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Principal Component Analysis for Quality Traits in Indigenous Moringa (*Moringa oleifera* L.) Germplasm Lines

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Authors' contributions

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

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ABSTRACT

The present investigation was carried out at Department of Vegetable Crops, Horticultural College and Research Institute (HC&RI), Tamil Nadu Agricultural University, Periyakulam during 2016 - 2017 with twenty genotypes in order to study the genetic diversity for different Quality characters of Moringa by principal component analysis. In this study, out of five principal components (PC), only three components exhibited eigenvalues greater than 0.5 and accounted for 84.12% variability. The

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PC1 accounted for the highest variability (52.53% of) the total variability, followed by PC2 (17.66%) then PC3 with 13.93%. Thus the results of the principal component analysis revealed, wide genetic variability exists in this Moringa genotype accessions.

Keywords: Moringa (Moringa oleifera L.); genotypes; PCA analysis; eigen values.

1. INTRODUCTION

"Moringa (*Moringa oleifera* L.) is a highly useful vegetable crop and native of India. *Moringa oleifera* is a valuable food that has drawn attention as it is the 'natural nutrition' of the tropical countries in the world. Both the businesses as well as scientific communities have shown interest in this crop owing to its economic and nutritional potential. The fruit, leaves, flowers and immature pods of this tree are highly nutritious and used as vegetable in many parts of the world, especially in Africa, India, Pakistan, Philippines, and Hawaii" [1]. "Moringa leaves possess rich source of protein, β-carotene, vitamin C, potassium and calcium, besides high concentrations of varied natural antioxidants. Various types of antioxidants such as ascorbic acid, flavonoids, phenolics and carotenoids present in moringa leaves offer several medicinal benefits to the human beings" as mentioned by Dillard and German, [2]; Siddhuraju and Becker, [3]. In Philippines, it is used to increase woman's milk production and is sometimes prescribed for treating anaemia. Therefore, moringa is called as 'mothers' best friend' [3]. "Moringa oleifera, native of the western and subHimalayan tracts, India, Pakistan, Asia Minor, Africa and Arabia" [4,5] is now distributed in the Philippines, Cambodia, Central America, North and South America and the Caribbean Islands [6]. In some parts of the world *M. oleifera* is referred to as the 'drumstick tree' or the 'horse radish tree', whereas in some coutries it is known as the kelor tree [1], while in the Nile valley, the name of the tree is 'Shagara al Rauwaq', which means 'tree for purifying' [7]. In Pakistan, *M. oleifera* is locally known as 'Sohanjna' and is grown and cultivated all over the country [8,9]. "PCA involves a mathematical procedure that transforms a number of (possibly) correlated variables into a number of uncorrelated variables called principal component" [10]. "PCA is an important statistical method through which we can easily identify important polygenic characters which are of great importance in a plant breeding programme. PCA provides an idea for how to reduce a complex data set to a lower dimension to reveal the sometimes hidden, simplified structures that often underlie it" [11]. "Principal component analysis (PCA) is an important multivariate method in modern data analysis because it is a simple, non-parametric method for extracting relevant information from confusing data sets and it was applied for assessment of genetic diversity within moringa genotypes. The eigenvalue of a particular principal component depicts the amount of variation present in traits and explained by that principal component which is very useful for the further breeding programme" [11].

2. MATERIALS AND METHODS

The present investigation was carried out to know the variability through principal component analysis in Moringa (*Moringa oleifera* L.) Germplasms cultivated in Telangana State at Department of Vegetable Crops, Horticultural College and Research Institute (HC&RI), Tamil Nadu Agricultural University, Periyakulam (PKM) during 2016 -2017.Twenty moringa accessions were collected from different regions of Telangana and the details of the plant materials used in the present study are listed in Table 1.

2.1 Quality Traits Estimation

2.1.1 Chlorophyll content

One gram of fresh leaf sample was collected and macerated with 10 ml of 80 per cent acetone and centrifuged at 3000 rpm for 10 minutes. After centrifugation, supernatant was collected and made up into 25 ml by using 80 per cent acetone. The color intensity was observed as OD values at 645 nm, 652 nm and 663 nm using a Spectrophotometer. The contents of chlorophyll 'a', chlorophyll 'b' and total chlorophyll were estimated and expressed as mg g^{-1} [12].

