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Analysis of genetic parameters and correlation for yield and quality traits in Indian mustard (*Brassica juncea* L.)

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Abstract

A set of 53 Indian mustard (*Brassica juncea* L) genotypes that include 40 crosses and 13 parents were evaluated for genetic variability and correlation for yield and quality traits during the *Rabi* season of 2014-15. The crosses were developed in line x tester design involving 8 lines and 5 testers (quality trait donors) during *Rabi* 2013-14.The study was undertaken to generate genetic information for seed yield per plant (g),1000-seed weight (g), days to maturity, oil content (%), saturated fatty acid (%), oleic acid (%), linoleic acid (%), linolenic acid (%), erucic acid (%) and glucosinolate content (µmoles/g of oil-free seed meal). Moreover, magnitude of relationships among these characters was also measured. Significant differences were observed for all the characters among the genotypes, which revealed the presence of sufficient variability for the characters. The phenotypic coefficient of variation (PCV) for all the characters was found to be higher than genotypic coefficient of variation (GCV). High PCV for erucic acid, oleic acid and glucosinolate content showed the significance of additive gene action. High heritability estimates coupled with high genetic advance as per cent of mean recorded for erucic acid and oleic acid also indicated the significance of additive genes action for the inheritance of these traits. Among the different characters seed yield per plant recorded lowest heritability estimates and low genetic advance indicating predominance of non-additive gene effects for this trait. Oleic acid was found negatively and significantly correlated with erucic acid (-0.893**) and oil content (-0.639**), while it had significant and positive correlation with linoleic acids (0.837**) and days to maturity (0.622**). Erucic acid was negatively and significantly correlated with the rest of the fatty acids. It had positive association with oil content (0.600**). Breeding for the development of lines with high oleic acid should be focused owing to its high extent of variability, heritability, genetic advance and negative correlation with erucic acid.

Key words: *Correlation, genetic variability, Indian mustard, quality traits, seed yield*

Introduction

Oilseed brassicas occupy a prominent position as second most important oilseeds in the world as well as in India. It is cultivated in about 5.76 million hectare area and 6.82 million tonnes seeds are produced with an average productivity of 1184 kg/ha (Anonymous, 2016) in India. *Brassica juncea* also known commonly by the name of Indian mustard is the most predominantly cultivated oilseed brassica crops in India and accounts more than 90% area as well as production.

The nutritional quality of oil and seed meal derived from seeds of *Brassica* is determined by the quality and quantity of fatty acids, proteins and essential amino acids. The seed of Indian mustard contains about 35-45% oil with high levels of erucic acid and glucosinolate in seed meal.The oil extracted from Indian mustard has lowest concentration (approx. 7%) of saturated fatty acids with higher proportion of unsaturated fatty acids *viz*. oleic (C18:1), linoleic (C18:2) and linolenic (C18:3) acid. Of the total fatty acids, there is predominance of erucic acid (C22:1) fraction (35.7-51.4%) in traditional varieties of Indian mustard (Chauhan *et al.,* 2007). Consumption of higher amount of mustard oil having high erucic acid (>20%), causes myocardial fibrosis, impaired myocardial conductance, lipidosis, etc. and also increases blood cholesterol (Ackmn *et al.,* 1977). Therefore, reduction in erucic acid is one of the important objectives in quality amelioration of Indian mustard seed oil. Also increase in oleic acid content in oil is highly desirable due to its less vulnerability to oxidation, as well as its effectiveness in reducing the total blood cholesterol level (Mattson and Grundy, 1985; Liu *et al*., 2002).

The seed meal of Indian mustard contains high quality proteins with well balanced amino acids compositions.

However, presence of high level of glucosinolate (49.9-120.3 µM/g of oil-free seed meal) (Chauhan *et al.*, 2007), limits its utilization as feed for livestock and poultry. The intact glucosinolate is harmless but after hydrolysis it splits into isothiocynates and nitriles, which reduces the feed palatability and affect the iodine uptake by the thyroid (Fenewick *et al.*, 1983). Hence, extensive breeding efforts are required to develop lines high in oleic acid (>60%), low in erucic acid (<2%) as well as low in glucosinolate (< 30 µM/g of oil free seed meal).

