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Genetic variability, heritability and genetic advance for quantitative traits in Indian mustard (*Brassica juncea* L. Czern and Coss.)

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Abstract
The experimental material comprising of 100 treatment *viz*., (10 parents + 45 F_1's and 45 F_2's) was evaluated in Randomized Block Design with three replications during *Rabi* 2020-2021, considerable variability for all 16 different characters under study. Number of secondary branches per plant, number of siliqua per plant, 1000-seed weight, harvest index and erucic acid showed moderate GCV and moderate PCV (10-20%) estimates in both generations. The estimates of heritability varied from 4.8% (number of seed per siliqua) to 31% (days to maturity) in F_1's and 1.8% (oil content) to 41.0% (leaf area index) in F_2's generation. The estimate of genetic advance over per cent of mean of the character ranges from 4.03% (days to 50% flowering) to 52.39% (total glucosinolate) and 3.65% (days to maturity) to 48.87% (total glucosinolate) in F_1 and F_2 generation respectively. Hence selection will be effective for this traits.

Keywords: Genetic advance, heritability, GCV, PCV, variability

1. Introduction
Indian mustard (*B. juncea* L. Czern and Coss) popularly known as rai, raya or laha is one of the most important oil seed crops of the country and it occupies considerably large acerage among the Brassica group of oil seed crops. It is estimated the total production of mustard seed in India about more than 72.82 lakh tones significantly. Rapeseed–mustard group of crops is the major oilseed crop of India. India holds the premier position in rapeseed-mustard economy of the world with 2 nd and 3rd rank in area and production respectively.
Mustard seed is largely crushed for edible oil, which is perhaps the cheapest source of oil in our daily diet. which is golden yellow fragrant and considered among the healthiest and most nutritional cooking medium. Its leaves are rich in protein, minerals and vitamin A and C after extraction of oil from seeds, the remnant is used as food for milching cattles.
The origin of *B. juncea* is conflicting. Middle East seems to be the place of origin since the putative parent species; *B. nigra* and *B. campestris* would have crossed. (Olsson, 1960) [5].

2. Material and Methods
The basic material in the present investigation comprised of ten diverse genotype of Indian mustard namely, Aashirwad, NDR 501-26, Rohini, Basanti, KMR 17-5-23, KMR 17-5-22, KMR 17-5-21, Narendra Rai 8501, PR 21 and PR-20 were taken from the germplasm maintained at Oilseed Section, Department of Genetics and Plant Breeding, C. S. Azad University of Agriculture and Technology, Kanpur.
The experimental material comprising of 100 treatment *viz*., (10 parents + 45 F1's and 45 F2's) was evaluated in Randomized Block Design with three replications during *Rabi* 2020-2021. Each parent and F1's planted in one row, and F2's in two rows of 5m long 45 cm apart, Plant to plant distance was maintained 15 cm by thinning. All the recommended agronomic practices were adopted for raising a good crop.
Ten plants in parents and F1's and 20 plants in F2's were taken randomly for each treatment in each replication and tagged for recording observations for days to 50% flowering, length of main raceme (c), leaf area index, days to maturity, plant height (c), seed yield per plants(g), no. of primary branches per plant, number of secondary branches per plant, number of siliqua per plant, no. of seed per siliqua, 1000-seed weight (%), harvest index (%), oil content (%), protein content (%), total glucosinolate (µmol) and erucic acid (%).

3. Results and Discussion

3.1 Analysis of variance

There was significant difference was observed among the treatments (parents, F_1's and F_2's) for all the sixteen characters. Parents vs. F_1's exhibited significance differences for all character except plant height; Parents vs. F_2's exhibited significance differences for all character except No. of Primary branches per plant, no. of seed per siliqua, 1000-seed weight and oil Content. Similar finding were reported by Tripathi *et al*. (2013) [8]

In general, phenotypic coefficient of variance was found to be higher than their genotypic coefficient of variance but difference was quite meager. Number of secondary branches per plant, number of siliqua per plant, 1000-seed weight, harvest index and erucic acid showed moderate GCV and moderate PCV (10-20%) estimates in both generations. Total glucosinolate were showed high estimates of GCV and PCV (>20%) in both generation. Days to 50% flowering, days to maturity, plant height and oil content were exhibited low estimates (<10%) of PCV & GCV in both the generation (Table 1a and 1b). Similar finding were reported by Hussain *et al*. (2016), Shrimal *et al.,* (2016) [6] and Singh *et al.* (2017) [17].

