International Journal of Agricultural Sciences
Volume **10** | Issue 1| January, 2014 | 146-150 ***RESEARCH PAPER***

Genetic analysis for oil content and oil quality traits in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]

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Abstract : Heterosis and combining ability was estimated for oil content and oil quality traits in Indian mustard with the help of line x tester matting design of total 34 accessions comprised of ten parental genotypes (six female and four male) and their 24 F_1 hybrids of Indian mustard at S.D.Agricultural University, Sardarkrushinagar. Eight hybrids recorded significant and positive heterobeltiosis for oil yield. The range of heterobeltiosis varied from -9.48 per cent (SKM-9033 x GM 2) to 6.96 per cent (BPR-610-50-6 x VARUNA). Parent PUSA BOLD was proved to be good donors for oil content, linolenic acid and glucosinolate. PBR-122 for oil content, oleic acid, linolenic acid, erucic acid and glucosinolate, PCR-7 good combiner for erucic acid, SKM-9033 having good gene for increasing oleic acid and linoleic acid content. Parent BPR-610-50-6 good for oil content, oleic acid, linolenic acid and glucosinolate. The hybrid SKM-9033 x VARUNA pursued by BPR-610-50-6 x VARUNA and BIO-902 x PUSA BOLD and SKM-9820 x GM 2 proved high sca effects for oil content.

Key Words : Line x tester, Combining ability, Heterosis, Oil content, Quality traits

View Point Article : Gami, R.A. and Chauhan, R.M. (2014). Genetic analysis for oil content and oil quality traits in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]. *Internat. J. agric. Sci.*, **10** (1): 146-150.

Article History : Received : 06.04.2013**; Revised :** 03.10.2013**; Accepted :** 30.10.2013

INTRODUCTION

The rapeseed-mustard is second most important edible oilseed crop of the world as well as of India after groundnut. Oilseed *Brassica* rapeseed and mustard accounting for over 13.2% of the world's edible oil supply are the third most important edible oil crop after soybean and palm. In India, *Brassica* ranks second in acreage with 4.6 million hectare next to the groundnut only. The *Brassica* have about 40% oil on a dry weight basis and the meal contains 38-44% quality protein. Mustard seed is largely crushed for oil, which is perhaps the cheapest source of oil in our daily diet. Mustard seeds contain about 38-42% oil, which is golden yellow, fragrant and considered among the healthiest and most nutritional cooking medium. The oil cake is the by-product after extraction of oil which is used as manure and also as an excellent animal/poultry feed. Mustard meal or cake contains about 12% oil and 38 to 42% protein (Nagraj, 1995).

Fatty acid composition of oils from different *Brassica* species makes them suitable for both edible and industrial purposes. Rapeseed-mustard oil has substantial amount of unsaturated fatty acids and around 7% saturated fatty acids, the lowest among the oil seed crops. Further, it contains significant amount (20-25%) of essential fatty acids like linoleic (cis, cis-9, 12-octadecadienoic : 18:2 n-6) and linolenic acid (cis, cis, cis-9, 12, 15-octadecadienoic : 18:3 n-3). Linolenic acid is also a sulfur-cholesterol scavenger. The saturated fatty acid palmictic acid (16:0) and stearic acid (18:0) are present in very low quantities totally about 5%. They have been implicated in increasing turombotic tendency in the blood platelets. The oil is also good source of required ratio 3-6 fatty acids and natural antioxidants and known to reduce the risk of cardiac diseases and enhances the quality of life (Shyam Prakash *et al*., 2001). The oil of *B. juncea* crop contains long chain fatty acid erucic acid (cis-1, 3-decasenoic : 22:1, n-9); The Indian cultivated varieties have high erucic acid in seed oil, which is nutritionally undesirable and have low oleic acid, while, high oleic is required for

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extended shelf life. The presence of high erucic acid in oil is considered antinutritional, as it has been reported to cause lipidosis in children and myocardial fibrosis in monkeys (Ackman *et al.*, 1977). The erucic acid content must be as low as possible and preferably zero. For international acceptance, erucic acid content should be below 2%. Therefore, minimization of erucic acid is an important objective in *Brassica* improvement.