A successful crop improvement programme for specific trait through selection requires genetic variability among the genotypes in association with high heritability. Correlation studies provide a better understanding of the association among different characters, which help breeders to formulate an appropriate breeding strategy to improve a number of traits simultaneously. Main thrust in breeding of Indian mustard is to enhance its seed yield along with good oil and meal quality. These important traits of Indian mustard are influenced by the environment because of their polygenic nature (Yadava *et al.*, 2011, Chauhan *et al.*, 2011). Knowledge of correlations between the seed yield and quality traits is of great importance for a successful breeding programme. Keeping all these facts in view, a study was carried out for determining the parameters of genetic variability and correlation among morphological and quality traits in Indian mustard.

Materials and Methods

The experimental materials used in the present study comprised of 13 diverse parents of Indian mustard including 8 lines *viz.* NRCHB-101, NRCDR-02, Kranti, Pusa Bold, Shivani, Pusa Mustard-25, BAUSM-92-1-1, BAUM 2007 and 5 testers (quality trait donors) *viz.* Pusa Mustard-21, Heera, EC552577, RLC-1 and NUDHYJ-5 crossed in line x tester mating design at Birsa Agricultural University, Ranchi during *Rabi* 2013-14. The 40 crosses along with 13 parents were evaluated during *Rabi* 2014-15 in randomized block design with two replications. Each treatment was raised in a single row of 5 m length kept at a distance of 30 cm between rows and 15 cm between plants. Standard agronomic practices were followed to raise the crop (N:P:K:S::80:40:40:40 kg/ha; four irrigations including pre sowing). Observations were recorded on randomly selected five competitive plants for three morphological traits *viz.* seed yield per plant (g) and 1000-seed weight (g) and days to maturity as well as for seven quality traits *viz.* oil content (%), glucosinolate content (µmoles/g of oil-free seed meal), saturated fatty acid (%), oleic acid (%), linoleic acid (%), linolenic acid (%) and erucic acid (%).

Determination of oil content and seed meal preparation

The seeds were thoroughly ground in a pestle and mortar and 10.0 g triplicates of ground seeds were extracted with hexane for 24 h in a Soxhlet apparatus (AOAC, 1997). Subsequently, hexane was removed from the oil by rotary evaporator under reduced pressure and the weights of the residual oils were calculated. The seed meal remaining after the extraction of total oil was preserved for estimation of glucosinolate.

Estimation of glucosinolate

Total glucosinolate content in the seed meal was estimated by complex formation between glucosinolate and sodium tetrachloropalladate solution. The intensity of the color produced was measured using spectrophotometer at 405 nm (Kumar *et al*., 2004).

Fatty acid analysis by Gas Liquid Chromatography (GLC)

Methyl esters of oil samples were prepared by transesterification according to the method described by Sarin *et al*. (2009) with slight modifications. 1.0 µl of the methyl ester sample was injected into SP 2300 + 2310 SS column. A Nucon model 5765 gas chromatograph equipped with flame ionization detector (FID) was used. The oven, injector and detector temperature were 240 °C, 230 °C and 250 °C, respectively. The carrier gas was nitrogen, at flow rate of 40-50 ml/min. Peaks of fatty acid methyl esters were identified by comparing their retention time with that of the known standards run under similar separation conditions. Individual fatty acids were expressed as percentage of the total fatty acids.

Analysis of variance (ANOVA) was calculated according to the formula described by Panse and Sukhatme (1978) and critical differences (CD) were determined at 5 and 1% probability level. Estimation of phenotypic and genotypic coefficient of variation, heritability in broad sense, genetic gain, and correlation coefficient between seed yield per plant and quality parameters were determined using Windostat version 8.5 software.

Results and Discussion

Analysis of variance over the environments of 53 genotypes including 13 parents and 40 crosses of Indian mustard revealed that these genotypes vary significantly for all the morphological and quality traits, which in turn indicated that selection for the traits responsible for high yield potential as well as for high oil and seed meal quality can be made effectively in the breeding material evaluated

Table 1: Estimates of different genetic parameters of variation in Indian mustard.

