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Correlation Analysis of Leafy Mustard (*Brassica juncea* var. *rugosa*) Genotypes for Morphological and Neutraceutical Attributes under *Tarai* Condition of Uttarakhand, India

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ABSTRACT

The phenotype coefficient of variation recorded highest in green leaves yield per plant and green leaves yield (kg/ha). Highest value of heritability was reported for green leaf yield/plot (99.90%) followed by green leaf yield/plant (99.07%), leaf area (98.24%) and days to last leaf harvest (73.42%) while lowest value of heritability was observed in no. of leaves/ plant at 30 days (47.52%). High heritability in conjunction with high genetic advance was observed for leaf area (169.99). Highest genetic advance as % of mean was recorded in leaf area (31.37%) followed by green leaf yield/plant (26.39%), Leaf width (25.04%) and Green leaf yield/plot (23.73%).

The genotypic and phenotypic correlation study revealed that leaf yield per plant was found to be positively and significantly correlated with Leaves per plant at 30 days, Days to last leaf harvest, Phosphorus (mg/100g) and Potassium (mg/100g) while, negative significant association of leaf yield was observed with leaf width (cm) and leaf length with petiole (cm).

Keywords Correlation, Mustard, *Brassica juncea,* Micronutrient and macronutrient.

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INTRODUCTION

The genus *Brassica* is an important member of the Brassicaceae family. It comprises of several economically important species which yield edible roots, stems, leaves, buds, flowers and seed as condiment. Most of the species are used as oilseed crop and some as forage. Mustard is commonly known as Rai, Rayada, Sarson. It is also known as "bamboo mustard" and "mustard cabbage". It is cool season crop. At national level it is grown over an area of 6.45 million ha with 7.28 million tons production and 1128 kg/ha productivity (Anonymous 2015). The green leaves can be eaten raw in salad form or cooked mustard green is very nutritious and high in vitamins and minerals like A, C and iron. A breeding program may rightly be formulated on the basis of available information on the extent of genetic diversity (Chauhan *et al*. 2008, Singh *et al*. 2013). *Brassicas* represent a rich diversity, which are cultivated in 23 states and union territories of India (Mishra *et al.* 2012). However, much of this diversity is concentrated in the Indo-Gangetic plains and the sub-mountain Himalayas.

Genetic variability in the base population is basis for survival and adaptation and plays a very important role in any crop-breeding program. The extent of diversity present in the germplasm determines the limit of selection for improvement. The characters of economic importance are generally quantitative in nature and exhibit considerable degree of interaction with the environment. Thus, it becomes imperative to compute variability present in the breeding material and its partitioning into genotypic, phenotypic and environmental ones Shukla *et al.* (2006).

Correlation coefficients measure the relationship between two or more series of variables. The genotypic correlation coefficient provides a measure of genotypic association between different characters, while phenotypic correlation includes both genotypic as well as environmental influences.

Therefore, considering the above facts, present investigation on "Correlation analysis of leafy mustard (*Brassica juncea* var. *rugosa*) genotypes for morphological and neutraceutical attributes under *Tarai* condition of Uttarakhand" was undertaken. The objective of this study was to evaluate the relationships among leaf yield attributing and nutrient content characters.

Evaluation is the most critical step determining the utilization of a collection, and a poorly assessed germplasm collection is unlikely to be of any use to anyone. However, evaluation of germplasm is very difficult and time consuming so that the actual diversity present in many germplasm collections is yet to be assessed. Further, this type of study remains worthwhile since they also provide the means of finding out the component traits of economic product and provide vital help to the breeder in various breeding programs.

