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Estimating genotype × environment interaction and stability parameters for oil and seed meal quality, seed yield and its contributing characters in Indian mustard (*Brassica juncea*)

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ABSTRACT

A study was conducted during 2003–06 to assess the genotype by environment interaction effects and stability parameters for oil and seed meal quality, seed yield and its contributing characters of 25 Indian mustard [*Brassica juncea* (L.) Czernj. & Cos.] varieties. Pooled analysis of variance indicated highly significant differences for genotypes (G), environment (E) and G × E interaction for oil, protein, glucosinolates, fatty acid profile, seed yield and contributing characters. The environment (linear) was highly significant for all the characters, while the linear component of genotype × environment interaction was highly significant for protein content only. Pooled deviation differed significantly for linoleic; linolenic, erucic acid, glucosinolates, days to maturity, 1000-seed weight and seeds/siliqua, suggesting the genotypes had varying level of stability over the cropping seasons for these characters. Stability parameters indicated that oil and protein content were fairly stable across environments in 14 and 11 varieties, respectively. Only 3 varieties, 'CS 52' (protein content, oleic, linoleic, linolenic, eicosenoic and erucic acid) ; 'Saurab' (oil content, protein content, oleic, linoleic, linolenic and erucic acid) and 'Sanjucta Asceh' (oil content, protein content, saturated fatty acid, oleic, linoleic and erucic acid) were stable for maximum of 6 quality characters. Three varieties ('Bio 902', 'PBR 97' and 'PCR 7') showed stable performance for seed yield over environments. 'Rohini' and 'GM 1' showed relatively stable maturity duration and 1000-seed weight, respectively over the environments.

Key words: *Brassica juncea* L., Oil and seed meal quality, G × E interaction, Stability analysis, Indian mustard, Seed yield, Yield components

Oilseed *Brassicas* commonly termed as rapeseed-mustard constitute an important source of edible oil next to groundnut in India. Indian mustard *(Brassica juncea* L Czernj & Coss.) is a predominant crop among the oilseed *Brassicas*. Oil content of the seed determines the commercial success of a variety, whereas fatty acid composition of oil is its major quality determinant. The quality of seed meal, an important source of high protein animal feed is judged by quantity and quality of glucosinolates. Oil and seed meal quality as with other morpho-agronomic characters are profoundly influenced by genotype, environment and their interactions. Stability in the genotypes for these characters in multi-location/season is foremost for both selection of a variety as well as for breeding programme. Knowledge on the interaction and stability is foremost in breeding varieties for wider adaptation in diverse agro-climatic conditions. Genotype × environment interaction effects for seed yield and its contributing characters has been very well documented in Indian mustard (Brar *et al.* 2009; Sah *et al.* 2009). The present investigation aimed at assessing genotype by environment interaction and stability parameters for oil, protein, glucosinolates, fatty acid profile, seed yield and its contributing characters in Indian mustard.

MATERIALS AND METHODS

The experimental materials consisted of 25 predominantly grown varieties of Indian mustard for quality characters, however, yield and yield-contributing characters were recorded on 23 varieties because of low plant population in 2 varieties, viz 'Basanti' and 'RCC 4'. The breeder seed was used to grow the crop in different cropping seasons. These varieties were grown in randomized complete block design during winter (*rabi*) 2003–06 with 3 replications in 5-row plot of 5 m length, keeping 45 cm row-to-row and 15 cm

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plant-to-plant spacing. The experiment was conducted with recommended package of practices and 2 irrigations were given at 35 and 60 days after sowing, respectively. The observations were recorded on composite sample from central 3 rows. The oil and protein oil content were analyzed using pre-calibrated NIR (Dicky John Instalab 600) following Kumar *et al*. (2003). Fatty acid profile of oil was analyzed by gas liquid chromatograph (Nucon Model 5765) using SP 2300+2310 SS columns. The detailed method for fatty acid analysis has been described earlier (Chauhan *et al.* 2002). Individual fatty acids have been 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 (Kumar *et al*. 2004), the intensity of the colour produced was measured using ELISA reader at 405 nm. ‘Hyola 401’, a double low hybrid of *gobhi sarson (Brassica napus)* and ‘Varuna’, non-canola variety of Indian mustard (*Brassica juncea*) were used as standard checks for comparing varieties for quality characters. Observations were also recorded on seed yield (kg/ha), days to maturity on plot basis, while a random sample of 5 plants/replication/genotype was taken for recording 1000-seed weight (g) and seeds/siliqua.

