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Research Article

GENETIC VARIABILITY, CHARACTERS ASSOCIATION AND PATH COEFFICIENT ANALYSIS IN GREEN MUSTARD (*Brassica juncea* L.) GENOTYPES

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ABSTRACT

Seven genotypes of green mustard (*Brassca juncea*) have been evaluated to determine the genetic variability, degree and direction of association between yield and its components characters. The direct and indirect effects on leaf yield have also been studied. High heritability with high genetic advance as percent of mean was registered for plant height, vitamin C content and yield per plant (g) which in fact demonstrated the presence of additive gene effects. The correlation studies revealed strong positive association of yield with Leaf area index (LAI), dry matter yield, number of leaves per plant at genotypic level, whereas at phenotypic level only dry matter yield showed a significant positive correlation. The result of path analysis indicated that dry matter yield had maximum direct effect on yield per plant followed by vitamin C content, total chlorophyll content and leaf length. The present study suggested that while selection, emphasis should be given on these characters in selection programme for increasing the yield of green mustard genotypes.

INTRODUCTION

Mustard (*Brassica juncea*) belongs to Brasssicaceae family**.** It is also known as Indian mustard or mustard greens or leaf mustard or lai patta, it is a perennial herb, usually grown as an annual or biennial. The primary center of origin of Indian mustard is thought to be central Asia while secondary centres in central and Western china. Major Indian mustard producing countries include Canada, China, Germany, France, Australia, Pakistan, Poland and India. Indian mustard is cultivated in the states of Punjab, Rajasthan, Uttar Pradesh, Assam, Gujarat, Haryana, Madhya Pradesh, and West Bengal as a *rabi* crop for seed production, whereas in North East Hill region it is mainly cultivated as leafy vegetables. Broad leaf mustard is one of the most popular and widely cultivated *rabi* leafy crops of hills and plains of North East India. It is a minor cool season crop which bears large green hairy leaves which can be used as green vegetable. It grows well in sandy soils and reaches a height of 60-70 cm or more than that (Pradhan, 2014). It is a rich source of flavonoids, carotenes, lutein and zea-xanthin. Moreover, fresh mustard leaves are an excellent source of vitamin A, C, several essential minerals such as calcium, iron, magnesium, potassium, zinc, selenium, and manganese as well as phyto-nutrients (Banerjee *et al.,* 2012). The *Brassica* family of vegetables contain phyto-nutrients recommended for their anticancer properties. Nagaland is bestowed with the agro-climatic condition, which is suitable for all type of vegetable crop grown in the region. But due to lack of proper knowledge about the cultivars best suited in the area, the potential of green mustard is not exploited and is still insufficient even to meet the demands of the people. As an established fact, yield is a complex trait and is dependent on many other ancillary characters which are mostly inherited quantitatively. The different morphological traits vary in their relationship with yield in terms of their nature as well as magnitude, though they show a continuous variation and are influenced by environment. The components which have high heritability and positive correlation with yield can be used in the indirect selection for yield and act as an alternate mode of selection for yield improvement. When the indirect associations become complex, path coefficient analysis is the most effective mean to find out direct and indirect causes of association among the different variables. However, information regarding inheritance of yield and its closely related components is essential to efficiently exploit the available genetic diversity in green mustard for yield. The present study was therefore, undertaken to find out and establish suitable selection criteria for green mustard genotypes through study of genetic variability, heritability, genetic advance and relationship between leaf yield and its components.

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MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm of Department of Horticulture, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland during *Rabi i.e.* October 2015 to Janaury 2016. Seven genotypes of green mustard *viz*. MGVAR-1, MGVAR-2, MGVAR-3, MGVAR-4, Pusa Sag-1-C, Meghalaya local and Nagaland local were grown in randomized block design with three replications. All the recommended agronomic practices were followed for raising a good crop. Observations were recorded on five randomly sampled plants in each replication for plant height, number of leaves per plant, leaf length, leaf width, leaf area index, dry matter content, dry matter yield, crude protein content, vitamin C, chlorophyll a, chlorophyll b, total chlorophyll content and yield per plant. Analysis of variance was done using standard statistical procedure. Heritability (broad sense) was estimated according to Allard (1960). Genotypic and phenotypic coefficients of variation were estimated as per Burton and Vane (1952). Genetic advance as per cent of mean was estimated according to Johnson *et al*. (1955). Genotypic and phenotypic correlation coefficients for all possible comparisons were computed as per formulae suggested by Al-Jibouri *et al*. (1958). The partitioning of genotypic correlation coefficient of traits into direct and indirect effects was carried out using the procedure suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Genetic variability, heritability and genetic advance

The analysis of variance revealed significant differences among the genotypes for all characters studied indicating a high degree of variability in the material. The estimates of phenotypic coefficient of variation (PCV) were higher than those of genotypic coefficient of variation (GCV) for all the traits indicating environmental factors influencing the characters (table 1).