MATERIALS AND METHODS

The current experiment was carried out at Vegetable Research Center (VRC), GB Pant University of Agriculture and Technology, Pantnagar, US Nagar (Uttarakhand) in *rabi* season of 2018–2019. The experimental material consisted of 31 leafy mustard genotypes out of which 30 were obtained from the Pantnagar Center for Plant Genetic Resources of GBPUA and T and 1 prominent check, PUSA SAG-1 was received from IARI. The experiment consisting of 31 germplasm were grown at the research area of Vegetable Research Center in Randomized Block Design with three replications. The entries were sown with spacing of 30 cm between rows and 15 cm between the plants. Observations were recorded on five randomly selected plants in each genotype and replication for different seventeen characters. The study on variability, heritability, genetic advance and genetic advance as percentage of mean was carried out in 31 leafy mustard genotypes.The genotypic and phenotypic correlation coefficients were estimated. Further protein and nitrogen content by Kjeldahl method, macronutrient (P and K) by spectrophotometer and flame photometer, micronutrient (Fe, Zn and Mn) by atomic absorption spectrophotometer.

The data will be statistically analyzed by using Randomized Block Design (RBD) and the significance of difference among treatment means will tested by F-test. The data recorded during the course of experiment were subjected to analysis through computer by using Windostat version 9.2 from indostat services, Hyderabad Licensed to Plant Breeding Division Sugarcane Breeding Institute, Coimbatore.

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance manifest high significant difference between all the genotypes for all traits under study which distinctly indicate that adequate variability for each trait between the genotypes which were included in the experiment (Table 1). Naula *et al.* (2018) also reported significant difference among different genotypes of methi for Nutrient content namely P, K, Fe, Mn, Zn and Cu, protein and Saponin.

Table 1. Analysis of Variance with respect to various characters studied in leafy mustard.

Source	df	NLPP 30DAS	NLPP 45DAS	leaf area (cm²)	leaf length (cm)	leaf width (cm)	LPL (leaf) (cm)	DFLH	DLLH
Replication	2	1.83	0.39	183.9	21.31	6.32	38.61	2.68	10.29
Treatment	30	16.63**	1.54**	20,919.52**	66.21**	16.63**	58.79**	16.89**	34.60**
Error	60	2.64	0.19	124.28	11.47	2.64	12.18	2.25	3.73

Table 1. Continued.

Source	GLY/ Plant (g)	GLY (kg/ha)	Protein (%)	N (%)	P (mg/100g)	K (mg/100g)	Fe (mg/100g)	Zn (mg/100g)	Mn (mg/100g)
Replication	43.95	0.076	4.49	0.11	13466.41	85160.01	0.03	0.06	0.037
Treatment	3,565.63**	4,740.31**	42.62**	1.61**	35,103.66**	205,733.42**	70.14**	1.2**	0.72**
Error	11.07	1.46	1.22	0.03	14,566.91	33,573.83	1.64	0.08	0.04

NLPP =Number of leaves per plant at 30 DAS, DFLH = Days to first leaf harvest, DLLH= Days to last leaf harvest ,GLY= Green leaf yield, LPL=Leaf petiole length with leaf (cm).

Mean performance of different genotypes for different quantitative characters and Nutrient characters are shown in Fig. 1-2, respectively.

Coefficient of variation

For the development of the better varieties by selection and breeding program the amount of phenotypic and genotypic variability should be present in the species. Variability is the lockstitch of the total hereditary effects from the alarmed gene as well as from the environment (Tewodros and Getachew 2013). So, variability is classified into heritable and non-heritable components with appropriate genetic parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) and environment coefficient of variation (ECV). These genetic parameters help to breeder to select the suitable genotype for genetic improvement of crops. Parameters like ECV, PCV, GCV, genetic advance, heritability are use to estimate the value for these variability (Table 2).

For all the characters phenotypic coefficient of variation (PCV) was found superior over genotypic coefficient of variation (GCV). The characters which are generally use for PCV are number of leaves per plant at 30 days, number of leaves per plant at 45 days, leaf area (cm²), Leaf length (cm), Leaf width (cm), Leaf length with petiole (cm), Days to 1st leaf harvest, Days to last leaf harvest, Green leaf yield per ha (kg/