Characters	Mean ± SEM	Range	CD		GCV	PCV	h^2_b	Genetic
			(P=0.05)	(P=0.01)	(%)	(%)	(%)	advance as % of mean (1%)
Glucosinolate (µM/g of oil-free seed meal)	68.28±0.32	26.37-103.20	0.92	1.22	30.93	30.94	0.99	63.71
Saturated fatty acid (%)	3.64±0.12	2.95-7.35	0.34	0.46	20.75	21.25	0.95	41.73
Oleic acid (%)	16.34±0.22	10.10-30.88	0.63	0.85	33.53	33.59	0.99	68.98
Linoleic acid (%)	22.33±0.14	16.85-28.14	0.39	0.52	16.40	16.42	0.99	33.73
Linolenic acid (%)	16.73±0.22	13.70-20.42	0.63	0.85	10.36	10.52	0.97	21.02
Erucic acid (%)	21.75±0.23	1.50-41.26	0.65	0.87	47.86	47.89	0.99	98.55
Oil content (%)	40.81±0.31	38.42-42.39	0.91	1.22	2.15	2.40	0.80	3.94
Days to maturity	122.78±1.32	111.50-129.00	3.79	5.09	2.67	3.07	0.76	4.78
1000 – seed weight (g)	3.80±0.13	2.04-6.05	0.36	0.48	22.45	22.93	0.96	45.29
Seed yield/plant (g)	6.61±0.83	2.98-9.98	2.40	3.23	15.77	23.82	0.44	21.51

in present study. A wide range of variation was observed in terms of estimates of mean and range for all the characters studied (Table 1). The most prominent range was obtained for erucic acid (1.50-41.26), glucosinolate (26.37-103.20), oleic acid (10.10-30.88) and days to maturity (111.5-129.0). On the other hand, characters like saturated fatty acid and 1000-seed weight exhibited narrow range of variation. The estimates of genotypic and phenotypic coefficients of variation were considerably high for erucic acid and oleic acid and glucosinolate content. High genotypic coefficient of variation for erucic acid (47.86), oleic acid (33.53) and glucosinolate content (30.93) provide good opportunity for selecting genotypes with desirable level of the fatty acids and glucosinolates. The phenotypic coefficient of variation (PCV) exhibited higher values than genotypic coefficient of variation (GCV) for all the characters, indicating environmental factors influencing their expression to some degree. Similar pattern of high genotypic and phenotypic coefficients of variation for fatty acids have also been reported by Kumar (2013) in Indian mustard. The estimates of PCV and GCV alone are not much helpful in determining heritable portion of the trait. The accountability of phenotypic value is proved by estimating heritability, which acts as a predictive instrument to express the phenotypic value. The amount of genetic advance to be expected from selection can be achieved by estimating heritability along with coefficient of variation. In the present study, the estimates of heritability (broad sense) varied from 44 % for seed yield per plant to 99% for glucosinolate content, oleic acid, linoleic acid and erucic acid. These results indicated that these characters are less influenced by the environmental factors and direct selection for these characters would be effective for further improvement. The results resembles to the findings of Chauhan *et al.* (2002). The high genetic advance was observed for erucic acid (98.6%), oleic acid (69.0%), and glucosinolate content (63.7%), while the remaining characters showed moderate to low genetic advance. High genetic advance may be expected when heritability is explained largely by the additive effect of genes (Panse, 1957). In the present study, high heritability was associated with high genetic advance for erucic acid, oleic acid and glucosinolate content suggesting the role of additive gene action in the inheritance of these characters. Similar observations were also being realized by Kumar *et al.* (2013). On other hand, character like seed yield per plant, oil content and days to maturity exhibited low heritability estimates along with low genetic advance, thereby, limiting the chances of improvement of these characters by simple selection.

The genotypic and phenotypic correlations were estimated for yield and quality traits in all possible combinations. The highly significant coefficient of correlation among the characters ranged from -0.478** to -0.893** (Table 2). Genotypic correlations were, in general, higher than phenotypic correlations. Seed yield per plant showed positive and significant correlations with 1000-seed weight (0.369*) and glucosinolate content (0.607**). 1000-seed weight also showed positive and highly significant correlations glucosinolate content (0.638**). The significant and positive correlation of glucosinolate content with 1000-seed weight was also reported earlier by Priyamedha *et al.* (2014). Oil content showed positive and highly significant correlations with erucic acid (0.600**).

