Selection Parameters for Yield, its Components and Oil Content in Indian Mustard [*Brassica juncea* (L.) Czern & Coss]

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Thirty six F_1s, 36F_2s hybrid combinations obtained from nine parents crossed in a dial lei fashion in Indian mustard (*Brassica juncea* (L.) Czern & Coss) were grown in complete randomized block design. Data were recorded on nine quantitative and one qualitative characters. Wide range of means was observed for all the ten characters. High value of phenotypic coefficient of variation (PCV) with their respective genotypic coefficient of variation (GCV) in both F_1 and F_2 analysis suggest that phenotypic selection may be useful. Parameteres of heritability, genetic advance, correlation and path analysis revealed that for enhancing seed yield/plant by selection in segregating hybrid populations major emphasis should be stressed largely upon five characters namely, test weight, secondary branches, plant height, primary branches and number of siliquae on main raceme.

Key words: Indian mustard, Diallel, Heritability, Genetic advance, Correlation, Path analysis

Indian mustard or rai (*Brassica juncea* (L.) Czern & Coss) is an important *rabi* oilseed crop. Every part of mustard plant is utilized commercially either directly or after processing. Since 2001, mustard cultivationn has gained more economic importance as compared to *rabi* cereals, pulses or even vegetables, because after threshing seeds for extracting edible mustard oil and cake the remaining plant part called *'turi'* has been purchased as fuel by brick furnace owners in Uttar Pradesh at profitable cost. Mustard is cultivated mostly in sub-marginal lands under unirrigated and rainfed confitions in different states of our country. Uttar Pradesh is one of the important mustard growing states of India. This accounts for nearly 35 per cent area and 40 per cent production of country. In Uttar Pradesh Indian mustard has occupied 2200.00 thousand hectare area with a productivity of 1000 Kg/ha. Average productivity of this crop in India is quite low (1013 Kg/ha) as compared to the world average of 1333 Kg/ha. So there is a much scope of enhancing the productivity level of mustard or *rai* in Uttar Pradesh. Many times breeders greatly depend upon the nature and magnitude of genetic variance of the characters under consideration and interrelationship them before taking up hybridization programme. Therefore in the present investigation diallel analysis was done to evaluate the nature and magnitude of genetic variances, heritability, genetic advance, association and path analysis for yield and its variables in Indian mustard.

Materials and Methods

The present investigation was conducted at Agricultural Research Farm, Narain College, Shikohabad affiliated to Dr BRA University (formerly Agra University), Agra during *rabi* season 2003-2004. The experimental material comprised of 36 F_1s and 36 F_2s cross combinations of nine divergent genotypes of Indian mustard *viz.* T-59, RH-30, Pusa Bold, RL-1359, RW-351, JGM-01-15, CS-52, RK-1418 and Pant Rai-16. All the above genotypes were choosen from rapeseed-mustard seed material collected in October, 2000 from National Research Centre for Rapeseed-Mustard, Sewar, Bharatpur, Rajasthan. The crosses were developed by adopting the diallel mating system in earlier years. F_1 and F_2 generations were grown in randomized complete block design with three replications. F_1s and F_2s were grown in single and three rows plots of 4 m long, spaced at 45 cm apart. The distance of 15 cm between plants within rows was maintained by thinning of densely grown plants after 15-20 days of sowing. One non-experimental row was sown on both sides of each replication to avoid border effect. A basal dose of NPK@40:20:20 Kg/ha was given just before seeding. Recommended cultural practices and plant protection measures were adopted as and when needed to raise a good and healthy crop under irrigated condition. The observations were recorded on ten (parents and (F_1s) and twenty (F_2s) randomly selected competitive plants in each plot and also from each replication for the following ten Characters *viz.*, days to first flowering (mean in days on row basis), plant height (cm), main raceme lingth (cm), primary branches/plant, secondary branches/plant, number of siliquae on main raceme, siliqua length (cm), 1000-seed weight (g), seed yield/plant (g) and oil content/

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plant (%). The oil content/plant in percent was measured by using official methods of analysis of the Association of Official Analytical Chemists (AOAC, 1985). Range, mean, coefficient of variability were computed using standard statistical methods (Gomez and Gomez, 1984). Heritability, genetic advance, correlation and path analysis were analysed as proposed by Johnson *et al.* (1955) and Dewey and Lu (1959). All these biometrical calculations were performed form F_1 and F_2 population's mean only.