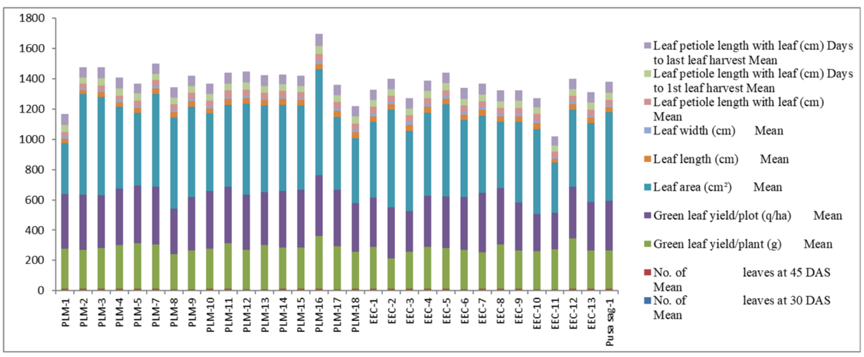

Fig. 1. Mean performance of different genotypes for different quantitative characters.

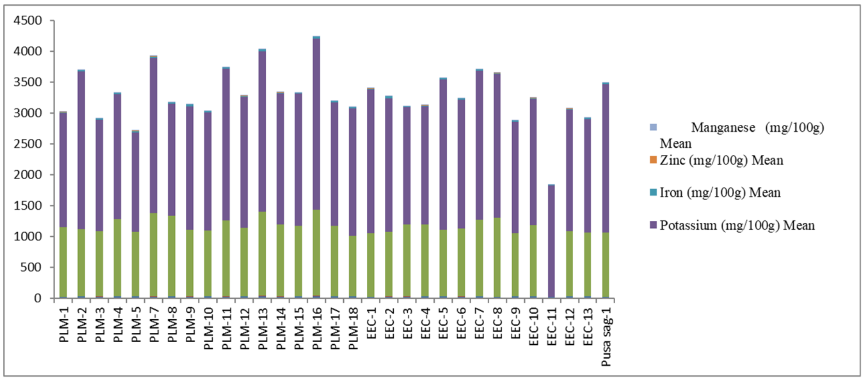

Fig. 2. Nutrient content present in different genotypes of leafy mustard.

ha) and Green leaf yield per plant (g) were generally higher in comparison to GCV.

PCV for this study were little higher but close to the commensurate with GCV value for all the characters which is ranged between 5.40% - 19.05 %. The highest PCV value was observed in leaf width (19.05%) followed by number of leaves per plant at 30 days (17.12%), leaf area (15.50%) and leaf length (15.23%) which comes under moderate category. The lowest PCV value was observed in days to last leaf harvest (5.41%) followed by days to first leaf harvest (5.92%), green leaf yield/plot (11.52%), number of leaves per plant at 45 days (11.88%) and green leaf yield/plant (11.93%). Shukla *et al.* (2006) estimated low PCV in vegetable amaranth while Mekonnen (2014) reported high PCV in Ethiopian mustard. Singh and Bhandari (2021) also recorded PCV ranged between 3.14-25.06 % in leafy mustard.

In this experiment the genotypic coefficient of variation (GCV) values were recorded highest in leaf area (15.37%) followed by Leaf width (15.22%), Green leaf yield/plant (12.87%), Leaf length (12.16%) and no. of leaves/plant at 30 days (11.80%), which is very closer to the moderate category ranged between >19.9% - 30.00%. This indicates the enough scope for the improvement of these traits by selection because reaction to the selection is directly proportional to the variability component. Azevedo *et al.* (2017) observed high GCV in kale plant for green leaves yield and number of leaves. Shukla *et al.* (2006) observed low GCV in amaranth for number of leaves per plant while observed high GCV for leaf area and green leaf yield in amaranth. Sarkar *et al.* (2014) also reported high GCV in amaranth for leaf area.