The mean values were used for analysis of variance for multiple randomized complete block design by Indostat software. The effects of genotype, environment and genotype × environment interactions were estimated following the method of Eberhart and Russell (1966).

RESULTS AND DISCUSSION

Significant genotypic differences over all the environments for all the charcters except protein content in 2005–06 and saturated fatty acids in 2004–05 cropping season were revealed by analysis of variance. Pooled anlysis of variance for genotype × environment interaction indicated highly significant differences for genotypes (G), environment (E) and G × E interaction for oil, protein and glucosinolate content, oleic, linoleic, linolenic, eicosenoic, erucic acid, seed yield, days to maturity, 1000-seed weight and seeds/silqua. The mean sum of squares due to genotypes and G × E interaction was significant, whereas environment effects were highly significant for saturated fatty acids (Table 1). The results of the analysis of variance suggested that oil and seed meal quality, seed yield and its contributing characters were highly influenced by the environmental conditions and also genotypes performed differentially in 3 cropping seasons.

Environment + (G × E) interaction was significant for oil and glucosinolate content and highly significant for protein content, oleic, linolenic, eicosenoic acid, days to maturity and 1000-seed weight. The environment (linear) component was highly significant for oil, protein, glucosinolates, fatty acid profile, seed yield and its components, thereby suggesting that variability with respect to these characters

Table 1 Pooled analysis of variance for oil, seed meal quality and yield-attributing characters in Indian mustard

Source	Mean sum of squares													
	d.f.	Oil content	Protein content	Saturated fatty acids	Oleic acid	Linoleic acid	Linolenic acid	Eicosenoic acid	Erucic acid	Glucosinolates	d.f.	Seed yield (kg/ha)	Days to maturity	1000-seed weight	Seeds/siliqua
Genotype (G)	24	5.68**	1.83**	1.18*	14.53**	24.43**	15.46**	6.12**	56.54**	233.19**	22	650176**	285.15**	5.13**	8.33**
Environment (E)	2	45.32**	9.53**	32.33**	261.07**	584.55**	215.62**	122.25**	178.82**	1902.77**	2	5641353**	212.01**	2.72**	15.25**
G × E	48	3.02**	1.35**	1.58*	8.88**	15.01**	8.16**	5.05**	19.01**	83.22**	44	119602**	39.21**	0.26**	4.36**
E + (G × E)	50	1.57*	0.56**	0.94	6.32**	12.6	5.49**	3.25**	8.47	52.00*	46	120	15.57**	0.12**	1.61
Environment (linear)	1	30.21**	6.35**	21.55**	174.05**	389.70**	143.75**	81.50**	119.22**	1268.51**	1	3760901**	141.34**	1.82**	10.17**
G × E (linear)	24	1.15	0.65**	0.34	3.23	4.33	2.36	1.31	5.45	26.39	22	47398	21.24**	0.11*	1.43
Pooled deviation	25	0.82	0.24	0.68	2.58	5.45*	2.96**	1.98	6.94**	27.93**	23	30930	4.40**	0.06*	1.41**
Pooled error	144	0.63	0.65	0.67	3.15	2.85	2.74	1.25	2.16	6.97	132	36003	1.47	0.04	0.65

*, ** significant at P=0.05 and P=0.01 levels, respectively.

