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Estimation of Genetic variability, correlation and path analysis for yield and yield contributing characters in Indian mustard (*Brassica juncea* L.)

Sipra Pal, Nidhi Dubey, Harshal Avinashe, Sudip Khan and J Pranay Reddy

Abstract
Phenotypic and genotypic coefficient of variation (PCV & GCV), heritability, genetic advance (GA), correlation and path analysis for thirteen characters in seven genotypes of Indian mustard (*Brassica juncea* L.) were evaluated for seed yield and its yield contributing traits. Genetic variability indicated that, the PCV was greater than GCV for all the traits studied was majorly due to the influence of environment. High heritability along with high genetic advance as per cent of mean were recorded for seed yield per plant, seeds per siliqua, siliqua length and secondary branches per plant indicating the breeding improvement through direct selection. In correlation analysis, seed yield per plant had significant and positive correlation with secondary branches per plant, siliqua per plant, biological yield per plant, harvest index, days to maturity, 1000 seed weight and oil content at both genotypic and phenotypic levels. Path coefficient analysis indicated that, among twelve yield contributing characters highest positive direct effects was noted for biological yield per plant followed by siliqua length, harvest index, 1000 seed weight, Siliqua per plant and primary branches per plant on the seed yield per plant. Other characters like seeds per siliqua, plant height, days to 50% flowering, days to maturity, secondary branches per plant and oil content had negative direct effect on seed yield. Therefore these traits should be given more priority for selection in breeding programme.

Keywords: Indian mustard, variability, genetic advance, heritability, correlation, path analysis

Introduction

Rapeseed (*Brassica spp.*) is one of the most important edible oilseed crop in the World. The group of rapeseed mustard is *Brassicaceae* belongs to *Cruciferae* family. Mustard crop is grown in both tropical and sub-tropical countries. There are many species of genus *Brassica* like *Brassica nigra* (n=8), *Brassica oleracea* (n=9), *Brassica Rapa* (n=10). *B. juncea* is a tetraploid species having chromosome no. 2n=36 obtained by crossing two diploid species i.e. *B. nigra* and *B. Rapa*. It is a self-pollinated crop with high genetic diversity having 310 genera along with 3500 species. Out of seven edible oilseed crops cultivated in India, rapeseed mustard occupies second position in area and production next to groundnut sharing 27.80% in the India oilseed economy and countries 28.60 % in the total oilseeds production (Shekhawat *et al.* 2012) [14]. Mustard is *Rabi* seasonal crop especially winter season crop are sown in October-November and harvesting time is February-March. Total area under Mustard crop in India for the year 2016-17 was 66.52lakh hectares as per the Government's estimates, estimated total production of Mustard was71.09 lakh tonnes. In this year average yield was 1069 kg per hectare. (SEA, 2016-2017).

Genetic variability is one of the most important requirement for crop improvement because it provides wider scope for selection. The relationship between seed yield and other traits is desirable to choose the appropriate selection in breeding programme because seed yield is a polygenic trait which often leads to changes in other characters. Correlation analysis measure the degree, direction and the strength of relationship between two or more variables during selection. Path coefficient analysis measures the direct and indirect effects of various independent characters on a dependent character (Dewey and Lu, 1959) [5].

Hence, the present study is conducted to estimation of heritability and genetic advance of genotypes for yield and yield contributing traits and to measure the extent of direct and indirect causes of association among traits through path coefficient analysis in mustard.

Materials and Methods

Seven diverse genotypes of Indian mustard which are collected from Directorate of Rapeseed Mustard Research (DRMR), Bharatpur were grown in randomized block design with three replications at Research Farm, Lovely Professional University, Punjab during *Rabi* season 2017-2018. Each genotype was sown in two rows plot and each row having 3.0 m length. Row to row and plant to plant distance was maintained at 45 cm and 15 cm respectively. For the growth of healthy crops all agronomical practices were recommended along with plant protection measures. Observations were recorded on five randomly selected plants in each genotype along with each replication for thirteen characters. Data was recorded on whole plot basis for days to 50% flowering and days to maturity whereas for plant height, primary branches per plant, secondary branches per plant, siliqua per plant, biological yield per plant, siliqua length, seeds per siliqua, 1000 seed weight, seed yield per plant, harvest index and oil content from individual selected plants. The mean values of each genotype were computed for statistical analysis. The standard method of analysis of variance was given by Panse and Sukhatme (1978) [11], phenotypic and genotypic coefficient of variation, heritability (Broad Sense) and genetic advance as percent of mean were estimated by the formula al suggested by Burton (1952) [2] and Johanson *et al.* (1955) [8]. The formula of genotypic correlation coefficients were estimated by Al-Jibouri *et al.* (1958) [1]. Path analysis along with genotypic correlation coefficient is applied to know the direct and indirect effects of the components on yield as suggested by Wright (1921) [18] and illustrated by Dewey and Lu (1959) [5].

