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Estimation of character association and path analysis for yield and its sub-characters in Indian Mustard (*Brassica juncea* L. Czern. and Coss)

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Abstract

A field experiment was conducted with twenty-five genotypes/cultivars of Indian mustard were sown in the *Rabi* season 2021-22. Agronomic yield data were collected and analysed for genetic variability, heritability (broad sense), genetic advance, correlation coefficient and path analysis. All sub-characters of yield and yield *per se* had shown highly significant variance except the 1000 seed-weight. All characters exhibited high heritability (h^2 *b.s*) except for maturity (low). Number of siliquae per plant, harvest-index, biological-yield, length of main raceme and plant-height had found a positively significant association, while, in contrast, days to maturity showed a negative value with seed yield per plant. A positive direct effect was found in path analysis for biological yield and harvest index, which was coupled with high heritability. Such traits would be treated as good characteristics during the period of selection of parents. The present investigation was carried out to know the genotypic variation on the characters basis as well as their relationship and outstanding genotypes which would be suggested for their attributes exploitation towards enhancing productivity.

Keywords*: Brassica juncea*, genetic variability, heritability, correlation, path analysis

Introduction

Vegetable oils are the most important food nutrients for growth, development and energy. Indian mustard/*Raya* in Hindi is an allotetraploid species (2n=4x=36, AABB genomes) due to synaptic chromosomal pairing. However, it evolved from six basic chromosomes, ABCDEF. Middle East may be the origin place of this species because it parental primary species *Brassica compestris* (A genome =10, chromosomal composition; AABCDDEFFF) and *Brassica nigra* (B genome =8, chromosomal composition; ABCDDEFF) were, probably, crossed each other followed by chromosomes doubling spontaneously 77 (Robelin, 1960). It spread from there in different parts of the world since cultivation started 5000 B.C. with two centers of diversity; separately as Chinese and Indian (drmr.res.in). According to Vavilove (1926), it originated in eastern Afghanistan and adjoining parts of India & Pakistan. It is predominantly autogamous, but being entomophic nature, an average of 7.5 to 30 per cent outcrossing was observed in natural field conditions (Yadav *et al*, 2021). The global area and production of mustard were estimated at 37.89 million hectares and 73.84 million metric tons, respectively, with 1.95 metric tons per hectare productivity in the marketing year of 2021-2022. (USDA). It shares 75-80% acreage and more than 80-85 per cent production in India among the rapeseed mustard group. It occupied 3^{rd}oilseed crop after soybean and peanut in India. Due to the mustard mission improvement, the rapeseed and mustard production had increased 40 per cent from 91.2 to 128.2 lakh tons in a last three year of period. The uses of this species were in various ways as *sag*, edible oil, condiments, pickles, massage oil, industrial usage, cake as cattle feed/piggery and biofertilizers. Three antinutritional factors in Indian mustard *viz;* erucic acid (40-50%), glucosinolates (180-120 %) and low iodine value (96-107) were reported. Fortunately, mustard oil has 3-6 per cent linolenic fatty acid for health benefits. Oil is a good source of vitamin-C, fibre and Sulphur but has poor cake quality due to the presence of a higher percentage of glucosinolates, which was observed, and furthermore a reduction of glucosinolates in cake done by breeding, which could provide an opportunity to its export in EU and America for pig-industry. North Indian prefer mustard oil due to its pungency in cuisine preparation from thousand and thousand years earlier. Plant height had the maximum grand. The study of the correlation between yield and its components was very important as selection criteria for crop improvement, with further explanation provided in the form of path analysis. The information about GCV, PCV, h^2(broad sense) and genetic advance was also purposeful. Therefore, knowledge of trait associations and path coefficients was essential for the simultaneous improvement of yield and yield components (Wright, 1921). The main objective of screening of the variant genotypes available from different sources regarding the sergeant breeding was taken.

Material and methods

The substances for the existing research consisted of twenty-five lines of Indian Mustard (*Brassica juncea* L. Czern and Coss,) which was collected from DRMR, Bharatpur. All of the 25 genotypes had been grown in a randomized block design (RBD) during *Rabi* 2021-2022 at Nidharia Farm, S.M.M Town (Post Graduate) College, Ballia (U.P.) with three replications. The characters were observed as days to 50 per cent flowering, number of secondary branches, days to maturity, plant height(cm), length of main raceme(cm), number of siliquae on main raceme, biological yield per plant(g), harvest-index (%) and seed yield per plant(g). Randomly selected five competitive plants from per treatment in per replication, data were chosen on a mean basis for observation of the trait. The analysis of variance and covariance was computed (Panse and Shukhatme,1961). While correlation coefficient (Miller *et al,* 1958), path analysis (Dewey and Lu, 1959), and other parameters (Singh and Chaudhary, 2019) were also estimated for above mentioned traits.

