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Suman Yadav
Department of Plant Breeding and Genetics, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Anil Pandey
Department of Plant Breeding and Genetics, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Correspondence
Suman Yadav
Department of Plant Breeding and Genetics, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Genetic variability and trait association studies in Indian mustard (*Brassica juncea* L.)

Suman Yadav and Anil Pandey

Abstract
An investigation was undertaken to study the variability and trait association of eighteen quantitative traits namely plant height, number of primary branches, number of secondary branches, length of primary mother axis, silique on primary branches, silique on secondary branches, silique on primary mother axis, silique length, number of seeds/silique, biological yield/plant, harvest index, test weight, seed yield/plant, days to first flower open, days to 50% flowering, vegetative phase duration, post-anthesis phase duration and physiological maturity in 20 Indian mustard (*Brassica juncea* L.) germplasm lines. The experiment material was evaluated in a randomized complete block design with three replications. Analysis of variance estimates of all the characters were found highly significant. Coefficient of variation for GCV and PCV were found high for the following traits i.e. seed yield per plant, biological yield per plant, test weight, harvest index and siliqua primary branches, secondary branches as well as on primary mother axis. Test weight, biological yield per plant, seed yield per plant and silique on primary mother axis exhibited higher heritability and higher genetic advance. Correlation study revealed that plant height, length of primary mother axis, number of primary branches as well as secondary branches, biological yield/plant and silliqua on primary branches, secondary branches as well as onmain raceme and physiological maturity exerted high positive significant genotypic correlation with seed yield per plant. Siliqua length, days to first flower open, vegetative phase duration, post-anthesis phase duration and test weight were found negatively correlated with seed yield per plant.

Keywords: GCV, PCV, genetic advance, heritability, variability, correlation

Introduction

Indian mustard [*Brasica juncea* (L.) Czern & Coss] is an important *rabi* season crop extensively gown as rain- fed as well as under irrigated conditions. Among the four oleiferous *Brassica* species, major area is under *Brassica juncea,* which contributes about 80 per cent of the total rapeseed-mustard production in the country. Among the various oilseed crops grown globally, the estimated area, production and yield of rapeseed-mustard in the world was33.57 mha, 60.56 mt and1800 kg/ha, respectively (USDA, 2011) [25]. India accounts for21.7 per cent and 10.7 per cent of the total acreage and production with area, production and productivity of rapeseed-mustard are 6.5mha, 8.79 mt and 1179 kg/ha, respectively (USDA, 2010) [24].

Yield is complex character which dependent on the various yield contributing characters. Thus the study of correlation between yield and its component is of primary importance in formulating the selection criteria under crop improvement. Selection of any desirable trait is generally performed based on the phenotypic value of the plants, which is partly determined by genotypes, which is heritable, and partly by environment which is non- heritable. Therefore, it is necessary to know the various components of the yield and its mutual correlation with other independent traits. This is because, selection would be more efficient if it is based on some components which is less sensitive to environment. Various components of seed yield very often exhibit varying degree of associations with seed yield as well as among themselves. Analysis of correlation coefficients between characters contributing directly or indirectly towards seed yield is a matter of considerable importance in exercising the selection programme. A study of correlation alone is not enough to provide an exact picture of relative importance of direct and indirect influences of each of the component traits on seed yield.

Materials and Methods

The present field experiment was conducted at Field Experimental center Department of Plant Breeding& Genetics, TCA Dholi, Dr. RPCAU Pusa (Bihar) in Randomized complete block design (RCBD) with three replications. The mustard crop was shown on 16.10.2017 and recommended packages of practices were followed with twenty genotypes of Indian mustard during Rabi 2017-2018. Observations were recorded on five randomly selected plants in each genotype and replication for different eighteen traits. These traits were computed on basis of mean data after computing for each character was subjected to standard method of analysis of variance following Panse and Sukhatme (1978) [15] 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) [5] and Johanson *et. al.* (1955) [9]. The genotypic correlation coefficients were estimated according to the formula given by Al-Jibouri *et al.* (1958) [2].

