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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(9): 377-381

www.thepharmajournal.com
Received: 05-06-2021
Accepted: 13-08-2021

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Assessment of selection parameters for yield and oil content in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]

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Abstract

The present experiment was accomplished during *Rabi* 2020-21 consisting of forty genotypes of Indian mustard. The analysis of variance revealed highly significant differences among all the forty genotypes of Indian mustard for all the twelve quantitative characters under study. The estimates of PCV and GCV were found high for harvest index, moderate for 1000-seed weight, seed yield per plant and number of secondary branches per plant while, low for number of siliquae per plant, days to 50% flowering, number of seeds per siliqua, plant height, oil content and days to maturity. Very low differences in the magnitude of PCV and GCV were observed for the characters *viz.*, days to maturity, days to 50% flowering and oil content indicated less influence of environment on these characters. High heritability coupled with high genetic advance as percent of mean was observed for harvest index, 1000-seed weight, number of secondary branches per plant and seed yield per plant. Harvest index, 1000-seed weight and number of siliquae per plant expressed highly significant and positive correlation with seed yield per plant at both genotypic and phenotypic level. Path coefficient analysis revealed the direct and positive influence of harvest index, number of siliquae per plant, 1000-seed weight and length of siliqua towards seed yield per plant.

Keywords: Selection parameters, variability, heritability, mustard, *Brassica juncea* L., path analysis

Introduction

The oilseed crops play a very significant role in the agricultural economy of our country. India is the largest producer of oilseeds in the world and contributes seven percent of the global vegetable oils production with fourteen percent share in the area. Total oilseeds area and production in the country is about 27.0 million hectares and 33.4 million tonnes respectively with an average yield of 1236 kg per hectare. (Anonymous, 2019-20) [1]. Rapeseed-mustard is the second most important oilseed crop in the country after soybean. It is cultivated on an area of about 6.8 million hectares with a production of about 9.1 million tonnes. The contribution of rapeseed-mustard to the total oilseed acreage and production of India is 25.19% and 27.25% respectively. The major rapeseed-mustard growing states in India are Rajasthan, Haryana and Uttar Pradesh. (Anonymous, 2019-20) [2].

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is cultivated throughout the world. It belongs to the family Cruciferae (Brassicaceae) under the genus *Brassica*. It is a natural amphidiploid (2n=36) of *Brassica campestris* (2n=20) and *Brassica nigra* (2n=16). It is self-compatible and highly self-pollinated crop (85-90%). Indian mustard is popularly known as rai, raya or laha and it cover up considerably large area among the *Brassica* group of oilseed crops contributes more than 85% to the total rapeseed-mustard production in the country. Mustard contains 36-42% oil, 17-25% protein, 8-10% fiber, 6-10% moisture and 10-12% extractable substances. Mustard oil is golden-yellow in colour, fragrant and is considered to be the healthiest and nutritious cooking medium. It is an important source of protein meal. Mustard oil possess one of the best fatty acids profile [low saturated fatty acids (8%), high mono unsaturated fatty acids (70%) and alpha linolenic acid (10%)] among the various vegetable oils, which reduces the risk of coronary heart diseases by almost 70%. The oil cake forms important cattle feed and furthermore utilized as natural compost. Mustard oil is utilized in India for cooking and frying purposes and also utilized in readiness of hair oil- and medicines. Delicate leaves of young plants are used as green vegetable and are acceptable wellspring of sulphur and different minerals in diet.

As yield is a composite character and an interactive effect of multiplication of several traits, the knowledge about the factors responsible for high yield is not easy. Therefore, it is necessary to simplify this complex problem for attainment of high yield level. Thus, the study of correlation between yield and its component traits is of prime importance in formulating the selection criteria in any crop. Selection is generally based on the phenotypic values of a character which is a combined result of genotype and environment. The characters that are largely influenced by environment are said to have low heritability while those which are less susceptible to environment variation shows high heritability. Therefore, it is necessary to know the various components of yield, their heritable and non-heritable variability and their mutual correlation. This is because selection would be more efficient, if it based on some components which are less susceptible to environmental variations. Suitable selection index can be formed by given appropriate weightage to the phenotypic values of different components to be used simultaneously for selection in order to obtain maximum genetic advance with a given selection intensity. The study of genetic advance is also important as it measures the genetic gain based on selection in a particular character. Therefore, in any crop improvement programme, the study of genetic variability and heritability together with genetic advance is necessary. Indirect selection is important in influencing the final product, grain yield in any crop species. A number of variables are studied in correlation, which give an idea about indirect selection. Path coefficient analysis determines the direct and indirect causes of associations giving the idea of specific forces which act to produce strong correlation and measures relative importance of each causal factor. Keeping the above facts in view, the present investigation was carried out.