Result and Discussion

The analysis of variance (Table 1) revealed that the treatments were highly significant for all the thirteen characters. This suggested that the genotypes selected were genetically variable and considerable amount of variability existed among them.

The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were observed in the experimental material for all the characters studied (Table 2). The PCV was higher than GCV for all the characters indicating that the visible variation in the expression of traits was not only due to varying influence of environment factor. High PCV and GCV was observed for secondary branches per plant (43.19, 41.99) followed by seeds per siliqua (38.83, 38.74), siliqua per plant (35.59, 34.95), seed yield per plant (31.27, 31.23), siliqua length (27.90, 27.87), biological yield per plant (27.24, 26.03), primary branches per plant (25.92, 23.61), harvest index (20.53, 17.78) and 1000 seed weight (15.35, 15.35). Similar findings were reported by Dawar *et al*. (2018) [3] and Bineeta Devi (2018) [4].

High heritability was observed for seed yield per plant (100%) followed by 1000 seed weight (100%), seeds per siliqua (100%), siliqua length (100%) followed by plant height (99%), days to 50% flowering (99%), siliqua per plant (96%), secondary branches per plant (95%) and days to maturity (94%).While in present study, low heritability was also reported for oil content (76%) and harvest index (75%). Genetic advance as per cent of mean was recorded maximum for secondary branches per plant (84.09) followed by seeds per siliqua (79.61), siliqua per plant (70.72), seed yield per plant (64.25), siliqua length (57.35), biological yield per plant (51.25) and primary branches per plant (44.30). In general, seed yield per plant, seeds per siliqua, siliqua length and secondary branches per plant revealed high heritability with high genetic advance. The estimates of high heritability (broad sense) and high genetic advance indicate that improvement in this trait could be done through direct selection for breeding programme. High heritability coupled with moderate genetic advance was observed for plant height, days to 50 % flowering, seed yield per plant and days to maturity indicating presence of G x E interaction which meant that simple selection may not be rewarding for these traits. The present findings corroborate the earlier report Tiwari *et al*. (2017) [17] and Sharma *et al.* (2014) [13].

Correlation coefficient analysis (Table 3) measure natural relation between 13 various plant characters and determine the component characters on which selection can be used for genetic improvement in yield. The correlation coefficient estimated positive and significant genotypic and phenotypic correlation in biological yield per plant (0.8079, 0.7710), siliqua per plant (0.7264, 0.7139), harvest index (0.6550, 0.5689), secondary branches per plant (0.5757, 0.5588), oil content (0.5352, 0.4546), 1000 seed weight (0.5050, 0.5039), days to maturity (0.4655, 0.4528), with seed yield per plant. Such positive correlation seed yield and these attributes have also been reported in mustard by Shweta and Om Prakash (2014) [15] and Ompal *et al*. (2018) [10].