The GCV value were low for all character but PCV value ranged between low to high that means low PCV character are mostly affected by environment and not stable but those showing moderate values are less affected by environment. Therefore, it is so easy for selection to improve the characters. Medium value for PCV and GCV indicated large amount of variability which was recorded for number of leaves per plant at 30 days, leaf area, leaf width and green leaf yield/plant. Azevedo *et al.* (2017) reported similar result in kale for variability. The difference between GCV and PCV was highest for number of leaves per plant at 30 days after sowing but for the rest characters it is less. The minor difference between GCV and PCV showed that little environment effect cause the variability between the genotypes which was predominantly due to genotypic distance. This type of result was also observed by Bhargava *et al.* (2003), Revanappa and Madalageri (1998) and Shukla *et al.* (2006).

Heritability, genetic advance and genetic advance as percent of mean

Heritability is an extent of genetic relationship between progeny and parents. Heritability is widely used to judge the degree of transmutability of a character from parents to offspring. It also indicates the importance of environment and heredity in the

Table 2. Coefficient of variation and other genetic parameters of leafy mustard.

Sl. No.	Characters	Mean	Range	Genotypic coefficient of variation (%)	Phenotypic coefficient of variation (%)	Heritability (%)	Genetic advance	Genetic advance as per cent of mean (%)
1	Number of leaves/plant at 30 days	4.44	3.27-6.17	11.80	17.12	47.52	0.74	16.75
2	Number of leaves/plant at 45 days	6.74	5.27-7.73	9.92	11.88	69.69	1.15	17.06
3	Leaf area (cm^2)	541.74	331-750	15.37	15.51	98.24	169.99	31.38
4	Leaf length (cm)	35.12	23.47-40.63	12.16	15.52	61.39	6.89	19.63
5	Leaf width (cm)	14.19	10-21	15.22	19.05	63.80	3.55	25.04
6	Leaf length with petiole (cm)	40.11	29.68-50.00	9.83	13.12`	56.06	6.08	15.16
7	Days to first leaf harvest	45.12	40.06-50.36	4.89	5.92	68.40	3.76	8.34
8	Days to last leaf harvest	69.23	61.20-80.44	4.63	5.41	73.4	5.66	8.18
9	Green leaf yield/plot (q/ha)	344.91	200-350	11.52	11.52	99.90	81.83	23.73
10	Green leaf yield/plant (g)	267.44	240-400	12.87	12.93	99.07	70.58	26.39

*Significant at p=0.05 (0.3125), **Significant at p=0.01(0.4032).

character expression. It helps the breeder to judge the range to which improvement is possible through selection (Robinson *et al.* 1949). In detailed, it is the ratio in percentage between genotypic variance to phenotypic variance. Generally it may be varies amid population and also for the same genotype from one environment to other environment. The values of heritability are helpful in estimation of the expected progress to be cognizable through the process of selection (Wright 1921).

Dabholkar (1992) classified heritability in detailed as high (30-60%), medium (10-30%) and low (5-10%). According to this classification, all character had got high heritability values in our study. Highest value of heritability estimated for Green leaf yield/plot (99.90%) followed by Green leaf yield/plant (99.07%), Leaf area (98.24%) and Days to last leaf harvest (73.42%) while lowest value of heritability was observed in number of leaves per plant at 30 days (47.52%) followed by Leaf length with petiole (56.06%), Leaf length (61.39%) and Leaf width (63.80%) and for other traits heritability ranges between 47.52-99.90% (Table 2). Azevedo *et al*. (2017) reported highest heritability for number of leaves and leaves yield in kale. High heritability for number of leaves was also obtained by Sarkar *et al.* (2014), Revanappa and Madalageri (1998) and Shukla *et al.* (2006). Mekonnen (2014) also reported high heritability in Ethiopian mustard for green leaves yield.

After study it suggested that for all characters high value of heritability traits are under control of genotypic. However, it will be admit here that genotypic variance is made up by unfixable variance, additive genetic variance and non-additive variance. Generally high heritability is not alone enough alone for sufficient improvement by selection unless including with sufficient amount of genetic advance (Bhargava *et al.* 2003). When heritability is used to calculate genetic advance hence utility of heritability is increased (Shukla *et al.* 2004). In selection based phenotypic appearance there is no practical importance of heritability value without genetic advance. Therefore in sequential selection of breeding program genetic advance should be considered along with heritability (Johnson *et al.* 1955).

