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Short Communication

Effect of outcrossing on quality characteristics in Indian mustard (*Brassica juncea* L.)

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Indian mustard (*Brassica juncea* L.) is an important oilseed crop covering about 80% of the rapeseed-mustard cropped area in the country. This crop is largely self-pollinated. Nevertheless, out crossing ranging from 11-24 % has earlier been reported in this crop [1-2], which necessitates growing the crop at an isolation distance of at least 100m for breeder seed and foundation seed and 50m for certified seed for maintaining genetic purity [3]. Quality of oil is determined by fatty acid profiles and glucosinolates content characterizes the quality of seed meal. Chauhan *et al*. [4] reported quality characteristics of 96 rapeseed-mustard varieties grown in India on the basis of breeder seed obtained from the concerned breeder/institute and concluded that except Pusa Karishma of Indian mustard (*Brassica juncea*), GSC-5, TERI (00) R 9903 and TERI (0) R 03 of Gobhi sarson (*Brassica napus*), the rest possessed high erucic, low oleic and high glucosinolates contents. Since, outcrossing deteriorates the genetic purity of the crop, consequently the oil and seed meal quality would also be affected. Information on such aspect is scanty in this crop. In the present investigation quality characteristics of breeder and open pollinated seeds of 25 varieties of Indian mustard were studied over three cropping seasons to obtain precise information on effect of out crossing on oil, protein and glucosinolates content and fatty acid profile.

The experimental materials consisted of breeder seed of 25 predominantly grown varieties of Indian mustard from the concerned breeder/institute (Table 1). The same source of breeder seed was used to grow the crop in different cropping seasons. These varieties were grown in randomized complete block design during *rabi* 2003-04, 2004-05 and 2005-06 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 under recommended package of practices and two irrigations at 35 and 60 days after sowing, respectively were given. The observations were recorded on composite sample from central three rows. The oil and protein oil content were analyzed using NIR (Dicky John Instalab 600) following Kumar *et al*. [5]. Fatty acid profiles of breeder and open pollinated seeds were analyzed by gas liquid chromatograph (Nucon Model 5765) using SP 2300+2310 SS columns. Hyola 401, a double low hybrid of gobhi sarson (*Brassica napus)* and Varuna, non-canola variety of Indian mustard were used as standard checks for comparing varieties for quality characteristics.

The detailed method for fatty acid analysis has been described elsewhere [6]. ELISA reader at 405 nm analyzed the glucosinolates content of the seeds following tetrachloropalladate method [7]. Range, mean and coefficient of variability were computed for each characteristic for both breeder, open pollinated seeds and cropping seasons. Significance between differences of means for various characteristics and between the years was tested by paired 't'-test [8]. Analysis of variance revealed significant differences for oil, protein and glucsinolates content and fatty acid profiles among the varieties studied. Environmental effects on the characteristics were also significant. Further, paired 't' test also revealed significant differences between means of various quality characteristics in breeder and open pollinated seeds as well as among the cropping seasons. The variability pattern and means were discussed for breeder; open pollinated seeds and the cropping seasons.

Breeder seed

Among the varieties investigated, oil content ranged from 35.1 % (PCR-7) to 40.1% (Pusa Jaikisan). Protein

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Table 1. Varieties of Indian mustard used in the present investigation

