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Short Communication

Diversity for fatty acid composition of advanced breeding lines of Indian mustard [*Brassica juncea* (L.) Czern & Coss]

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In general the yield performance or resistance against important pests or both are considered for the submission of any advanced breeding line into the All India Coordinated Research Project on Rapeseed-Mustard (AICRP-RM) and for its further release as new variety or as registered donor for a particular trait. But recently it is being felt that such Indian mustard varieties should be developed with output traits which are better suited for oil quality. Oil quality is one of the most important criterion for the release of any breeding line as new variety because, oil quality affects the use of its oil for edible purposes as certain antinutritional factors present in oil like high erucic acid causes atherosclerosis in adults, lipidoxies in children besides this high amount of linolenic acid in oil reduces the shelf life of oil. Other than fatty acids presence of high levels of glucosinolates also causes serious health problems in humans as well as in animal. On one hand oil industries are interested in the mustard varieties having better natural shelf life of their oil as partial hydrogenation performed on vegetable oils to increase the oxidative stability of the oil is not only uneconomical but also leads to the formation of trans fatty acids that implicate serious health concerns [1], whereas consumers are interested in oil with low erucic acid as it causes serious health problems *viz*., heart disease like atherosclerosis and lipidoxies.

The shelf life of oil depends on the oxidative stability of it as determined by its fatty acid composition. Among the unsaturated fatty acids linolenic acid is most susceptible while oleic acid is least susceptible to oxidation, as the rate of linolenic ($C_{18.3}$), linoleic ($C_{18.2}$) and oleic acid ($C_{18.1}$) is 21.6:10:3.1%, respectively [2]. Hence cultivars with low linolenic acid and high oleic acid coupled with low erucic acid (<2 %) content are being developed. Considerable variability for different fatty acids has been reported in Indian mustard [3, 4]. And now all the advanced breeding lines are screened for their fatty acid composition together with yield performance for their release as new varieties.

Fifty six advanced breeding lines selected for superior oil quality (i.e. low erucic acid in oil) [twelve PRQ (RC-78J x Zem-1), thirty three PLEM (Kranti x Zem-1), three DL [(BJ-1058 x Kranti) x (RC-781 x Zem-l)] and eight LG (BJ-1058 x Kranti)] along with three checks *viz.* Kranti and Pusa Karisma and PRQ-2005-1 (registered donor for low erucic acid IC-546946) were grown in Augmented Block Design in eight blocks and all the recommended cultural practices were performed in *rabi* 2005-06 and *rabi* 2006-07. Self seeds from all the advanced lines and checks were harvested upon maturity. Days to maturity for each advanced line were recorded. Mature seeds were dried in hot air oven at 60^{o}C till they become moisture free and 1000 seed weight was taken with the help of numerical seed counter and electronic balance. The oil content (%) in seeds was determined by Newport Analyzer-4000 based on the principle of Nuclear Magnetic Resonance (NMR). Fatty acid methyl esters were prepared from the seeds of each line using bulk seed method by crushing 10-15 seeds of each line in petroleum ether and were esterified using IN Sodium Methoxide [5] and the supernatant was taken and analyzed for fatty acid composition in gas

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Table 1. Days to maturity (DM), 1000-seed weight (1000 SW), oil content %, percent fatty acid composition, monounsaturated (M): polyunsaturated fatty acids (P) and linoleic (ω-6 or n-6): linolenic acid (ω-3 or n-3) ratio of advanced breeding lines of Indian mustard grown in *rabi* 2005-06 and *rabi* 2006-07 under All India Coordinated Research Project at Pantnagar