MATERIAL AND METHODS

The experimental material consisted of six lines (BIO 902, PCR 7, SKM- 9033, SKM- 9820, PBR-122 and BPR-610-50- 6) and four testers (GM 2, GM 3, PUSA BOLD and VARUNA) crossed in line x tester mating design. The resultant 24 hybrids along with their ten parents were evaluated in Randomized Block Design with three replications at Main Castor - Mustard Research Station, S. D. Agricultural University, Sardarkrushinagar during *Rabi* 2010-2011. A random sample of seeds weighing approximately 12 g was taken from bulk seeds harvested from five selected plants of each genotype and oven dried. Oil content of each samples were estimated in percentage by using nuclear magnetic resonance technique (NMR) (Tiwari *et al.*, 1974), while fatty acids composition; (linolenic acid (%), oleic acid (%), lenoleic acid (%), glucosinolate content (%), erucic acid (%) of each sample was estimated in percentage by using fourier transferable near infrared (FT-NIR) technique. The data pertaining to various traits were analysed as per the procedure of RBD given by Panse and Sukhatame (1978). The combining ability analysis was performed for a line x tester matting design as per the method suggested by Kempthorne (1957). The hybrid performance (%) tested in comparison with mean value of batter parent ((Heterobeltiosis/BPH) and with standard parent/check (standard heterosis/SH) as per the formulae BPH=100 x (F_1-BP/BP); (Fonseca and Patterson, 1968) and SPH=100 x (F_1-SP/SP) ; (Meredith and Bridge, 1972), respectively. Where F_1=mean hybrid performance, BP=Mean performance of batter parents and SP= mean performance of standard parent/check (GM 3). For the characters *viz*., erucic acid, glucosinolate and linolenic acid low scoring parent was considered as better parent for the estimation of heterobeltiosis and standard heterosis. Whereas, high scoring parent was considered as better parent for the rest of quality traits.

RESULTS AND DISCUSSION

Table 1 illustrated that analysis of variance revealed significant difference among the parents for majority of quality parameters stated considerable amount of variability among the parents. Mean squares due to hybrids were significant for all quality traits except glucosinolate, revealed existence of extensive variability in the parental materials. Comparison of mean squares due to parent vs. hybrids was found highly significant for almost all the quality parameters except linolenic acid which indicating that mean of hybrids were significantly different from that of the parents as a group for these traits.

For oil content eight hybrids evidenced significant and positive heterobeltiosis varied from -9.48 per cent (SKM-9033 x GM 2) to 6.96 per cent (BPR-610-50-6 x VARUNA).The minimum and maximum values for standard heterosis were -9.61 per cent (SKM - 9033 x GM 2) and 5.51 per cent (PBR-122 x GM 2), respectively. Five hybrids traced significant standard heterosis in desired direction. The positive desirable heterosis and heterobeltiosis for oil content was also reported by Patel and Sharma (1999), Sohan Ram (2009) and Patel *et al.* (2010). For fatty acid composition comprised linolenic acid, erucic acid and glucosinolate negative heterosis desired while oleic acid and linoleic acid heterosis desired in positive direction. Desired heterosis and heteobeltiosis observed are in agreement with those reported by Chauhan *et al.* (2002), Chauhan *et al.* (2009) and Tyagi *et al.* (2009).

From the analysis of variance for combining ability exposed the mean squares due to females (lines) were significant for erucic acid and glucosinolate, while non-significantly for oil content, oleic acid, linolenic acid and linoleic acid which showed that female significant contributed towards general combining ability variance

Table 1 : Analysis of variance (mean square) for parents and hybrids foroil content and oil quality parame characters

Source of variation	d.f.	Oil content	Linolenic acid	Oleic acid	Erucic acid	Linoleic acid	Glucosinolate
Replications	2	0.73	0.10	0.88	6.03	2.49	2.06
Parents	9	1.63**	8.09**	8.09**	66.30**	42.46**	990.09**
Females	5	1.92**	10.46**	10.41**	72.65**	27.55**	1137.23**
Males	3	1.56*	4.69**	6.10**	67.49**	76.27**	302.20**
Female vs. Male	1	0.34	6.44**	2.50	30.99**	15.62**	2318.14**
Parent vs. hybrid	1	12.01**	0.08	2226.07**	3638**	161.46**	1104.18**
Hybrids	23	5.99**	25.25**	122.24**	237.20**	62.48**	473.93
Error	66	0.52	0.47	1.42	3.12	1.13	3.22