Name of variety/source of materials	Pedigree
CSAUA&T, Kanpur (UP)	
Basanti	Varuna x RK-1
Rohini	Selection from natural population of Varuna
Vardan	Bi-parental mating involving Varuna, Keshari, CSU-10 and IB-1775
Varuna	Selection from Varanasi local
IARI, New Delhi	
Pusa Agrani (Sej-2)	*Brassica juncea* x synthetic amphidiploid (*B. compestris* var. toria x *B. nigra*)
Pusa Bahar	[(Pusa Rai-28 x Varuna) x (Pusa Rai-30 x T-6342)]
Pusa Bold	Varuna x BIC-1780
Pusa Jagannath	Varuna x Synthetic *juncea*
Pusa Jaikisan (Bio- 902)	Somaclone of Varuna
CCS-HAU, Hisar (Haryana)/PC Unit NRCRM, Bharatpur	
Rajat (PCR- 7)	Selection from Kutchh germplasm line JMG-36-6, HAU, Hisar
Laxmi (RH 8812)	PR-15 x RH-30A
RH-30	Selection from P-26/3-1
RH- 781	(RL-18 x P-26/3-1) x RL-18
RH- 819	Prakash x Bulk pollen
Saurabh (RH- 8113)	T-59 x RC-781
CSSRI, Karnal (Haryana)	
CS- 52	Selection from DIRA 343
SAREC, CSKHPKVV Kangara	
RCC-4	Multiple cross involving Varuna, Pusa Bold, Pusa Bold-75-2, Pant Rai-18, RH-30, RLM-171, RH-7301 and RLM-504
GBPUA&T, Pantnagar (Uttarakhand)	
Kranti	Selection from Varuna
Krishna	Selection from Varuna
PAU-Ludhiana (Punjab)	
PBR-91	(RLM-511 X PR-18) x CM-1
PBR-97	[(DIR-202 x PR-34) x V-3 x (RLM-619 x Varuna)]
RL 1359	RLM-514 x Varuna
SDAU, SK Nagar (Gujarat)	
Gujarat Mustard-1 (GM-1)	MR-71-3-2 x TM-24
Gujarat Mustard-2 (GM-2)	Selection from material collected from Vendancha (Gujarat)
PORS, Berhampore, Murshidabad (WB)	
Sunjucta Asech	TM-4 x RK-2

content was the highest in the variety Pusa Jaikisan. The varieties exhibited low coefficients of variation for oil and protein content (Table 2). The minimum (2.8%) and maximum (7.4%) saturated (palmitic+ stearic acid) fatty acid was recorded for variety Rohini and PCR-7, respectively. Among the varieties, oleic acid was maximum in RH-781 (14.8 %). Variety PBR-91 had the highest linoleic acid (26.7%) but it had lowest linolenic acid (11.1%). Eicosenoic acid varied from 3.5% (Krishna) to 10.1% (PBR-97). Variety Basanti had the minimum erucic acid (31.5%), whereas, maximum erucic acid was recorded in variety Krishna (Table 2). The glucosinolates content was lowest for the variety RCC-4. Eicosenoic, oleic and saturated fatty acids were quite variable in these varieties (CV >25%). Rest of the characteristics showed low to moderate variation (CV 10.4-16.5%). The least variability was recorded for oil and protein content. These characteristics were reported to have low level of variation in earlier studies also [9, 10].

Table 2. Range, mean and coefficient of variation (CV) for various quality characteristics in Indian mustard varieties

Characteristic	Breeder seed (2002-03)			Open pollinated seeds (On the basis of 3 years data)		
	Range	Mean ± SEM	CV (%)	Range	Mean ± SEM	CV (%)
Oil content (%)	35.1-40.1	37.25±0.27	3.6	36.3-42.4	39.52±0.16	2.0
Protein content (%)	17.8-20.5	18.74±0.12	2.2	18.1-21.2	19.86±0.09	2.2
Saturated fatty acid (%)	2.8-7.4	4.12±0.25	29.4	2.2-6.2	3.76±0.07	9.6
Oleic acid (%)	4.1-14.8	10.70±0.57	26.2	8.0-21.7	13.02±0.26	10.0
Linoleic acid (%)	12.9-26.7	17.47±0.59	16.5	14.6-31.7	18.2±0.33	9.1
Linolenic acid (%)	11.1-26.6	16.83±0.65	19.0	7.4-20.6	14.13±0.27	9.4
Eicosenoic acid (%)	3.5-10.1	6.08±0.36	28.8	3.9-10.7	6.9 4±0.17	12.0
Erucic acid (%)	35.6-51.4	44.52±0.95	10.4	31.5-54.3	43.40±0.54	6.2
Glucosinolatess content*	48.7-106.3	77.00±2.51	16.0	72.1-122.3	102.44±1.57	7.7

*μ moles/g defatted seed meal

Table 3. Comparison of means of (a) breeder vs open pollinated seeds (b) open pollinated seeds from different cropping seasons for various quality characteristics of Indian mustard

Characteristic	Breeder vs open pollinated seeds			Open pollinated seeds		
	2003-04	2004-05	2005-06	2003-04 vs 2004-05	2003-04 vs 2005-06	2004-05 vs 2005-06
Oil content	**	**	**	**	**	**
Protein content	**	**	**	*	NS	**
Saturated fatty acids	**	NS	NS	*	**	**
Oleic acid	**	NS	*	**	**	*
Linoleic acid	**	NS	**	**	**	**
Linolenic acid	**	NS	**	**	NS	**
Eicosenoic acid	NS	NS	NS	NS	**	**
Erucic acid	*	NS	NS	**	**	NS
Glucosinolatess content	**	**	**	**	NS	*

NS: Non-significant; *, **: Significant at P=0.05 and P=0.01 level, respectively.