Materials and Methods

The experimental materials for the present work consisted of forty genotypes (released varieties and advance lines) of Indian mustard obtained from different sources. The field experiment was laid out in a Randomized Block Design (RBD) with three replications and forty test genotypes. Each genotype was represented by 3 lines of 4.0 meters row length having 30 cm spacing between lines and 10 cm spacing between plants. Observations on various characters in each replication were recorded timely, on five randomly selected plants in each replication whereas, days to 50% flowering, days to maturity and oil content (%) were recorded on the plot basis. Analysis of variance was carried out for all the recorded characters. Mean values of five plants per plot for plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of siliquae per plant, length of siliqua (cm), number of seeds per siliqua, 1000-seed weight (g), harvest index (%) and seed yield per plant (g) were used for statistical analysis. While, mean values for the characters *viz.*, days to 50% flowering, days to maturity and oil content (%) were recorded on plot basis.

Analysis of variance (ANOVA) for Randomized Block Design for all the characters was done as per method suggested by Panse and Sukhatme (1985). Heritability in broad sense $h^2_{(bs)}$ was computed as a ratio of genotypic variance to phenotypic variance as per Burton and De Vane (1953). The expected genetic advance under selection for the different characters was estimated as suggested by Johnson *et al.* (1955) and Allard (1960). The correlation coefficients were calculated to determine the degree of association of the characters with yield and its attributes. Genotypic and phenotypic correlation coefficients were worked out by the method described by Singh and Chaudhary (1979). The proportion of direct and indirect contributions of various characteristics to the total correlation coefficients with seed yield was estimated through path coefficient analysis as suggested by Wright (1921, 1934) and elaborated by Dewey and Lu (1959).

Results and Discussion

Analysis of variance

The analysis of variance was carried out for all the characters for testing the differences among the genotypes. The analysis of variance (ANOVA) exhibited highly significant differences among the genotypes for all the twelve characters studied *viz.*, days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of siliquae per plant, length of siliqua (cm), number of seeds per siliqua, 1000-seed weight (g), oil content (%), harvest index (%) and seed yield per plant (g), indicating wide spectrum of variation among the genotypes. The mean sum of squares for seed yield per plant and its components are presented in Table 1.

Estimation of variability

Estimates of different variability parameters such as Range, Mean, GCV and PCV are presented in the Table 2.

Coefficient of variation

The estimates of PCV (Phenotypic Coefficient of Variation) were higher than GCV (Genotypic coefficient of variation) for all the twelve characters studied. High phenotypic coefficient of variation (PCV) was observed for harvest index (23.84%). Moderate PCV was observed for 1000-seed weight (19.79%), seed yield per plant (14.70%), number of secondary branches per plant (14.67%), number of primary branches per plant (13.55%) and length of siliqua (10.35%). Low estimates of PCV were recorded for number of siliquae per plant (8.77%), days to 50% flowering (7.48%), number of seeds per siliqua (7.21%), plant height (6.74%), oil content (3.26%) and days to maturity (2.58%). Estimates of genotypic coefficient of variation (GCV) were high for harvest index (23.27%). Moderate value of GCV was recorded for the characters *viz.*, 1000-seed weight (19.46%), number of secondary branches per plant (13.59%) and seed yield per plant (12.20%). Lower estimates of GCV were recorded for number of primary branches per plant (9.93%), length of siliqua (8.87%), days to 50% flowering (7.36%), number of siliquae per plant (7.28%), number of seeds per siliqua (6.57%), plant height (6.28%), oil content (3.13%) and days to maturity (2.53%). High variability for most of these characters has been also reported earlier by Trivedi *et al.* (2016) [18], Raliya *et al.* (2018) [9], Pal *et al.* (2019) [8], Ray *et al.* (2019) [10], Rout *et al.* (2019) and Tiwari (2019) [17].

Heritability and genetic advance

The estimates of heritability in broad sense and genetic advance worked out for all the twelve characters and their values are presented in table 2.