Entry	DM	1000 SW (%)	Oil content	$C_{16.0}$ palmitic acid	$C_{18.0}$ stearic acid	$C_{16.1}$ oleic acid	$C_{18.2}$ linolenic acid	$C_{18.3}$ linolenic acid	$C_{20.1}$ eicose-noic	$C_{20.1}$ erucic acid	M:P	ω-6/ω-3
PRQ 2005-1#	131	4.307	39.45	3.374	1.581	38.147	36.711	14.285	1.739	1.077	0.803	2.569
Pusa Karisma#	133	3.115	39.14	3.698	1.231	34.926	34.671	17.758	2.130	1.972	0.744	1.952
Kranti[P,] #	133	3.698	40.48	2.876	0.947	10.213	16.492	10.669	5.608	48.798	2.379	1.546
RC-781[P]	152	2.551	39.85	2.280	1.140	10.891	14.862	13.470	7.843	50.376	2.439	1.103
BJ-1058[P]	148	2.382	36.19	3.381	1.805	12.336	18.691	10.286	9.864	43.367	2.263	1.817
Zem-1[P]	148	2.850	40.25	4.473	Trace	36.611	31.392	26.842	7.279	0.405	0.761	1.169
1. PLEM-2005-1	127	3.302	39.10	5.057	1.619	38.591	32.079	14.136	4.206	0.821	0.943	2.269
2. PLEM-2005-2	128	3.601	39.42	4.568	1.596	35.530	34.906	14.734	1.489	3.035	0.806	2.369
3. PLEM-2005-3	131	3.201	37.91	4.232	1.746	41.262	32.664	15.462	1.552	1.446	0.919	2.112
4. PLEM-2005-7	131	3.554	38.91	3.912	2.399	38.277	36.839	12.536	1.382	0.712	0.817	2.938
5. PLEM-200S-8	137	4.194	37.84	4.256	1.747	33.255	32394	15.196	4.356	4.396	0882	2.131
6. PLEM-2005-9	132	2.789	38.71	4.339	1.699	39.812	36.797	12.992	2.063	0.413	0.849	2.832
7. PLEM-2005-10	131	3.232	38.02	4.491	1.495	38.017	35.072	17.711	1.266	0.356	0.750	1.980
8. PLEM-2005-11	125	2.919	37.59	3.610	2.282	36.700	31.494	15.295	1.240	1.534	0.843	2.059
9. PLEM-2005-12	130	3.485	38.33	4.467	2.128	39.086	37.086	14.135	1.396	0.468	0.799	2.623
10. PLEM-2005-13	130	2.697	38.13	5.549	1.509	26.730	36.590	17.137	2.625	2.063	0.584	2.135
11. PLEM-2005-14	132	3.308	37.89	4.927	1.798	38.463	39.296	13.643	1.130	0.321	0.753	2.880
12. PLEM-2005-15	130	4.577	37.03	4.645	1.410	36.367	36.975	13.436	1.032	0.339	0.748	2.751
13. PLEM-2005-16	139	4.232	37.80	4.275	1.995	38.115	36.874	12.090	0.712	1.274	0.818	3.049
14. PLEM-2005-17	132	4.068	39.50	4.826	1.985	37.503	38.836	13.340	0.462	1.586	0.758	2.911
15. PLEM-2005-18	132	4.806	38.50	3.972	1.680	38.264	37.158	12.654	1.087	0.545	0.800	2.936
16. PLEM-2005-19	132	3.999	38.46	3.617	1.619	33.422	36.830	11.479	1.922	0.512	0.742	3.208
17. PLEM-2005-20	133	4.470	38.11	3.785	1.364	38.009	36.277	11.274	1.381	0.685	0.842	3.217
18. PLEM-2005-21	136	4.575	38.28	4.455	1.137	33.590	34.659	9.552	1.415	1.134	0.817	3.628
19. PLEM-2005-22	132	3.26	38.06	3.693	1.441	36.953	41.150	9.442	1.788	0.638	0.778	4.358
20. PLEM-2005-23	140	3.338	37.78	4.134	1.726	37.885	42.691	9.933	1.184	0.857	0.758	4.297
21. PLEM-2005-24	139	3.861	36.69	5.022	1.583	28.121	44.205	11.116	0.933	0.853	0.540	3.976
22. PLEM-2005-25	132	3.377	38.87	3.967	0.975	34.425	39.909	13.630	1.726	2.547	0.722	2.928
23. PLEM-2005-26	143	3.601	38.58	4.688	1.143	31.433	45.798	13.905	1.197	0.437	0.553	3.293
24. PLEM-2005-27	135	3.670	37.89	3.383	1.150	32.708	45.493	14.214	1.245	0.554	0.577	3.200
25. DL-2005-82	134	3.729	38.99	2.721	0.893	15.052	25.565	9.414	7.332	32.105	1.557	2.715
26. DL-2005-6-43	133	3.082	38.26	3.931	1.253	34.371	37.707	18.473	1.653	1.930	0.675	2.041
27. LGBC-2005-5-1	143	3.830	35.11	3.944	1.549	16.438	24.710	9.480	9.271	27.454	1.554	2.606
28. LGBC-2005-6-8	139	3.041	38.33	2.832	0.863	17.050	24.636	7.686	8.976	34.143	1.861	3.205
29. LG-2005-1-2	135	3.096	40.76	2.965	1.591	13.630	22963	8.522	6.713	41.223	1.955	2.694
30. LG-2005-3-8	131	4.719	38.62	2.625	0.995	14.074	20.337	10.715	5.280	39.069	1.881	1.897

