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Environmental effects on genetic parameters for oil and seed meal quality components of Indian mustard (*Brassica juncea* L.)

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Abstract

The effects of environmental factors on genetic parameters for oil, protein content, fatty acid profile and glucosinolate content in a set of Indian mustard (*Brassica juncea* L.) varieties and their interrelationships were studied. The growing environments greatly influenced the estimates of phenotypic and genotypic coefficient of variation, heritability and genetic advance. The highest and the lowest PCV were observed for eicosenoic acid (15.7-34.6%) and oil content (2.1-4.1%) in different growing seasons. The genetic variability, in general, over the 3 growing seasons was the highest for eicosenoic acid followed by saturated fatty acid and linolenic acid. Erucic acid, by and large, consistently expressed high heritability estimates (> 70.0%) while eicosenoic acid showed moderate heritability irrespective of the growing seasons. The saturated fatty acids (SFA), linoleic, linolenic and eicosenoic acid consistently showed moderate to high genetic advance over the growing seasons. Low to moderate heritability associated with moderate to high genetic advance for linoleic, linolenic and eicosenoic acid suggested the pre-dominance of non-additive gene effects in the expression of these characters. None of the characters investigated showed a consistent pattern of association over the 3 cropping seasons. Erucic acid showed negative and significant relationship with oleic and linoleic acid.

Key words: Environmental effects, genetic parameters, oil, protein, glucosinolate content, fatty acid profiles, Indian mustard

Introduction

Indian mustard (*Brassica juncea* L.) is an important oilseed crop in India. Besides seed yield; improving oil and seed meal quality is foremost in the mustard-breeding programme. Oil quality is judged by the fatty acid profile, whereas, glucosinolate content determines the quality of seed meal. Quality indices as with other characters of yield are usually influenced by the environmental conditions besides the genotypic background. Knowledge of genetic parameters for different quality indices and the relative contribution of environmental factors to the expression of the characters would enable breeders to adopt appropriate selection strategy in the breeding programme for their improvement. Estimating genetic parameters in a single growing year/location may lead to biased estimates. Therefore, it is pertinent to estimate the genetic parameters in diverse environments to obtain precise information regarding the genetic architecture of the target characters. Such information for oil and seed meal quality characters of Indian mustard is lacking. Hence the present investigation attempts to obtain information on the consistency of genetic parmeters for oil, protein, fatty acid profile and glucosinolate content over different growing seasons.

Materials and methods

The experimental material consisted 25 varieties of Indian mustard (Basanti, Bio 902, CS 52, GM 1, GM 2, Kranti, Krishna, Pusa Bahar, Pusa Bold, Pusa Jagannath, PBR 91, PBR 97, P CR 7, RCC 4, RH 781, RH 8113, RH 819, RH 30, RL 1359, RH 8812, Rohini, Sunjucta Asech, Sej 2, Vardan and Varuna) grown in randomized complete block design during 2003-04, 2004-05 and 2005-06 *rabi* seasons with three replications in 5-row plot of 5 m length, keeping 45 cm row–to-row and 15 cm plant-to-plant spacing. The experiment was conducted at 80: 40: 40 kg/ha of N: P_2O_5 : K_2O. Half the dose of nitrogen and full doses of P_2O_5 and K_2O were given basally at the time of sowing and the remaining dose of nitrogen was top dressed after first irrigation (35 days after sowing). The crop was

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also irrigated at 60 days after sowing. The observations were recorded on composite sample from the central three rows. The oil and protein content were measured using a pre-calibrated NIR Analyzer (Dicky John Instalab 600) as described by Kumar *et al.* [1]. Fatty acid profiles of oil were analyzed by gas liquid chromatography (Nucon Model 5765) using SP 2300+2310 SS columns [2]. Individual fatty acids were identified on the basis of comparison of retention times with the standard samples and expressed as the percentage of total fatty acids present in the oil. Total glucosinolate content in the seed meal was estimated by complex formation between glucosinolates and sodium tetrachloropalladate solution. The intensity of the color produced was measured using ELISA reader at 405 nm [3]. Hyola 401, a double low hybrid of gobhi sarson and Varuna, non-canola variety of Indian mustard were used as checks for the analysis of glucosinolate and fatty acid profile.

The mean values were used for analysis of variance using multiple randomized complete block design by indostat software to investigate the effects of genotype, environment (years) and genotype x environment interactions. The genotypic (GCV) and phenotypic coefficients of variation (PCV) and expected genetic advance at 5 % selection intensity [4] the estimation of heritability in broad-sense (h^2) [5] and simple correlation coefficients among quality characters were worked out as per the standard procedures [6].

