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Estimates of Genetic Variability, Correlation and Path Analysis in Indian Mustard [*Brassica juncea* (L.) Czern & Coss]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The Present investigation was undertaken to study the genetic variability, correlation and path analysis of twelve quantitative traits in Twenty Indian mustard (*Brassica juncea* L.) lines. The experiment material was evaluated in a randomized block design with three replications. The analysis of variance showed significant difference among genotype for all the characters. Results from the study indicated that heritability was high for all traits studied. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were low to medium for all the traits studied and genetic advance as percent of mean showed low to high values for most of the traits

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studied. Path coefficient at phenotypic and genotypic level revealed direct positive effect on seed yield per plant for about 50% of the traits studied. The significance for these results and their basis for selection of improved Indian mustard lines for further breeding in the program were discussed.

Keywords: Genetic advancement; genetic variability; heritability; correlation; path coefficient.

1. INTRODUCTION

"Oilseeds occupy prime importance in Indian economy, which is evident from the impact created by yellow revolution" [1]. "Indian mustard [*Brassica juncea* (L.) Czern & Coss] is an important oil seed crop of the world. It is popularly known as rai, raya or laha in India. It is an important *rabi*season oilseed crop in India and occupies a premier position due to its high oil content. It plays a major role in catering to edible oil demand of the country" [1].

"The genus *Brassica*, belongs to Cruciferae or Brassicaceae family and includes six cultivated species. Among those, *Brassica nigra* (n=8), *B. oleraceae* (n=9), *B. rapa* (n=10) are diploids. Rest of the three, namely *B. carinata* (n=17), *B. napus* (n=19) and *B. juncea* (n=18) are amphidiploids" [2]. "Indian mustard is a natural amphidiploid (2n=36) of *Brassica campestris* (2n=20) and *Brassica nigra* (2n=16). It originated in Asia with its major center of diversity in China" [3]. "It was introduced in India from China and from where it spread to Afghanistan and other countries. It is largely self-pollinated crop (85-90%). However, owing to insects, especially the honeybees, the extent of cross-pollination varies from 4.0 to 16.6%" [4]. "Mustard is a Rabi season crop of temperate region, which requires relatively cool temperature. Mustard seed is largely crushed for edible oil, which is perhaps the cheapest source of oil in our daily diet. Oilseeds occupy a place of prime importance in Indian economy which is evident from the impact created by yellow revolution. India is the third producer of mustard seed contributing around 11% of world's total production. Mustard seeds contain about 38-42% oil, which is golden yellow, fragrant and considered among the healthiest and most nutritional cooking medium. It is also utilized as a condiment, for medicinal uses and has industrial applications. Mustard meal or cake is also nutritious and contains about 12% oil and 38 to 42% protein" [5]. "Indian oilseed types contain primarily 3-butenyl glucosinolate in their seeds and vegetative tissue, while *B. juncea* from China contains only 2-propenyl (allyl) glucosinolate, and only trace amounts of 3-buteny glucosinolate" [5].

"India with an area of 6.78 million hectares, 9.12 million tonnes production and 1345 kg/ha productivity ranks second in area and third in production in rapeseed-mustard scenario of the world" [6]. "Rajasthan is the largest producer of rapeseed-mustard followed by Uttar Pradesh, Haryana, Madhya Pradesh, West Bengal, Gujarat and Assam. Rajasthan state ranks first both in area and production. In Uttar Pradesh, the estimated area, production and productivity of rapeseed- mustard had 12.25 lakh ha, 17.10 lakh tonnes and 11.85 q/ha, respectively" [6]. Rapeseed- mustard is cultivated in Agra, Mathura, Aligarh, Kanpur, Auraiya, Unnao and Hatras. Mathura is the rapeseed-mustard-producing district in terms of area, production, and productivity. The crop improvement in Indian mustard is complex in nature due to a complex nature of inheritance of yield and its attributes.

The availability of genetic variation is advantageous for crop improvements. Such types of variability brought about by a group of genes which have a small individual effect, can be studied through quantitative measurement. The genetic facts are inferred from observation on phenotypes. Because phenotype is determined by the interaction of genotype and environment, non-genetic factors have a significant impact on genetic variation. As a result, multiple genetic indices such as heritability, genetic progress, and others must be used to assess exploitable variability. A study like this appears to be critical for planning genetic improvements in Indian mustard.