Table 1: ANOVA for different characters in the present investigation

S. No.	Characters	Mean sum of squares		F Value
		Replication (d.f.=2)	Treatments (d.f.=19)	
1.	Days to 50% Flowering	3.9500	68.5780	2.4521**
2.	Plant Height (cm)	381.1153	508.65	3.46**
3.	Primary branches/ plant	0.8182	1.0178	5.4254**
4.	Secondary branches/ plant	0.3910	31.2885	3.9062**
5.	Length of primary mother axis (cm)	16.2058	118.7823	3.7359**
6.	Silliqua on Primary branches	359.0320	806.5024	4.6498**
7.	Silliqua on secondary branches	1421.6510	10959.4928	2.8604**
8.	Siliqua on primary mother axis	39.6668	84.5767	4.8544**
9.	Siliqua length (cm)	0.0854	0.1777	2.4178*
10.	No. of seeds per siliqua	0.2284	2.1535	2.2101*
11.	Biological yield/plant (gm)	27.6047	5284.6392	22.5619**
12	Harvest Index (%)	43.8900	136.0127	3.3078**
13	Test weight (g)	0.0241	3.9638	73.1207**
14	Seed yield/plant (g)	3.7938	279.7425	18.77**
15	Days to first flower open	29.8166	82.7403	5.8329**
16	Vegetative phase duration	12.9500	25.7640	5.8473**
17	Post anthesis phase duration	12.0666	88.0447	6.2513**
18	Physiological maturity	4.3291	2.6412	1.9175*

*,** significant at 5% and 1% level of significance

Table 2: Estimates of GCV, PCV, Heritability, Genetic Advance & Genetic Advance as percent of mean

S. No.	Characters	GCV	PCV	H2 (bs) %	GA 5%	GA as % OF Mean 5%
1.	Days to 50% Flowering	6.168	10.800	32	4.32	7.25
2.	Plant Height (cm)	5.99	8.93	45	15.18	8.29
3.	Primary branches/ plant	13.11	16.98	59	0.83	20.84
4.	Secondary branches/ plant	17.39	24.79	49	4.02	25.13
5.	Length of primary mother axis (cm)	7.79	11.28	47	7.66	11.08
6.	Silliqua on Primary branches	13.54	18.28	54	22.17	20.67
7.	Silliqua on secondary branches	20.25	32.74	38	62.12	25.81
8.	Siliqua on primary mother axis	10.39	13.86	56	7.30	16.05
9.	Siliqua length (cm)	3.84	6.78	32	0.21	4.48
10.	No.of seeds per siliqua	5.37	10.01	28	0.69	5.93
11.	Biological yield/plant (g)	48.98	52.27	87	79.19	94.53
12	Harvest Index (%)	24.20	36.70	43	7.64	32.88
13	Test weight (g)	25.64	26.17	96	2.30	51.76
14	Seed yield/plant (g)	51.46	55.64	85	17.90	98.07
15	Days to first flower open	10.00	12.74	61	7.73	16.19
16	Vegetative phase duration	7.30	9.28	61	4.32	11.81
17	Post anthesis phase duration	6.45	8.09	63	8.16	10.61
18	Physiological maturity	0.55	1.14	23	0.64	0.55

Table 3: Genotypic (r_g) and phenotypic (r_p) correlations coefficients among 18 characters of mustard