31. LG-2005-4-7	128	4.518	39.76	2.228	0.629	13.026	20.260	7.786	5.807	43.940	2.238	2.602
32. LG-2005-5-9	131	4.326	40.35	2.145	0.572	12.787	18.574	8.841	7.379	45.965	2.412	2.100
33. LG-2005-7-4	137	2.505	38.24	4.391	0.981	10.844	24.421	9.219	4.954	39.190	1.634	2.648
34. LG-2005-7-7	132	2.533	38.20	3.118	0.902	7.414	20.485	8.968	5.751	44.530	1.958	2.284
35. DL-2005-3-47(Y)	128	3.342	39.02	4.344	1.151	38.725	31.965	16.124	1.089	0.583	0.840	1.982
36. PRQ-2005-11(BE)	132	3.450	38.22	3.221	1.410	17.518	25.671	9.488	8.158	29.426	1.567	2.705
37. PRQ-2002-4(YE)	136	3.912	38.97	4.993	1.623	35.573	41.602	1 1 .964	1.013	0.646	0.695	3.477
38. PRQ-2004-8(YL)	141	3.032	38.80	3.131	0.837	32.176	26.642	9.973	5.701	10.905	1.332	2.671
39. PRQ-2004-9(B)	131	2.512	38.18	2.936	0.804	13.107	23.275	9.362	6.676	36.161	1.714	2.486
40. PRQ-2004-5(Y)	134	4.671	38.99	3.595	1.194	35.324	36.800	1 1 .745	2.263	8.475	0.948	3.133
41. PRQ-2005-3-6	133	3.483	38.14	2.327	0.525	14.928	19.092	1 1 .644	5.372	39.251	1.937	1.639
42. PRQ-2005-5-1	133	4.017	38.37	2.627	0.699	13.618	22.833	10.959	5.981	39.236	1.741	2.083
43. PRQ-2005-5	139	3.543	38.92	2.709	0.848	17.199	21.220	8.044	6.855	19.565	1.490	2.637
44. PRQ-2005-4 (BL)	142	2.380	38.08	2.786	0.809	15.134	25.479	9.697	4.064	38.117	1.629	2.627
45. PRQ-2005-6-8	132	2.894	38.55	4.244	0.849	19.769	33.483	8.259	3.428	6.858	0.720	4.054
46. PRQ-2001-3(Y)	140	3.265	38.43	3.153	0.919	28.717	34.958	13.103	3.768	11.478	0.914	2.667
47. PRQ-2002-3(B)	137	3.433	38.11	4.171	0.588	38.334	38.685	14.132	1.787	1.759	0.792	2.737
48. PLEIM-2005-28	135	2.922	38.88	3.642	1.124	39.464	38.991	13.331	1.026	1.481	0.802	2.924
49. PLEM-2005-29	135	4.105	40.02	3.570	0.480	33.659	40.899	12.140	1.106	4.103	0.732	3.368
50. PLEM-2005-30	133	3.903	38.27	3.168	0.621	26.045	39.219	13.204	3.795	50.183	1.526	2.970
51. PLEM-2005-31	135	2.368	38.43	3.302	0.708	35.620	44.610	12.286	0.835	0.449	0.648	3.630
52. PLEM-2005-32	136	3.865	39.08	3.436	2.698	28.289	36.577	16.543	1.020	2.397	0.596	2.211
53. PLEM-2005-33	139	3.715	38.76	4.449	1.346	34.109	41.284	14.175	0.715	0.950	0.645	2.912
54. PLEM-2005-34	136	3.405	37.75	4.009	0.749	40.500	36.691	15.374	1.000	0.436	0.805	2.386
55. PLEM-2005-35	134	3.813	37.24	3.820	0.926	36.585	42.500	12.612	1.417	1.213	0.711	3.369
56. PLEM-2005-36	143	3.6.76	38.15	4.341	1.449	36.761	41.284	12.658	1.297	1.630	0.735	3.261

*Values given are mean of two year data based on five samples; # Check and P Parents of quality lines

chromatograph, Chemito GC 7610, using capillary column BPX70 of 25 m length and 0.22 mm internal diameter.