The fatty acid profile and relative proportion of saturated and unsaturated fatty acids determine oil quality, whereas, glucosinolate content determine the quality of seed meal. Saturated fatty acids had positive and significant

Table 2: Genotypic (rg) and phenotypic (rp) correlation coefficients between different morphological and quality traits in Indian mustard.

Characters		GLS	SFA	OA	LA	LNA	EA	OC	DM	TW	SY/P
GLS	rg	1.000	0.167	-0.110	-0.139	0.033	0.252	-0.323	-0.403*	0.638**	0.607**
	rp	1.000	0.163	-0.109	-0.139	0.032	0.252	-0.288	-0.347*	0.623**	0.401**
SFA	rg		1.000	0.615**	0.724**	0.266	-0.478**	-0.662**	0.167	0.017	0.164
	rp		1.000	0.605**	0.710**	0.244	-0.468**	-0.564**	0.173	0.018	0.118
OA	rg			1.000	0.837**	0.305	-0.893**	-0.639**	0.622**	-0.249	-0.235
	rp			1.000	0.834**	0.300	-0.890**	-0.577**	0.546**	-0.245	-0.143
LA	rg				1.000	0.516**	-0.859**	-0.629**	0.541**	-0.276	-0.021
	rp				1.000	0.507**	-0.857**	-0.554**	0.476**	-0.268	-0.015
LNA	rg					1.000	-0.380*	-0.406*	0.158	0.087	-0.022
	rp					1.000	-0.374*	-0.366*	0.119	0.077	-0.024
EA	rg						1.000	0. 600**	-0.686**	0.314	0.206
	rp						1.000	0.530**	-0.596**	0.307	0.139
OC	rg							1.000	-0.277	-0.339	-0.153
	rp							1.000	-0.187	-0.296	-0.125
DM	rg								1.000	-0.334	-0.322
	rp								1.000	-0.291	-0.115
TW	rg									1.000	0.369*
	rp									1.000	0.350*
SY/P	rg										1.000
	rp										1.000

GLS: Glucosinolate (µM/g of oil-free seed meal), SFA: Saturated fatty acid (%), OA: Oleic acid (%), LA: Linoleic acid (%), LNA: Linolenic acid (%), EA:
Erucic acid (%), OC: Oil content (%), DM: Days to maturity, TW: 1000 – seed weight (g), SY/P: Seed yield/plant (g)

association with oleic acid (0.615**) and linoleic acid (0.724**) while, their association with erucic acid (-0.478**) and oil content (-0.662**) was negative and significant. Oleic acid was found correlated significantly and positively with linoleic acid (0.837**) and days to maturity (0.622**). Oleic acid had highly significant and negative association with erucic acid (-0.893**) and oil content (-0.639**). The negative relationship between erucic and oleic acid has also been reported earlier (Zhou and Liu, 1987; Singh *et al.*, 2001; Meena, 2006 and Kumar, 2013). Similarly, linoleic acid and linolenic acid exhibited significant but negative correlation with erucic acid (-0.859**; -0.380*) and oil content (-0.629**; -0.406*). Similar pattern of correlation among these traits have also been reported by Singh *et al.* (2001), Kumar *et al.* (2013) and Meena *et al.* (2014).

Holland (2006) observed that genetic correlations between traits are due to linkage and/or pleiotropy. He also emphasized the relative efficiency of correlations in indirect selection of traits. The present findings indicate that since the traits are highly correlated, correlations based selection may be practiced for indirect selections for genotypes with high quality of oil and seed meal. The biggest challenge in breeding for quality in Indian mustard is to unite quality traits with high seed yield, as all are quantitative traits governed by multiple genes. In present study, positive and significant correlation of glucosinolate content with 1000-seed weight and erucic acid with oil content confirms the reduction in seed size and oil content in double low varieties compared to non quality varieties of Indian mustard. On the basis of present study, more attention should be paid on enhancement of the percentage of oleic acid and reduction of erucic acid, owing to their high extent of variability, heritability and genetic advance. The results suggest breeding for quality enhancement should be focused on development of lines with high oleic acid and low erucic acid percentage in oil.

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