Open pollinated seed

Oil content among the 3 cropping seasons ranged from 36.3 % (PBR-91) and 42.4% (Rohini) and Saurabh had the highest protein content of 21.2%. The variability was low for these characteristics across the seasons (CV 2.0-2.2 %). Variety Basanti had the lowest amount of saturated fatty acids. Oleic acid was maximum in the variety Kranti (21.7%). Linoleic acid varied from 14.6 % in Pusa Jaikisan to 31.7% in Basanti. The minimum and maximum linolenic acid was observed in variety Kranti (7.4%) and Pusa Jagannath (20.6%), respectively (Table 2). Variety CS-52 had the highest eicosenoic acid (10.7%), whereas, Krishna exhibited the highest erucic acid (54.3%). PBR-97 and RCC-4 possessed the minimum (72.1 μ moles/g defatted seed meal) and maximum (122.3 μ moles/g defatted seed meal) glucosinolates content. The pattern of variation for quality characteristics investigated was, by and large, similar to that of breeder seed.

Breeder vs open pollinated seeds and seasons

The coefficients of variability were, in general, higher in breeder seed for all the characteristics except for protein content as compared to those of open pollinated seeds. It was expected as the breeder seed was produced at different locations under diverse agro-climatic conditions and management conditions with recommended isolation distance, thus, greatly influenced by the environmental factors rather than cross pollination. The open pollinated seeds were produced at NRCRM, Bharatpur relatively under uniform agronomic management without any isolation distance, hence environmental influence was substantially reduced and there could be effect of out crossing. Further, except

for means of saturated fatty acid (palmitic + stearic acid), linolenic and erucic acid, which were almost similar for both breeder and open pollinated seeds (difference < 1%), means for other characteristics were higher in open pollinated seeds than those of breeder seed. But glucosinolates content showed appreciable variation (difference 25 μ moles). The open pollinated seeds of 2003-04 crop season had significant differences as compared with the means of breeder seed for all the characteristics except eicosenoic acid as revealed by paired 't' test. Barring oil, protein and glucosinolates content of open pollinated seeds produced during 2004-05, the rest of the characteristics did not differ significantly from that of the breeder seed. Except saturated fatty acids, eicosenoic and erucic acid, the remaining characteristics were significantly different for breeder and open pollinated seeds produced during 2005-06. The oil, protein and glucosinolates content of open pollinated seeds showed consistently and significantly different means than those of breeder seed during all the three growing seasons but rest of the characteristics had variable trend. Means of open pollinated seeds for all the characteristics differed significantly among the growing seasons indicating environmental influence. Significant differences were recorded between open pollinated seeds produced during 2003-04 and 2004-05 for all the characteristics except eicosenoic acid. The differences were significant for oil content, saturated fatty acids, oleic, linoleic, eicosenoic and erucic acid between open pollinated seeds produced during 2003-04 and 2005-06. Open pollinated seeds of 2004-05 and 2005-06 cropping seasons were also significantly different for all the characteristics except erucic acid (Table 3). The variable trend could be due to environmental factors influencing extent of out crossing like relative humidity, temperature, sunlight, wind velocity and direction and honeybee movement. The study also suggested that ageing of seeds for up to 48 months did not affect the oil and seed meal quality of these varieties to an appreciable extent. In an earlier study [11] it was observed that oil and protein content of mustard did not vary due to seed storage up to 27 months. Since all the varieties investigated in the present study had less variation for quality characteristics like erucic acid and glucosinolates content (all were high), the outcrossing effects were manifested to a lesser extent. To further substantiate the findings of the present investigation it would be interesting to study the pattern of changes due to open pollination by including lines/varieties having distinct variability for quality characteristics, low erotic acid and/or low glucosinolates content.

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