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Table 2 Estimates of stability parameters for oil and seed meal quality characters in Indian mustard

Varieties	Oil content (%)			Protein content (%)			Saturated fatty acid (%)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
'Basanti'	39.40	1.28**	0.41	19.68	2.18**	0.13	3.33	1.9**	0.02
'Bio 902'	39.14	1.38	3.02*	20.05	0.34	1.53	3.99	1.15	0.27
'CS 52'	39.21	1.44**	0.00	19.92	–1.1	0.41	3.81	0.63**	0.09
'GM 1'	40.94	0.7	3.06*	19.70	–1.65	0.00	3.18	0.34**	0.00
'GM 2'	39.07	2.32	1.51	19.88	–1.38	0.01	3.23	1.22**	0.05
'Kranti'	39.05	2.04**	0.00	19.75	–0.51	0.05	4.42	0.07	0.54
'Krishna'	39.72	1.13**	0.05	19.95	0.14**	0.06	3.96	1.08	0.39
'Pusa Bahar'	40.26	0.6**	0.19	18.96	3.79**	0.04	3.33	0.76**	0.00
'Pusa Bold'	39.78	0.43	0.81	19.26	2.79**	0.10	3.37	0.79**	0.06
'Pusa Jagannath'	38.60	2.03	1.20	19.45	2.9**	0.01	3.65	0.67**	0.05
'PBR 91'	38.84	2.98	0.69	20.14	1.31**	0.00	3.87	0.02	1.64
'PBR 97'	39.95	1.43**	0.06	20.19	1.59**	0.2	3.63	1.72	1.40
'PCR 7'	38.13	2	0.62	20.73	*–1.67*	0.27	3.66	–0.01	2.06
'RCC4'	39.42	0.21**	0.01	20.34	1.5**	0.00	4.11	0.95	0.50
'RH 781'	38.80	–0.19	0.18	20.01	1.8	0.11	3.95	0.97	1.26
'RH 8113'	40.22	–0.05	1.00	20.40	–0.28	1.05	3.83	0.95**	0.05
'RH 819'	39.88	1.18	1.49	19.96	0.65**	0.00	3.54	1.16*	0.15
'RH 30'	38.55	0.3	0.10	19.30	–0.4	0.11	4.10	1.82	2.22
'RL 1359'	39.56	1.47**	0.04	20.23	1.43**	0.14	4.02	1.03	2.11
'RH 8812'	39.56	1.15**	0.27	20.09	0.83	0.45	3.65	0.53**	0.05
'Rohini'	41.33	–1.72	1.40	19.16	3.19**	0.13	4.08	0.87	3.27**
'Sanjucta Asech'	39.83	0.96	0.95	20.47	1.03	0.69	3.90	1.87	0.45
'Sej 2'	40.35	–0.25	0.04	19.64	0.73*	0.31	3.66	1.43**	0.09
'Vardan'	40.33	0.99	1.43	19.37	3.51**	0.08	4.57	2.54*	0.13
'Varuna'	38.33	1.19	2.02	19.64	2.29**	0.02	3.37	0.54	0.27
Mean	39.53			19.86			3.77		
SEbi (±)		0.39			0.23			0.24	
SEm (±)	0.64			0.35			0.58		