Results and discussion

The genotypes were found highly significant for all attributes (P=0.01) except number of primary branches, number of seeds per siliqua and test-weight. Hence, these non-significant characters did not compute further parameter estimates. Although three attributes *viz*. length of main raceme, number of siliquae on main raceme and number of siliquae per plant, also exhibited significant at the block level, probably due to higher experimental error (Table 1). The highest mean and range was accounted for by the number of siliquae per plant, followed by plant height, while the lowest one for the number of secondary branches (Fig-1).

The magnitudes of genotypic coefficient of variance (GCV) were found to be lower than corresponding phenotypic coefficient of variance (PCV) for all ten significant attributes, showing the effect of environment at the expression of genes to yield and its sub-characters. Sprague (1967) reported that the heritability might be noted at different signs and magnitudes with poor precision and hence would be unstable and affected by environmental variance, composed by additive and dominance components in h^2(b.s). He also opined that heritability and genetic correlations for traits were important for population improvements via selection. Highest critical difference (CD) was noted for number of siliquae per plant followed by biological yield, siliquae on main raceme and plant height. Whereas, the lowest one found for secondary branches and days to 50% flowering Table -2 is indicating that few genotypes would have more values over others as better genotypes for the character enhancement.

Table 1- Analysis of variance for 13 characters in Indian Mustard (*Brasica juncea* L.)

Source of variation	f	DF	NSB	DM	PH (cm.)	LMR (cm.)	NSMR	NSPP	SPS	BY (g)	1000 Seed weight (g)	HI (%)	YPP (g)
Replication	2	0.373	0.593	2.08	2.877	8.544**	40.538**	12.161**	0.303	0.986	0.007	1.07	.535
Genotypes	24	27.763**	25.373**	4.269**	312.419**	94.36**	147.691**	5869.384**	1.06	210.036**	0.215	42.295**	1.673**
Error	48	1.457	0.557	2.052	6.329	4.041	7.699	442.71	0.241	8.522	0.082	5.426	.238

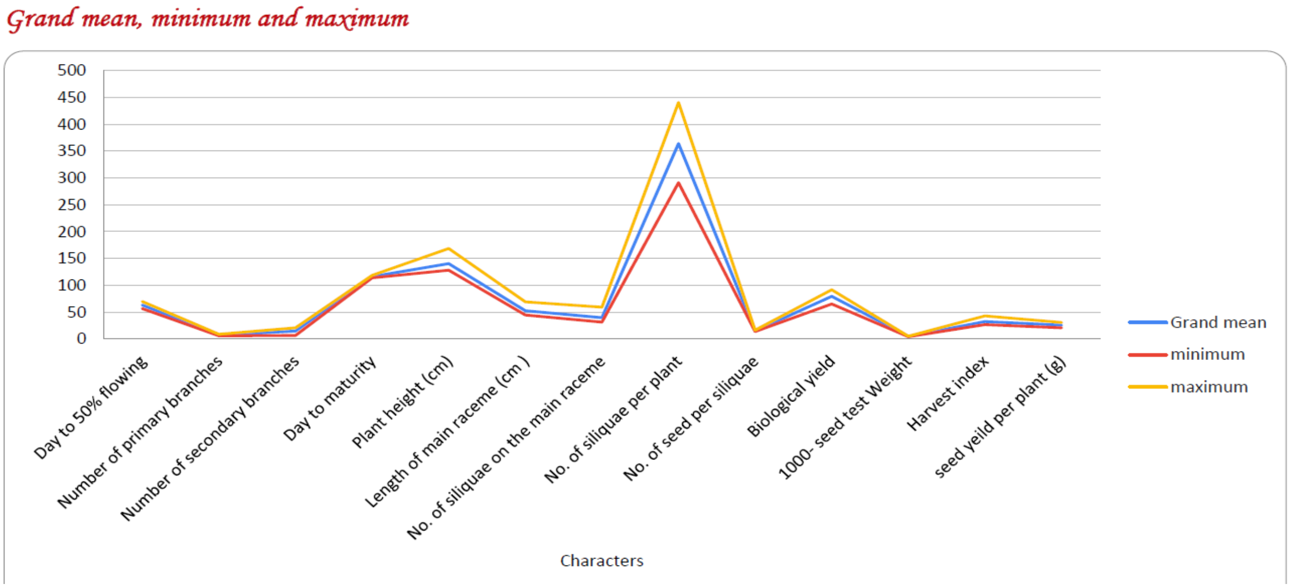

Figure-1

Table 2- Genotypic and phenotypic coefficient of variation, heritability (broad sense), genetic advance in percent of mean in Indian mustard