Results and discussion

Analysis of variance revealed highly significant differences due to genotypes, environments and genotype x environment interactions (Table 1) suggesting that the genotypes differed significantly among themselves for oil, protein, glucosinolate content and fatty acid profile. Further, all the characters studied were highly influenced by the environmental factors and genotypes performed differentially in the three environments. The growing environments largely influenced the estimates of PCV and GCV. The highest and the lowest PCV were observed for eicosenoic acid (15.7-34.6%) and oil content (2.1-4.1%) in different growing seasons. The GCV was, in general, lower than PCV in all the 3 growing seasons. The genetic variability in the present set of genotypes was low for oil and protein content irrespective of the growing seasons. Eicosenoic acid during the 2004-05 growing season exhibited the highest PCV and GCV. The genetic variability, in general, over the 3 growing seasons was the highest for eicosenoic acid followed by saturated fatty acid and linolenic acid (Table 2). Nevertheless, such estimates varied substantially in different growing seasons. In earlier studies also [7] low variability was reported for oil and protein content, whereas, eicosenoic acid and SFA showed appreciable variation.

The heritability estimates ranged from 50% for eicosenoic acid to 92% for oil content during 2003-04 growing season (Table 2), from 23.9 % (oleic acid) to 91.4% (glucosinolate content) in 2004-05 and 47.3 % (oil content) to 71.9% (erucic acid) in 2005-06 cropping season. The results revealed that heritability estimates were greatly influenced by the environmental factors. Erucic acid, by and large, consistently expressed high heritability estimates (> 70.0%) and eicosenoic acid showed moderate heritability (50.0-53.5%) irrespective of the growing seasons. During the 3 cropping seasons glucosinolate content exhibited moderate to high hertiability. A wide variability ranging from low to very high in heritability estimates was recorded for the remaining characters (Table 2). The genetic advance as per cent of mean varied from 4.6 (protein content) –26.7 (linoleic acid), 3.7 (oil and protein content) –37.8

Table 1. Pooled analysis of variance for oil, protein content, fatty acid profile and glucosinolate content in Indian mustard

Sources of variation	d. f.	Mean sum of squares								
		Oil content	Protein content	SFA[a]	Oleic acid	Linoleic acid	Linolenic acid	Eicosenoic acid	Erucic acid	Gluco-sinolate content[b]
Environments	2	16.68**	1.10**	23.81**	30.19**	39.67**	26.59**	28.68**	12.26**	6.96**
Replication	2	4.32**	0.26	2.25*	0.50	1.30**	0.25	1.86**	0.84**	0.30
Genotypes	24	25.10**	27.14**	10.16*	18.32**	19.97**	23.69**	17.67**	47.29**	11.5
Env*Gen	48	26.80**	64.32**	27.44**	26.59**	24.61**	24.19**	28.95**	32.63**	24.38
Error	148	27.10	7.20	36.34	24.41	14.45	24.67	22.83	6.98	56.85

[a]SFA: saturated fatty acid (palmitic + stearic acid) ; [b]µ moles / g defatted seed meal ; * and **: Significant at P = 0.05 and P = 0.01, respectively

(eicosenoic acid) and 2.0 (oil content)- 17.8 (linoleic acid) during 2003-04, 2004-05 and 2005-06 cropping season, respectively. Low genetic advance was evident for oil and protein content consistently over the growing seasons. This could be due to limited variability in the present set of genotypes for these two characters. The SFA, linoleic, linolenic and eicosenoic acid consistently showed moderate to high genetic advance over the growing seasons (Table 2). Low to moderate heritability associated with moderate to high genetic advance for linoleic, linolenic and eicosenoic acid suggested the predominance of non-additive gene effects in the expression of these characters. The other characters such as oleic, erucic and glucosinolate content had widely variable estimates of genetic advance in the three growing seasons. The study suggested greater role of non-additive gene action in the inheritance of these characters.

The correlation coefficients among different quality components were also largely affected by the growing seasons. None of the characters investigated showed a consistent pattern of association over the 3 cropping seasons. However, erucic acid showed negative and significant relationship with oleic and linoleic acid during 2003-04 and 2004-05 growing seasons (Table 3). During the growing season of 2005-06, protein content had negative and significant correlations with linolenic and eicosenoic acid, whereas, its association was positive and significant with linoleic acid (r = 0.416*). The relationships of linoleic acid were negative and significant with linolenic (r = -0.579**) and eicosenoic acid (r = -0.464*) in the cropping season of 2005-06. Similarly, linolenic and eicosenoic acid showed growing season specific association with erucic acid.

