D-5550
[1-6]

RESEARCH ARTICLE Agricultural Science Digest, Volume Issue : ()

Genetic Variability and Trait Association in Indian Mustard [*Brassica juncea* (L.) Czern and Coss]

Kashinath Mandal[1], Aditi Ghosh[1], T. Dasgupta[2], S. Kundagrami[1] 10.18805/ag.D-5550

ABSTRACT

Background: Twenty-four released varieties of Indian Mustard were evaluated during *rabi* 2015-16 and 2016-17 under irrigated environment to study character association for seed yield and its component traits.

Methods: Analysis of variance on thirteen quantitative characters was carried out and pooled over the years. Path analysis was carried out using correlation coefficients to know the yield contributing traits.

Result: Significant differences were noticed for all the traits among the genotypes. The genotypic and phenotypic variation is higher for seed yield/plant, 1000 seed weight, secondary branches/plant and total siliquae/plant. Heritability estimate were very high for 1000 seed weight, siliqua length, plant height, seeds/siliqua, total siliquae/plant and days to maturity. Genetic advance as percent of mean were high for seed yield/plant, 1000 seed weight, secondary branches/plant and total siliquae/plant. The correlation of seed yield/plant shows significant positive association with days to maturity, primary branches/plant, secondary branches/plant, total siliquae/plant, siliqua length, seeds/siliqua, 1000 seed weight and length of main shoot. From correlation coefficients and path analysis it appeared that length of main shoot, 1000 seed weight, number of secondary branches/plant and days to maturity were most important yield components having highly positive direct and indirect effects.

Key words: *Brassica juncea*, Correlation, GCV, Path analysis, PCV, Variability.

INTRODUCTION

Rapeseed-Mustard (*Brassica* spp) is the second largest oilseed crop in India after soybean in production among eight annual edible oilseeds cultivated in our country. It is cultivated in *rabi* season mainly in North-west India and contributes nearly 27 percent to edible oil pool of the country. Major mustard growing states are Rajasthan, U.P., M.P., Haryana, West Bengal, Gujarat, Bihar and Punjab in India. In terms of area, Rajasthan is the leading state and occupies nearly 45% of the total area and contributes in the same proportion towards the production to the national oilseed pool. Apart from direct human and animal consumption, industrial uses include the manufacture of rapeseed oil and conversion biomass to bio-energy, have been developed in the recent years in world (Ofori and Becker, 2008). Total area, production and productivity of rapeseed-mustard in world during 2019-20 was 35.95 mha, 71.49 mt and 1990 kg/ha respectively. In India rapeseed-mustard area, production and productivity was 6.86 mha, 9.12 mt and 1331 kg/ha respectively during 2019-20. Globally, India continues to be rank 2nd after Canada in acreage (19.81%) and rank 4th after Canada, European Union and China in production (10.37%)(AICRP PC Report-2021, ICAR-DRMR).

The essentiality of oil and oil seed by-products in our daily diet were well realized. Biochemically, edible mustard oil is an excellent source of energy in comparison to carbohydrates and proteins. Mustard oil is extensively used in the delicious food preparation, enhancing food palatability and flavor of the food. Mustard oil is also used as hair oil, lubricants, a folk remedy for arthritis, foot ache, lumbago and rheumatism (Duke and Wain 1981). The oil seed cake is also used as cattle feed and fertilizers (Reed, 1976). Mustard seed is also used as a spice in many of the Indian dishes. Young tender leaves of mustard are also popular for salads, garnishing and even as vegetables. In ever growing population throughout the world, the demand for edible oils as well as food is also increasing. Thus, the cultivation of oilseed crops is gaining more importance day by day. In the last few decades, several mustard varieties were released to enhance the productivity.

A large number of high-yielding area specific varieties have been developed in Indian mustard but unfortunately, in spite of having the varieties with the yield potential of 2.0-2.5 tonnes/ha, our national average is revolving around 1331

[1]Institute of Agricultural Science, University of Calcutta, Kolkata-700 073, West Bengal, India.
[2]School of Agriculture and Rural Development, Ramakrishna Mission Vivekananda Educational and Research Institute, Narendrapur, Ramakrishna Mission Campus, Kolkata-700 103, West Bangal, India.