Results and Discussion

The genetic parameters of variability in F_1 and F_2 diallel progenies for different characters studied are presented in Table 1. The genotypic variance (GCV) in general were observed to be lower in magnitude than the corresponding phenotypic coefficient of variances, indicating environment masking influence on the expression of genetic variability. Comparison of relative magnitude of genotypic coefficient of variation for F_1 and F_2 diallel population revealed that maximum amount of genetic variability was present for seed yield/plant in both (42.76%) F_1 and F_2 (41.28%). High amount of genotypic coefficient of variation in F_1 generation was possessed by number of secondary branches per plant (22.26%), 1000-seed weight (20.73%), number of siliquae on main raceme (18.78%), number of primary branches per plant (16.81%) and length of main raceme (15.47%) comparatively parallel but higher magnitude of GCV was also exhibited in F_2 for all the characters studied except length of main raceme. This indicates good scope for the genetic improvement of these traits. Similar findings were also reported by Mahla *et al.* (2003) in Indian mustard. In the present study minimum genetic variation was recorded for oil content per plant in the study material with overall mean 39.33 per cent in F_1 and 39.26 per cent in F_2.

Narrow sense heritability estimates in per cent ranged from 7.28 per cent (seed yield per plant in F_1) to 66.70 per cent (days to first flower in F_2). The magnitudes of heritability in F_2s were found higher than those of F_1s for all the characters except siliqua length (36.55%). The genetic advance computed as per cent of mean ranged from 0.87 per cent (siliqua length) to 28.26 per cent (plant height) in F_1 and from 0.73 per cent (siliqua length) to 23.00 per cent (plant height) in F_2. The estimates of genetic advance in F_1 were recorded higher than in F_2. High heritability coupled with high genetic advance was observed for days to flower, plant height and main raceme length, while 1000-seed weight and siliqua length exhibited high heritability coupled with extremely low genetic advance in F_1 as well as F_2. Low heritability was observed for primary branches, secondary branches and siliquae on main raceme in F_1. Since heritability in narrow sense is a ratio of additive genetic variance to phenotypic variance, relative higher proportion of dominant component for

Table 1. Genetic parameters of variation for 10 traits in diallel populations of Indian mustard

Populations	Parameters		Days to flower	Plant height	Main raceme length	Primary branches	Secondary branches	Siliquae on main raceme	Siliqua length	Test weight	Seed yield/plant	Oil content
	Mean		38.22	184.05	71.42	7.20	22.25	44.50	4.60	3.40	14.10	39.33
	Range	Min	35.00	140.00	41.25	5.00	10.00	25.00	3.70	2.10	5.26	34.55
F_1		Max.	46.25	224.00	101.38	12.00	50.25	76.25	5.00	5.22	33.76	41.62
	PCV		4.20	9.33	16.69	22.75	25.21	20.16	11.26	22.26	45.82	5.14
	GCV		3.72	8.77	15.47	16.81	22.26	18.78	10.35	20.73	42.76	3.45
	h^2(ns)		60.09	30.66	40.33	8.59	11.36	13.01	38.26	51.93	7.28	15.75
	GA* (as % of mean)		8.36	28.26	17.11	2.82	7.36	11.86	0.87	0.99	5.32	4.65
	Mean		36.25	181.25	66.25	7.60	22.15	44.00	4.5	3.3	12.15	39.26
	Range	Min.	33.21	141.25	42.35	5.00	9.25	23.00	3.6	2.00	5.25	35.25
F_2		Max.	48.25	216.75	96.25	13.50	47.35	78.65	5.9	5.15	30.45	41.45
	PCV		4.51	9.78	16.21	23.66	26.45	21.35	10.77	24.16	44.05	5.21
	GCV		3.92	8.56	15.32	17.28	24.15	19.23	10.26	22.67	41.28	4.32
	hzjns)		66.70	58.39	60.03	40.19	40.71	23.03	36.55	54.00	28.41	21.25
	GA* (as % of mean)		6.71	23.00	10.74	1.17	2.33	8.35	0.73	0.85	2.39	3.72

PCV = Phenotypic coefficient of variation, GCV = Genotypic coefficient of variation, h^2 = Heritability, GA = Genetic advance

* The selection differential used was 2.06 at 5% selection intensity.