2. MATERIALS AND METHODS

The present field experiment was undertaken during Rabi 2021-22 (indicate the period of establishing the trial) at field experimentation center of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (Uttar Pradesh). The Randomized complete block design (RCBD) with three replications was used. Twenty Indian mustard genotypes was sown at row-to-row distance of 45 cm and plant to plant distance of 10 cm. Recommended packages of practices were followed during the trial period.. "Observations were recorded on five randomly selected plants in each genotype and replication for different 12 traits. These traits were computed on basis of mean data after computing for each character was subjected to standard method of analysis of variance" following Singh and Choudhary [7]. Phenotypic and genotypic coefficient of variation, heritability (Broad Sense) and genetic advance as percent of mean were estimated by the formula al suggested by Burton [8] and Johanson et. al. [9]. The genotypic correlation coefficients were estimated according to the formula given by Singh and Choudhary [7]. "While path analysis was carried out using the genotypic correlation coefficient to know direct and indirect effects of the components on yield" as suggested by Wright (1921) and illustrated by Dewey and Lu [10].

3. RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the twelve genotypes for all the twelve quantitative traits presented (Table 1). "The perusals of data revealed that phenotypic variance was higher than the corresponding genotypic variance for all the traits studied" [1]. Data presented in (Table 2) showed maximum GCV and PCV was recorded for seed yield per plant, biological yield per plant, 1000 seed weight and harvest index. These results were well supported by similar findings by Singh et al. [11], Shekhawat et al. [12], Singh et al. [13], Kumar et al. [14] reported high values for PCV and GCV for the biological yield per plant and seed yield per plant. High heritability (broad sense) was observed for High estimate of heritability coupled with genetic advance as percentage of mean was observed for seed yield per plant, 1000 seed weight, biological yield, silliqua per plant. High genotypic and phenotypic coefficient of variation are studied for seed yield per plant, biological yield per plant, 1000 seed weight, harvest index. High heritability in conjunction with high genetic advance indicated additive gene effects, but high heritability in conjunction with low genetic advance indicated dominance and epistatic effects. These results are in conformity with those obtained by Acharya and Pati [15], Singh and Singh [16], Singh et al. [13] and Yadava et al. [17].

"In the present study, the genotypic correlation coefficients were higher in magnitude than their respective phenotypic correlation coefficients for most of the traits indicating the depression of phenotypic expression by the environmental influence. Seed yield/ plant was found to be positively and significantly correlated with biological yield per plant, number of primary branches and seeds per silliqua. (Tables 3 a & b)". Prasad and Patil [18], Lakra et al. [19], Nandi et al., [20]. However seed yield was negatively and significantly correlated with plant height and oil content.

Table 1. Analysis of variance for 12 characters in Indian mustard

S. No	Source	Mean sum of square		
		Replication	**Treatment**	**Error**
	Degree of freedom	2	19	38
1.	Days to 50% flowering	0.117	39.75**	0.62
2.	Days to maturity	1.03	94.80**	0.48
3.	Plant height (cm)	311.55	553.47**	37.53
4.	Number of primary branches	0.24	1.65**	0.34
5.	Number of secondary branches	6.49	15.97**	3.02
6.	Number of siliquae per plant	785.23	4567.74**	747.7
7.	Number of seeds per siliqua	4.68	5.64**	2.04
8.	Test weight (1000 seeds weight) (g)	33.77	251.98**	22.62
9.	Biological yield (g)	1.63	23.36**	1.4
10.	Harvest index (%)	0.14	1.48**	0.056
11.	Oil content (%)	0.38	6.23**	0.2
12.	Seed yield per plant (g)	3.39	15.71**	0.67

Table 2. Genetic variability parameters for seed yield and its contributing characters in Indian mustard

Sr. No.	Characters	GCV (%)	PCV (%)	H(bs) (%)	Genetic advance	Genetic Advance as percentage of mean
1.	Days to 50 % flowering	7.18	7.34	95.24	7.26	14.43
2.	Days to maturity	4.21	4.26	98.49	11.46	8.62
3.	Plant height	5.85	6.46	82.08	24.47	10.98
4.	No. of primary branches per plant	8.26	10.96	56.17	1.02	12.68
5.	No. of secondary branches per plant	9.34	12.18	58.77	3.28	14.75
6.	Siliqua per plant	9.18	11.56	62.99	58.34	15.09
7.	Seeds per siliqua	7.18	11.81	36.97	1.37	8.99
8.	Biological yield	17.02	19.35	77.16	15.82	30.76
9.	Harvest index	11.84	12.93	83.85	5.10	22.33
10.	Test weight	15.91	16.27	89.47	1.34	29.90
11.	Oil content	3.48	3.46	90.90	2.78	6.18
12.	Seed yield per plant	18.54	19.73	88.21	4.33	35.87

Table 3a. Genotypic correlation between different yield and yield related traits of Indian mustard