Varieties	Oleic acid (%)			Linoleic acid (%)			Linolenic acid (%)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
'Basanti'	15.07	0.53*	1.26	22.92	2.75	3.63	12.88	1.17**	0.15
'Bio 902'	13.78	0.83	7.36	16.74	0.6	5.51	13.00	1.54	3.7*
'CS 52'	13.20	0.85	3.88	19.17	1.32	2.88	12.23	–0.55	0.02
'GM 1'	14.37	2.13**	0.21	18.32	1.31	7.88	15.89	0.5	4.57*
'GM2'	14.44	2.22	7.23	16.22	1.77**	0.64	14.83	0.51	1.65
'Kranti'	14.97	1.86**	0.00	20.29	1.12	17.30*	11.76	1.58	14.9**
'Krishna'	9.49	–0.39	11.96*	15.21	0.53	25.06**	13.75	0.77	4.96*
'Pusa Bahar'	14.94	0.75	4.39	18.38	0.93*	1.68	12.57	0.86	2.16
'Pusa Bold'	13.55	1.11**	0.08	16.67	1.09**	0.00	14.91	1.45**	0.41
'Pusa Jagannath'	12.48	1.28**	0.27	17.92	0.98	17.90*	15.84	2.38**	0.84
'PBR 91'	12.89	0.14**	0.43	20.28	1.04**	0.58	14.48	0.12	8.11**
'PBR 97'	12.52	1.23**	1.03	17.14	1.17**	0.23	14.05	0.54	1.56
'PCR 7'	12.99	1.32*	1.62	17.93	1.04**	0.23	15.73	1.45**	0.57
'RCC4'	12.99	1.20**	0.00	19.44	0.4	35.02**	13.21	1.33	6.21**
'RH 781'	13.08	2.15**	0.02	18.03	0.44**	0.04	15.66	1.9**	0.35
'RH 8113'	12.79	0.71	2.57	17.20	1.27	3.14	14.97	0.28	1.73
'RH 819'	14.28	0.98	2.48	18.61	0.76	0.00	11.56	0.96	1.29
'RH 30'	13.19	1.32**	0.42	19.02	1.06	2.33	15.81	1.12**	0.64
'RL 1359'	12.26	1.81	1.85	19.58	0.89**	0.18	13.97	1.13**	0.37
'RH 8812'	11.88	0.8**	0.03	16.56	0.45**	0.48	14.08	0.35**	0.12
'Rohini'	13.53	0.46	2.00	16.78	0.23	2.95	13.16	0.61	2.59

(*Contd...*)

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'Sanjucta Asech'	12.43	–0.04	0.08	18.23	1.35**	0.09	13.44	1.98**	0.05
'Sej 2'	12.58	0.45**	0.06	18.66	1.34	7.57	15.13	0.86	0.39
'Vardan'	11.09	0.97	3.75	16.42	0.41**	0.47	15.10	1.17	5.12
'Varuna'	11.71	0.33	11.57	19.17	0.75**	0.44	14.85	1.06	11.49**
Mean	12.91			18.03			13.97		
SEbi (±)		1.08			1.02			0.90	
SEm (±)	1.14			1.65			1.22		

Varieties	Eicosenoic acid (%)			Erucic acid (%)			Glucosinolates (μ moles/g defatted seed meal)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
'Basanti'	7.91	0.71	1.55	36.8	2.15	5.34	106.5	0.36	24.98
'Bio 902'	6.26	1.25**	0.06	44.7	1.3	3.22	101.2	1.04**	1.97
'CS 52'	7.81	1.89	0.88	42.3	2.67	7.03	101.0	2.22**	3.63
'GM 1'	7.60	1.67	2.37	40.3	2.15**	0.25	105.9	0.11*	10.44
'GM 2'	6.51	2.22	2.85	42.9	2.06	20.58**	97.7	0.7**	1.84
'Kranti'	6.28	0.82	1.66	42.3	2.18**	0.08	108.6	1.56**	2.70
'Krishna'	7.52	0.12	1.30	49.9	–0.32	34.97**	113.5	0.3	62.85**
'Pusa Bahar'	6.10	0.83**	0.49	44.2	2.33**	0.00	100.2	0.37	1.74
'Pusa Bold'	8.08	0.94	0.74	42.0	1.56	7.66	96.6	2.37	15.86
'Pusa Jagannath'	7.42	0.51	8.50**	42.7	1.09**	0.01	107.6	0.91	17.86
'PBR 91'	6.43	1.3	0.94	39.1	0.8	20.19**	104.1	0.21	15.36
'PBR 97'	6.58	1.69**	0.01	46.3	0.96	18.10**	91.9	0.92**	9.25
'PCR 7'	6.45	1.43	0.00	43.2	2.2**	1.47	95.6	1.8	14.50
'RCC4'	8.31	–0.47	2.96	42.6	–0.81	3.95	106.9	1.97	181.26**
'RH 781'	6.30	1.22	6.25	42.0	1.86	7.98	91.9	0.24	35.24*
'RH 8113'	8.28	0.97	6.97*	42.4	0.63**	0.31	99.4	0.72	15.41
'RH 819'	6.53	1.74**	0.05	45.2	–0.2	0.47	101.2	0.91**	0.47
'RH 30'	7.79	0.78	4.85*	39.7	0.26**	0.35	102.6	2.23**	1.82
'RL 1359'	6.74	0.73	0.88	45.2	1.64	15.47*	98.8	0.69	51.12**
'RH 8812'	7.19	1.07**	0.3	45.2	0.93**	0.03	102.8	0.7**	0.19
'Rohini'	7.03	0.33**	0.34	45.4	–0.68	4.42	104.8	1.25**	3.53
'Sanjucta Asech'	6.18	1.18	3.00	45.2	–0.7	12.25	96.8	0.89**	1.20
'Sej 2'	6.64	1.45	0.70	43.5	0.4	2.76	96.3	0.62**	7.33
'Vardan'	6.88	–0.11	1.39	45.0	–0.18	6.47	94.0	0.02	55.84**
'Varuna'	4.82	0.7**	0.39	45.9	0.74**	0.03	103.2	1.93	161.74**
Mean	7.00			43.98			101.22		
SEbi (±)		0.46			0.76			2.31	
SEm (±)	0.99			1.86			3.74		