Most of the characters under study exhibited high heritability (> 60%). Estimates of heritability were higher for the characters namely 1000-seed weight (96.74%), days to maturity (95.90%), harvest index (95.28%), oil content (92.59%), plant height (86.91%), number of secondary branches per plant (85.82%), number of seeds per siliqua (83.02%), length of siliqua (73.41%), number of siliquae per plant (68.91%) and seed yield per plant (68.84%). Moderate estimate of heritability was recorded for number of primary branches per plant (53.69%). The expected genetic advance expressed as percent of mean ranged from 5.10 (days to maturity) to 46.79 (harvest index). The estimates of genetic advance as percent of mean recorded highest for the character harvest index (46.79%) followed by 1000-seed weight (39.43%), number of secondary branches per plant (25.94%) and seed yield per plant (20.85%). Moderate estimates of genetic advance as percent of mean (10-20%) recorded for the characters *viz.*, length of siliqua (15.65%), number of primary branches per plant (14.99%), days to 50% flowering (14.92%), number of siliquae per plant (12.45%), number of seeds per siliqua (12.33%) and plant height (12.06%). Low values of genetic advance as percent of mean (<10%) were recorded for the characters *viz.*, oil content (6.21%) and days to maturity (5.10%). high heritability coupled with high genetic advance has been reported for harvest index [Trivedi *et al.* (2016) [18], Tiwari *et al.* (2017) [16] and Rout *et al.* (2019)], for 1000-seed weight [Maurya *et al.* (2018) [6], Singh *et al.* (2018) [5] and Rout *et al.* (2019)], for number of secondary branches per plant [Tiwari *et al.* (2017) [16], Maurya *et al.* (2018) [6], Ray *et al.* (2019) [10] and Rout *et al.* (2019)], for seed yield per plant [Tiwari *et al.* (2017) [16], Maurya *et al.* (2018) [6], Singh *et al.* (2018) [5], Jat *et al.* (2019) [4], Ray *et al.* (2019) [11] and Rout *et al.* (2019)]. Such high heritability coupled with high genetic advance for the characters mentioned above indicates the predominance of additive gene action on these traits.

Estimation of correlation coefficient

To study the association between various component traits and their relative importance in selection process, the correlation coefficients were estimated at genotypic and phenotypic level. The values of correlation coefficients are presented in Table 3.

The genotypic correlation coefficients, in general, were similar in sign and slightly higher in magnitude than their corresponding phenotypic correlation coefficients. It indicates the inherent association among the traits. The estimates of phenotypic correlation coefficient revealed that seed yield per plant was positively and significantly correlated with harvest index, 1000-seed weight, and number of siliquae per plant. Positive and significant association of seed yield with these characters was earlier reported by Gupta *et al.* (2018) [3], Kumar *et al.* (2018) [9], Ompal *et al.* (2018) [7] and Ray *et al.* (2019) [11]. Apart from showing strong correlations with seed yield per plant, the characters harvest index, 1000-seed weight and number of siliquae per plant also showed strong positive correlation among themselves. Strong and positive correlation of these characters with seed yield and also with one another indicates their utility in selection programme.

Path coefficient analysis

Simple correlation coefficients measure only the mutual relationships between two characters. They do not deal with the complex relationships present among the set of variables. The path coefficient analysis not only specify the effective measure of direct and indirect causes of association but also depicts the relative importance of each factor involved in contributing to the yield. In the present investigation a considerably high positive direct effect on seed yield was observed to be exerted by harvest index, number of siliquae per plant, 1000-seed weight and length of siliqua. This confirms the previous findings reported by Shekhawat *et al.* (2014) [14], Rout *et al.* (2018) [13] and Pal *et al.* (2019) [8].

On the basis of correlation and path analysis studies it is evident that three traits *viz.*, harvest index, 1000-seed weight and number of siliquae per plant are undisputedly most important components for further yield improvement in mustard.

Table 1: Analysis of variance (ANOVA) for 12 quantitative characters in Indian mustard genotypes

Source of variation	D.F.	Mean sum of squares											
		Days to 50% flowering	Days to maturity	Plant Height (cm)	No. of primary branches per plant	No. of secondary branches per plant	No. of siliquae per plant	Length of siliqua (cm)	No. of seeds per siliqua	1000 seed weight (g)	Oil Content (%)	Harvest index (%)	Seed yield per plant (g)
Replication	2	1.42	0.41	33.00	0.41	0.42	765.92	0.14	0.43	0.00	0.54*	0.33	0.80
Treatment	39	44.19**	33.89**	563.96**	1.27**	10.84**	2694.82**	0.71**	2.89**	1.75**	4.65**	66.62**	10.82**
Error	78	0.48	0.48	26.96	0.28	0.57	352.33	0.08	0.18	0.02	0.12	1.08	1.42

