

Genetic Variability in the Germplasm of Indian Mustard

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Abstract

The investigation was carried out with a set of eight varieties of Indian mustard and their 28 F₁'s obtained through diallel crossing excluding reciprocals. These were grown in randomized block design with three replications during *rabi* season of 2005 and studied for 12 quantitative characters. Out of these, white rust infections per plant were so negligible to affect the economic yield. The analysis of variance was done with 36 entries including 8% separately for 12 quantitative characters to test the significance of differences among all the genotypes, parents and crosses. The analysis of variance showed highly significant differences among combined genotypes (parents and crosses) for all the characters studied except number of seeds / siliqua. The tests of significance of differences were also done among parents and crosses individually. All the eight parents and 28 crosses were found to differ significantly for all the characters studied, except plant height for parents and number of seeds/siliqua for parents as well as crosses. Parents vs crosses were also highly significant for all characters except number of seeds per siliqua and 1,000-seeds weight. The estimates of genotypic coefficient of variation revealed that alternaria blight infection per plant both in parents and crosses were the most variable character. The estimates of phenotypic coefficient of variation revealed that alternaria blight infection per plant was the most variable character among parents and aphids infestation per plant at pod formation stage was the most variable character among crosses. The highest value of heritability was observed in alternaria blight infection per plant among parents, whereas among crosses the highest heritability was observed in number of siliqua/plant. The highest value for genetic advance was recorded for number of siliqua per plant among parents and crosses. Genetic advance expressed as percent of mean was the maximum in alternaria blight infection among the parents and crosses

Key words : *Brassica juncea* Linn., Genetic variability, Germplasm improvement.

Indian mustard *Brassica juncea* L. Czern. and Coss. is the most important *rabi* oilseed crop. It occupies a prominent position in Indian oilseeds scenario and plays a vital role in oil seed economy of our country. The productivity of this crop has shown slight decline in India during the recent past from 1,151 kg/ha in 2003-04 to 1,117 kg/ha during 2005-06. The productivity of 566 kg/ha in Jharkhand is still lower (1). Variability studies in a crop are pre-requisite for starting any crop improvement program. Crop improvement depends on the magnitude of genetic variability and the extent to which desirable characters are heritable. Thus, the study of the extent of genetic variability is of paramount importance for the breeders in making the final selection of lines for yield. Among the different components of higher productivity, improved variety alone constitutes 90% of overall yield increases. As the present improved varieties situation has reached a plateau, extensive hybridization program to produce a large variability

for selection of superior genotypes is the present need. Thus a survey of genetic parameter such as genetic co-efficient of variation, heritability estimates and genetic advance are essential for selection of genotype for effective breeding program.

Methods

The experiment was carried out in the field of Mustard Research Scheme of the Department of Plant Breeding and Genetics, Birsa Agricultural University, Ranchi, geographically situated at 23° 17' N latitude and 85° 19' E longitude and the altitude is 625 MSL. The genetic materials comprised of eight varieties of Indian mustard (*Brassica juncea* (L.) Czern. & Coss.) viz., BAUSM 92-1-1, BR-40, BIO-902, Laxmi, Varuna, JMM-991, SKM-0149 and Pusa bold. The above eight varieties were sown in a crossing block on two different dates at interval of ten days during *rabi* season 2005 to synchronize

Table 1. ANOVA for 36 genotypes of Indian mustard including parents and crosses. *Significant at 5% probability level, **Significant at 1% probability level.