Highest genetic advance was obtained in leaf area (169.99) followed by green leaf yield/plot (81.83) and green leaf yield/plant (70.58) indicating that these traits are more reliable for effective selection for advancement in leafy mustard crop due to additive gene effect. Genetic advance as % of mean measure required genetic progress which would result after selecting the best operating genotype evaluated for a character (Allard 1999). Genetic advance as % of mean ranged from 8.18-31.37% (Table 2). Highest genetic advance as % of mean was recorded in leaf area (31.37%) followed by green leaf yield/plant (26.39 (2%)). Low to moderate genetic advance was recorded in days to last leaf harvest (8.18%) followed by days to first leaf harvest (8.34%), leaf length with petiole (15.16%) and number of leaves per plant at 30 days (16.75%). Sarkar *et al*. (2014) recorded high genetic advance as % of mean for green leaves yield, number of leaves and leaf area. Shukla *et al*. (2006) recorded high genetic advance as % of mean for green leaves yield and leaf area. Singh and Bhandari (2021) also reported high genetic advance as % of mean for leaf width and green leaves yield/plant.

Characters such as green leaves yield (kg/ha), green leaves yield/plant and leaf petiole length showed moderate heritability which is coupled with genetic advance as percent of mean. This indicated that these characters will respond to selection more than those which have low genetic advance and high heritability. The moderate heritability with moderate genetic advance as percent of mean was ejective for leaf length, leaf length with petiole and no. of leaves at 30 DAS. These traits can equally improved by selection because these traits are govern by additive gene action while Days to first leaf harvest, Days to last leaf harvest and leaf length with petiole showed moderate heritability with low genetic advance as % of mean or moderate genetic advance as % of mean with low heritability which display that these characters are governed with non-additive gene action and for these traits selection would not effectively respond. Shukla and Singh (2000) and Shukla *et al*. (2006) obtained high genetic advance as % of mean with high heritability of mean for green leaves yield, number of leaves and leaf area. Sarkar *et al.* (2014) also found high genetic advance as % of mean with high heritability of mean for number of leaves.

Correlation coefficient analysis

To determinate the degree of relationship of parameters with yield correlation coefficient were calculated. Phenotypic and genotypic correlation coefficient data between traits were obtained from all the 17

Table 3. Genotypic correlation coefficient for various characters in leafy mustard genotypes.

Characters	Leaves per plant at 30 days	Leaves per plant at 45 days	Leaf area (cm²)	Leaf length (cm)	Leaf width (cm)	Leaf length with petiole (cm)	Days to 1st leaf harvest	Days to last leaf harvest
Leaves per plant at 30 days	1.00	0.38**	0.34**	0.39**	0.41**	0.28**	0.14	0.62**
Leaves per plant at 45 days		1.00	0.26*	0.26*	0.43**	0.19	0.47**	0.60**
Leaf area (cm²)			1.00	0.30**	0.26*	0.12	0.12	0.38**
Leaf length (cm)				1.00	0.57**	0.87**	0.13	0.29**
Leaf width (cm)					1.00	0.47**	0.42**	0.52**
Leaf length with petiole (cm)						1.00	-0.02	0.19
Days to first leaf harvest							1.00	0.70**
Days to last leaf harvest								100
Protein (%)								
Nitrogen (%)								
Phosphorus (mg/100g)								
Potassium (mg/100g)								
Iron (mg/100g)								
Zinc (mg/100g)								
Manganese (mg/100g)								
Green leaves yield (q/ha)								
Green leaves yield/plant (g)								

Table 3. Continued.