*, ** Significant at 5% and 1% levels, respectively

D.F. = Degree of freedom

Table 2: Estimates of different parameters of variability, heritability and genetic advance for 12 characters in forty genotypes of Indian mustard

Characters	Range		Mean	GCV (%)	PCV (%)	Heritability $h^2_{(bs)}$ (%)	Genetic advance (%)
	Minimum	Maximum					
Days to 50% flowering	44.33	60.67	51.85	7.36	7.48	96.83	14.92
Days to maturity	122.33	139..33	131.97	2.53	2.58	95.90	5.10
Plant height (cm)	179.07	240.07	213.06	6.28	6.74	86.91	12.06
Number of primary branches per plant	4.63	7.17	5.77	9.93	13.55	53.69	14.99
Number of secondary branches per plant	09.30	19.00	13.61	13.59	14.67	85.82	25.94
Number of siliquae per plant	308.17	433.13	383.80	7.28	8.77	68.91	12.45
Length of siliqua (cm)	4.08	6.22	5.17	8.87	10.35	73.41	15.65
Number of seeds per siliqua	12.60	17.13	14.46	6.57	7.21	83.02	12.33
1000-seed weight (g)	2.18	5.66	3.91	19.46	19.79	96.74	39.43
Oil content (%)	36.06	41.71	39.19	3.13	3.26	92.59	6.21
Harvest index (%)	11.10	28.15	20.09	23.27	23.84	95.28	46.79
Seed yield per plant (g)	09.20	17.54	14.52	12.20	14.70	68.84	20.85

Table 3: Estimates of correlation coefficient at genotypic (G) and phenotypic (P) levels among twelve quantitative characters in Indian mustard

Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches per plant	Number of secondary branches per plant	Number of siliquae per plant	Length of siliqua (cm)	Number of seeds per siliqua	1000-seed weight (g)	Oil content (%)	Harvest index (%)	Seed yield per plant (g)
Days to 50% flowering	G	1.000											
	P	1.000											
Days to maturity	G	0.448**	1.000										
	P	0.437**	1.000										
Plant height (cm)	G	0.115	0.439**	1.000									
	P	0.113	0.412**	1.000									
Number of primary branches per plant	G	0.060	-0.312**	-0.646**	1.000								
	P	0.043	-0.254**	-0.471**	1.000								
Number of secondary branches per plant	G	-0.057	-0.100	-0.555**	0.822**	1.000							
	P	-0.038	-0.101	-0.465**	0.647**	1.000							
Number of siliquae per plant	G	-0.074	0.146	-0.224*	0.242**	0.433**	1.000						
	P	-0.036	0.100	-0.165	0.213*	0.414**	1.000						
Length of siliqua (cm)	G	-0.048	0.494**	0.064	-0.066	0.050	0.166	1.000					
	P	-0.037	0.426**	0.033	-0.099	0.012	0.107	1.000					
Number of seeds per silique	G	0.076	0.015	-0.056	-0.226*	-0.177	0.027	0.166	1.000				
	P	0.058	0.019	-0.051	-0.162	-0.132	0.003	0.171	1.000				
1000-seed weight (g)	G	-0.264**	0.189*	-0.195*	0.174	0.132	0.359**	0.443**	-0.192*	1.000			
	P	-0.254**	0.176	-0.178	0.130	0.122	0.296**	0.374**	-0.170	1.000			
Oil content (%)	G	-0.254**	-0.375**	-0.160	-0.066	-0.010	-0.048	-0.131	-0.004	-0.430**	1.000		
	P	-0.240**	-0.349**	-0.137	-0.049	0.031	-0.034	-0.129	0.003	-0.399**	1.000		
Harvest index (%)	G	-0.199*	-0.004	-0.322**	0.151	0.163	0.389**	0.343**	-0.109	0.573**	0.011	1.000	
	P	-0.189*	0.003	-0.315**	0.143	0.144	0.286**	0.289**	-0.092	0.549**	0.033	1.000	
Seed yield per plant (g)	G	-0.263**	0.014	-0.035	-0.283**	-0.208*	0.313**	0.293**	-0.162	0.397**	0.033	0.523**	1.000
	P	-0.229*	-0.021	-0.009	-0.196*	-0.171	0.216*	0.125	-0.174	0.339**	0.014	0.408**	1.000

*, ** Significant at 5% and 1% levels, respectively

Table 4: Path coefficient analysis showing the direct and indirect effect of 11 characters on seed yield at genotypic and phenotypic level in Indian mustard