* and ** indicate significance of values at $P \leq 0.05$ and $P \leq 0.01$, respectively

component. The variances due to males (testers) were non-significant for all the traits. The line x testers interaction was significant for all the traits signified the contribution of hybrids for specific combining ability variance components. The variance component due to females were higher than that of males for oil content, oleic acid, linolenic acid, erucic acid and glucosinolate which indicated greater contribution of females towards σ^2_{gca} (Table 2).The ratio of σ^2_{gca} / σ^2_{sca} being less than unity for all the traits. This indicated that non-additive components played greater role in the inheritance of these characters (Table 2). The presence of predominantly large amount of non-additive gene action would be necessitate the maintenance of heterozygosity in the population. Such results are in accordance with the findings of Solanki *et al.*, 2009 and Singh and Ranjeet, 2010 for oil content. Chauhan *et al*. (2002), Chauhan *et al*. (2009), Tyagi *et al*. (2009) and Satyanarayana *et al*. (2010) for fatty acid composition.

An overall appraisal of general combining ability effects of parents revealed that parent BIO-902 was also good general combiners for one or more of its component traits *i.e.*, oleic acid and glucosinolate, while parent PUSA BOLD was proved to be good donors for oil content, linolenic acid and glucosinolate. PBR-122 was good for oil content, oleic acid, linolenic acid, erucic acid and glucosinolate PCR-7 was good combiner for erucic acid, SKM-9033 having good gene for increasing oleic acid and linoleic acid content. Parent BPR-610-50-6 was good for oil content, oleic acid, linolenic acid and glucosinolate (Table 3).

The hybrid SKM-9033 x VARUNA pursued by BPR-610-50-6 x VARUNA ,BIO-902 x PUSA BOLD and SKM-9820 x GM 2 be evidenced for significant and positive sca effects for oil content. The cross PBR-122 x PUSA BOLD registered significant and negative sca effects for erucic acid

Table 2 : Analysis of variance (mean square) for combining ability, estimates of components of variance and their ratio for various quality characters in mustard

Source of variation	d.f.	Oil content	Oleic acid	Linolenic acid	Erucic acid	Linoleic acid	Glucosinolate
Replications	2	0.63	0.70	0.39	4.26	1.06	1.44
Crosses	23	5.99**	122.25**	25.26**	237.20**	62.48**	473.93**
Females (Lines)	5	8.86	170.61	34.83	202.52**	78.59	1308.33**
Males (Testers)	3	4.29	48.68	10.53	20.10	115.98	188.72
Females x Males	23	5.37**	120.84**	25.01**	292.18	46.41**	252.85**
Error		0.55	1.92	0.61	2.79	1.29	3.19
Components of variance							
σ^2 Females		0.29	4.15	0.82	-7.47	2.68	87.96
σ^2 Males		-0.06	-4.01	-0.80	-15.12	3.86	-3.56
σ^2_{gca}		0.08	0.75	0.16	12.06	3.39	33.05
σ^2_{sca}		1.62	39.81	8.18	96.35	15.09	83.21
σ^2_{gca} / σ^2_{sca}		0.05	0.02	0.02	0.13	0.22	0.40

* and ** indicate significance of values at P ≤ 0.05 and P ≤ 0.01, respectively

Table 3 : The estimates of general combining ability (gca) effects of the parents for various quality traits in mustard

Parents	Oil content	Oleic acid	Linolenic acid	Erucic acid	Linoleic acid	Glucosinolate
Female parents (Lines)						
BIO-902	-0.25	0.88*	1.57**	1.46**	0.33	-4.59**
PCR-7	-0.43**	-4.18**	2.49**	-2.03**	-3.07**	3.20**
SKM- 9033	-0.76**	5.47**	-0.02	-0.26	3.43**	2.44**
SKM- 9820	-0.60**	-4.49**	-0.89**	7.03**	2.16**	16.30**
PBR-122	1.48**	1.07**	-1.75**	-5.27**	-0.28	-1.91**
BPR-610-50-6	0.56 **	1.27**	-1.40**	-0.92	-2.58**	-15.44**
S.E.±	0.21	0.34	0.20	0.51	0.31	0.52
Male parents (Testers)						
GM 2	-0.11	0.63*	1.03**	0.56	2.12**	4.82**
GM 3	-0.42**	1.89**	-0.36*	-0.06	1.87**	-1.16**
PUSA BOLD	0.70**	-0.50*	-0.74**	0.96*	-0.70**	-2.16**
VARUNA	-0.17	-1.99**	0.08	-1.45**	-3.29	-1.50**
S.E.±	0.17	0.28	0.16	0.41	0.25	0.42