When characters having direct bearing on yield are selected, their association with other character are to be considered simultaneously as they will indirectly affect the yield. Days to 50% flowering implied highly positive and significant correlation at both levels with days to maturity (0.8706, 0.8264), siliqua per plant (0.7490, 0.7413), secondary branches per plant (0.7285, 0.6965), plant height (0.6321, 0.6254), 1000 seed weight (0.6040, 0.6009) whereas positive and significant correlation with primary branches per plant (0.5200, 0.4686) and biological yield per plant (0.5132, 0.4887), while negatively significant with seeds per siliqua (-0.4812, 0.4780). Days to maturity had highly positive and significant correlation at both genotypic and phenotypic level with primary branches per plant (0.7388, 0.6145), siliqua per plant (0.6925, 0.6356), plant height (0.5745, 0.5535) whereas positive and significant correlation at both level with biological yield per plant (0.6224, 0.5867), 1000 seed weight (0.5309, 0.5139), secondary branches per plant (0.5241, 0.4998). Plant height had highly positive and significant correlation in both levels with 1000 seed per plant (0.8382, 0.8328), secondary branches per plant (0.7421, 0.7177), siliqua per plant (0.6701, 0.6605), biological yield per plant (0.6143, 0.6001) while highly negative significant with seeds per siliqua (-0.7316, -0.7253) whereas negative significant in both level with siliqua length (-0.4897, -0.4848), Primary branches per plant had highly positive and significant correlation with siliqua length (0.6326, 0.5859) in both levels. Secondary branches per plant had highly positive and significant correlation with siliqua per plant (0.9293, 0.8903), 1000 seed weight (0.7579, 0.7368) biological yield per plant (0.7164, 0.6486), while highly negative significant with seeds per siliqua (-0.8936, -0.8778), siliqua length (0.6281, -0.6167). Siliqua per plant had highly positive and significant correlation with biological yield per plant (0.7905, 0.7387), 1000 seed weight (0.7523, 0.7374) while highly negative significant with seeds per siliqua (-0.8406, -0.8266), siliqua length (-0.6281, 0.6167). Biological yield per plant had highly positive and significant correlation with 1000 seed weight (0.8803, 0.8405) and negative significant correlation with seeds per siliqua (-0.5529,-0.5196), siliqua length (-0.4657,-0.4402). Siliqua length had highly positive and significant correlation with seeds per siliqua (0.8987, 0.8970) while highly negative significant correlation with 1000 seed weight (-0.6282, -0.6278).Seeds per siliqua had highly negatively significant correlation with 1000 seed weight (0.7090, -0.7070). Harvest index had highly positive and significant correlation at both levels with oil content (0.8577, 0.6723).

Path coefficient analysis is more useful for separating of direct and indirect effects of correlation and also enables to compare the component factors on the basis of their relative contributors. Path coefficient analysis (Table 4) imposed high positive direct effects for biological yield per plant (0.8454) followed by siliqua length (0.7997), harvest index (0.4268), 1000 seed weight (0.1634), siliqua per plant (0.1146) and primary branches per plant (0.0709) on the dependent character i.e., seed yield per plant. The maximum and positive direct effects of biological yield per plant and harvest index were also reported by Roy *et al.* (2018) [12] and Gupta *et al.* (2018) [7] So that, these characters should be considered as main components for selection for higher seed yield. Seeds per siliqua (-0.9756) imposed high negative direct effect followed by plant height (-0.2877), days to 50% flowering (-0.2162), days to maturity (-0.1949), secondary branches per plant (-0.1003) and oil content (-0.0298).

Plant height had moderate positive indirect effect via seeds per siliqua (0.2105). Biological yield per plant had high positive indirect effect via 1000 seed weight (0.7442), days to siliqua per plant (0.6683), secondary branches per plant (0.6056), days to maturity (0.5262), plant height (0.5193), 50% flowering (0.4338). Siliqua length had high positive indirect effect via seeds per siliqua (0.7187) and primary branches per plant (0.5059). Seeds per siliqua had high positive indirect effect via secondary branches per plant (0.8718), siliqua per plant (0.8201), days to plant height (0.7137), 1000 seed weight (0.6917) biological yield per plant (0.5394), 50% flowering (0.4694), and also moderate positive indirect effect via oil content (0.2542) and days to maturity (0.2501). Harvest index imposed moderate positive indirect effect via oil content (0.3661). Similar result also reported by Dipti *et al.* (2016) [6] and Kumar *et al.* (2016) [9].