Corresponding Author: Kashinath Mandal, Institute of Agricultural Science, University of Calcutta, Kolkata-700 073, West Bengal, India. Email: kashinath_pors@yahoo.com

How to cite this article: Mandal, K.N., Ghosh, A., Dasgupta, T. and Kundagrami, S. (2022). Genetic Variability and Trait Association in Indian Mustard [*Brassica juncea* (L.) Czern and Coss]. Agricultural Science Digest. DOI: 10.18805/ag.D-5550.

Submitted: 08-01-2022 **Accepted:** 22-03-2022 **Online:** 25-04-2022

kg/ha (2019-20). Moreover, yield levels are also not sustainable and fluctuate year after year leading to fluctuation in production.

The success of breeding programme largely depends on heritability, genetic advance and genetic variability present in the available germplasm of a particular crop. Breeding for high seed yield and other economic traits is a very important objective in any crop improvement programme. Yield is a complex character dependent on many other ancillary characters which are mostly inherited quantitatively. Path coefficient analysis is the most effective mean to find out direct and indirect causes of association among the different variables. Therefore, the knowledge of direct and indirect effects of different components on yield is most important thing in selection of high yielding genotypes. Keeping this fact in view, this study was carried out by involving some popularly cultivated and newly released cultivars of Indian mustard.

MATERIALS AND METHODS

The experiments were conducted at the experimental farm of Pulses and Oilseeds Research Station, Berhampore, West Bengal during *rabi* season 2015-16 and 2016-17 under irrigated condition. The material for present study consisted of 24 popular varieties of *B. Juncea* with wider adaptability in areas of their recommendation *viz.* PM 21, PM 22, PM 24, PM 25, PM 26, PM 27, PM 28, PM 29, PM 30, Pusa Tarak, Pusa Vijay, Pusa Karishma, Pusa Agrani, JD-6, Sanjukta Asech, Seeta, Bhagirathi, Sarama, Pusa Bold, Kranti, NRCHB-101, Shibani,, DRMR-150-35 and Gujarat Mustard-1.

During both the years, the trials were laid out in randomized block design with 3 replications with plot size of 5.0 m × 1.5 m. Row-to-row and plant-to-plant distance was kept at 30 cm × 10 cm. The data was recorded on 13 characters, *viz.*, days to flowering, days to 50% flowering, days to maturity, plant height (cm), number of primary branches/plant, number of secondary branches/plant, length of main shoot (cm), number of siliquae on main shoot, siliquae length (cm), number of seeds/siliqua, 1000-seed weight (g), total siliquae/ plant and seed yield/plant (g). Except days to flowering, days to 50% flowering and days to maturity, where data was recorded on plot basis, the data for rest of the morphological characters was recorded from randomly selected 5 competitive plants in the middle 3 rows of each plot in all 3 replications. The recommended package of practices was followed to raise a good crop. The mean values of 5 samples, except for characters recorded on whole plot basis, were used for detailed statistical analysis. Analysis of variance was performed following the procedures suggested by Gomez and Gomez (1984). The correlation coefficients at genotypic and phenotypic level were calculated according to Johnson *et al.*(1955) and path coefficient was done as suggested by Dewey and Lu (1959). In the present studied path coefficient analysis was done by taking seed yield/plant as dependent variable and other traits as independent variables for the pooled data.