Large genotypic variation for 1000 seed weight, days to maturity and total oil content was observed among these 56 advanced quality lines. 1000 seed weight ranged from 2.368 g [PLEM-2005-31] to 4.806 g [PLEM-2005-18], while days to maturity ranged from 125 days [PLEM-2005-11] to 143 days [PLEM-2005-26] and oil content (%) varied from 35.11 % [LGBC-2005-5-1] to 40.76 % [LG-2005-1-2], whereas, different fatty acid components *viz*. palmitic acid ($C_{16.0}$) ranged from 2.145 % [LG-2005-5-9] to 5.549 % [PLEM-2005-13] with mean value of 3.78 %, stearic acid ($C_{18.0}$) ranged from 0.480 % [PLEM-2005-29] to 2.698 % [PLEM-2005-32], oleic acid ($C_{18.1}$) between 7.414 % [LG-2005-7] and 41.262 % [PLEM-2005-3], linoleic acid ($C_{18.2}$) ranged from 18.574 % [LG-2005-5-9] to 45.798 % [PLEM-2005-26] and linolenic acid ($C_{18.3}$) varied from 7.686 % [LGBC-2005-6-8] to 18.473 % [DL-2005-6-43], while eicosenoic acid ($C_{20.1}$) ranged from 0.462 % [PLEM-2005-17] to 9.271 % [LGBC-2005-5-1] and erucic acid ($C_{22.1}$) recorded lowest value of 0.321 % [PLEM-2005-14] and highest value of 50.183 % [PLEM-2005-30] (Table 1). None of the lines of cross (BJ-1058 x Kranti) recorded low erucic acid as both the parents involved in the cross were high in erucic acid, but when these F_1s were crossed with the progenies of the cross (RC-781 x Zem-1) and (Kranti x Zem-1), they produced the progenies with low and high erucic acid (characterized as DL under present investigation), while progenies of cross (RC-781 x Zem-1) and (Kranti x Zem-1) produced the lines having low, high and intermediate erucic acid in their oil.

The ratio of monounsaturated fatty acids (M) to polyunsaturated fatty acids (P) is considered as an indicator of the oxidative stability of the vegetable oil. In general mustard oil possesses M: P ratio of $\leq$ 2.3, whereas olive, corn, soybean and sunflower oil have the M: P ratio of 7.0, 0.5, 0.5 and 0.2, respectively. The M: P ratio in present investigation varied from 0.540 for PLEM-2005-24 to 2.412 for LG-2005-5-9 (Table 1). For mustard varieties, a range of M: P ratio from 0.8 to 2.09 has been reported for the release of varieties. In present study 7 lines showed M: P ratio less than 0.7 while 44 lines showed M: P ratio in the range of 0.7 to 1.9 and 5 lines showed an M: P ratio value above 1.90. The checks Kranti, Pusa Karisma and PRQ-2005-1 exhibited an M: P ratio of 2.379, 0.744 and 0.803, respectively. Besides M: P ratio the ratio of w-6 to w-3 fatty acids is also used as an indicator of the shelf life of oil. ω-6/ ω-3 or n-6/n-3 (linoleic acid/linolenic acid) ratio varied from 1.639 for PRQ-2005-3-6 to 4.358 for PLEM-2005-22, which was in the range of FAO recommendations for most of the advanced breeding lines [6]. Correlation studies indicated highly significant positive correlation of oleic acid with linoleic acid and linolenic acid ($p < 0.01$). In relation to M: P ratio and ω-6/ω-3 ratio, oleic acid observed highly significant negative ($p < 0.01$) and significant positive correlation ($p < 0.05$). Further linolenic acid observed highly significant negative correlation with M:P ratio, ω-6/ω-3 ($p < 0.01$) and non significant negative correlation with 1000-seed weight and highly significant positive correlation with linoleic acid ($p < 0.01$). Further oleic acid observed highly significant negative correlation with erucic acid and eicosenoic acid ($p < 0.01$) [6].

None of the advanced breeding lines possessed linolenic acid of less than 4 % and oleic acid of around 60 % or more [7] as desired for improved shelf life of oil of mustard varieties, but the results suggests that many of the above advanced breeding lines which have high oleic acid and low erucic acid may be exploited for developing new varieties with improved oil quality with improved oxidative stability of mustard oil.

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