Table 1: Analysis of variance for yield contributing characters in Indian mustard

Source	D.F.	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
Replication	2	2.95	0.42	0.53	2.52	7.09	5321.48	415.13	0.01	0.25	0.0003	0.88	8.59	1.09
Treatment	6	164.87**	50.00**	1238.24**	14.04**	392.77**	296373.77**	11097.42**	8.06**	192.80**	1.15**	1071.70**	73.54**	10.90**
Error	12	0.58	1.09	3.85	0.89	7.46	3586.73	340.45	0.005	0.31	0.0002	0.94	7.35	1.02

X1= Days to 50% flowering, X2= Days to maturity, X3= Plant height, X4= Primary branches per plant, X5= Secondary branches per plant, X6= Siliqua per plant, X7=Biological yield per plant, X8= Siliqua length, X9= Seeds per siliqua, X10= 1000 Seed weight, X11=Seed yield per plant, X12= Harvest index, X13= Oil content.

Table 2: Estimation of variability, heritability and genetic advance as percent of mean in Indian mustard

Characters	Range		Mean	Heritability (%)	Coefficient of variance (%)		Genetic advance	GA as per mean
	Min	Max			PCV	GCV		
Days to 50% flowering	70.00	88.33	81.52	99.00	9.13	9.08	18.60	18.60
Days to maturity	129.00	141.33	135.00	94.00	3.09	2.99	5.96	5.96
Plant height (cm)	149.13	209.60	189.40	99.00	10.76	10.71	21.96	21.96
Primary branches per plant	7.06	13.06	8.87	83.00	25.92	23.61	44.29	44.30
Secondary branches per plant	6.33	39.66	26.99	95.00	43.19	41.99	84.08	84.09
Siliqua per plant	281.40	1141.73	893.77	96.00	35.59	34.95	70.71	70.72
Biological yield per plant (gm)	150.13	336.60	230.03	91.00	27.24	26.03	51.24	51.25
Siliqua length (cm)	4.80	8.61	5.88	100.00	27.90	27.87	57.34	57.35
Seeds per siliqua	13.93	35.96	20.68	100.00	38.83	38.74	79.61	79.61
1000 seed weight(gm)	3.04	4.94	4.05	100.00	15.35	15.35	31.61	31.61
Seed yield per plant(gm)	36.18	87.44	60.50	100.00	31.27	31.23	38.86	64.25
Harvest index (%)	22.34	37.08	26.42	75.00	20.53	17.78	8.37	31.72
Oil content (%)	35.25	40.33	37.62	76.00	5.52	4.82	3.26	8.68

Table 3: Genotypic (G) and Phenotypic (P) correlation among the different characters in Indian mustard

Source		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X1	G	1.0000	0.8706**	0.6321**	0.5200*	0.7285**	0.7490**	0.5132*	-0.1723	-0.4812*	0.6040**	-0.3031	0.0404	0.2155
	P	1.0000	0.8264**	0.6254**	0.4686*	0.6965**	0.7413**	0.4887*	-0.1711	-0.4780*	0.6009**	-0.2653	0.0452	0.2147
X2	G		1.0000	0.5745**	0.7388**	0.5241*	0.6925**	0.6224**	0.1130	-0.2564	0.5309*	-0.0190	0.3567	0.4655*
	P		1.0000	0.5535**	0.6145**	0.4998*	0.6356**	0.5867**	0.1112	-0.2508	0.5139*	-0.0048	0.2846	0.4528*
X3	G			1.0000	0.2356	0.7421**	0.6701**	0.6143**	-0.4897*	-0.7316**	0.8382**	-0.1509	0.3036	0.3878
	P			1.0000	0.2246	0.7177**	0.6605**	0.6001**	-0.4848*	-0.7253**	0.8328**	-0.1566	0.2681	0.3853
X4	G				1.0000	0.0951	0.0804	0.1424	0.6326**	0.2889	0.0111	-0.0820	0.2027	0.0516
	P				1.0000	0.0801	0.0545	0.1478	0.5859**	0.2757	0.0096	-0.1270	0.1571	0.0495
X5	G					1.0000	0.9293**	0.7164**	-0.7191**	-0.8936**	0.7579**	0.0308	0.1185	0.5757**
	P					1.0000	0.8903**	0.6486**	-0.7015**	-0.8778**	0.7368**	0.0487	0.1125	0.5588**
X6	G						1.0000	0.7905**	-0.6281**	-0.8406**	0.7523**	0.2086	0.3057	0.7264**
	P						1.0000	0.7387**	-0.6167**	-0.8266**	0.7374**	0.1758	0.2621	0.7139**
X7	G							1.0000	-0.4657*	-0.5529**	0.8803**	0.0786	0.0539	0.8079**
	P							1.0000	-0.4402*	-0.5196*	0.8405**	-0.0771	0.0233	0.7710**
X8	G								1.0000	0.8987**	-0.6282**	-0.0508	0.0470	-0.3954
	P								1.0000	0.8970**	-0.6278**	-0.0498	0.0462	-0.3939