Character		Plant height	Number of primary branches	Number of secondary branches	Length of primary mother axis	Silique on primary branches	Silique on secondary branches	Siliqua on primary mother axis	Siliqua length	Number of seeds/siliqua	Bioogical yield/plant	Harvest index	Days to first flower open	Vegetative phase duration	Physiological maturity	Post anthesis phase duration	Days to 50% flowering	Test weight	Seed yield per plant
Plant height	rg	1.00	0.56**	0.69**	0.45**	0.56*	0.49**	0.34**	-0.23	-0.62	0.61**	0.18	0.56**	0.21	1.20**	-0.69	0.60**	-0.36	0.74**
	rp	1.00	0.33**	0.47**	0.45**	0.34**	0.41**	0.41**	-0.04	-0.13	0.52**	-0.07	0.27*	0.21	0.18	-0.28*	0.20	-0.23	0.46**
No. of primary branches	rg		1.00	0.98**	0.62**	0.66**	0.86**	0.80**	-0.30*	-0.26	0.96**	-0.08	0.06	-0.26*	0.90**	-0.29*	0.46**	-0.02	0.95**
	rp		1.00	0.74**	0.33*	0.59**	0.57**	0.56**	-0.02	-0.08	0.75**	-0.11	-0.009	-0.09	0.34**	-0.11	0.28*	-0.01	0.67**
No.of secondary branches	rg			1.00	0.66**	0.62**	0.87**	0.86**	-0.45**	-0.26*	1.01**	-0.04	0.02	-0.14	1.27	-0.29*	0.48**	0.00	1.00**
	rp			1.00	0.32*	0.62**	0.73**	0.66**	-0.06	-0.21*	0.79**	-0.03	0.02	0.05	0.35**	-0.11	0.23*	0.002	0.78**
Length of primary mother axis	rg				1.00	0.53**	0.48**	0.66**	-0.31*	-0.43**	0.53**	-0.07	0.36**	0.12	0.52**	-0.50**	0.32*	0.19	0.52**
	rp				1.00	0.25*	0.26*	0.39**	-0.20*	-0.005	0.47**	-0.25*	0.15	0.13	0.11	-0.20*	0.17	0.15	0.29*
Siliqua on primary	rg					1.00	1.00**	0.78**	-0.35**	-0.39**	0.82**	-0.12	0.44**	0.34**	0.85**	-0.60**	0.63**	0.05	0.72**
	rp					1.00	0.70**	0.58**	-0.04	-0.23*	0.65**	-0.12	0.28*	0.34**	0.45**	-0.34**	0.38**	0.03	0.53**
Siliqua on secondary branches	rg						1.00	0.90**	-0.43**	-0.28*	1.07**	-0.06	0.28*	0.18	1.36**	-0.53**	0.74**	0.18	0.96**
	rp						1.00	0.66**	-0.18	-0.18	0.76**	-0.23*	0.24*	0.29*	0.31*	-0.30*	0.26*	0.08	0.57**
Silique on primary mother axis	rg							1.00	-0.42**	-0.30*	0.77**	-0.23*	0.37**	0.24*	0.92**	-0.60**	0.70**	0.29*	0.73**
	rp							1.00	-0.14	-0.13	0.65**	-0.31*	0.31*	0.33*	0.29*	-0.39**	0.29*	0.23*	0.49**
Silique length	rg								1.00	0.71**	-0.28*	0.42**	-0.45**	-0.45**	-0.34**	0.48**	-0.46**	-0.45**	-0.18*
	rp								1.00	0.33*	-0.12	0.36**	-0.14	-0.03	-0.03	0.20	-0.003	-0.25*	0.02
No.of seeds/siliqua	rg									1.00	-0.32*	0.63***	-0.33**	-0.47**	0.01	0.41**	-0.34**	0.32*	-0.11
	rp									1.00	-0.16	0.22*	-0.22*	-0.21*	-0.16	0.19	-0.27*	0.17	-0.09
Biological yield/plant	rg										1.00	-0.13	0.11	-0.05	1.02**	-0.32*	0.58**	-0.04	0.90**
	rp										1.00	-0.19	0.14	0.01	0.41**	-0.28*	0.34**	-0.03	0.81**
Harvest index	rg											1.00	-0.50**	-0.10	0.44**	0.51**	-0.96**	-0.12	0.21*
	rp											1.00	-0.41**	-0.16	0.07	0.43**	-0.30*	-0.11	0.31*
Days to first flower open	rg												1.00	0.77**	0.32*	-1.00**	1.06**	0.16	-0.09
	rp												1.00	0.65**	0.21*	-0.95**	0.53**	0.12	-0.08
Vegetative phase duration	rg													1.00	0.41**	-0.77**	0.59**	0.21	-0.07
	rp													1.00	0.19	-0.57**	0.43**	0.14	-0.03
Physiological maturity	rg														1.00	-0.53**	0.51**	-0.28	1.12**
	rp														1.00	-0.25*	0.22*	-0.09	0.43**
Post anthesis phase duration	rg															1.00	-1.16**	-0.18	-0.11
	rp															1.00	-0.53**	-0.15	-0.05
Days to 50% flowering	rg																1.00	0.02	0.21*
	rp																1.00	-0.02	0.15
Test weight	rg																	1.00	-0.06
	rp																	1.00	-0.07