Source	Rep.	Treatment	Mean Squares		Parents Vs crosses	Error
			Parents	Crosses		
Degree of freedom	2	35	7	27	1	70
Characters						
Days to 50% flowering	0.259	35.837**	24.38**	36.73**	92.017**	0.63
Days to maturity	1.037	11.583**	11.33**	11.89**	5.122**	0.685
Plant height (cm)	24.01	195.811*	64.98	220.983**	432.00*	102.11
Number of siliquae / plant	11.09	13590.93**	2740.88**	11863.40**	136184.50**	151.965
Number of seeds/siliqua	0.560	1.102	1.322	1.039	1.290	0.881
Seed yield/plant (g)	0.995	26.38**	14.689**	22.49**	213.14**	1.312
1000-seeds weight (g)	0.21	0.59**	0.565**	0.619**	0.231	0.091
Alternaria blight infection/ plant (%)	10.258	314.41**	438.64**	253.763**	1082.24**	9.276
Aphids infestation/plant at full blooming stage (number)	0.798	4.173**	1.57**	4.827**	4.707**	0.501
Aphids infestation/plant at siliqua formation stage (number)	2.11	23.13**	13.48**	26.456**	1.009	1.462
Oil content (%)	3.69	3.31**	4.81**	2.819*	6.153**	1.526

flowering duration between some of the early and late flowering in all possible combinations excluding reciprocals in a diallel fashion. Thus, eight parents and 28 F₁ obtained from these parents constituted the experimental material for the present investigation.

Data on days to 50% flowering, days to maturity, plant height, number of siliqua, number of siliqua per plants, average number of seeds per siliqua, seed

yield, 1,000 weight, percentage, alternaria disease infection at maturity, percentage white rust disease infection at full blooming and maturity were recorded on each of five randomly selected plants from each plot. The oil content for the seeds of selected plants was estimated using Oxford 4000 nuclear magnetic resonance (NMR) spectrometer available at Department of Agronomy, BAU and expressed in percent-

Table 2. Mean performance of parents for eleven characters in Indian mustard.

Parents	Days to 50% flowering (days)	Days to maturity (days)	Plant height (cm)	Number of siliquae/plant	Number of seeds/siliqua	Seed yield/plant (g)	1000-seeds weight (g)	Alternaria blight infection/plant (%)	Aphids infestation/plant at full blooming stage (no.)	Aphids infestation/plant at siliqua formation stage (no.)	Oil content percent
BAUSM 92-1-1	58.00	118.33	128.87	246.93	12.30	8.88	4.26	20.00	4.27	10.00	40.79
BR-40	55.00	114.00	131.53	263.80	13.68	10.97	3.54	27.73	2.73	5.00	39.00
BIO-902	57.00	117.67	131.27	233.53	12.67	13.49	4.71	35.47	4.40	8.067	38.87
Laxmi	59.00	118.00	138.33	218.27	13.49	11.12	4.53	54.13	3.07	4.60	40.50
Varuna	58.333	115.00	127.87	274.20	14.09	10.27	3.66	37.07	3.133	9.533	41.95
JMM-991	64.00	119.67	140.47	230.67	13.85	10.55	4.48	30.40	4.13	8.667	38.35
SKM-0149	62.00	119.00	136.67	266.47	12.64	15.73	4.56	23.20	3.27	7.333	39.72
Pusa bold	60.33	117.00	136.53	312.93	12.83	13.36	4.42	15.47	2.53	5.267	38.54
CD at 5%	1.65	1.49	NS	20.43	NS	1.35	0.53	4.44	NS	2.030	1.69
SE (d) ±	0.76	0.69	8.98	9.44	0.78	0.62	0.25	2.05	0.69	0.937	0.78
SE (m) ±	0.54	0.47	6.35	6.67	0.55	0.44	0.17	1.45	0.49	0.663	0.55
CV %	1.58	0.72	8.21	4.52	7.26	6.48	7.05	8.16	24.36	15.708	2.41

Table 3. Mean performance of crosses for eleven characters in Indian mustard. *Significant at 5% probability level, **Significant at 1% probability level.