Table 1 Genetic parameters on growth attributes of thirteen (13) characters in various green mustard genotypes

Sl. No.	Characters	Grand mean SEM±	Range	Variance			Coefficient of variation			Heritability	G. A. (%)
				$\sigma^2 g$	$\sigma^2 p$	$\sigma^2 e$	GCV	PCV	ECV	h^2	
1.	Plant height (cm)	89.75±5.90	41.64 - 136.25	1342.13	1446.48	104.35	40.82	42.37	11.38	92.79	72.69
2.	Number of leaves plant^{-1}	14.34±0.69	12.40 – 16.33	0.94	2.35	1.41	6.77	10.69	8.27	40.12	1.27
3.	Leaf length (cm)	22.40±1.03	21.49 - 26.17	3.09	6.30	3.20	7.85	11.20	7.99	49.13	2.54
4.	Leaf width(cm)	15.91±0.47	15.17 - 17.79	0.53	1.20	0.67	4.58	6.90	5.16	44.02	1.00
5.	Leaf Area Index	0.338±0.01	0.310 - 0.350	0.000	0.001	0.001	4.96	9.60	8.22	26.70	0.02
6.	Dry matter content (%)	57.32±2.43	44.33 - 63.33	36.66	54.40	17.74	10.56	12.87	7.35	67.40	10.24
7.	Dry matter yield (q ha^{-1})	1.74±0.09	1.26 - 2.05	83.04	105.65	22.61	17.00	19.18	8.87	78.60	0.54
8.	Crude protein content (%)	3.56±0.22	76.40 - 97.37	0.13	0.27	0.14	10.02	14.50	10.48	47.75	0.51
9.	Vitamin C content (mg 100g^{-1} of leaf)	20.76±1.49	2.49 - 3.51	25.43	32.11	6.68	24.29	27.30	12.45	79.19	9.24
10.	Chlorophyll a	0.398±0.03	76.99 - 108.19	0.005	0.008	0.003	18.13	23.11	14.33	61.53	0.12
11.	Chlorophyll b	0.231±0.01	2.91 - 4.08	0.001	0.002	0.001	16.64	20.06	11.21	68.77	0.07
12.	Total chlorophyll (mg 100g^{-1} of leaf)	0.629±0.04	13.65 - 26.47	0.01	0.02	0.01	17.02	20.81	11.98	66.86	0.18
13.	Yield plant^{-1} (g)	84.02±3.22	0.322 - 0.520	85.47	116.64	31.18	11.00	12.85	6.65	73.27	16.30

The highest PCV and GCV were recorded plant height, vitamin C, chlorophyll a, chlorophyll b and total chlorophyll indicating presence of ample variation for these traits in the present material. Burton & Vane (1952) has suggested that genotypic coefficient of variation together with heritability estimates gives best option expected for selection. A fair measure of efficiency of selection for any quantitative traits can be derived from the estimates of heritability for the characters under consideration. But reliability of selection depends not only on heritability but it should also be accompanied by high genetic advance Johnson *et al*. (1955). High heritability coupled with high genetic advance shows that a progress can be made through selection as it suggests the presence of additive gene effects. In the present study, high estimates of heritability and genetic advance were obtained for plant height, vitamin C content and yield per plant. Thus, selection for these traits is likely to accumulate more additive genes leading to further improvement of their performance and these traits may be used as selection criteria in green mustard breeding program. Similar results have also been reported by Gangapur *et al.* (2011), Tiwari *et al.* (2017) and Arifullah *et al.* (2013).

Mean performance of genotypes for different traits

Mean performance for all the traits under study have been mentioned in table 2. The genotype 2014/MGVAR-4 exhibited maximum value for plant height (136.25 cm) at 60 DAS followed by that of 2014/MGVAR-3 (120.07 cm) while the genotype 2014/MGVAR-1 revealed least plant height (41.64 cm). The genotype 2014/MGVAR-4 revealed maximum value for number of leaves per plant (16.33), leaf length (26.17 cm) and leaf width (17.79 cm) at 60 DAS. The highest value for leaf area index was observed in MGVAR-2 (0.369) followed by that of MGVAR-3 (0.355). The dry matter content (%) was maximum for MGVAR-3 (63.33%) and minimum for MGVAR-2 (44.33%). Crude protein content was maximum for MGVAR-1 (4.08%). Maximum vitamin C content was observed in MGVAR-2 (26.47 mg/100g). Total chlorophyll content was the highest for MGVAR-3 (0.793 mg/100g). The genotype 2014/MGVAR-4 exhibited maximum yield per plant (97.37 g) followed by that of MGVAR-1 (92.65 g per plant).

