (0.0262), siliqua length (0.0221), number of seeds/siliqua (0.0271), biological yield/plant (0.0291), harvest index (0.0069), test weight (0.0170) while negative indirect through days to first flowering (-0.0154), days to 50% flowering (-0.0150) and days to maturity (-0.0217).

Number of siliqua/plant had positive correlation indirect effect via days to first flowering (0.0031), days to 50% flowering (0.0023) and days to maturity (0.0034), while negative indirect effect through number of primary branches/plant (-0.0026), number of secondary branches/plant (-0.0039), plant height (-0.0049), siliqua length (-0.0047), number of seeds/siliqua (-0.0067), biological yield/plant (-0.0028), harvest index (-0.0012) and test weight (-0.0038).

Siliqua length had positive indirect effect via number of primary branches/plant (0.0082), number of secondary branches/plant (0.0228), plant height (0.0386), number of siliquae/plant (0.0434), number of seeds/siliqua (0.0595), biological yield/plant (0.0140) and harvest index (0.0155) while negative indirect effect through days to first flowering (-0.0198), days to 50% flowering (-0.0103), days to maturity (-0.0451) and test weight (-0.0054).

Number of seeds/siliqua had positive correlation indirect effect via days to first flowering (0.0270), days to 50% flowering (0.0241) and days to maturity (0,0191) while negative indirect effect through number of primary branches/plant (-0.0091), number of secondary branches/plant (-0.0149), plant height (-0.0330), number of siliquae/plant (-0.0434), siliqua length (-0.0416), biological yield/plant (-0.0021), harvest index (-0.0206) and test weight (-0.0083).

Days to maturity had positive correlation indirect effect via days to first flowering (0.0071), days to 50% flowering (0.0167) and biological yield/plant (0.0003) while negative indirect effect through number of primary branches/plant (-0.0069), number of secondary branches/plant (-0.0133), plant height (-0.0285), number of siliquae/plant (-0.0238), siliqua length (-0.0340), number of seeds/siliqua (-0.0207), harvest index (-0.0078) and test weight (-0.0017).

Biological yield/plant had positive correlation indirect effect via number of primary branches/plant (0.3412), number of secondary branches/plant (0.2435), plant height (0.3270), number of siliquae/plant (0.1660), siliqua length (0.0903), number of seeds/siliqua (0.0190), days to maturity (0.0023) and test weight (0.1493) while negative indirect effect through days to first flowering (-0.1678), days to 50% flowering (-0.1406) and harvest index (-0.3938).

Harvest index had positive correlation indirect effect via days to first flowering (0.1089), days to 50% flowering (0.0739), number of primary branches/plant (0.0795), number of secondary branches/plant (0.0223), plant height (0.0617), number of siliquae/plant (0.0550), siliqua length (0.0798), number of seeds/siliqua (0.1516) and test weight (0.1455) while negative indirect effect through days to maturity (-0.0531) and biological yield/plant (-0.3138).

Test weight had positive correlation effect via number of primary branches/plant (0.0011), number of secondary branches/plant (0.0014), plant height (0.0010), number of siliquae/plant (0.0012), number of seeds/siliqua (0.0004), biological yield/plant (0.0008) and harvest index (0.0010) while negative indirect effect through days to first flowering (-0.0007), days to 50% flowering (-0.0009), siliqua length (-0.0002) and days to maturity (-0.0001). These results are in conformity with the findings of Sirohi *et al*. (2004), Kumar and Pandey (2014), Roy *et al*. (2018) and Kumar *et al*. (2018a)

Heritability and genetic advance

Analysis of variance revealed significant differences for all the thirteen 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. High magnitude of variability has been reported in Indian mustard germplasm and varieties for various characters by many workers for total siliquae/plant, seed yield per plant and biological yield/plant. The reason for high magnitude of variability in the present study may be due the fact that the genotypes selected were developed in different breeding programme representing different agro-climatic conditions of the country. The estimates of genetic variability parameters for all the traits were worked out and are presented in Table 3. It was evident from the result that the phenotypic variance is greater than genotypic variance indicating the influence of environment on the expression of the trait.