Crosses	Days to 50% flowering	Days to maturity	Plant height	No. of siliquae/plant	No. of seeds/silique
BAUSM-92-1-1 × BR-40	51	110.33	126.47	340.13	13.01
BAUSM-92-1-1 × BIO-902	54.67	116.33	132.93	294.13	13.96
BAUSM-92-1-1 × Laxmi	53.33	116.33	133.47	271.87	14.06
BAUSM-92-1-1 × Varuna	56.33	117.00	141.20	347.40	12.79
BAUSM-92-1-1 × JMM-991	54.33	117.67	147.80	407.67	12.49
BAUSM-92-1-1 × SKM-0149	56.33	116.33	139.53	335.87	12.83
BAUSM-92-1-1 × Pusa bold	55.33	115.33	136.53	438.40	12.93
BR-40 × BIO-902	53.67	116.33	142.73	384.20	13.68
BR-40 × Laxmi	55.33	116.33	136.47	387.07	12.59
BR-40 × Varuna	54.33	115.00	132.07	497.13	14.23
BR-40 × JMM-991	59.33	114.67	134.87	453.40	14.57
BR-40 × SKM-0149	53.67	114.33	144.80	397.93	14.33
BR-40 × Pusa bold	51.67	114.00	131.27	309.07	13.28
BIO-902 × Laxmi	61.67	119.00	136.67	291.60	13.47
BIO-902 × Varuna	57.33	119.00	135.47	345.20	14.29
BIO-902 × JMM-991	58.33	118.67	143.80	366.33	13.33
BIO-902 × SKM-0149	54.67	118.67	147.93	351.73	13.15
BIO-902 × Pusa bold	54.67	117.67	136.13	329.00	13.73
Laxmi × Varuna	59.67	118.00	130.07	264.73	13.62
Laxmi × JMM-991	62.33	118.33	135.73	287.80	13.64
Laxmi × SKM-0149	61.33	119.00	134.80	251.80	13.52
Laxmi × Pusa bold	55.33	115.00	140.93	286.13	13.24
Varuna × JMM-991	60.67	117.00	168.60	356.47	13.68
Varuna × SKM-0149	58.00	118.33	144.87	239.33	14.07
Varuna × Pusa bold	60.00	118.00	129.13	350.40	13.38
JMM-991 × SKM-0149	65.00	119.00	152.67	284.93	13.67
JMM-991 × Pusa bold	56.00	117.00	136.73	386.13	12.94
SKM-0149 × Pusa bold	61.33	118.00	131.40	299.53	12.30
CD at 5%	1.212	1.286	16.470	19.997	NS
SE (d) ±	0.603	0.639	8.192	9.947	0.730
SE (m) ±	0.426	0.452	5.793	7.033	0.516
CV %	1.296	0.670	7.231	3.570	6.633

age. Oil yield per plant was calculated as percent ratio of seed yield per plant (g) multiplied with oil content (%) gave yield per plant. The mean value was used to compute analysis of variance (ANOVA), phenotypic coefficient of variation, genotypic coefficient of variance, heritability and genetic advance. The genotypic variance (σ^2_g) was obtained following Burton (2). Heritability was obtained from the variance component analysis Hanson et al. (3) and the expected genetic advance (%) was calculated Johnson et al. (4).

Results and Discussion

Anova for 36 Genotypes

The analysis of variance was done with 36 en-

tries including eight parents separately for 12 quantitative characters to test the significance of differences among all the genotypes, parents and crosses. The mean sum of squares for each character is presented (Table 1). The analysis of variance showed highly significant differences among combined genotypes for all the characters except number of seeds per silique. The tests of significance of differences were also done among parents as well as crosses individually. All the eight parents and 28 crosses were found to differ significantly for all the characters studied, except plant height for parents and number of seeds per silique for parents as well as crosses. Parents vs crosses were also highly significant for all characters except number of seeds per silique and 1,000-seeds

Table 4. Mean performance of crosses for eleven characters in Indian mustard. *Significant at 5% probability level, **Significant at 1% probability level.