Table 2. Genotypic (upper values) and phenotypic (lower values) correlations among nine character in Fi (above the diagonal) and F2 (below the diagonal) of Indian mustard

Characters	Days to flower	Plant height	Main raceme length	Primary branches	Secondary branches	Siliquae on main raceme	Siliqua length (cm)	Test weight (g)	Seed yield/plant (g)	Oil content (%)
Days to	Fi→ G	0.710**	0.053	0.295	0.159	0.268	–0.379*	–0.403**	–0.234	0.085
flower	F_2↓ P	0.665**	0.048	0.277	0.152	0.258	–0.352*	–0.376**	–0.220	0.072
Plant	G0.712**		0.326*	0.415**	0.450**	0.638**	–0.112	–0.216	0.172	0.105
height	P 0.643**		0.321*	0.407**	0.443**	0.634**	–0.112	–0.215	0.162	0.095
Main raceme	0.297	0.054		0.198	0.223	0.589**	0.386*	0.352*	0.289	–0.162
length	0.241	0.040		0.196	0.222	0.581**	0.384*	0.351*	0.286	–0.155
Primary	0.264	0.396**	–0.388*		0.581**	0.330*	0.191	0.270	0.503**	–0.045
branches	0.233	0.357*	0.322*		0.573**	0.322*	0.189	0.266	0.493**	–0.031
Secondary	–0.183	0.017	–0.512**	0.189		0.414**	0.244	0.195	0.652**	–0.378*
branches	–0.171	0.017	–0.468**	0.183		0.407**	0.241	0.195	0.643**	–0.365*
Siliquae on	–0.628**	0.605**	0.280	0.162	–0.462**		0.327*	0.246	0.396**	–0.210
main raceme	0.55**	0.58**	0.262	0.155	–0.425"		0.320*	0.241	0.387*	–0.202
Siliqua	–0.318**	–0.301	–0.046	–0.254	0.033	0.043		0.782**	0.543**	0.115
length	–0.293	–0.292	–0.039	–0.230	0.030	0.043		0.765**	0.535**	0.112
Test	–0.542**	–0.571**	–0.402**	–0.128	0.306*	–0.573**	0.267		0.585**	–0.055
weight	–0.496**	–0.544**	–0.360*	–0.115	0.286	–0.547**	0.299		0.535**	–0.050
Seed yield/	–0.271*	–0.037	–0.174	–0.163	0.221	–0.082	0.109	0.302		–0.295
plant	–0.259	–0.038	–0.163	–0.153	0.204	–0.076	0.108	0.310		–0.283
Oil content	0.088	0.091	–0.155	–0.033	–0.295	–0.198	0.101	–0.050	–0.188	–
	0.070	0.090	0.141	–0.026	–0.271	–0.190	0.086	–0.038	–0.181	–

*, ** Significant at 5% and 1% level of probability; G = Genotypic; P = phenotypic

primary and secondary branches may have resulted into lower estimates of narrow sense heritability for these characters as compared to other component characters of yield. The major character seed yield per plant (g) and important trait oil content per cent both expressed low heritability with low genetic advance in F_1s and F_2s, indicating prevalence of non-fixable type of genetic variation for the expression of these traits. Earlier findings of Trivedi and Mukherjee (1986) and Sikarwar *et al.* (2000) were in agreement with present study.

The genotypic and phenotypic correlation coefficients analysed for the ten characters in the F_1s and F_2s are summarized in Table 2. The computed data showed that genotypic coefficients of correlation in general, were higher in magnitude than the corresponding phenotypic coefficient of correlation in F_1s as well F_2s, indicating that there was an inherent association among the various characters and the phenotypic expression of correlation was lessened under the influence of environment. Correlation study also revealed that highly significant positive correlation of seed yield per plant existed with number of primary branches (0.503 G and 0.493 P), number of secondary branches (0.652 G and 0.643 P), number of siliquae on main raceme (0.396 G and 0.387 P), siliqua length (0.543 G and 0.535 P) and 1000-seed weight (0.585 G and 0.576 P) whereas, it was negative with oil content (-0.295 G and - 0.283 P) and days to flower (-0.234 G and -0.220 P) which promote early maturity in F_1 population. These results corroborated the earlier findings of Rawat and Anand (1977) and Satyavathi *et al.* (2000).

In F_2 population the results regarding correlation of seed yield with its component characters was completely different than F_1s, because positive but non-significant correlation of seed yield per plant was recorded with only secondary branches (0.0221 G and 0.204 P) siliqua length (0.109 G and 0.108 P) and test weight (0.302 G and 0.310 P) and correlation of days to flower (-0.271 G and -0.259 P) and oil content (-0.188 G and -0.181 P) with seed yield were negative at both genatypic and phenotypic levels in F_2 hybrids. These results were concordant with those of Anand *et al.* (1975).