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences for individual as well as pooled data among the genotypes for all the traits indicating presence of wide spectrum of variability within the genotypes (Table 1). High magnitude of variability has been reported in Indian mustard germplasm and varieties for characters by many workers (Kumar and Misra 2007, Yadava *et al.* 2011) for days to 50% flowering, days to maturity, plant height, total siliquae/plant and seed yield/plant. Phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the observed characters (Table 2). High PCV and GCV were found for seed yield/plant, 1000 seed weight, number of secondary branches/plant, total number of siliquae/plant and moderate for days to flowering, days to 50%flowering, plant height, number of siliquae on main shoot, length of main shoot and length of siliqua. High PCV and GCV in Indian mustard for seed yield/plant, 1000 seed weight, secondary branches/ plant were similarly observed by Singh (2004) and Yadava *et al.*(2011). High PCV and GCV in Indian mustard for secondary branches/plant and seed yield/plant was also observed by Raj *et al.*(1998), Das *et al.* (1998) and Devmani *et al.*(2014). High values of GCV and PCV coupled with high heritability were observed for 1000 seed weight, secondary branches/plant, seed yield/plant and total siliquae/plant (Table 2) indicating that additive gene action might play major role in the expression of these traits and selection would be effective in further improvement of these traits. The results showed presence of high amount of genetic variability in the observed genotypes for the major yield contributing characters along with seed yield that indicated further improvement for these traits is possible.

In the present study highest heritability in broad sense has estimated for 1000 seed weight, length of siliqua, plant height, seeds/siliqua, total number of siliquae/plant and days to maturity (Table 2). High heritability for 1000 seed weight has been reported earlier (Mahla *et al.* 2003, Singh 2004, Yadava *et al.* 2011). High variability for different characters under study , like plant height and total siliquae/plant (Singh 2004, Kumar and Misra 2007) has been reported earlier also. High variability for length of siliqua and days to maturity also reported earlier by Yadava *et al.* (2011). Genetic advance as percent of mean was higher for seed yield/plant, 1000 seed weight, secondary branches/plant and total siliquae/plant indicating that selection for these characters would be effective for the improvement of this crop. High heritability with high genetic advance as percent of mean for seed yield/plant has been also reported by Singh (2004), Kumar and Misra (2007) and Yadava *et al.* (2011), which supports the results of the present study.

Correlation coefficients (Table 3) were estimated between seed yield and other twelve characters under study which expressed that seed yield had significant positive association with days to maturity, primary branches/plant,

Table 1: Analysis of variance (ANOVA) for thirteen characters in twenty four genotypes in Indian mustard (Pooled).

Source of variation	d.f.	Days to flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches /plant	Secondary branches /plant	Total siliquae /plant	Length of siliqua (cm)	Seeds /siliqua	1000 seed weight (g)	Length of main shoot (cm)	Siliquae on main shoot	Seed yield /plant (g)
Replication	2	0.010	0.135	0.094	0.011	0.006	0.027	0.373	0.000	0.001	0.000	0.128	0.241	0.155
Treatment	23	111.65**	130.77**	124.71**	6.52**	0.64**	7.77**	6815.78**	1.12**	3.47**	1.51**	257.46**	115.14**	157.83**
Error	46	0.483	0.668	0.231	0.016	0.005	0.046	5.806	0.000	0.002	0.000	1.400	1.392	1.000

*Significant at 5% and **Significant at 1% probability level.

Table 2: Estimates of different genetic parameters of variation (Pooled) in Indian mustard.

Character	Mean	Range	PCV	GCV	Heritability	GA	GA as per cent of mean
Days to flowering	43.10	34.72-57.72	14.22	14.13	98.71	12.46	28.91
Days to 50% flowering	50.19	41.50-65.67	13.22	13.12	98.48	13.46	26.83
Days to maturity	110.81	102.00-124.17	5.83	5.81	99.45	13.23	11.94
Plant height (cm)	191.08	135.65-244.65	13.10	13.09	99.91	51.50	26.95
Primary branches/plant	4.88	4.20-6.00	9.56	9.45	97.66	0.94	19.24
Secondary branches/plant	9.10	5.90-11.60	17.89	17.63	98.26	3.28	36.00
Total siliquae/plant	279.45	191.14-395.77	17.07	17.05	99.75	98.02	35.08
Length of siliqua (cm)	5.14	4.02-6.28	11.90	11.89	99.92	1.26	24.49
Seeds/siliqua	12.01	9.76-13.68	8.96	8.95	99.81	2.21	18.41
1000 seed weight (g)	3.93	2.58-5.05	18.06	18.05	99.98	1.46	37.19
Length of main shoot (cm)	79.88	58.37-97.55	11.66	11.57	98.39	18.88	23.63
Siliquae on main shoot	51.12	39.07-62.53	12.27	12.05	96.46	12.46	24.37
Seed yield/plant (g)	13.86	7.70-21.60	28.85	28.58	98.12	8.08	58.31

Table 3: Genotypic (above diagonal) and phenotypic (below diagonal) correlation (Pooled) of different characters in Indian mustard.