bi *, ** = Regression co-efficient significantly deviating from unity at P=0.05 and P=0.01 levels, respectively.
S^2di *, ** = Deviation from regression significantly different from zero at P=0.05 and P=0.01 levels, respectively.

among the 3 cropping seasons was linear. The G × E (linear) was significant for protein content, days to maturity and 1000-seed weight indicating that stability of genotypes could be judged on the basis of relative magnitude of variances. The genotypes had unpredictable performance over the environments for rest of the characters. The observed high magnitude of environmental (linear) effect in comparison to G × E (linear) for all the characters investigated suggested that high magnitude of environmental (linear) effect might be responsible for high adaptation of these genotypes in relation to quality and yield. Pooled deviation differed significantly for linoleic; linolenic, erucic acid, glucosinolates, days to maturity, 1000-seed weight and seeds/siliqua (Table 1), suggesting the genotypes had varying level of stability over the cropping seasons for these characters.

An ideal stable variety is characterized by high or desirable *per se* performance coupled with linear regression co-efficient (b) equal or close to unity and mean square deviations (S^2di) equal or close to zero (non-significant). Oil and protein content were fairly stable across the 3 environments except 'GM 1' for oil content with S^2di significantly different from zero (Table 2). Dhillon *et al.* (1999) also reported oil content to be fairly stable over environments. Significant linear regression co-efficient value (b > 1) for oil content suggested above average stability for the varieties 'Basanti', 'CS 52', 'Kranti', 'Krishna', 'PBR 97', 'RL 1359' and 'RH 8812'. The varieties 'Pusa Bahar', 'RCC4', 'Sej 2' and 'RH 781' were significantly least

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responsive to environmental conditions for oil content (b < 1). The top 4 highly environment-responsive varieties with b > 1 for protein content were 'Pusa Bahar', 'Vardan', 'Rohini' and 'Pusa Bold' (Table 2). The highly significant S^2di for the variety 'Rohini' and 'Krishna' revealed their instability across environments for SFA and oleic acid, respectively. 'Sej 2', 'Varuna', 'RH 819', 'GM 2' and 'Basanti' were the most responsive varieties for SFA. For oleic acid, 'RH 781' followed by 'GM 1' and 'Kranti' had the highest responsiveness to environments. The least responsive genotypes were 'Sunjucta Asceh', 'PBR 91' and 'Sej 2'. Except 'Kranti', 'Krishna', 'Pusa Jagannath' and 'RCC 4', the rest of the varieties had non- significant deviations from regression co-efficient from 0 for linoleic acid suggesting their stability. The significance of linear regression with magnitude of more than unity for linoleic acid revealed high responsiveness of 'GM 2', 'Pusa bold', 'PBR 91', 'PBR 97', 'PCR 7' and 'Sanjucta Asceh'. The varieties 'Bio 902', 'GM 1', 'Kranti', 'Krishna', 'PBR 91', 'RCC 4' and 'Varuna' had S^2di highly significant from 0 for linolenic acid, thus showing instability for this character in different environments (Table 2). The environment-responsive varieties for linolenic acid were 'Pusa Jagannath', 'Sanjucta Asech', 'RH 781', 'Pusa bold' and 'PCR 7', 'RH 30' and 'RL 1359' (b>1). 'RH 8812' was the least responsive variety with b = 0.35*.