S. No.	Characters	An	Range		Critical Difference	CV	CV	Heritability (h^2) %	Genetic Advance	Genetic Advance in % of mean
			in.	ax.						
1	Days to 50% flowering	63.34	56.67	70.0	1.98	4.67	5.048	85.75	5.64	8.91
2	No. of secondary Branches	14.86	6.37	20.63	1.22	19.35	19.99	93.69	5.73	38.59

3	Days of maturity	116.28	114.0	118.66	2.35	0.73	1.43	26.47	0.91	0.78
4	Plant height	140.57	128.33	168.73	4.21	7.18	7.40	94.16	20.19	14.36
5	Length of main raceme (cm)	52.72	44.59	69.32	3.28	10.40	11.08	88.16	10.61	20.13
6	No. of siliquae on the mainraceme	39.74	31.40	59.20	4.54	17.18	18.55	85.83	13.03	32.8
7	No. of siliquae per plant	364.31	291.20	440.98	35.19	1.67	3.02	80.33	78.53	21.55
8	Biological yield (g)	79.53	65.13	91.80	4.88	10.3	10.93	88.74	15.9	19.99
9	Harvest index (%)	32.27	26.83	43.11	3.89	10.86	13.04	69.37	6.01	18.63
10	Seed yield per plant (g)	25.59	20.90	30.667	2.48	12.23	13.56	81.42	5.82	22.74

A high heritability (broad sense) was recorded for all characters (69.37 to 94.16) except days to maturity. It is indicated that a higher heritable variance exists among genotypes for the selection purpose except maturity, probably, because winter hot wind was responsible for almost maturity at same time among genotypes. No of siliquae per plant, biological yield and plant height had higher genetic advance but lowest one for maturity period. High heritability coupled with high genetic advance would be preferable parameters during time of parental selection for the hybridization. Genetic variability, heritability and mode of reproduction are primarily essential parameters during operation of suitable segregant selection. The yield and its sub-character association were due to either pleiotropic gene action or gene linkage (Falconer, 1960). Hence the yield, which was positively and significantly correlated with numbers of siliquae per plant, harvest index, biological yield, length of main raceme and plant height at both genotypic and phenotypic levels, respectively. (Table 3.) Were meaningful. However, days to maturity exhibited a negative associationship with seed yield. In general, phenotypic correlation coefficients were lower than the corresponding genotypic ones due to the modifying effects of genes in the environments on the association of the characters. Days to 50 per cent flowering exhibited positive significant associationship with plant height and harvest index but negative for length of main raceme; siliquae number present on it; Number of siliquae per plant and biological yield. The early maturing (-0.432) and tall genotypes having a greater number of secondary branches plus more siliquae number at main raceme (0.360) with high biological yield (0.453) but poor harvest-index and days to maturity (due to positive and negative associationship with respective attributes) are important attributes. Similarly, number of siliquae on the main raceme and length of main raceme also shown positive correlation coefficient with its biological yield (0.316) and (0.347), respectively at genotypic level. While, harvest-index is negatively correlated with biological yield (-0.292) and siliquae number on main raceme (-0.439). These results were general agreement also somehow with the findings of Singh,1994; Gangapur *et al.* 2009; Lodhi *et al.* 2014; Kumar and Pandey, 2014; Ray *et al.* 2019; Meena *et al.* 2020; Yadav *et al.* 2021; and Narayan *et al.* 2022. If negative association between two variable characters was due to pleiotropic effects, it would be hard to obtain the desired recombinants without mutation breeding. While, if linkage was involved, special breeding programmes are needed to break brown such negative linkages (Al-Jibouri *et.al.*1958). Similarly, Miller and Rawlings (1967) opined that the undesirable correlations could be re-arranged by recurrent selection programmes. The biparental mating are also useful not only to break down the undesirable corrections but significant for new arrangement of genes. A pedigree programme with supercharacter, yield per plant and sub characters of a particular genotype would be the selection criteria. (Kaltsikes and Lee, 1971).