*,** significant at 5% and 1% level of significance

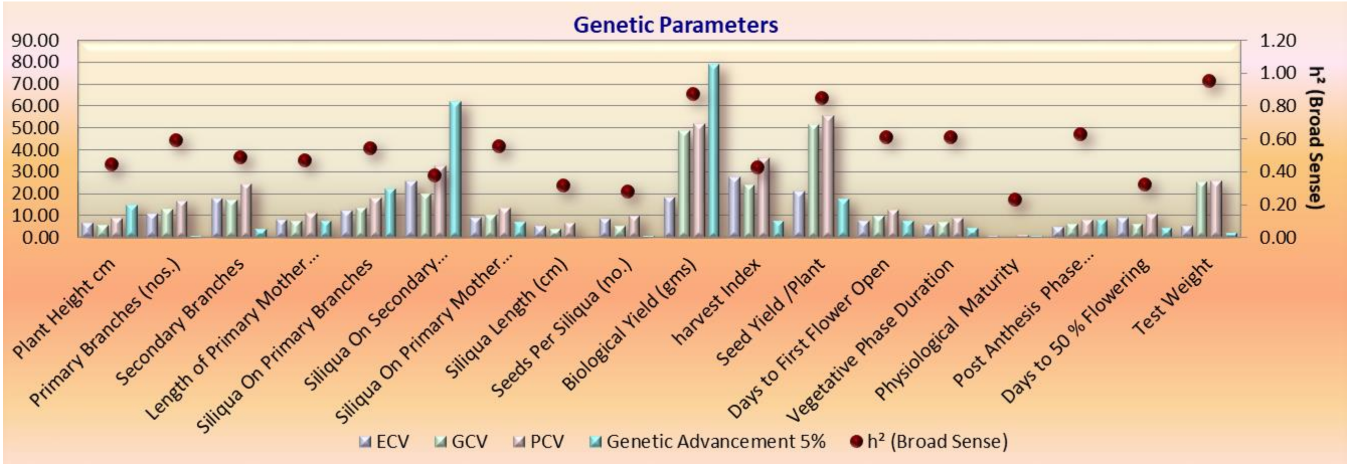

Fig 1: Genetic parameters

Result and Discussion

The analysis of variance (Table-1) revealed that mean squares due to genotypes were highly significant for all the eighteen characters indicating the presence of sufficient amount of variability among the genotypes**.** The perusals of data revealed that phenotypic variance were higher than the corresponding genotypic variance for all the traits studies. Which indicated the influences of environmental factor on these traits. Data presented in Table- 2 showed maximum GCV and PCV was recorded for seed yield per plant (51.46 and 55.64) followed by biological yield per plant (48.98 and 52.27), harvest index (24.20 and 36.70), test weight (25.64 and 26.17) and siliqua on main primary mother axis (10.39 and 13.86). These results were well sported by similar findings by Shekhawat *et al*. (2012) [19], and Mondal & Khajuria (2000) [14] reported high values for PCV and GCV for the biological yield per plant and seed yield per plant. These traits suggested the possibility of yield improvement through selection. Siliqua on primary branches as well as secondary branches and number of primary branches and secondary branches show moderate estimates of coefficient of variance respectively (13.54 and 18.28) and (20.25 and 32.74), (13.11 and 16.98) and (17.39 and 24.79). The minimum estimates of coefficient of variation recorded in these following traits plant height (5.99 and 8.93), length of primary mother axis (7.79 and 11.28), silique length (3.84 and 6.78), seeds per siliqua (5.37 and 10.01), days to first flower open (10.00 and 12.74), vegetative phase duration (7.30 and 9.28), days to 50% flowering (6.16 and 10.80), post-anthesis phase duration (6.45 and 8.09) and physiological maturity (0.55 and 1.14). High heritability (board sense) (Fig-1) was observed for test weight (96%) followed by biological yield per plant (87%), seed yield per plant (85%), post-anthesis phase duration (63%), days to first flower open (61%), vegetative phase duration (61%), silliqua on main raceme (56%), silique on primary branches (54%) and number of primary branches (59%).Moderate estimates of heritability recorded in plant height (45%), number of secondary branches (49%),length of primary mother axis(47%), silique on secondary branches (38%), silique length (32%), daysto first flower open (32%). The minimum estimates of heritability recorded in physiological maturity (23%) and seeds per silique (28%). high estimates of heritability was reported for plant height (Chaudhry and Sharma, 1982) [6]. High magnitude of genetic advance estimated for biological yield per plant (79.19) followed bysilique on secondary branches (62.12), silique on primary branches (22.17), plant height(15.18), seed yield per plant (17.90) were earlier reported by which indicated that improvement in this trait could be done through selection for breeding programme. The moderate estimates of genetic advancement were observe in post-anthesis phase duration (8.16) days to first flower open (7.73), harvest index (7.64), length of primary mother axis (7.66), silique on primary mother axis (7.30). The minimum estimates of genetic advance recorded in vegetative phase duration(4.32), days to 50% flowering (4.32), test weight (2.30), number of secondary branches (4.02), silique length (0.21), seeds per silique (0.69), physiological maturity (0.64). High genetic advance as percent of mean with high heritability was observed for seed yield per plant (98% and 85.6) followed by biological yield per plant (94% and 79.19) and test weight (51.76 and 96%) as reported by Mondal and Khajuria (2000) [14].