Traits	Days to flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches /plant	Secondary branches /plant	Total siliquae /plant	Length of siliqua (cm)	Seeds /siliqua	1000 seed weight (g)	Length of main shoot (cm)	Siliquae on main shoot	Seed yield /plant(g)
Days to flowering	1.000	0.983**	0.874**	0.708**	0.148^{NS}	0.040^{NS}	0.081^{NS}	0.280*	-0.257*	0.043^{NS}	0.312**	0.146^{NS}	0.165^{NS}
Days to 50% flowering	0.980**	1.000	0.897**	0.732**	0.106^{NS}	-0.028^{NS}	0.033^{NS}	0.287*	-0.249*	0.074^{NS}	0.269*	0.153^{NS}	0.118^{NS}
Days to maturity	0.868**	0.888**	1.000	0.813**	0.064^{NS}	0.024^{NS}	0.174^{NS}	0.324**	-0.201^{NS}	0.023^{NS}	0.384**	0.275*	0.236*
Plant height(cm)	0.702**	0.725**	0.810**	1.000	0.188^{NS}	-0.072^{NS}	0.414**	0.239*	-0.180^{NS}	0.025^{NS}	0.525**	0.563**	0.227^{NS}
Primary branches/plant	0.144^{NS}	0.104^{NS}	0.062^{NS}	0.187^{NS}	1.000	0.205^{NS}	0.388**	-0.096^{NS}	-0.221^{NS}	0.102^{NS}	0.045^{NS}	0.042^{NS}	0.248*
Secondary branches/plant	0.038^{NS}	-0.026^{NS}	0.022^{NS}	-0.071^{NS}	0.208^{NS}	1.000	0.564**	0.300*	0.165^{NS}	0.085^{NS}	0.215^{NS}	0.159^{NS}	0.550**
Total siliquae/plant	0.081^{NS}	0.033^{NS}	0.173^{NS}	0.413**	0.382**	0.561**	1.000	-0.015^{NS}	0.094^{NS}	-0.085^{NS}	0.386**	0.600**	0.434**
Length of siliqua (cm)	0.278*	0.284*	0.323**	0.238*	-0.095^{NS}	0.297*	-0.015^{NS}	1.000	0.402**	0.746**	0.367**	-0.156^{NS}	0.508**
Seeds/siliqua	-0.255*	-0.248*	-0.200^{NS}	-0.180^{NS}	-0.219^{NS}	0.163^{NS}	0.094^{NS}	0.403**	1.000	0.247*	0.353**	-0.110^{NS}	0.557**
1000 seed weight (g)	0.043^{NS}	0.073^{NS}	0.023^{NS}	0.025^{NS}	0.101^{NS}	0.085^{NS}	-0.085^{NS}	0.746**	0.247*	1.000	0.044^{NS}	-0.270*	0.287*
Length of main shoot (cm)	0.307**	0.265*	0.381**	0.520**	0.039^{NS}	0.207^{NS}	0.381**	0.364**	0.351**	0.043^{NS}	1.000	0.526**	0.617**
Siliquae on main shoot	0.143^{NS}	0.147^{NS}	0.271*	0.552**	0.035^{NS}	0.149^{NS}	0.587**	-0.153^{NS}	-0.106^{NS}	-0.265*	0.533**	1.000	0.181^{NS}
Seed yield/plant (g)	0.165^{NS}	0.119^{NS}	0.233*	0.225^{NS}	0.243*	0.538**	0.427**	0.504**	0.552**	0.285*	0.611**	0.182^{NS}	1.000

Upper diagonal- Genotypic correlation; Lower diagonal- Phenotypic correlation; *Significant at 5% and **Significant at 1% probability level.