Most of the varieties except 'Pusa Jagannath', 'RH 8113' and 'RH 30' were stable for eicosenoic acid. The most responsive varieties were 'PBR 97', 'RH 819', 'Bio 902' and 'RH 8812' while 'Rohini' followed by 'Varuna' and 'Pusa Bahar' the least responsive. Erucic acid was quite unstable as indicated by significant S^2di in the varieties 'GM 2', 'Krishna', 'PBR 91', 'PBR 97' and 'RL 1359'. Variable response to environment was observed for erucic acid with 'Pusa Bahar' and 'RH 819' showing the highest, 2.2**and lowest, –0.20* linear regression co-efficient. Varieties 'Krishna', 'RCC 4', 'RH 781', 'RL1359', 'Vardan' and 'Vaurna' were unstable for glucosinolates in different environments as they had highly significant S^2di values. The 3 most responsive varieties were 'RH 30', 'CS 52' and 'Kranti'. Variety 'GM 1', followed by 'Sej 2', 'RH 8812' and 'GM 2' were the least responsive to environmental conditions as indicated by significant b < 1.

Varieties 'Bio 902', 'PBR 97', 'PCR 7' and 'RH 781' had

Table 3 Estimates of stability parameters for yield and yield-attributing characters in Indian mustard

Varieties	Seed yield/plot (kg/ha)			Days to maturity			1000-seed weight (g)			Seeds/siliqua		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
'Bio 902'	1 759	1.02*	3.52	122.9	–0.54**	0.11	5.71	–0.14	0.00	14.3	1.98	4.97*
'CS 52'	1 045	0.14	2.38	133.4	0.76**	0.19	3.24	2.02**	3.31	16.3	0.89	2.27
'GM 1'	1 964	0.95	11.97**	125.2	3.48**	5.90*	4.15	1.11*	1.55	14.0	1.63	2.89
'GM 2'	2 059	1.56**	0.09	129.2	2.40*	12.71**	4.65	2.76	19.31**	15.5	–0.10	0.43
'Kranti'	1 906	1.29**	0.02	129.1	2.44**	4.37*	3.54	2.03**	0.02	16.1	0.44	1.39
'Krishna'	2 018	0.98**	0.16	124.4	–0.90	3.40	3.61	0.01	0.13	16.1	4.90**	1.76
'Pusa Bahar'	1 724	1.01	11.08**	124.4	–0.21	1.06	4.73	0.43**	0.12	15.3	2.29	15.48**
'Pusa Bold'	1 891	1.79**	0.56	126.8	1.22	8.07**	5.76	1.25**	1.17	15.4	2.90	21.99**
'Pusa Jagannath'	1 572	0.55	1.66	128.8	2.48**	1.38	4.74	0.71**	0.17	16.0	–0.11	0.01
'PBR 91'	1 422	0.77	3.66	135.6	3.09**	0.48	4.42	–0.14	0.50	16.8	–0.07	0.31
'PBR 97'	1 795	1.01**	0.01	136.6	3.74**	1.18	4.19	2.20*	6.50*	15.2	–0.23	57.75**
'PCR 7'	1 643	1.03**	0.76	133.8	4.70**	12.08**	4.42	0.64	3.84	15.9	1.72	9.29**
'RH 781'	1 365	0.99**	0.30	130.2	–0.14	15.81**	4.21	3.07	30.49**	15.0	–1.14	1.21
'RH 8113'	1 576	0.63**	0.12	137.7	1.33**	0.05	3.68	1.69**	1.05	15.1	0.30	0.16
'RH 819'	1 596	0.91*	2.76	126.8	–0.97	5.70	4.07	0.95	14.52**	15.7	1.34**	0.09
'RH 30'	1 636	0.86	4.70*	129.6	–3.09**	6.19*	4.91	0.71	22.52**	15.2	1.67**	0.00
'RL 1359'	1 837	0.79**	0.14	130.2	1.63	63.74**	3.54	–0.64	0.75	16.0	–1.08	2.39
'RH 8812'	1 613	–0.06	0.02	125.1	0.61*	0.68	4.80	–0.39**	0.01	15.5	4.75**	1.22
'Rohini'	1 748	2.52**	3.92*	128.1	1.08**	0.06	3.68	2.84**	4.06*	17.4	–2.91	4.99*
'Sanjucta Asech'	1 261	1.78**	3.68	114.8	0.40**	0.00	3.06	2.36**	0.17	14.7	1.63	11.13**
'Sej 2'	1 477	0.87**	1.45	116.6	1.07	11.23**	3.62	0.49*	0.30	15.2	2.15**	0.45
'Vardan'	1 142	0.88*	1.60	125.1	–1.87**	2.08	3.53	0.02	2.59	14.4	0.48	1.91
'Varuna'	1 458	0.73	4.04*	124.7	0.29	0.60	5.37	–0.99**	0.03	12.9	–0.43**	0.01
Mean	1 631			127.8			4.24			15.39		
SE bi (±)		0.43			0.85			0.89			1.79	
SEm (±)	124.4			1.48			0.17			0.84		