Correlation coefficients

Genotypic and phenotypic correlation coefficients among yield and its components are presented in (table 3). In some cases, the genotypic correlation coefficients were higher than the phenotypic correlation coefficients. These observations indicate that the expressions of character associations had not been appreciably influenced by the environment and the apparent association may be largely due to genetic reason. The difference between genotypic and phenotypic correlation was in general low, indicating that the environmental effects did not have much influence on these characters. Dutta *et al.* (2002) also reported that the magnitudes of genotypic correlation were higher than their respective phenotypic correlations. The most economic trait *i.e.* leaf yield had positive and significant association with number of leaves per plant, leaf area index and dry matter yield at genotypic level, while at phenotypic level it had positive and significant relationship only with dry matter yield. Number of leaves per plant was positively correlated with leaf length and leaf width. Leaf area index also showed a significant correlation with total chlorophyll, whereas dry matter yield had a negative association with vitamin C, which is similar with the findings of Esiyok *et al.* (2011), Lodhi *et al.* (2014) and Hasan *et al.* (2013).

Table 2 Mean performance of seven genotypes of green mustard for in different characters

Genotypes	Plant height (cm) 60DAS	No. of leaves per plant	Leaf length (cm) 60 DAS	Leaf width (cm) 60 DAS	Leaf area index 60 DAS	Dry matter content (%)	Crude protein content (%)	Vitamin C (mg /100g)	Total chlorophyll (mg/100g)	Yield per plant (g)
2014/MGVAR-1	41.64	14.73	21.79	15.17	0.347	60.83	**4.08**	13.65	0.77	92.65
2014/MGVAR-2	47.17	14.07	23.9	15.41	**0.369**	44.33	3.73	**26.47**	0.666	78.68
2014/MGVAR-3	120.07	14.8	21.49	15.66	0.355	**63.33**	3.9	14.32	**0.793**	88.03
2014/MGVAR-4	**136.25**	**16.33**	**26.17**	**17.79**	0.35	58.43	3.23	19.71	0.506	**97.37**
Pusa Sag 1- C	108.67	13.8	20.44	15.55	0.316	53.67	3.76	26.45	0.537	85.69
Meghalaya Local	68.79	12.4	20.54	15.84	0.31	62.00	2.91	21.21	0.569	76.4
Nagaland Local	105.69	14.27	22.46	15.96	0.318	58.67	3.32	23.49	0.561	69.29
Grand Mean	89.75	14.34	22.4	15.91	0.338	57.32	3.56	20.76	0.629	84.02
SE(m)±	5.9	0.69	1.03	0.47	0.016	2.43	0.22	1.49	0.043	3.22
CD	18.17	2.11	3.18	1.46	0.049	7.49	0.66	4.6	0.134	9.93

Table 3 Genotypic correlation coefficients for combination of 11 characters in various green mustard genotypes

Parameters	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Leaf width (cm)	Leaf Area Index	Dry matter content (%)	Dry matter yield (q ha^{-1})	Protein content (%)	Vitamin C content (mg 100 g^{-1} leaf)	Total chlorophyll (mg 100 g^{-1} leaf)	Yield plant^{-1} (g)
Plant height (cm)	1	0.579	0.181	0.941**	-0.726*	0.244	0.413	-0.354	0.194	-0.665*	0.33
Number of leaves per plant	0.041	1	0.692*	0.724*	0.235	0.034	0.54	0.39	-0.465	0.209	0.792*
Leaf length (cm)	0.17	0.278	1	0.925*	0.973**	-0.466	0.096	-0.269	0.113	-0.285	0.584
Leaf width (cm)	0.464	0.461	0.326	1	0.056	0.359	0.524	-0.672*	-0.037	-0.841**	0.435
Leaf Area Index	-0.082	0.217	0.416	0.044	1	-0.707*	0.074	1.013	-0.359	0.967**	0.834**
Dry matter content (%)	0.269	0.079	-0.123	-0.044	-0.162	1	0.792**	-0.28	-0.768**	0.288	0.258
Dry matter yield (q ha^{-1})	0.36	0.455	0.001	0.236	-0.029	0.748*	1	0.123	-0.849**	0.314	0.793*
Protein content (%)	-0.405	0.257	-0.047	-0.449	0.239	-0.049	0.11	1	-0.396	0.832**	0.486
Vitamin C content (mg 100 g^{-1} of leaf)	0.085	-0.287	-0.039	0.049	-0.221	-0.719*	-0.752*	-0.264	1	-0.780**	-0.615
Total chlorophyll (mg 100 g^{-1} of leaf)	-0.54	-0.03	-0.215	-0.346	0.279	0.039	0.079	0.680*	-0.52	1	0.253
Yield plant^{-1} (g)	0.207	0.594	0.11	0.34	0.114	0.124	0.748*	0.264	-0.427	0.12	1