Path analysis results exhibited a highly significant on genotypic coefficient between yield and the rest of the characters, are depicted in Table 4. Positive direct contribution of number of siliquae per plant, harvest- index, biological yield, length of main raceme and plant height were observed, indicating their positive direct role to the seed yield at the time of selection, along with the rest sub-characters. Indirect effects with trace magnitudes were also observed Some indirect effects as days to maturity and biological yield (1.43) or number of siliquae per plant and biological yield (1.378) were exhibited as their main role for the significance of the traits with yield, similar result were also reported by Singh,1994, Khan *et al.* 2019 and Singh *et al.* 2020. The contribution of residual effects, which influenced seed yield per plant was very low (-0.002). Ramanujam and Rai (1963) opined that only correlation and path analysis studies would not provide better combinations of components of yield at high yield levels in *B. campestris,* but Cronstad and Foote (1964) suggested that the direct selection based on yield primarily me out of poor effective than its component character. Brijraj, Narendra Rai, Krishna, Novagold, RH781, Varuna and Pusa Gold were recognized as outstanding genotypes on the totality of all of the above-mentioned attributes. Half seed sowing might be responsible for the reduction of antinutritional factors, reported by breeders.

Table 3- Genotypic and phenotypic correlation coefficient for 10 characters in Indian mustard

Character	DF	NSB	DM	PH (cm)	LMR (cm)	NSMR	NSPP	BY (g)	HI (%)	SYP (g)
DF	**r_g**	-0.140	0.211	0.258*	-0.385**	-0.340**	-0.424**	-0.481**	0.261*	-0.167
	r_p	-0.131	0.124	0.249*	-0.357**	-0.285*	-0.364**	-0.404**	0.163	-0.170
NSB		**r_g**	-0.330**	0.090	0.028	0.360**	0.444**	0.453**	-0.237*	0.158
		r_p	-0.161	0.076	0.011	0.325**	0.393**	0.409**	-0.169	0.125
DM			**r_g**	-0.432**	-0.324**	-0.819**	-0.724**	-0.936**	0.307**	-0.510**
			r_p	-0.215	-0.147	-0.378**	-0.326**	-0.474**	0.034	-0.346**
PH (cm)				**r_g**	0.132	0.270*	0.176	0.260*	0.070	0.276*
				r_p	0.104	0.219	0.157	0.235*	0.046	0.231*
LMR (cm)					**r_g**	0.268*	0.306**	0.438**	-0.031	0.338**
					r_p	0.262*	0.198	0.347**	0.022	0.294**
NSMR						**r_g**	0.215	0.395**	-0.439**	-0.063
						r_p	0.151	0.316**	-0.294**	-0.043
NSPP							**r_g**	0.901**	-0.052	0.710**
							r_p	0.866**	-0.112	0.606**
BY (g)								**r_g**	-0.292**	0.592**
								r_p	-0.338**	0.497**
HI (%)									**r_g**	0.596**
									r_p	0.640**

**: Highly significant *: Significant

Table 4 - Direct and indirect effects of different characters in Indian mustard

Character	DF	NSB	DM	PH (cm)	LMR (cm)	NSMR	NSPP	BY (g)	HI (%)	Correlation coefficient of Seed yield
DF	-0.175	-0.005	-0.046	0.029	-0.021	0.124	0.477	-0.735	0.376	-0.167
NSB	0.024	0.040	0.072	0.009	0.001	-0.132	-0.500	-0.692	-0.341	0.158
DM	-0.037	-0.013	-0.218	-0.045	-0.017	0.300	0.816	-1.431	0.442	-0.510**
PH (cm)	-0.050	0.003	0.094	0.104	0.007	-0.099	-0.198	0.398	0.101	0.276**
LMR (cm)	0.067	0.001	0.070	0.013	0.055	-0.098	-0.345	0.669	-0.044	0.338**
NSMR	0.059	0.014	0.179	0.028	0.014	-0.367	-0.242	0.604	-0.631	-0.063
NSPP	0.074	0.017	0.158	0.018	0.016	-0.078	-1.127	1.378	-0.074	0.710**
BY (g)	0.084	0.018	0.204	0.027	0.024	-0.144	-1.015	1.530	-0.421	0.529**
HI (%)	-0.045	-0.009	-0.067	0.007	-0.001	0.161	0.058	-0.447	1.440	0.596**

Residual effect - 0.00236

Conclusion

In the present investigation, genetic variability, heritability, considering correlations and path coefficient analyses it would be concluded that number of siliquae per plant, harvest- index, biological- yield, length of main raceme and plant height were the most important attributes for improvement of seed yield per plant in mustard if a breeder considers then as their selection criteria.

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