bi *, ** = Regression co-efficient significantly deviating from unity at *P*=0.05 and *P*=0.01 levels, respectively.
S^2di *, ** = Deviation from regression significantly different from zero at *P*=0.05 and *P*=0.01 levels, respectively.

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regression near to unity and non-significant pooled deviation. But the mean performance of RH 781 was below the average performance, hence remaining 3 varieties 'Bio 902', 'PBR 97' and 'PCR 7' were found stable for seed yield (Table 3). Varieties 'GM 2' and 'Pusa Bold' ($b > 1.0$, S^2di = non-significant) were better for input rich favourable environments, while varieties 'GM 1', 'Pusa Bahar', 'RH 30', 'Rohini' and 'Varuna' had significant pooled deviation-indicating their poor stability for seed yield. This was also observed that the varieties lacked stability for other yield-contributing characters as regression co-efficients significantly differed from unity for days to maturity, 1000-seed weight and seeds/siliqua. 'Rohini', however, showed relatively stable maturity duration over the environments. The 1000-seed weight varied from 3.06 ('Sanjucta Asech') to 5.71 g ('Bio 902'). 'GM 1' displayed relatively stable 1000-seed weight as the pooled deviation was non-significant and regression co-efficient was 1.11 (Table 2). Seeds/siliqua varied from 12.9 ('Varuna') to 17.4 ('Rohini'). But varieties showed varied response for this character under different environments.

The estimates of stability parameters (b and S^2di) suggested that none of the varieties showed stable performance for all the 9 quality characters investigated. Three varieties namely, 'CS 52' (protein content, oleic, linoleic, linolenic, eicosenoic and erucic acid) ; 'RH 8113' (oil content, protein content, oleic, linoleic, linolenic and erucic acid) and 'Sanjucta Asceh' (oil content, protein content, saturated fatty acid, oleic, linoleic and erucic acid) showed stability for maximum of 6 characters. Eight ('Bio 902', 'GM 2', 'PCR 7', 'RH 781', 'RH 819', 'Rohini', 'Sej 2' and 'Vardan') and 4 varieties ('Basanti', 'Pusa Bold', 'PBR 97' and 'RH 30') respectively exhibited stable performance for 5 and 4 of the 9 quality characters studied. Further, 3 varieties ('Bio 902', 'PBR 97' and 'PCR 7') showed stable performance for seed yield over environments. In earlier studies (Singh *et al.* 2006) variety 'Bio 902' has been reported to be stable for seed yield. The results of the present investigation revealed that G × E interaction largely affected oil and meal quality, seed yield and its component characters of Indian mustard to varying levels depending on the character. Therefore in the breeding programme appropriate selection strategy should be adopted to accommodate the influence of G × E interaction on the expression of quality and seed yield.

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