Note: Values in the column are genotypic and phenotypic correlation coefficients
*, **: Significant at 5% and 1% level of significance respectively

Table 4 Genotypic path coefficient analysis showing direct (bold) and indirect effects of different characters in various green mustard genotypes

Parameters	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Leaf width (cm)	Leaf Area Index	Dry matter content (%)	Dry matter yield (q ha^{-1})	Crude protein content (%)	Vitamin C content (mg 100 g^{-1} leaf)	Total chlorophyll (mg 100 g^{-1} leaf)	Correlation with yield plant^{-1} (g)
Plant height (cm)	-0.083	-0.042	0.008	-0.067	-0.030	-0.250	0.806	0.051	0.065	-0.128	0.330
Number of leaves per plant	-0.048	-0.073	0.063	-0.051	0.056	-0.034	1.054	-0.057	-0.156	0.040	0.792**
Leaf length (cm)	-0.015	-0.094	0.048	-0.084	0.040	0.478	0.187	0.039	0.0380	-0.054	0.584
Leaf width (cm)	-0.079	-0.053	0.057	-0.071	0.002	-0.368	1.023	0.098	-0.012	-0.162	0.435
Leaf Area Index	0.060	-0.099	0.047	-0.004	0.041	0.726	0.144	-0.145	-0.120	0.186	0.834**
Dry matter content (%)	-0.020	-0.002	-0.022	-0.025	-0.029	-1.026	1.547	0.041	-0.258	0.055	0.258
Dry matter yield (q ha^{-1})	-0.034	-0.039	0.004	-0.037	0.003	-0.813	1.953	-0.018	-0.285	0.060	0.793**
Crude protein content (%)	0.029	-0.028	-0.013	0.047	0.041	0.287	0.240	-0.146	-0.133	0.160	0.486
Vitamin C content (mg 100 g^{-1} of leaf)	-0.016	0.034	0.005	0.002	-0.014	0.788	-1.658	0.058	0.336	-0.150	-0.615*
Total chlorophyll (mg 100 g^{-1} leaf)	0.055	-0.015	-0.013	0.059	0.040	-0.295	0.613	-0.122	-0.262	0.192	0.253

Note: Values in the column are genotypic path coefficients
*, **: Significant at 5% and 1% level of significance respectively
Residual effect R = 0.374 (Genotypic path)

Path coefficients analysis

The result of path analysis studied (table 3) revealed that dry matter yield, vitamin C content, total chlorophyll content and leaf length exhibited positive direct effect on yield per plant while the highest negative direct effect was exerted by dry matter content, crude protein content, plant height and number of leaves per plant. Similar observations were also recorded by Shalini *et al.* (2000), Lodhi *et al.* (2014) and Verma *et al.* (2008). The residual effect estimated was 0.374 indicating that the traits under study are not sufficient to account for variability and there might be a few more pertinent characters other than those studied in the present investigation. Thus, the material studied is of diverse nature and information emanated would help in designing the selection methodology which further be used in the breeding programme. Therefore considering these traits as selection, emphasis should be given to these particular characters will be advantageous in bringing improvement in green mustard genotypes.

CONCLUSIONS

The present study was undertaken to estimate the genetic parameters, association of different yield contributing characters and their direct and indirect effects on leaf yield of green mustard genotypes. Additive gene effect was noticed for plant height, vitamin C content and yield plant^{-1} as high heritability with high genetic advance was recorded. Yield per plant exhibited strong positive association with number of leaves per plant, leaf area index and dry matter yield at genotypic and phenotypic level. Path analysis indicated that dry matter yield, vitamin C content, total chlorophyll content and leaf length exhibited positive direct effect on yield per plant. It would therefore, be rewarding to lay stress on these characters in selection program for increasing marketable yield of green mustard genotypes.

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