The association analysis revealed that,in general, the values of genotypic correlations were higher than their phenotypic correlations indicating the inherent association among the traits. Similar findings were also reported by Shah *et al*. (2002) [20], Singh *et al*. (2003) [21] and Joshi *et al*. (2009) [11]. Correlation coefficient analysis revealed (Table-3) that seed yield had significant and positive association with physiological maturity (1.12G & 0.43P), number of secondary branches (1.00G & 0.78P),silique on secondary branches (0.96G &0.57P), number of primary branches (0.95G & 0.67) and biological yield per plant (0.90G & 0.81P),plant height (0.74G & 0.46P), silique on primary mother axis (0.73G & 0.49P),silique on primary branches (0.72G & 0.53P), length of primary mother axis (0.52G & 0.29P) at genotypic and phenotypic levels. Thus, these above said attributes can serve as marker characters for seed yield improvement in mustard. Such positive interrelationships between seed yield and these attributes have also been reported in mustard by Illmulwar *et al*. (2003) [10], Sirohi *et al*. (2004) [23], Kardam and Singh (2005) [12], Acharya (2006) [1], Singh and Singh (2010) [17, 22].

The estimates of minimum positive non-significant correlation with yield for two characters only days to 50 %flowering (0.21G & 015P) and harvest index (0.21G & 0.31P) and six characters were found negative and non-significance genotypic correlation with seed yield/plant viz. silique length (-0.18), number of seeds per silique (-0.11), post-anthesis phase duration (-0.11), days to first flower open (-.09), vegetative phase duration (-0.07) and test weight (-0.06). Similar findings have been given by the following authors Singh and Singh (2010) [17, 22], Shweta and Om Prakash (2014) [18], and Tiwari *et al*. (2017) [3].

Days to physiological maturity, which had significant and positive association with days to 50 per cent flowering, is an important component in identifying and deciding the duration of the crop. Both these traits had positive interrelationship with plant height, number of primary branches per plant, number of secondary branches per plant, length of primary mother axis, silique on primary branches, silique on secondary branches, silique on primary mother axis, biological yield per plant, harvest index and number of seeds per silique at genotypic level. Such relationship may bring collective improvement in different characters and in turn the seed yield. Plant height had significant and positive correlation with days to 50 per cent flowering, days to physiological maturity, number of primary branches per plant, number of secondary branches per plant, length of primary mother axis, number of siliquae on primary branches, number of silique on secondary branches, number of silique on primary mother axis, days to first flower open and biological yield per plant at both levels, which is in accordance with the findings of Pant *et al*. (2002) [16] and Dastidar and Patra (2004) [7] in mustard. Significant and positive association between number of siliquae per plant and biological yield per plant has reported by Joshi *et al*. (2009) [11]. Number of primary as well as secondary branches per plant and number of siliquae per plant had significant and positive correlation among themselves at both levels. These characters were indicating their true relationship with yield.

Conclusion

From the present investigation, it can be concluded that seed yield/plant had significant and positive association with physiological maturity, number of primary as well as secondary branches per plant, silique on primary branches as well as secondary and primary mother axis and biological yield per plantat genotypic and phenotypic levels. 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 selection for higher seed yield in mustard. However, a study of correlation alone is not enough to provide an exact picture of relative importance of direct and indirect influences of each of the component traits on seed yield.

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