secondary branches/plant, total siliquae/plant, siliqua length, seeds/siliqua, 1000 seed weight and length of main shoot, indicating that these are the major yield contributing characters. Selection would be helpful in simultaneous improvement in these traits for increasing yield of *B. juncea*. Positive and significant association with total siliquae/plant, 1000 seed weight and seeds/siliqua were also observed by Shekhawat *et al.*(2014).Seed yield/plant had positive significant association with total number of siliquae/plant and test weight was earlier reported by Patra *et al.* (2006). Highly positive correlation between total siliquae/plant and seed yield /plant were also reported by Khayat *et al.* (2012) and Hasan *et al.* (2014). In general the genotypic correlations were slightly higher than the phenotypic ones; similar finding was earlier reported by Mahla *et al.* (2003) and Patel *et al.* (2019). The genotypic correlation was greater than the phenotypic correlation for all the traits under study except length of main shoot. In the present study positive non significant association were observed for days to flowering, days to 50% flowering, plant height and siliquae on main shoot.

Path coefficient analysis (Table 4) helped to partition the correlation coefficients of seed yield with the different component traits into direct and indirect effects. It was found from the analysis that the traits like number of seeds/siliqua and number of secondary branches/plant were the most important yield components followed by days to maturity, number of primary branches/plant, 1000 seed weight and length of main shoot as all these traits exhibited highly positive direct effects on seed yield and their indirect effects to seed yield *via* several other traits were mostly positive both at phenotypic and genotypic level. Moreover, these six traits showed significantly positive phenotypic and genotypic correlation coefficients with seed yield. The results also revealed that days to flowering had the highest direct effect on seed yield per plant which was earlier reported by Patel *et al.* (2019). But in the present study, the direct contribution of days to 50% flowering was found to be high and negative. But as days to flowering or days to 50% flowering did not show significantly positive correlation coefficient with seed yield, so these two traits will not be considered as important yield components, inspite of their highly positive or highly negative direct effects on seed yield. Negative direct effect of days to 50% flowering and siliquae length to seed yield/ plant was also reported by Swetha *et al.* (2019). On the contrary, total siliquae number/plant and length of siliqua were correlated significantly and positively with seed yield/ plant, but path analysis disclosed that the direct effects of these two traits on seed yield were high and negative. The results highlighted that the findings based on correlation coefficients may not be valid and precise in the selection strategy unless the path analysis results are compared. From the path coefficient analysis it was revealed that that selection of plants on the basis of total siliquae number/ plant and length of siliqua would not produce desired genetic improvement in seed yield as their direct contribution to seed

Table 4: Genotypic and phenotypic path coefficients (Pooled) of different characters in Indian mustard.