Among the yield attributes maximum PCV and GCV was depicted by biological yield/plant (30.98 and 22.29) followed by number of siliqua/plant (27.36 and 25.49), seed yield/plant (26.51 and 23.51), number of secondary branches/plant (23.78 and 19.61), number of primary branches/plant (22.08 and 15.55), harvest index (19.61 and 15.39), test weight (19.45 and 11.75), number of seeds/siliqua (9.40 and 7.10), siliqua length (8.42 and 5.09), days to first flowering (7.44 and 5.72), plant height (6.80 and 4.86), days to 50% flowering (5.56 and 3.61) and days to maturity (2.32 and 1.84) respectively. The high values of PCV and GCV indicating that selection may be effective on these traits. The lowest value for PCV and GCV was indicating less scope of selection as they are under less influence of environment. Wide difference between PCV and GCV was observed for number of seeds/siliqua, number of primary branches/plant, number of secondary branches/plant and days to first flowering which may indicate the high contribution of environmental variance to the phenotypic variance. Similar results have been found earlier by Khan *et al.* (2006), Roy *et al.*, (2011), Lohia *et al.* (2013) and Maurya *et al*. (2018).

The highest heritability was recorded on number of siliquae/plant (87%) with genetic advance and expected genetic advance over percentage of mean of (249.57 and 62.67%) followed by seed yield/plant (79%) with genetic advance and an expected genetic advance over percentage of mean of (18.66 and 55.05%), number of secondary branches/plant (68%) with genetic and an expected genetic advance over percentage of mean of (6.14 and 42.68%), days to maturity (63%) with genetic advance and an expected genetic advance over percentage of mean of (5.69 and 3.85%), harvest index (62%) with genetic advance and an expected genetic advance over percentage of mean of (8.44 and 31.89%), days to first flowering (59%) with genetic advance and an expected genetic advance over percentage of mean of (5.22 and 11.60%), number of seeds/siliqua (57%) with genetic advance and an expected genetic advance over percentage of mean of (1.61 and 14.16%), biological yield/plant (52%) with genetic advance and an expected genetic advance over percentage of mean of (56.21 and 42.34%), plant height (51%) with genetic advance and an expected genetic advance over percentage of mean of (16.28 and 9.16%), number of primary branches/plant (50%) with genetic advance and an expected genetic advance over percentage of mean of (1.76 and 28.91%), days to 50% flowering (42%) with genetic advance and an expected genetic advance over percentage of mean of (3.50 and 6.18%), siliqua length (37%) with genetic advance and an expected genetic advance over percentage of mean of (0.34 and 8.13%) and test weight (36%) with genetic advance and an expected genetic advance over percentage of mean (0.63 and 18.73%), respectively. Similar finding were also observed by Upadhyay and Kumar (2009), Tele *et al*. (2014), Akabari and Niranjana (2015) and Maurya *et al*. (2018).

Conclusion

The association studies among different characters revealed that seed yield/plant (g) had significant positive correlation with biological yield/plant and other yield traits at phenotypic level. Path coefficient analysis of twelve yield contributing characters clearly indicated that biological yield/plant (g) had the highest positive direct effect relationship with seed yield/plant. High heritability estimates in broad sense along with high genetic advance as percent of mean was found under the control of additive genetic variance. The high PCV and GCV were observed for biological yield/plant (g) whereas, moderate GCV and PCV was recorded for number of siliquae/plant, seed yield/plant and number of secondary branches/plant indicating prevalence of genetic variability for these traits, which can successfully be utilized for genetic improvement of seed yield in Indian mustard. Thus, selection of genotypes based on the character will be useful in further breeding programmes.

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