Table 2. Effect of different growing seasons on phenotypic (PCV), genotypic variability (GCV), hertitability and genetic advance as percentage of mean for oil and seed meal quality traits in Indian mustard

Character	Year	Range	Mean ± SEM	PCV (%)	GCV (%)	Heritability(%)	Genetic advance
Oil content (%)	2003-04	37.1- 42.4	39.5 ± 0.23	3.6	3.4	92.0	6.8
	2004-05	36.3- 42.1	38.8 ± 0.68	4.1	2.7	44.5	3.7
	2005-06	38.5-41.4	40.3 ± 0.35	2.1	1.4	47.3	2.0
Protein content (%)	2003-04	19.1-21.2	20.0 ± 0.26	3.6	2.8	61.5	4.6
	2004-05	17.6-21.5	19.5 ± 0.66	6.8	2.7	44.5	3.7
	2005-06	19.0-20.9	20.1± 0.39	3.7	1.6	17.4	1.3
SFA[a] (%)	2003-04	2.2-4.7	3.2 ± 0.29	22.6	16.0	50.3	23.4
	2004-05	2.6-5.5	3.7 ± 0.66	38.3	11.5	9.0	3.3
	2005-06	3.2-6.2	4.5 ± 0.39	19.8	12.9	43.3	17.7
Oleic acid (%)	2003-04	8.0-18.5	14.9 ± 0.97	18.6	14.7	63.1	24.1
	2004-05	8.1-15.0	11.4 ± 1.41	23.5	11.9	23.5	9.1
	2005-06	11.0-15.3	12.4 ± 0.47	10.2	7.8	59.3	11.0
Linoleic acid (%)	2003-04	16.9-23.6	20.7± 0.48	14.1	13.5	91.8	26.7
	2004-05	10.9-24.1	17.8 ± 1.54	20.2	13.5	44.6	20.2
	2005-06	12.0-17.6	15.6 ± 0.48	10.0	8.4	71.1	17.8
Linolenic acid (%)	2003-04	7.4-16.2	12.7 ± 0.95	20.2	15.5	58.7	24.4
	2004-05	11.2-19.4	15.8 ± 1.06	17.0	10.1	35.6	12.4
	2005-06	10.8-15.8	13.4 ± 0.54	11.8	9.5	64.6	15.7
Eicosenoic acid (%)	2003-04	4.7-7.8	6.1 ± 0.43	17.2	12.2	50.0	17.7
	2004-05	3.7-10.1	6.5 ± 0.89	34.6	25.2	53.0	37.8
	2005-06	5.9-10.7	8.4 ± 0.52	15.7	11.5	53.5	17.3
Erucic acid (%)	2003-04	37.2-49.6	42.4 ± 1.27	9.5	8.2	74.4	14.5
	2004-05	37.2-54.3	44.3± 0.64	8.3	7.9	90.8	15.4
	2005-06	40.4-46.9	44.6 ± 0.60	4.4	3.7	71.9	6.5
Glucosinolate content [b]	2003-04	81.7-115.3	96.9 ± 1.27	7.9	7.6	91.7	14.9
	2004-05	90.7-122.3	102.6 ± 1.30	7.0	6.7	91.4	13.1
	2005-06	72.1-113.4	100.2 ± 1.91	5.4	4.3	62.9	7.0

[a]SFA: Saturated fatty acids(palmitic + stearic acid); [b]µ moles / g defatted seed meal

Table 3. Environmental influence on correlations among quality components in Indian mustard

Character	Year	Correlation coefficient (r)						
		Oil content	Protein content	SFA	Oleic acid	Linoleic acid	Linolenic acid	Eicose-noic acid
Protein content	2003-04	-0.016						
	2004-05	-0.333						
	2005-06	-0.105						
SFA	2003-04	-0.300	-0.075					
	2004-05	0.200	-0.010					
	2005-06	-0.171	0.061					
Oleic acid	2003-04	-0.143	-0.113	-0.329				
	2004-05	0.166	-0.116	-0.083				
	2005-06	0.031	-0.316	-0.177				
Linoleic acid	2003-04	-0.387	0.164	0.082	0.115			
	2004-05	-0.060	0.026	0.100	0.042			
	2005-06	-0.296	0.416*	-0.041	-0.112			
Linolenic acid	2003-04	-0.122	0.074	-0.006	-0.116	0.005		
	2004-05	0.021	-0.009	-0.092	-0.394	0.035		
	2005-06	-0.080	-0.431*	0.111	-0.190	-0.579**		
Eicosenoic acid	2003-04	0.300	0.008	-0.100	-0.003	-0.370	-0.181	
	2004-05	0.129	-0.101	0.107	-0.130	-0.095	-0.161	
	2005-06	0.247	-0.456*	-0.190	-0.112	-0.464*	0.424*	
Erucic acid	2003-04	0.414*	0.067	-0.089	-0.642**	-0.507**	-0.412*	0.083
	2004-05	-0.047	0.186	-0.027	-0.420*	-0.528**	-0.193	-0.286
	2005-06	0.277	0.481*	-0.238	-0.379	-0.003	-0.364	-0.410*

* and **: Significant at P = 0.05 and P = 0.01, respectively

The present investigation revealed that genetic parameters like genetic variability, heritability and genetic advance along with associations among quality characters were greatly affected by the environmental factors but to varying levels. Therefore, genotypes should be evaluated during different cropping seasons/ locations to identify suitable donors for quality characters for utilization in the breeding programme.

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