Traits		Days to flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches /plant	Secondary branches /plant	Total siliquae /plant	Length of siliqua (cm)	Seeds /siliqua	1000 seed weight (g)	Length of main shoot (cm)	Siliquae on main shoot	Correlation with seed yield/plant
Days to	G	1.021	-1.422	0.500	0.182	0.041	0.021	-0.029	-0.065	-0.157	0.012	0.049	0.0139	0.165^{NS}
flowering	P	0.655	-0.924	0.389	0.112	0.038	0.017	-0.021	-0.046	-0.141	0.009	0.220	0.066	0.165^{NS}
Days to 50%	G	1.003	-1.447	0.513	0.188	0.029	-0.014	-0.012	-0.067	-0.152	0.020	0.043	0.015	0.118^{NS}
flowering	P	0.642	-0943	0.398	0.115	0.027	-0.012	-0.008	-0.047	-0.137	0.016	0.058	0.010	0.119^{NS}
Days to	G	0.893	-1.298	0.571	0.209	0.017	0.012	-0.063	-0.076	-0.123	0.006	0.061	0.026	0.236*
maturity	P	0.568	-0.837	0.448	0.129	0.016	0.010	-0.045	-0.054	-0.111	0.005	0.084	0.018	0.233*
Plant height	G	0.723	-1.059	0.464	0.257	0.051	-0.037	-0.150	-0.056	-0.110	0.007	0.083	0.054	0.227^{NS}
(cm)	P	0.460	-0.684	0.363	0.159	0.049	-0.033	-0.107	-0.040	-0.099	0.006	0.114	0.036	0.225^{NS}
Primary	G	0.152	-0.154	0.037	0.048	0.273	0.107	-0.141	0.022	-0.135	0.027	0.007	0.004	0.248*
branches/plant	P	0.094	-0.098	0.028	0.030	0.263	0.097	-0.099	0.016	-0.121	0.022	0.009	0.002	0.243*
Secondary	G	0.041	0.040	0.014	-0.019	0.056	0.519	-0.205	-0.070	0.101	0.023	0.034	0.015	0.550**
branches/plant	P	0.025	0.024	0.010	-0.011	0.055	0.466	-0.145	-0.049	0.090	0.019	0.045	0.010	0.538**
Total siliquae	G	0.083	-0.048	0.099	0.107	0.106	0.293	-0.363	0.004	0.058	-0.023	0.061	0.057	0.434**
/plant	P	0.053	-0.031	0.078	0.066	0.100	0.261	-0.259	0.003	0.052	-0.019	0.084	0.039	0.427**
Length of	G	0.286	-0.416	0.185	0.061	-0.026	0.156	0.006	-0.234	0.246	0.201	0.058	-0.015	0.508**
siliqua (cm)	P	0.182	-0.268	0.145	0.038	-0.025	0.139	0.004	-0.166	0.223	0.163	0.080	-0.010	0.504**
Seeds/siliqua	G	-0.262	0.360	-0.115	-0.046	-0.060	0.086	-0.034	-0.094	0.611	0.067	0.056	-0.011	0.557**
	P	-0.167	0.234	-0.090	-0.029	-0.058	0.076	-0.024	-0.067	0.553	0.054	0.077	-0.007	0.552**
1000 seed	G	0.044	-0.106	0.013	0.006	0.028	0.044	0.031	-0.174	0.151	0.269	0.007	-0.026	0.287*
weight (g)	P	0.028	-0.069	0.010	0.004	0.027	0.040	0.022	-0.124	0.136	0.218	0.009	-0.017	0.285*
Length of main	G	0.318	-0.390	0.219	0.135	0.012	0.112	-0.140	-0.086	0.216	0.012	0.158	0.050	0.617**
shoot (cm)	P	0.201	-0.249	0.171	0.083	0.010	0.096	-0.098	-0.060	0.194	0.009	0.220	0.035	0.611**
Siliquae on	G	0.149	-0.221	0.157	0.145	0.011	0.082	-0.218	0.037	-0.067	-0.073	0.083	0.095	0.181^{NS}
main shoot	P	0.094	-0.139	0.121	0.088	0.009	0.069	-0.152	0.025	-0.059	-0.058	0.117	0.066	0.182^{NS}

yield was negative. Thus, 1000 seed weight, number of secondary branches/plant, length of main shoot, number of seeds/siliqua and days to maturity transpired as important yield components having high correlation coefficients coupled with highly positive direct effects on seed yield. Out of these six traits, some traits were significantly inter-correlated positively both at phenotypic and genotypic level namely, length of main shoot with days to flowering, days to 50% flowering, number of seeds/siliqua, total siliqua /plant, days to maturity and length of siliqua. Similarly, days to maturity was correlated significantly with plant height, days to flowering, siliqua on main shoot. Such inter-correlation was found between 1000 seed weight and seeds/siliqua, secondary branches /plant with total siliquae/plant and length of siliqua. So, selection for improved trait for one character will have correlated positive response of other traits. So selection criteria based on longer main shoot, more number of secondary branches/plant and more 1000 seed weight appeared to generate higher yield in Indian mustard. But such developed genotypes must be medium to fit into the crop rotation program. Such genotype would also produce more number of seeds/siliqua, total siliquae/plant and long siliqua because of correlated response of the selected traits.