3.2 Heritability and Genetic advance

Heritability along with genetic advance is useful in estimating the influence of environment. High heritability estimates along with high genetic gain render the selection effective (Johnson *et al.*, 1955) [4]. Burton (1952) indicated that genetic variability together with heritability estimates would give a better idea on the amount of genetic advance expected out of selection.

Efficiency of selection depends on such variability which is highly transmissible from parents to their offspring. The breeding objective in mustard improvement program is to obtain genetic progress in yield component traits along with maintaining a high amount of variability. Heritability alone has no reliable for remark of genetic progress from individual genotype selection. Hence knowledge about heritability along with genetic gain is very useful (Johnson *et al*., 1955) [4].

If the estimated value of heritability is below 10% it wiil be said to be having low heritability, while if heritability ranged from 10 – 30% then medium heritability but if it is greater than 30% it would be highly heritable.

The estimate of heritability was calculated as per the method suggested by (Crumpacker and Allard, 1962) [3]. The estimates of heritability varied from 4.8% (number of seed per siliqua) to 31% (days to maturity) in F_1's and 1.8% (oil content) to 41.0% (leaf area index) in F_2's generation (Table 2).

In F_1's, estimate of narrow sense were observe high in days to maturity, erucic acid and number of siliqua per plant; medium in harvest index, plant height, leaf area index, oil content, days to 50% flowering, length of main raceme, seed yield per plant, 1000-seed weight, protein content, number of secondary branches, glucosinolate content; and low in no. of primary branches and no. of seed per siliqua. In F_2's, estimate of narrow sense were observe high in leaf area index, protein content and plant height; moderate in erucic acid, length of main raceme, no. of seed per siliqua, no. of secondary branches per plant, 1000-seed weight, no. of primary branches per plant, days to 50% flowering, harvest index, days to maturity and no. of siliqua per plant; and low in glucosinolate, seed yield per plant and oil content.

The genetic advance over per cent of mean was calculated for the entire 16 attribute. The arbitrary scale for genetic advance suggested into three categories *viz*. high (above 20%), medium (10-20%) and low (less than 10%). The estimate of genetic advance over per cent of mean of the character ranges from 4.03% (days to 50% flowering) to 52.39% (total glucosinolate) and 3.65% (days to maturity) to 48.87% (total glucosinolate) in F_1 and F_2 generation respectively. High genetic advance over per cent of mean value were recorded for glucosinolate, leaf area index, erucic acid and seed yield per plant in both generation; moderate genetic advance plant height, no. of primary branches, no. of secondary branches, no. of siliqua per plant, 1000-seed weight, harvest index, oil content and protein content; and low in days to 50% flowering and days to maturity. Similar finding were reported by Singh *et al.* (2017) [7] and Awasthi *et al.* (2020) [1].

Table 1a: Analysis of variance for parents and F_1's in 10 x 10 diallel cross of Indian mustard (*B. juncea* L. Czern and Coss) for seed yield and its components: Mean Sum of Square