The estimates of direct and indirect effects of different characters on seed yield per plant are presented in Table 3. The path coefficient analysis revealed that yield contributing characters like secondary branches per plant (0.421 F_1 and 0.267 F_2) number of siliquae on main raceme (0.038 F_1 and 0.472 F_2) and 1000-seed weight (0.346 F_1 and 0.457 F_2) had highest direct positive effect on seed yield per plant in both F_1s and

Table 3. Path coefficient at genotypic levels of nine characters on seed yield per plant in India mustard

Characters	Populations	Days to first flower	Plant height (cm)	Main raceme length (cm)	Primary branches	Secondary branches	Siliquae on main raceme	Siliqua length (cm)	Test weight (9)	Oil content (%)	Genotypic correlation (seed yield / plant)
Days to	F_1	**–0.394**	–0.270	–0.021	–0.117	–0.063	–0.105	0.148	0.157	–0.183	–0.234
flower	F_2	**–0.625**	0.301	0.019	–0.069	–0.049	0.295	0.063	–0.249	–0.115	–0.271
Plant	F_1	0.186	**0.263**	0.086	0.110	0.119	0.171	–0.030	–0.057	0.152	0.172
height	F_2	–0.45	**0.421**	0.004	–0.104	0.005	0.289	0.059	–0.261	0.144	–0.037
Main	F_1	–0323	–0.020	**–0.061**	–0.012	–0.014	–0.037	–0.024	–0.022	0.185	0.289
raceme length	F_2	–0.176	0.023	**–0.064**	0.101	–0.135	0.132	0.009	–0.182	–0.095	–0.174
Primary	F_1	0.049	–0.067	0.033	**0.165**	0.097	0.055	0.031	0.045	0.132	0.503**
branches	F_2	–0.165	0.167	–0.025	**–0.026**	0.052	0.077	0.050	–0.058	–0.041	–0.163
Secondary	F_1	0.067	0.193	0.095	0.248	**0.421**	0.176	0.104	0.083	–0.110	0.652**
branches	F_2	0.114	0.007	–0.033	–0.048	**0.267**	–0.220	–0.007	0.140	–0.231	0.221
Siliquae on	F_1	0.011	0.026	0.024	0.013	0.016	**0.038**	0.013	0.010	0.086	0.396**
main raceme	F_2	–0.394	0.251	0.018	–0.042	–0.124	**–0.472**	–0009	–0.263	0.201	–0.082
Siliqua	F_1	–0.011	–0.003	0.011	0.005	0.007	0009	**0.028**	0.022	0115	0.543**
length	F_2	0.199	–0.124	–0.003	–0.042	0.009	0.021	**–0.192**	0.141	–0100	0.109
Test	F_1	–0.140	–0.075	0.123	0.005	0.068	0.085	0.271	**0.346**	–0.153	0.585**
weight	F_2	0.332	–0.241	–0.026	0.066	0.082	–0.272	–0.060	**0.457**	0.121	0.302*
Oil content	F_1	–0.136	0.080	0.096	0.175	0.236	0.137	0.125	0.165	**–0.435**	–0295
	F_2	0.101	0.155	–0.072	–0.211	–0.210	0.225	0.116	0.098	**–0.336**	–0118

*, ** Significant at 5% and 1% levels of probability, respectively. The bold diagonals are direct effects and the remaining indirect effects. The genotypic residual effects were 0.2813 in F_1 and 0.1421 in F_2.

well as F_2s and growth character like plant height (0.263 F_1 and 0.421 F_2) and primary branches only in F_1 (0.165) follow them for direct positive effect. Similar results had earlier been obtained by Singh and Chaudhary (1983).

The negative direct effect on seed yield was observed in oil content (-0.435 F_1 and 0.336 F_2) and days to flower (-0394 F_1 and -0.625 F_2), followed by main raceme length (-0.031 F_1), primary branches (-0.026 F_2) and siliqua length (-0.060 F_2). As a matter of fact, plant height was the only character whose correlation with seed yield was non-significant but it was one of the top three direct contributors to seed yield. However, this was offset due to strongly negative indirect effect through days to flower and test weight in F_2. The estimates of character association in a sizable case were changed not only in magnitude but in direction also from F_1 to F_2, which may be attributed to the recombination and breaking of linkages at the time of segregation. Similar trend in path-analysis was also recorded. Thus, in order to increase seed yield, attributes like test weight, secondary branches, siliquae on main raceme and plant height were indentified as important components of yield. Emphasis must also be given for traitses, having negative, direct association like main raceme length, primary branches and siliqua length.

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