Characters	Protein (%)	Nitrogen (%)	Phosphorus (mg/100g)	Potassium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)	Manganese (mg/100g)	Green leaves yield (kg/ha)	Green leaves yield/plant (g)
Leaves per plant at 30 days	0.29**	-0.03	0.35**	0.34**	0.09	0.07	0.08	0.62**	0.56**
Leaves per plant at 45 days	0.03	0.30**	0.14	0.04	0.08	-0.02	0.12	0.29**	0.39**
Leaf area (cm²)	0.41**	0.39**	0.36**	0.43**	0.48**	0.15	0.37**	0.26*	0.25*
Leaf length (cm)	0.14	0.35**	0.33**	0.14	0.24*	0.16	0.17	0.07	0.33**
Leaf width (cm)	0.16	0.46**	0.13	0.08	0.14	-0.16	0.18	-0.03	0.23*
Leaf length with petiole (cm)	0.03	0.19	0.21*	0.03	0.04	-0.09	-0.00	-0.17	0.16
Days to first leaf harvest	0.28**	0.41**	0.06	-0.05	0.27*	0.22*	0.37**	0.32**	0.48**
Days to last leaf harvest	0.29**	0.31**	0.24*	0.37**	0.07	0.25*	0.34**	0.52**	0.56**
Protein (%)	1.00	0.20*	0.23*	0.13	0.31**	0.25*	0.07	0.25*	0.31**
Nitrogen (%)		1.00	0.21*	0.07	0.45**	0.23*	0.55**	0.04	0.34**
Phosphorus (mg/100g)			1.00	0.62**	0.28**	0.21*	0.51**	0.45**	0.53**
Potassium (mg/100g)				1.00	0.34**	0.48**	0.13	0.38**	0.25*
Iron (mg/100g)					1.00	0.17	0.51**	0.16	0.13
Zinc (mg/100g)						1.00	0.17	0.30**	0.34**
Manganese (mg/100g)							1.00	0.33**	0.23*
Green leaves yield (q/ha)								1.00	0.61**
Green leaves yield/plant (g)									100

*Significant at p=0.05 (0.3125), **Significant at p = 0.01 (0.4032).

Table 4. Phenotypic correlation coefficient for various characters in leafy mustard genotypes. * Significant at p = 0.05 (0.3125), ** Significant at p = 0.01 (0.4032).

Characters	Leaves per plant at 30 days	Leaves per plant at 45 days	Leaf area (cm²)	Leaf length (cm)	Leaf width (cm)	Leaf length with petiole (cm)	Days to 1st leaf harvest	Days to last leaf harvest
Leaves per plant at 30 days	1.00	0.24*	0.24*	0.24*	0.24*	0.18	0.18	0.26*
Leaves per plant at 45 days		1.00	0.21*	0.21*	0.33**	0.15	0.36**	0.46**
Leaf area (cm²)			1.00	0.22*	0.20	0.08	0.08	0.33**
Leaf length (cm)				1.00	0.55**	0.89**	0.15	0.14
Leaf width (cm)					1.00	0.47**	0.28**	0.32**
Leaf length with petiole (cm)						1.00	0.05	0.07
Days to first leaf harvest							100	0.41**
Days to last leaf harvest								100
Protein (%)								
Nitrogen (%)								
Phosphorus (mg/100g)								
Potassium (mg/100g)								
Iron (mg/100g)								
Zinc (mg/100g)								
Manganese (mg/100g)								
Green leaves yield (q/ha)								
Green leaves yield/plant (g)								

Table 4. Continued.