Source of variation	d.f.	Days to 50% flowering	Days to maturity	Leaf Area Index	Plant Height	No. of Primary branches per plant	No. of Secondary branches per plant	No. of siliqua per plant	No. of seed per siliqua
Replication	2	126.35 **	9.242	0.016	364.21 **	0.880	21.858 **	1890.806 *	2.977
Treatments	54	15.763 **	38.064 **	0.378 **	454.218 **	0.804 **	22.649 **	5541.195 **	5.854 **
Parents	9	12.015 *	43.867 **	0.035 **	694.830 **	0.209	6.726 **	1783.244 **	4.633 **
Hybrid	44	15.711 **	35.561 **	0.411 **	411.463 **	0.848 **	23.886 ***	5747.218 **	5.903 **
Patents *Hybrids	1	51.739 *	96.012 **	2.003 **	169.922	4.243 **	111.527 ***	30297.710 **	14.676 **
Error	108	4.623	4.341	0.008	31.171	0.317	2.525	291.306	1.267
Total	164	9.775	15.505	0.130	174.528	0.484	9.387	2039.434	2.798
Source of variation	d.f.	Length of Main Raceme	1000-seed weight	Harvest Index	Oil Content	Protein content	Erucic Acid	Total Glucosinolate	Seed Yield per Plant
Replication	2	29.682	0.023	5.563	15.540 *	2.068	3.198 *	2.547	6.219
Treatments	54	87.272 **	1.324 **	20.416 **	21.867 **	20.403 **	66.820 **	910.099 **	34.963 **
Parents	9	21.541	0.234	6.763 **	14.688 **	15.584 **	17.884 **	449.481 **	19.359 **
Hybrid	44	84.522 **	1.384 **	22.331 **	21.736 **	14.448 **	64.148 **	1006.779 **	35.988 **
Patents *Hybrids	1	799.888 **	8.459 **	59.021 **	92.238 **	325.813 **	624.777 **	801.737 **	130.306 **
Error	108	25.552	0.094	1.855	2.908	1.620	0.952	8.466	2.776
Total	164	45.925	0.498	8.012	9.304	7.810	22.668	305.273	13.416

• Significance Levels * = <.05 and ** = <.01 respectively.

Table 1b: Analysis of variance for parents and F_2's in 10 x 10 diallel cross of Indian mustard (*B. juncea* L. Czern and Coss) for seed yield and its components: Mean Sum of Square

Characters	d.f.	Days to 50% flowering	Days to maturity	Leaf Area Index	Plant Height (c)	No. of Primary branches per plant	No. of Secondary branches per plant	No. of siliqua per plant	No. of seed per siliqua
Replication	2	157.436 **	19.170	0.036	151.756	1.116 *	75.646 **	8633.461 **	7.686
Treatments	54	18.759 **	36.893 **	0.341 **	693.731 **	0.941 **	7.810 **	2962.556 **	4.685 **
Parents	9	12.015 *	43.867 **	0.035	694.830 **	0.209	6.726 *	1783.244 **	4.633 *
Hybrid	44	17.470 **	30.326 **	0.407 **	636.066 **	1.104 **	7.828 **	2685.50**	4.787 **
Patents *Hybrids	1	136.194 **	263.117 **	0.187 *	3221.094 **	0.316	16.793 *	25766.840 **	0.670
Error	108	4.189	6.491	0.022	43.029	0.170	2.274	492.55	1.918
Total	164	10.856	16.656	0.127	258.611	0.435	4.992	1405.16	2.900
Characters	**d.f.**	**Length of Main Raceme (c)**	**1000-seed weight %**	**Harvest Index %**	**Oil Content %**	**Protein content %**	**Erucic Acid %**	**Total Glucosinolate (µmol)**	**Seed Yield per Plant (g)**
Replication	2	1977.314 **	0.187	17.598 *	6.448	2.561	0.623	3.222	26.486 **
Treatments	54	316.719 **	1.138 **	14.536 **	16.905 **	26.326 **	69.119 **	817.342 **	28.599 **
Parents	9	21.541	0.234	6.763 **	14.688 **	15.584 **	17.884 **	449.481 **	19.359 **
Hybrid	44	328.947 **	1.341 **	15.008 **	17.733 **	26.252 **	75.581 **	903.314 **	28.420 **
Patents *Hybrids	1	2435.311 ***	0.317	63.712 ***	0.432	126.233 **	245.906 **	345.307 **	119.609 **
Error	108	42.088	0.109	2.454	1.771	1.101	1.005	4.406	3.510
Total	164	156.115	0.448	6.617	6.811	9.425	23.428	272.066	12.051

• Significance Levels * = <.05 and ** = <.01 respectively.

Table 2: Genetic parameters of variation in F_1's and F_2's for 16 attributing traits in Indian mustard (B. juncea L. Czern and Coss).