Crosses	Seed yield/ plant (g)	1000-seeds weight (g)	Alternaria blight infection/ plant	Aphids infesta- tion/plant at full blooming stage	Aphids infes- tation/ plant at siliqua forma- tion stage	Oil content percent
BAUSM-92-1-1 × BR-40	13.35	3.72	20.53	5.20	6.33	39.81
BAUSM-92-1-1 × BIO-902	12.55	4.32	15.20	3.73	5.13	40.90
BAUSM-92-1-1 × Laxmi	11.44	4.00	24.00	3.93	7.40	39.72
BAUSM-92-1-1 × Varuna	14.65	4.29	33.60	4.73	8.60	40.27
BAUSM-92-1-1 × JMM-991	21.49	4.23	23.20	2.57	3.80	39.23
BAUSM-92-1-1 × SKM-0149	12.97	4.08	19.20	1.77	2.63	40.47
BAUSM-92-1-1 × Pusa bold	14.26	4.22	12.53	3.80	8.87	39.25
BR-40 × BIO-902	13.45	4.23	16.53	4.24	6.38	39.83
BR-40 × Laxmi	16.10	4.24	34.13	7.60	14.40	41.36
BR-40 × Varuna	18.76	3.26	29.60	5.40	11.40	41.42
BR-40 × JMM-991	15.73	3.74	26.67	3.03	5.73	38.96
BR-40 × SKM-0149	18.56	3.54	28.27	3.13	4.87	41.08
BR-40 × Pusa bold	14.24	3.64	12.27	3.80	6.87	41.79
BIO-902 × Laxmi	17.50	4.83	37.87	3.67	6.73	38.63
BIO-902 × Varuna	18.39	4.80	40.53	5.93	11.60	40.23
BIO-902 × JMM-991	19.44	4.78	12.53	3.93	9.20	39.46
BIO-902 × SKM-0149	17.74	5.26	16.53	3.90	10.71	39.73
BIO-902 × Pusa bold	17.19	4.79	16.27	3.87	9.69	40.72
Laxmi × Varuna	13.66	4.03	10.40	4.53	10.27	42.01
Laxmi × JMM-991	14.12	4.41	9.07	2.85	5.20	39.86
Laxmi × SKM-0149	12.33	4.42	32.80	6.20	13.20	41.63
Laxmi × Pusa bold	11.69	3.71	34.67	2.33	3.80	41.14
Varuna × JMM-991	16.65	4.09	18.13	2.60	5.33	40.86
Varuna × SKM-0149	10.97	3.90	34.40	3.53	5.80	39.38
Varuna × Pusa bold	13.86	3.73	28.00	3.67	7.33	41.23
JMM-991 × SKM-0149	16.47	4.37	18.40	4.47	9.40	38.49
JMM-991 × Pusa bold	15.55	3.85	13.07	3.20	5.53	40.46
SKM-0149 × Pusa bold	11.78	3.94	20.53	2.80	4.93	40.20
CD at 5%	2.017	0.501	3.987	1.122	2.00	1.985
SE (d) ±	1.003	0.249	1.983	0.558	0.995	0.988
SE (m) ±	0.709	0.176	1.402	0.395	0.704	0.698
CV %	8.096	7.337	10.475	17.338	16.161	2.999

weight. Similar trend was also found by Teklewold et al. (5). The coefficient of variation was the maximum for aphids' infestation per plant at full blooming stage and the minimum for days to maturity.

Mean Performance of Parents and Crosses

The mean performance of eight parents and 28 crosses for 12 characters has been provided in Tables 2, 3 and 4, respectively. Days to 50% flowering

ranged from 55 days for BR-40 to 64 days in JMM-991 in parents with a mean 59.00, while in crosses the range was 51 days (BAUSM-92-1-1 × BR-40) to 65 days in JMM-991 × SKM-0149 with the F_1 mean value of 56.99 days. The days to maturity ranged from 114 days (BR-40) to 119.67 days in JMM-991 in parents with a mean of 117.33 days while in crosses the range was 111.00 days (BAUSM-92-1-1 × BR-40) to 119.00 days (BIO-902 × Laxmi, BIO-902 × Varuna, Laxmi × SKM-0149 and JMM-991 × SKM-0149) with F_1 mean value of 117.33 days. Plant height in

Table 5. Genotype, phenotypic and environmental coefficient of variance, heritability and genetic advance among oil yield and yield contributing characters in parents and crosses. P = Parents ; C = Crosses.