CONCLUSION

The genotypes studied over two years are of diverse nature and the characters *viz.*, seed yield/plant, 1000 seed weight, number of secondary branches/plant and length of main shoot showed high GCV, PCV, heritability coupled with high genetic advance percentage of mean. The traits namely, length of main shoot, 1000 seed weight, number of secondary branches/plant and days to maturity were identified as important yield components based on correlation coefficient and path coefficient analysis both at phenotypic and genotypic on data pooled over two years and information obtained would be helpful in restructuring plant type and designing the selection methodology which can be further used in the breeding program for improvement of Indian mustard.

Conflict of interest: None.

REFERENCES

AICRP-RM (2020-21). Project Coordinator's Report at 28th Annual AICRP (R and M) Group Meeting, ICAR-Directorate of Rapeseed-Mustard Research, Sewar, Bharatpur, Rajasthan.

Das, K., Barura, P.K. and Hazarika, G.N. (1998). Genetic variability and correlation in Indian mustard. Journal of Agricultural Science. 11(2): 262-64.

Devmani, B., Singh, D. and Dwivedi, V.K. (2014). Genetic Variability and Character Association in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. Agricultural Science Digest. 34(3): 183-188.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. Agronomy Journal. 51: 515-518.

Duke, J.A. and Wain, K.K. (1981). Medicinal Plants of the World. 3: 1654.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. Wiley Interscience publication. ISBN: 978-0-471-87092-0. pp 75-83.

Hasan, Ejaz-Ul, Mustafa, H.S.B, Bibi, T. and Mahmood, T. (2014). Genetic variability, correlation and path analysis in advanced lines of rapeseed (*Brassica napus* L.) for yield components. Cercetari Agronomice in Moldova. 97(1): 71-79.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimates of Genetic and Environmental Variability in Soybeans. Agronomy Journal. 47: 314-18

Khayat, M., Lack, S. and Karami, H. (2012). Correlation and path analysis of traits affecting grain yield of canola (*Brassica napus* L.) varieties. J. Basic. Appl. Sci. Res. 2(6): 5555-5562.

Kumar Satyendra and Misra, M.N. (2007). Study on genetic variability, heritability and genetic advance in populations in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. International Journal of Plant Sciences. 2(1): 188-90.

Mahla, H.R., Jambhulkar, S.J., Yadav, D.K. and Sharma, R. (2003). Genetic variability, correlation and path analysis in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. Indian Journal of Genetics and Plant Breeding. 63: 171-72.

Ofori, A. and Becker, H.C. (2008). Breeding of *Brassica rapa* for biogas production: Heterosis and combining ability of biomass yield. Bio-energy Res. 1: 98-104.

Patel, J.R., Prajapati, K.P., Patel, P.J., Patel, B.K., Jat, A.L. and Desai, A.G. (2019). Genetic variability and character association analysis for seed yield and its attributes in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. The Pharrma Innovation Journal. 2019. 8(4): 872-76.

Patra, T., Maiti, S. and Mitra, B. (2006). Variability, correlation and path analysis of the yield attributing characters of mustard (*Brassica spp.*). Research on Crops. 7(1): 191-193.

Raj, L., Singh, H. and Singh, V.P. (1998). Variability studies in rapeseed and mustard. Ann. Agric. Res. 19(1):87-88.

Reed, C.F. (1976). Information summaries on 1000 economic plants. Typescripts submitted to the USDA.

Shekhawat, N., Jadeja, G.C., Singh, J. and Shekhawat, R.S. (2014). Character association studies among yield and its component characters in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. The Bioscan. 9(2): 685-88.

Singh, B. (2004). Character association and path analysis under dry land condition in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. Cruciferae Newsletter. 25: 99-100.

Swetha, M., Janeja, H. S., Singh, H., Sravani, M., Rajaneesh, K. and Madakemohekar, A.H. (2019). Genetic evaluation of Indian mustard (*Brassica juncea* L.) genotypes for yield and quality parameters. Plant Archives. 19(1): 413-417.

Yadava, D.K., Giri, S.C., Vignesh, M., Vasudev, S., Yadav, A.K., Dass, B., Singh, R., Singh, N., Mohapatra, T. and Prabhu, K.V. (2011). Genetic variability and trait association studies in Indian mustard (*Brassica juncea*). Indian Journal of Agricultural Sciences. 81(8): 712-6.