X9	G									1.0000	-0.7090**	-0.1537	-0.2605	-0.5197*
	P									1.0000	-0.7070**	-0.1455	-0.2303	-0.5187*
X10	G										1.0000	-0.3036	-0.0631	0.5050*
	P										1.0000	-0.2621	-0.0580	0.5039*
X11	G											1.0000	0.8577**	0.6550**
	P											1.0000	0.6723**	0.5689**
X12	G												1.0000	0.5352*
	P												1.0000	0.4546*

*and ** significant for 5% and 1% level

X1= Days to 50% flowering, X2= Days to maturity, X3= Plant height, X4= Primary branches per plant, X5= Secondary branches per plant, X6= Siliqua per plant, X7=Biological yield per plant, X8= Siliqua length, X9= Seeds per siliqua, X10= 1000 Seed weight, X11= Harvest index, X12= Oil content, X13= Seed yield per plant

Table 4: Path coefficient showing (diagonal) and indirect effect (off diagonal) of different characters on seed yield per plant in Indian mustard

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	-0.2162	-0.1882	-0.1366	-0.1124	-0.1575	-0.1619	-0.1109	0.0373	0.1040	-0.1306	0.0655	-0.0087
X2	-0.1696	-0.1949	-0.1119	-0.1440	-0.1021	-0.1349	-0.1213	-0.0220	0.0500	-0.1035	0.0037	-0.0695
X3	-0.1819	-0.1653	-0.2877	-0.0678	-0.2135	-0.1928	-0.1768	0.1409	0.2105	-0.2412	0.0434	-0.0874
X4	0.0369	0.0524	0.0167	0.0709	0.0067	0.0057	0.0101	0.0449	0.0205	0.0008	-0.0058	0.0144
X5	-0.0731	-0.0526	-0.0744	-0.0095	-0.1003	-0.0932	-0.0718	0.0721	0.0896	-0.0760	-0.0031	-0.0119
X6	0.0858	0.0793	0.0768	0.0092	0.1065	0.1146	0.0906	-0.0720	-0.0963	0.0862	0.0239	0.0350
X7	0.4338	0.5262	0.5193	0.1204	0.6056	0.6683	0.8454	-0.3937	-0.4674	0.7442	0.0664	0.0456
X8	-0.1378	0.0904	-0.3916	0.5059	-0.5750	-0.5023	-0.3724	0.7997	0.7187	-0.5024	-0.0406	0.0376
X9	0.4694	0.2501	0.7137	-0.2818	0.8718	0.8201	0.5394	-0.8768	-0.9756	0.6917	0.1500	0.2542
X10	0.0987	0.0868	0.1370	0.0018	0.1239	0.1229	0.1439	-0.1027	-0.1159	0.1634	-0.0496	-0.0103
X11	-0.1294	-0.0081	-0.0644	-0.0350	0.0131	0.0890	0.0335	-0.0217	-0.0656	-0.1296	0.4268	0.3661
X12	-0.0012	-0.0106	-0.0091	-0.0060	-0.0035	-0.0091	-0.0016	-0.0014	0.0078	0.0019	-0.0256	-0.0298

X1= Days to 50% flowering, X2= Days to maturity, X3= Plant height, X4= Primary branches per plant, X5= Secondary branches per plant, X6= Siliqua per plant, X7=Biological yield per plant, X8= Siliqua length, X9= Seeds per siliqua, X10= 1000 Seed weight, X11= Harvest index, X12= Oil content

Hence it is concluded that in mustard, some traits like, siliqua per plant, biological yield per plant, harvest index and 1000 seed weight showed positive correlation with yield along with the direct effect on yield. Hence, these traits can be used as selection indices for breeding programme in mustard to bring about the improvement in yield.

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