Characters	Protein (%)	Nitrogen (%)	Phosphorus (mg/100g)	Potassium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)	Manganese (mg/100g)	Green leaves yield (kg/ha)	Green leaves yield/plant (g)
Leaves per plant at 30 days	0.19	0.04	0.01	0.15	0.08	0.02	0.05	0.43**	0.38**
Leaves per plant at 45 days	0.01	0.29**	0.09	0.05	0.06	-0.04	0.09	0.25*	0.32**
Leaf area (cm²)	0.39**	0.38**	0.21*	0.30**	0.45**	0.14	0.34**	0.26*	0.25*
Leaf length (cm)	0.10	0.26*	0.09	0.13	0.14	0.08	0.19	0.05	0.26*
Leaf width (cm)	0.12	0.37**	0.05	0.12	0.09	-0.11	0.15	-0.03	0.18
Leaf length with petiole (cm)	0.01	0.14	0.07	0.04	-0.03	-0.10	-0.01[N]	-0.12	0.12
Days to first leaf harvest	0.24*	0.34**	-0.04	0.00	0.22*	0.16	0.30**	0.27**	0.39**
Days to last leaf harvest	0.20	0.26*	0.24*	0.24*	0.06	0.23*	0.27**	0.44**	0.49**
Protein (%)	1.00	0.20	0.13	0.07	0.28**	0.25*	0.09	0.24*	0.29**
Nitrogen (%)		1.00	0.13	0.07	0.43**	0.21*	0.51**	0.04	0.33**
Phosphorus (mg/100g)			1.00	0.29**	0.11	0.14	0.27**	0.26*	0.31**
Potassium (mg/100g)				1.00	0.28**	0.37**	0.09	0.30**	0.19
Iron (mg/100g)					1.00	0.17	0.46**	0.16	0.13
Zinc (mg/100g)						1.00	0.20	0.27**	0.31**
Manganese (mg/100g)							1.00	0.31**	0.21*
Green leaves yield (q/ha)								1.00	0.61**
Green leaves yield/plant (g)									100

characters among all the 31 genotypes (Tables 3 - 4).

Genotypic correlation coefficient

The estimate of genotypic correlation coefficient for different character is given in Table 3.Number of leaves per plant at 30 DAS viewed positive correlation and highly significant with leaves per plant at 45 DAS, leaf area, leaf length, leaf width, days to last green leaves harvest, leaf length with petiole, protein content, P and K content, green leaves yield per plant (g) and green leaves yield (kg/ha). Non-significant and negative correlation associated with nitrogen content. Leaf area showed positive and highly significant correlation with all the characters except days to first green leaves harvest, Number of leaves/plant at 30 days, Number of leaves/plant at 45 days.

Leaf length showed positive correlation and highly significant associated with leaf width, leaf length with petiole, days to last green leaves harvest, N, P, Fe and green leaves yield per plant (g). While positive correlation and non-significant associated with days to first green leaves harvest, green leaves yield (kg/ha), protein content, K, Zn and Mn content.

Leaf width showed positive correlation and highly significant associated with leaf length with petiole, days to first green leaves harvest, days to last green leaves harvest, green leaves yield per plant (g), N and Zn content. While non-significant and negative correlation associated with protein content, zinc content and green leaves yield (kg/ha).

Leaf length with petiole showed positive correlation and highly significant associated with P and green leaves yield per plant (g). While positive correlation and non-significant associated with days to last green leaves harvest, protein content, N, K and Fe content.

Days to first green leaves harvest showed positive correlation and highly significant associated with most of the traits except P content. Non-significant and negative correlation associated with potassium content.

Days to last green leaves harvest showed positive correlation and highly significant associated with green leaves yield per plant (g), green leaves yield (kg/ha), protein content, N, P, K, Mn, and Zn. While positive correlation and non-significant associated with Fe.

Protein content showed positive correlation and highly significant associated with N, P, Fe, Zn content, green leaves yield (kg/ha) and green leaves yield per plant (g). While positive correlation and non-significant associated with K and Mn. Nitrogen content showed positive correlation and highly significant associated with P, Fe, Zn and green leaves yield per plant (g). While positive correlation and non-significant associated with green leaves yield (kg/ha), K and Mn content. Phosphorus content showed positive correlation and highly significant associated with K, Fe, Zn content, green leaves yield (kg/ha) and green leaves yield per plant (g).

Potassium content showed positive correlation and highly significant associated with Fe, Zn, green leaves yield (kg/ha) and green leaves yield per plant (g). While positive correlation and non-significant associated with Mn content. Iron content showed positive correlation and highly significant associated with Mn content while positive correlation and non-significant associated with green leaves yield per plant (g), green leaves yield (kg/ha) and Zn content. Zinc content showed positive correlation and highly significant associated with green leaves yield per plant (g) and green leaves yield (kg/ha) while positive correlation and non-significant associated with Mn content. Manganese content showed positive correlation and highly significant associated with green leaves yield (kg/ha) and green leaves yield per plant (g).