Characters	Mean	PCV (%)		GCV (%)		h^2ns		G.A. as % of mean	
		F_1's	F_2's	F_1's	F_2's	F_1's	F_2's	F_1's	F_2's
Days to 50% flowering	66.8	4.40	4.63	2.93	3.39	0.234	0.125	4.03	5.15
Days to maturity	137.53	2.90	2.9	2.46	2.27	0.310	0.113	4.31	3.65
Leaf Area Index	1.56	20.21	21.93	19.57	19.98	0.244	0.410	39.07	37.50
Plant height	179.53	7.39	9.47	6.69	8.65	0.247	0.321	12.48	16.28
No. of primary branches per plant	4.40	14.60	15.16	8.50	11.77	0.088	0.135	10.20	18.81
No. of secondary branches per plant	14.01	19.29	15.22	16.44	10.19	0.149	0.180	28.87	14.05
No. of siliqua per plant	258.73	15.71	15.62	14.55	12.35	0.303	0.106	27.75	20.13
No. of seed per siliqua	13.85	11.54	12.29	8.54	7.00	0.048	0.214	13.00	8.22
Length of Main Raceme	87.43	7.34	14.58	4.92	12.06	0.210	0.251	6.77	20.57
1000-seed weight	4.76	13.54	13.83	12.20	12.05	0.163	0.168	22.67	21.64
Harvest Index	19.73	13.50	13.84	11.84	10.90	0.288	0.121	21.40	17.70
Oil Content	37.10	7.85	7.0	6.49	6.03	0.238	0.018	11.07	10.69
Protein content	23.86	10.45	11.99	9.32	11.27	0.153	0.327	17.11	21.83
Erusic acid	31.35	17.58	16.92	17.21	16.56	0.307	0.278	34.71	33.39
Total Glucosinolates	71.9	26.15	24.11	25.79	23.91	0.112	0.075	52.39	48.87
Seed Yield Per Plant	17.59	18.87	21.83	16.81	18.32	0.164	0.073	30.88	31.67

Table 3: Mean and range for 16 characters derived from 10 parental diallel crosses in Indian mustard (B. juncea L. Czern and Coss).

Characters	Mean			Range					
	Parents	F_1's	F_2's	Parents		F_1's		F_2's	
				Min.	Max.	Min.	Max.	Min.	Max.
Days to 50% flowering	66.8	65.61	64.87	65.33	70.33	61.33	70.33	59.67	70.33
Days to maturity	137.53	135.91	140.21	128.67	141.00	128.66	142.00	128.67	147.67
Leaf Area Index	1.56	1.79	1.63	1.45	1.75	1.31	2.99	1.00	2.52
Plant height	179.53	177.38	170.16	144.33	193.67	144.33	198.00	141.97	196.2
No. of primary branches per plant	4.40	4.74	4.31	3.97	4.85	3.52	6.30	3.07	5.57
No. of secondary branches per plant	14.01	15.75	13.33	12.23	16.83	11.10	22.30	10.67	17.1
No. of siliqua per plant	258.73	287.47	232.22	227.3	296.3	218.33	377.00	165.33	296.33
No. of seed per siliqua	13.85	14.47	13.71	11.40	15.23	11.40	17.80	11.07	17.13
Length of Main Raceme	87.43	92.09	79.28	81.03	90.5	81.03	102.16	57.47	99.0
1000-seed weight	4.76	5.24	4.86	4.17	5.03	4.03	6.60	3.77	6.0
Harvest Index	19.73	20.99	18.41	17.33	22.2	16.23	27.66	14.4	22.57
Oil Content	37.10	38.68	37.21	34.17	39.23	34.16	44.83	32.87	41.63
Protein content	23.86	26.84	25.72	20.67	26.2	20.66	31.53	19.9	32.27
Erusic acid	31.35	27.22	28.76	28.53	33.47	17.93	35.50	19.67	41.23
Total Glucosinolates	71.9	67.22	68.83	56.50	90.77	24.30	104.46	44.00	101.2
Seed Yield Per Plant	17.59	19.47	15.72	13.73	21.10	13.46	27.76	10.0	21.10

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