2.1.2 Leaf soluble protein

The soluble protein content was estimated at 660 nm using Foline Ciocalteau reagent by following the procedure described by Lowry et al. [13] and expressed in mg g^{-1} of fresh weight of leaves. The soluble protein was extracted from the leaf samples with phosphate buffer. One ml of the

extract was reacted with 5 ml of alkali copper reagent for 30 min, followed by the addition of 0.5 ml of phenol reagent and the colour intensity was measured at 660 nm. From the standard graph, the amount of soluble protein present in leaf sample was calculated and expressed as mg albumin equivalent to soluble g^{-1} on fresh weight basis. Crude protein was estimated through Kjeldahl method by A.O.A.C [14]. Ascorbic acid was estimated according to the procedure given by A.O.A.C. [14].

Twenty moringa genotypes were evaluated by using International Plant Genetic Recourses Institute (IPGRI) minimal descriptors. The recommended agronomic practices were followed. Observations were recorded for five biochemical characters. Data were recorded on five different traits *viz*. chlorophyll a (mg g^{-1}), chlorophyll b (mg g^{-1}), leaf soluble protein (mg/100 g), crude protein (%), and ascorbic acid (mg/g) using leaf material. The PCA analysis

Table 1. List of moringa accessions employed in the study

S.No.	Name of Accession	Description of Accession	Place of collection & District	Latitude & Longitude
1.	MO 1	Long poded perennial type	Warangal, Warangal	18^0 0' 38.60N, 79^0 36'0 .10 E
2.	MO 2	Long poded perennial type	Malyal, Warangal	18^0 21' 48.80 N, 80^0 18' 23.66 E
3.	MO 3	Medium poded perennial type	Ghanpur, Warangal	17^0 49' 58.89 N, 78^0 59' 57.35 E
4.	MO 4	Short poded perennial type	Regonda, Warangal	18^0 23' 77.70 N, 79^0 77' 50.80 E
5.	MO 5	Long podedperennial type	Jagithyala, Karimnagar	18^0 46'0.66 N, 78^0 54'42 .83 E
6.	MO 6	Short poded perennial type	Peddapally, Karimnagar	18^0 37' 24.72 N, 79^0 22' 47.59 E
7.	MO 7	Short poded perennial type	Armor, Nizamabad	18^0 48' 37.14 N, 78^0 17' 7.00 E
8.	MO 8	Short poded perennial type	Nandipeta, Nizamabad	18^0 52' 34.06 N, 78^0 31' 14.68 E
9.	MO 9	MediumPoded perennial type	Rudrur, Nizamabad	18^0 34' 45.48 N, 77^0 52' 31.27 E
10.	MO 10	Short poded perennial type	Satyanarayanapuram,Nizamabad	18^0 32' 40.61 N, 77^0 53' 31.39 E
11.	MO 11	Medium poded perennial type	Basara, Nirmal	18^0 52' 40.63 N, 77^0 56' 57.01 E
12.	MO 12	Short poded perennial type	Mudhol, Nirmal	18^0 98' 26.81 N, 77^0 92' 05.10 E
13.	MO 13	Short poded perennial type	Ichoda, Adilabad	19^0 26' 1.02 N, 78^0 27' 14.82 E
14.	MO 14	Short poded perennial type	Adilabad, Adilabad	19^0 38' 53.14 N, 78^0 31' 14.68 E
15.	MO 15	Medium poded perennial type	Amaravathi,Manchiriyal	18^0 54' 15.05 N, 79^0 28' 58.30 E
16.	MO 16	Short poded perennial type	Doragaripalli, Manchiriyal	18^0 53' 59.5 N, 79^0 27' 41.2 E
17.	MO 17	Medium poded perennial type	Kyathanpalli, Manchiriyal	18^0 55'18.8 N, 79^0 28' 13.4 E
18.	MO 18	Short poded perennial type	Suryapeta, Nalgonda	17^0 14' 8.70 N, 79^0 36' 34.07 E
19.	MO 19	Medium poded perennial type	Gollapally, Nalgonda	17^0 31' 23.59 N, $80^0$52' 19.91 E
20.	MO 20	Short poded perennial type	Narayanapuram,Nalgonda	17^0 10' 36.74 N, 80^0 52' 19.91 E

reduces the dimensions of a multivariate data to a few principal axes, generates an eigenvector for each axis and produces component scores for the characters [15,16-25].