Characters	Days to 50% flowering	Days to maturity	Plant height	No. primary branches per plant	No. of secondary branches/ plant	Siliqua per plant	Seeds per siliqua	BY per plant	Harvest Index	Test weight	Oil content
Days to maturity	0.683**	**1.000**									
Plant height	0.253	0.097	**1.000**								
No. of primary branches per plant	0.107	-0.052	0.295*	**1.000**							
No. of secondary branches per plant	-0.318*	0.038	-0.278*	-0.240	**1.000**						
Siliqua per plant	0.149	0.096	0.082	0.744**	-0.335**	**1.000**					
Seeds per siliqua	-0.059	0.078	0.227	0.065	0.454**	0.399**	**1.000**				
Biological yield	0.316*	0.276*	-0.494**	0.182	-0.372**	0.236	-0.235	**1.000**			
Harvest index	-0.146	-0.059	-0.507**	0.131	0.324*	0.138	0.163	0.091	**1.000**		
test weight	0.006	-0.088	0.112	0.125	0.465**	-0.193	-0.161	-0.170	0.270*	**1.000**	
Oil content	-0.082	0.233	0.100	0.180	0.011	0.287*	0.085	-0.148	-0.024	-241	**1.000**
Seed yield per plant	0.233	0.004	-0.413**	0.258*	-0.058	0.193	0.257*	0.492**	0.099	-0.118	-0.433**

Table 3b. Phenotypic correlation between different yield and yield related traits of Indian mustard

Characters	Days to 50% flowering	Days to maturity	Plant height	Primary branches per plant	Secondary branches/ plant	Siliqua per plant	Seeds per siliqua	BY per plant	Harvest Index	Test weight	Oil content
Days to maturity	0.662**	**1.000**									
Plant height	0.246	0.099	**1.000**								
Primary branches per plant	0.077	-0.051	0.241*	**1.000**							
Secondary branches per plant	-0.277	0.036	-0.196*	-0.175	**1.000**						
Siliqua per plant	0.115	0.081	0.096	0.620**	-0.236**	**1.000**					
Seeds per siliqua	-0.009	0.069	0.205	0.022	0.306**	0.291**	**1.000**				
Biological yield	0.256*	0.264*	-0.432**	0.152	-0.290*	0.227	-157	**1.000**			
Harvest index	-0.140	-0.054	-0.484**	0.093	0.283*	0.108	0.136	0.054	**1.000**		
Test weight	0.002	-0.077	0.121	0.123	0.416**	-0.172	-0.115	-0.155	0.257*	**1.000**	
Oil content	-0.072	0.218	0.084	0.158	0.005	0.263*	0.037	-0.138	-0.018	-0.232	**1.000**
Seed yield per plant	0.210	0.002	-0.377**	0.236*	-0.056	0.187	0.232*	0.490**	0.088	-0.115	-0.415**

Table 4a. Direct (diagonal) and indirect effects of yield components on seed yield per plant at phenotypic level in mustard genotypes

Characters	Days to 50% flowering	Days to maturity	Plant height	No. primary branches per plant	No. of secondary branches/ plant	Siliqua per plant	Seeds per siliqua	BY per plant	Harvest Index	Test weight	Oil content	Seed yield Per Plant
Days to 50 % flowering	**0.3605**	0.2438	0.0903	0.0338	-0.1008	0.0487	-0.0126	0.1058	-0.0509	-0.0012	-0.0307	0.210
Days to maturity	-0.0463	**-0.0685**	-0.0067	0.0037	-0.0025	-0.0061	-0.0049	-0.0186	0.0039	0.0058	-0.0156	0.002
Plant height	-0.2245	-0.0878	**-0.8968**	-0.2163	0.1758	-0.0869	-0.1846	0.3877	0.4341	-0.1085	-0.0760	-0.377**
Primary branches/plant	0.0540	-0.0309	0.1389	**0.5758**	-0.1012	0.3571	0.0128	0.0878	0.0537	0.0713	0.0915	0.236*
Secondary branches/plant	0.0437	-0.0057	0.0306	0.0275	**-0.1562**	0.0369	-0.0478	0.0453	-0.0443	-0.0650	-0.0008	-0.056
Siliqua per plant	-0.0243	-0.0161	-0.0174	-0.1116	0.0425	**-0.1799**	-0.0524	-0.0410	-0.0195	0.0310	-0.0473	0.187
Seeds per siliqua	-0.0206	0.0424	0.1216	0.0132	0.1810	0.1722	**0.5909**	-0.0932	0.0804	-0.0682	0.0224	0.232*
Biological yield	-0.0021	-0.0019	0.0031	-0.0011	0.0021	-0.0016	0.0011	**-0.0072**	-0.0004	0.0011	0.0010	0.490**
Harvest index	0.0541	0.0219	0.1855	-0.0358	-0.1087	-0.0415	-0.0521	-0.0210	**-0.3833**	-0.0987	0.0071	0.088
Test weight	-0.0001	-0.0028	0.0040	0.0041	0.0137	-0.0057	-0.0038	-0.0051	0.0085	**0.0328**	-0.0076	-0.115
Oil content	0.0307	-0.0819	-0.0305	-0.0572	-0.0018	-0.0946	-0.0136	0.0498	0.0067	0.0837	**-0.3598**	-0.415*