Sarkar *et al.* (2014) found in his experiment that leaf area, fiber content and diameter of base of stem had positive and highly significant genotypic correlation along with foliage yield.

The genotypic correlation coefficient was slightly higher but very closer to the commensurate phenotypic correlation coefficient value for all characters which indicates additive gene action for these characters. Shukla *et al.* (2010) also reported high magnitude of genotypic correlation coefficient than respective phenotypic correlation coefficient between different traits in amaranth. He also noticed similar significant positive federation in vegetable amaranth for green leaf yield with diameter of base of stem, fiber content and plant height.

Phenotypic correlation coefficient

The estimate of phenotypic correlation coefficient for different character is given in Table 4.Number of leaves per plant at 30 DAS viewed positive and highly significant correlation with leaves per plant at 45 DAS, leaf area, leaf length, leaf width, protein content, N, K, Fe, Mn content and green leaves yield per plant.

Number of leaves per plant at 45 DAS viewed positive and highly significant correlation with days to first green leaves harvest, leaf area, green leaves yield per plant, protein content, N, K, Mn content and green leaves yield per plant. Leaf area showed positive and highly significant correlation with days to first green leaves harvest, days to last green leaves harvest, leaf area, leaf width, leaf length with petiole, green leaves yield, protein content and green leaves yield per plant. Leaf length positively and highly significantly associated with leaf length with petiole, days to first green leaves harvest, days to last green leaves harvest, K and Zn and Mn content. While positively and non-significant associated with leaf width, protein content, N, P, Fe and green leaves yield per plant.

Leaf width showed positive and highly significant correlation with leaf length with petiole, protein content, N, Fe, Zn and Mn content. Leaf length with petiole showed positive correlation and highly significant associated with days to first green leaves harvest, days to last green leaves harvest, protein content, Zn and green leaves yield per plant.

Days to first green leaves harvest showed positive correlation and highly significantly associated with days to last green leaves harvest, protein content, N, Zn and Mn. While it showed non-significant and negative association with phosphorus content.

Days to last green leaves harvest showed positive correlation and highly significant association with protein content, N and Zn. Green leaves yield/plant (kg/ha) showed significantly and positively correlated with number of leaves per plant at 30 DAS, number of leaves per plant at 45 DAS, days to first leaves harvest, days to last leaves harvest, p and zn content. Similar findings were reported by Bhandari (2017).

Protein content showed positive and highly significant correlation with N and Zn. Nitrogen content showed positive and non-significant correlation with P, Fe, Zn, Mn content and green leaves yield per plant.

Phosphorus and potassium content showed positive and highly significant correlation with Zn content. While positive correlation and non-significant association with Fe, K and green leaves yield per plant..

Iron content showed positive and highly significant correlation with Zn and Mn. Iron Content had positive correlation and non-significant association with green leaves yield per plant. Zinc content showed positive correlation and significantly associated with Mn and green leaves yield per plant.

Sarkar *et al.* (2014) observed foliage yield had positive and significant correlation with leaf area, fiber content, diameter of stem base, leaves per plant and plant height and also observed considerable positive correlation with ascorbic acid and manganese.

CONCLUSION

On the basis of findings of the study, it was concluded that there was a huge difference between the germplasm for all the traits. This study of variability for different traits showed that there is a considerable scope present for the improvement of the leafy mustard cultivars.

Out of the 31 germplasm PLM-16 has the largest green leaf yield per plant followed by EEC-12, PLM-11, PLM-5 and EEC-8. After the proper testing in multi location trials, these germplasm can be recommended for large scale cultivation and superior germplasm can be used in breeding program to increase the yield of leafy mustard. All genotypes were rich in macronutrient (N, P, and K), micronutrient (Fe, Zn and Mn) and protein content. Therefore, these genotypes considered as long lived effectors which will encourage the overall health status on consumption to meet out the daily need of nutrition.

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