3. RESULTS AND DISCUSSION

Twenty accessions of moringa collected from various parts of Telangana were evaluated for different morphological and biochemical traits. Observations on biochemical characters *viz.,* chlorophyll a (mg g^{-1}), chlorophyll b (mg g^{-1}), leaf soluble protein (mg/100 g), crude protein (%), and ascorbic acid (mg/g). The accessions exhibited wide variability for morphological characters revealed that most of the accessions possessed phenotypic variations among them. The results of PCA explained the genetic variation among the genotypes for quality characters under study. Data were considered in each component with Eigen values more than 0.5.which determines as a minimum 10% of the variation. Superior Eigen values are considered as best attributes in principal components. In our study, three components exhibited Eigen values of greater than 0.5 and showed cumulative variation of 84.12%. It indicates that the identified characters within these components exhibited immense influence on the phenotype of the genotypes. Table 2 presents principal components, Eigen values and percentage contribution of each component to the total variation in the rice germplasm. The three components *viz.* PC1, PC2, andPC3 showed 52.53%, 17.66% and 13.93% of variations among the characters respectively. Only well loaded characters in each component values within 10% of the highest factor loading were retained for further explanation. Results revealed by rotated component matrix showed that the PC1 which accounted for the maximum variability (52.53%) and highly loaded with characters such as chlorophyll a content (0.478), ascorbic acid (0.455), chlorophyll b (0.448), leaf soluble protein (0.444) and crude protein (0.406), it clearly indicated that the variation in PC1 is mainly contributed by quality characters. PC2 accounted 17.66% of the total variation and loaded with the traits *viz.* crude protein (0.612), chlorophyll b (0.492), contributed in positive direction. Whereas chlorophyll a (-0.442), ascorbic acid (-0.397) and leaf soluble protein (-0.173) contributed in negative direction. PC3 had the contribution from the characters like ascorbic acid (0.538), crude protein (0.445), which accounted for 13.93% of the total variation. It

Table 2. Eigen values, per cent variance and cumulative variance values of moringa germplasm

	PC1	PC2	PC3	PC4	PC5
Eigen value	2.62	0.88	0.69	0.47	0.31
Total Variance	52.53	17.66	13.93	9.53	6.35
Cumulative Variance (%	52.53	70.19	84.12	93.65	100.00
Trait	**Eigenvectors**				
Chlorophyll a(mg g-1)	0.478	-0.442	0.0094	-0.517	-0.554
Chlorophyll b(mg g-1)	0.448	0.492	-0.333	-0.493	0.449
Leaf soluble protein (mg/100g)	0.444	-0.173	-0.632	0.607	-0.0561
Crude protein (%)	0.406	0.612	0.445	0.303	-0.412
Ascorbic acid (mg/g)	0.455	-0.397	0.538	0.166	0.563

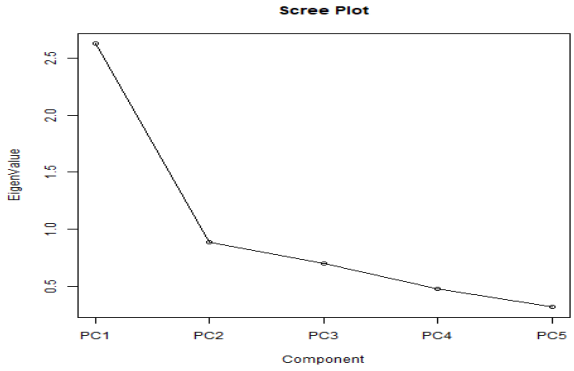

Fig. 1. Scree plot

clearly showed that the variation in this component is contributed by the quality characters. Quality characters like leaf soluble protein (0.607) and crude protein (0.303) had contributed 9.53% of the total variation in PC 4. PC5 is accounted for 6.35% of total variation and it was loaded by the traits such as ascorbic acid (0.563), chlorophyll b (0.449).

Scree plot showed in the Fig.1 explained the percentage of variation associated with each principal component obtained by drawing a graph between Eigen values and principal component numbers. PC1 showed 52.53% variability with the Eigen value of 2.62. The Eigen values are gradually declined from PC1 to PC5. The Eigen values are 0.88, 0.69, 0.47, and 0.31 for PC2, PC3, PC4, and PC5 respectively. Elbow type line is obtained after PC3 tended to straight with minute difference observed in each PC and it is clearly showed that the utmost variation was observed in PC1.

4. CONCLUSION

The phenotypic value of each trait measures the importance and contribution of each component to the total variance. The component contributed the maximum for phenological traits, Chlorophyll a, Chlorophyll b, Leaf soluble protein, Crude protein, Ascorbic acid are the chief contributors towards genetic divergence in moringa genotypes. Thus, the prominent characters coming together in different principal components and contributing towards explaining the variability and have the tendency to remain together this may be kept into consideration during the utilization of these characters in the breeding program.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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