* and ** indicate significance of values at P ≤ 0.05 and P ≤ 0.01, respectively

Table 4 : Three top ranking parents with respect to *per se* performance and gca effects and the three top ranking hybrids with respect to *per se* performance and sca effects and heterosis over better parent and standard check (GM 3)

Characters	Best performing parent (*per se* performance)	Best general combiners	Best performing hybrids *per se* performance	Status of the parents	Hybrids with high sca effects	GCA of the parents	SCA effects	Heterosis (%) over Better parent	Heterosis (%) over Standard check (GM 3)
Oil content	PCR-7	PBR-122	PBR-122 x GM 2	G x A	SKM-9033 x VARUNA	P x A	1.60	4.26	1.83
	GM 3	BPR-610-50-6	BPR-610-50-6 x VARUNA	G x A	BPR-610-50-6 x VARUNA	G x A	1.40	6.96	4.80
	GM 2	PUSA BOLD	BIO-902 x PUSA BOLD	A x G	BIO-902 x PUSA BOLD	A x G	1.26	6.82	4.60
Oleic acid	BIO-902	GM 3	PCR-7 x GM 2	P x A	SKM-9033 x GM 2	G x G	12.53	171.02	235.02
	GM 3	BPR-610-50-6	BIO -902 x VARUNA	G x P	PBR-122 x VARUNA	G x P	6.05	88.13	126.82
	GM 2	PBR-122	SKM-9033 x GM 2	G x G	PCR-7 x PUSA BOLD	P x P	5.57	90.83	92.92
Linolenic acid	BPR-610-50-6	PBR-122	PCR-7 x VARUNA	P x A	PCR-7 x VARUNA	P x A	-3.43	-	-21.26
	SKM-9820	BPR-610-50-6	SKM-9033 x PUSA BOLD	A x G	BIO- 902 x GM 2	P x P	-2.84	-9.63	-16.75
	PCR-7	SKM-9820	SKM-9820 x PUSA BOLD	G x G	BIO-902 x PUSA BOLD	P x G	-2.53	-8.84	-27.53
Erucic acid	BPR-610-50-6	PBR-122	PBR-122 x PUSA BOLD	G x P	SKM-9033 x PUSA BOLD	A x P	-11.10	-41.94	-41.48
	GM 3	PCR-7	PCR-7 x GM 3	G x A	PCR-7 x GM 3	G x A	10.05	-45.46	-45.46
	SKM-9820	VARUNA	BIO 902 x VARUNA	P x G	PBR-122 x PUSA BOLD	G x P	10.01	-57.49	-50.51
Linoleic acid	VARUNA	SKM-9033	SKM -9033 x GM 3	G x G	BIO-902 x PUSA BOLD	A x P	5.46	55.49	108.93
	PCR-7	SKM-9820	BIO-902 x GM 3	A x G	PCR-7 x VARUNA	P x A	5.35	-	59.40
	PBR-122	GM 2	BIO-902 x PUSA BOLD	A x P	SKM-9033 x GM 3	G x G	4.81	150.52	150.45
Glucosinolate	VARUNA	BPR-610-50-6	BPR-610-50-6 x GM 3	G x G	BIO-902 x GM 2	G x G	-15.15	-	-
	PCR-7	BIO-902	BPR-610-50-6 x PUSA BOLD	G x G	PBR-122 x GM 3	G x G	-9.38	-	-
	GM 2	PUSA BOLD	BPR-610-50-6 x GM 2	G x P	PCR-7 x PUSA BOLD	P x G	-8.26	-	-

and glucosinolate, while hybrid BIO-902 x GM 2 manifested significant and negative sca effects for glucosinolate and significant and positive sca effects for linoleic acid. The best three crosses were selected on the basis of *per se* performance, their sca effects and heterosis over better parent and standard check (GM 3) for different characters (Table 4). The cross BPR-610-50-6 x VARUNA and BIO-902 x PUSA BOLD registered high per se performance, standard heterosis and sca effects for oil content with involved both average and good combiner parents.

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