Characters		$\sigma^2 g$	$\sigma^2 p$	$\sigma^2 e$	GCV	PCV	Herita- bility %	GA	GA as per- cent of mean
Days to 50% flowering (days)	P	7.92	8.55	0.63	4.75	4.94	92.62	5.58	9.42
	C	12.03	12.66		5.86	6.01	95.02	6.97	12.22
Days to maturity (days)	P	3.55	4.23	0.69	1.606	1.75	83.82	3.55	3.03
	C	3.73	4.42		1.65	1.79	84.49	3.66	3.13
Plant height (cm)	P	12.37	89.74	102.11	2.63	7.07	13.78	2.69	2.01
	C	39.62	141.74		4.69	8.85	27.96	6.86	4.94
No. of siliquae/plant	P	862.97	1014.94	151.97	11.48	12.45	85.03	55.80	21.81
	C	3903.81	4055.78		24.42	24.89	96.25	126.27	37.00
No. of seeds/siliqua	P	0.15	1.03	0.88	2.91	7.69	14.29	0.29	2.26
	C	0.05	0.93		1.71	7.18	5.64	1.12	8.35
Seed yield/plant (g)	P	4.46	5.77	1.31	17.9	20.36	77.27	3.82	32.42
	C	7.06	8.37		22.53	24.53	84.33	5.03	33.13
1000-seed weight (g)	P	0.16	0.25	0.09	9.31	11.69	63.45	0.65	15.23
	C	2.27	2.362		36.24	36.96	96.15	3.04	73.21
Alternaria blight infection/plant	P	143.12	152.39	9.028	39.31	40.56	93.91	23.88	78.47
	C	81.49	90.77		39.56	41.75	89.78	17.62	77.22
Aphids infestation/plant at full blooming stage (number)	P	0.36	0.86	0.50	17.36	26.91	41.61	0.79	23.07
	C	1.44	1.94		34.89	40.50	74.22	2.13	54.01
Aphids infestation/plant at siliqua formation stage (number)	P	4.01	5.47	1.46	27.38	31.99	73.26	3.53	48.30
	C	8.33	9.79		39.49	42.82	85.07	5.48	72.67
Oil content (%)	P	1.09	2.62	1.53	2.63	4.08	41.78	1.39	3.51
	C	0.43	1.96		1.63	3.47	22.02	0.63	1.58

parents 127.867 cm (Varuna) to 140.467 cm (JMM-991) with parental mean of 133.94 cm, while in crosses, it ranged from 126.47 cm (BAUSM-92-1-1 × BR-40) to 168.60 cm (Varuna × JMM-991) with F_1 mean value of 138.75 cm. Number of siliqua per plant 218.27 (Laxmi) to 312.93 days (Pusa bold) in parents with mean value of 255.85, while in crosses 239.33 (Varuna × SKM-0149) to 497.13 (BR-40 × Varuna) with F_1 s mean value of 341.264. Number of seeds per siliqua ranged from 12.30 (BAUSM-92-1-1) to 14.093 (Varuna) in parents with parental mean of 13.19 while in crosses the range was 12.30 (SKM-0149 × Pusa bold) to 14.57 (BR-40 × JMM-991) with F_1 mean value of 13.46. Seed yield per plant ranged from 8.88 g (BAUSM-92-1-1) to 15.727 g (SKM-0149) in parents with parental mean to 11.797 while in crosses the range was 10.97 g (Varuna × SKM-0149) to 21.49 g (BAUSM-92-1-1 × JMM-991) with F_1 mean value of 15.176. 1000-seed weight (g) in parents ranged from 3.54 (BR-40) to 4.71 g (BIO-