Table 4b. Direct (diagonal) and indirect effects of yield components on seed yield per plant at genotypic level in mustard genotypes

Characters	Days to 50% flowering	Days to maturity	Plant height	No. primary branches per plant	No. of secondary branches/ plant	Siliqua per plant	Seeds per siliqua	BY per plant	Harvest Index (%)	1000-seed weight	Oil content (%)	Seed yield Per Plant (g)
Days to 50 % flowering	**0.6200**	0.4237	0.1570	0.0662	-0.1974	0.0924	-0.0364	0.1959	-0.0879	-0.0039	-0.0507	0.233
Days to maturity	-0.4301	**-0.6293**	-0.0613	0.0330	-0.0238	-0.0606	-0.0491	-0.1735	0.0371	0.0554	-0.1466	0.004
Plant height	0.0774	0.0297	**0.3055**	0.0900	-0.0849	0.0251	0.0694	-0.1508	-0.1549	0.0343	0.0306	-0.413**
Primary branches/plant	0.0126	-0.0062	0.0347	**0.1176**	-0.0282	0.0875	0.0077	0.0214	0.0154	0.0147	0.0212	0.258*
Secondary branches/ plant	-0.3713	0.0441	-0.3243	-0.2796	**0.1664**	-0.3909	0.5299	-0.4343	0.3782	0.5425	0.0130	-0.058
Siliqua per plant	0.0624	0.0403	0.0344	0.3116	-0.1403	**0.4186**	0.1672	0.0988	0.0580	-0.0806	0.1201	0.193
Seeds per siliqua	0.0217	-0.0288	-0.0839	-0.0240	-0.1678	-0.1475	**-0.3693**	0.0869	-0.0601	0.0596	-0.0316	0.257*
Biological yield	0.2036	0.1777	-0.3181	0.1174	-0.2400	0.1522	-0.1517	**0.6446**	0.0588	-0.1093	-0.0951	0.492**
Harvest index	-0.0068	-0.0028	-0.0245	0.0063	0.0156	0.0067	0.0079	0.0044	**0.0482**	0.0130	-0.0012	0.098
Test weight	0.0048	0.0668	-0.0853	-0.0946	-0.3527	0.1460	0.1224	0.1286	-0.2048	**-0.7583**	0.1827	-0.118
Oil content	0.0389	-0.1108	-0.0476	-0.0858	-0.0053	-0.1364	-0.0406	0.0702	0.0114	0.1146	**-0.4756**	-0.433**

The estimates of correlation coefficient, although, indicate inter- relationship of different traits, but it does not furnish information on cause and effect. Under such situation path analysis helps the breeder to identify the index of selection. Biological yield, primary branches, seeds per siliqua, days to 50 % flowering, siliqua per plant, harvest index and days to maturity showed the highest positive direct effect on seed yield per plant (Tables 4a & b). “Therefore, considering these traits as selection criteria will be advantageous in bringing improvement in Indian mustard”. Pandey and Singh [21], Verma et al. [22] and kumar et al. [14]. Thus, the material analyzed is of a diversified character, and the information obtained will aid in the creation of the selection approach, which will be further employed in the breeding program to boost seed yield.

4. CONCLUSIONS

The study concluded that significant variation was observed in Indian mustard germplasm and maximum yield was recorded by Ashirwad followed by BR 40, Kranti, Aravali, Geeta genotypes. Seed yield per plant, biological yield, test weight, harvest index and number secondary branches recorded high magnitude of phenotypic and genotypic coefficient of variation. Seed yield per plant showed positive and significant association with biological yield per plant, number of primary branches and seeds per siliquae at both genotypic and phenotypic levels. Biological yield, primary branches, seeds per siliqua, days to 50% flowering, siliqua per plant, harvest index and days to maturity had high positively direct effect on seed yield per plant. The characters number primary branches, seeds per siliqua and siliqua per plant may be given due to consideration during selection for yield improvement of Indian mustard.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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