Characters		Days to 50% flowering	Days to maturity	Plant height	No. of primary branches per plant	No. of secondary branches per plant	No. of siliquae per plant	Length of siliqua	No. of seeds per siliqua	1000-seed weight (g)	Oil content (%)	Harvest index (%)	Correlation with seed yield per plant
Days to 50% flowering	G	0.0913	-0.1921	-0.0334	-0.0433	0.0064	-0.0286	-0.0187	-0.0312	0.0019	0.0351	-0.0501	-0.263**
	P	-0.0665	-0.0490	-0.0028	-0.0090	0.0093	-0.0088	-0.0012	-0.0113	-0.0318	-0.0034	-0.0542	-0.229*
Days to maturity	G	0.0409	-0.4287	-0.1280	0.2262	0.0112	0.0564	0.1919	-0.0060	-0.0014	0.0518	-0.0010	0.014
	P	-0.0291	-0.1122	-0.0102	0.0540	0.0245	0.0245	0.0140	-0.0038	0.0220	-0.0050	0.0008	-0.021
Plant height (cm)	G	0.0105	-0.1884	-0.2908	0.4680	0.0622	-0.0863	0.0248	0.0230	0.0014	0.0221	-0.0812	-0.035
	P	-0.0075	-0.0462	-0.0249	0.1001	0.1132	-0.0404	0.0011	0.0099	-0.0223	-0.0020	-0.0904	-0.009
No. of primary branches per plant	G	0.0055	0.1339	0.1880	-0.7240	-0.0921	0.0930	-0.0255	0.0928	-0.0013	0.0091	0.0381	-0.283**
	P	-0.0029	0.0285	0.0117	-0.2126	-0.1577	0.0525	-0.0032	0.0314	0.0162	-0.0007	0.0409	-0.196*
No. of secondary branches per plant	G	-0.0052	0.0430	0.1616	-0.5953	-0.1120	0.1666	0.0193	0.0729	-0.0010	0.0013	0.0409	-0.208*
	P	0.0025	0.0113	0.0116	-0.1376	-0.2437	0.1018	0.0004	0.0256	0.0153	0.0004	0.0412	-0.171
No. of siliquae per plant	G	-0.0068	-0.0628	0.0652	-0.1750	-0.0485	0.3847	0.0647	-0.0110	-0.0026	0.0067	0.0979	0.313**
	P	0.0024	-0.0112	0.0041	-0.0454	-0.1009	0.2458	0.0035	-0.0005	0.0370	-0.0005	0.0820	0.216*
Length of siliqua (cm)	G	-0.0044	-0.2116	-0.0185	0.0475	-0.0056	0.0640	0.3889	-0.0685	-0.0032	0.0181	0.0863	0.293**
	P	0.0025	-0.0478	-0.0008	0.0210	-0.0030	0.0264	0.0328	-0.0332	0.0468	-0.0018	0.0827	0.125
No. of seeds per siliqua	G	0.0069	-0.0062	0.0163	0.1633	0.0199	0.0103	0.0648	-0.4113	0.0014	0.0006	-0.0275	-0.162
	P	-0.0039	-0.0022	0.0013	0.0344	0.0321	0.0007	0.0056	-0.1943	-0.0212	0.0000	-0.0263	-0.174
1000-seed weight (g)	G	-0.0241	-0.0812	0.0567	-0.1258	-0.0148	0.1381	0.1725	0.0788	-0.0073	0.0594	0.1443	0.397**
	P	0.0169	-0.0197	0.0044	-0.0276	-0.0298	0.0728	0.0123	0.0329	0.1250	-0.0057	0.1573	0.339**
Oil content (%)	G	-0.0232	0.1608	0.0465	0.0475	0.0011	-0.0186	-0.0511	0.0017	0.0031	-0.1380	0.0029	0.033
	P	0.0160	0.0391	0.0034	0.0105	-0.0076	-0.0083	-0.0042	-0.0006	-0.0499	0.0142	0.0018	0.014
Harvest index (%)	G	-0.0182	0.0018	0.0937	-0.1095	-0.0182	0.1496	0.1332	0.0449	-0.0042	-0.0016	0.2519	0.523**
	P	0.0126	-0.0003	0.0078	-0.0303	-0.0350	0.0703	0.0095	0.0178	0.0686	0.0001	0.2867	0.408**

*, ** Significant at 5% and 1% levels, respectively Residual Effect = 0.2333(Genotypic) Residual Effect = 0.3167 (Phenotypic)

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