902) with parental mean of 4.27, while in crosses 3.26 (BR-40 × Varuna) to 5.26 g (BIO-902 × SKM-0149) with F_1 mean of 4.16. Alternaria blight infection per plant (%) in parents ranged from 15.467 (Pusa bold) to 54.13 (Laxmi) with parental mean of 30.43, while in crosses the range was 9.07 (Laxmi × JMM-991) to 40.53 (BIO-902 × Varuna) with F_1 mean value of 22.82. Aphids infestation per plant at full blooming in parents ranged from 2.53 (Pusa bold) to 4.4 (BIO-902) with parental mean value of 3.44, while in crosses it range from 1.77 (BAUSM-92-1-1 × SKM-0149) to 7.6 (BR-40 × Laxmi) with F_1 s mean value of 3.94. Aphids' infestation per plant at siliqua formation in parents ranged from 4.60 (Laxmi) to 10.00 (BAUSM-92-1-1) with parental mean value of 7.31 ; while in crosses there was 2.63 (BAUSM-92-1-1 × SKM-0149) to 14.40 (BR-40 × Laxmi) with F_1 s mean value of 7.54. Oil content percent in parents ranged from 38.35 (JMM-991) to 41.95 (Varuna) with parental mean value of 39.72, while in crosses

the range was 38.49 (JMM-991 × SKM-0149) to 42.01 (BR-40 × Pusa bold) with F_1 mean value of 40.29%.

GCV, PCV, Heritability and Genetic Advance

Table 4 shows that the estimates of genotypic coefficient of variation (GCV) revealed that alternaria blight infection per plant both in case of parents and crosses were the most variable character. The estimates of phenotypic coefficient of variation (PCV) revealed that alternaria blight infection per plant was the most variable characters among parents and aphid's infestation per plant at siliqua formation stage was the most variable characters among crosses. Among other characters high degree of variability was observed for number of siliqua/plant, seed yield per plant, 1,000-seed weight, aphid's infestation per plant at full blooming stage (number) and aphid's infestation per plant at siliqua formation stage on the basis of GCV and PCV values. Similar result was also found by Shalini et al. (6). The estimates of heritability percent for the eleven characters ranged from 13.78 in plant height to 93.91 in alternaria blight infection per plant among parents, whereas among crosses it varied observed between 5.64 in number of seeds per siliqua to 96.25 in number of siliqua per plant. Among other characters high heritability percent was observed for days to 50% flowering (92.62 for parents and 95.02 for crosses), days to maturity (83.82 for parents and 84.5 for crosses), number of siliqua per plant (85.03 for parents), seed yield per plant (77.27 for parents and 96.15 for crosses), alternaria blight infection (93.91 for parent and 89.78 for cross) and aphids infection per plant at siliqua formation stage (73.26 for parent and 85.07 for crosses). The estimates of genetic advance showed large difference among all the characters studied within parents as well as crosses. The highest value was recorded for number of siliqua per plant 55.80 and 126.27 among parents and crosses respectively. The

lowest value was observed in number of seeds per siliqua (0.298) among parents and oil content (0.64) in crosses. Genetic advance expressed as percent of mean ranged from 2.01 in plant height to 78.47 percent in alternaria blight infection among the parents. While, among the crosses it ranged from 1.576 in oil content to 77.22 in alternaria blight infection. In parents the characters like number of siliqua per plant (21.81), seed yield per plant (32.42), alternaria blight infection (78.6), aphids infection per plant at full blooming stage (23.07) and aphids infection per plant at siliqua formation stage (48.30%) showed higher genetic advance as percent of mean, whereas, days to 50% flowering (9.42%) and 1000-seed weight (15.23%) showed moderate genetic advance as percent of mean. Contrary to the present finding Wan and Hu (7) observed higher genetic advance and heritability for days to flowering. However, results obtained by Patel and Patel (8) were similar to the present investigation.

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