https://dx.doi.org/10.4314/ijs.v21i1.13

MORPHOLOGICAL CHARACTERIZATION OF MANGO (MANGIFERA INDICA L.) CULTIVARS FROM SOUTH-WEST NIGERIA

Igbari*, A. D., Nodza, G. I., Adeusi, A. D. and Ogundipe, O. T.
Department of Botany, University of Lagos, Akoka, Yaba Lagos, Nigeria
*Corresponding author's email: dlparamide2012@gmail.com
(Received: 20th July, 2018; Accepted: 31st December, 2018)

ABSTRACT

Mango (Mangifera indica L.) is an economically important tropical fruit consumed all over the world. So far, little attention has been paid towards the documentation and characterization of its cultivars. Occupying a unique position among edible fruit crops in Nigeria, information on the exact number of cultivars has not been recorded, leading to a lack of accurately named germplasms and cultivars. To gain phenomenal insight on cultivars' diversity, a morphological technique employing both cluster and principal component analysis were adopted. Morphological characters of seven cultivars collected from National Horticultural Research Institute (NIHORT), Ibadan Nigeria, which includes: leaf length and width, leaf apex, petiole length, fruit length and width, fruit colour and shape were assessed. The results of principal component analysis based on similarity matrix revealed a correlation between leaf length and petiole length, fruit length, width and shape whereas fruit colour exhibited no correlation with any of the other parameters. Cluster and dendrogram analysis based on farthest neighbour, mean character difference and constrained clustering strategy, revealed that mango cultivars are distinctively divided into two groups based on their fruit features: Cluster A comprises Julie, Edward, Palmer, and Kent whereas cluster B comprises Saigon, Madoe and Lipen. This study provides a solid baseline for the further characterization of the different mango cultivars in Nigeria, and will be useful for germplasm management and crop breeding.

Keywords: Mango varieties, Morphometrics, Numerical Taxonomy, Principal Component Analysis

INTRODUCTION

Mango (Mangifera indica L.) is one of the choicest fruits in the world (Joshi et al., 2013). It belongs to the family of Anacardiaceae, one of the most important species of the family and one of the most preferential fruit crops of the tropical and subtropical regions of the world for human consumption (Vasugi et al., 2012). Due to its popularity and importance, M. indica is often named "King of fruits" for its luscious flavour and taste. Its social and economic impact are most relevant in developing and emerging countries, where mango is a high-valued component in diet, rich in vitamins and minerals (Ribeiro et al., 2007). Mangifera indica has been an important component of the Ayurvedic and indigenous medical systems for over 4000 years (Singh, 1968; Joshi et al., 2013).

Various parts of the plant are used as a dentrifrice, antiseptic, astringent, diaphoretic, stomachic, vermifuge, tonic, laxative and diuretic. According to Gálvez-López et al., (2010), all parts can be used to treat abscesses, broken horn, rabid dog or jackal bite, tumour, snakebite, stings, acute poisoning due to ingestion of Datura spp., heat stroke, miscarriage, anthrax, blisters, mouth wounds, tympanitis, colic, diarrhoea, glossitis, indigestion, bacillosis, bloody dysentery, liver disorders, excessive urination, tetanus and asthma. Fruits of M. indica may be used to make juices, mango nectar, or flavouring as a major ingredient in ice cream and sorbets (Bompard, 1993; Mukherjee, 1997). Bark from mango trees possesses 16% to 20% tannin and has been employed for tanning hides. Wood from mango tree is extensively used for low-cost furniture, ceiling boards, window frames, heavy packing cases, match splints, brush backs, oar blades, agricultural implements etc. (Krishna and Singh, 2007).

There are over 1,000 named mango cultivars throughout the world which are divided into two broad classes: Indochinese and West Indian (EOL, 2015; ITIS, 2015). The Indochinese group is characterized by flattened, kidney-shaped, a bit elongated fruit with light green or yellow skin, and little or no red blush colour. On the other hand, the West Indian cultivars are more rounded and plump, and generally have a bright red blush colour. It should be emphasized that many cultivars are products of breeding and genetic

improvement practices (Bompard, 1993).

Mangifera indica occupies a unique position among edible fruit crops in Nigeria as it grows in all ecological zones of the country (Illoh, 1986; Illoh and Olorode, 1991; Aguoru et al., 2016). Trees of mango cultivars in Nigeria are often distinguished by their fruit characteristics and therefore assigned common names. In the north central part of the county, the common cultivars are the Big-no-fibre, Small-fibre, Julie and Opioro whereas Saigon, Kent, Julie, Sherry, Palaba, Opioro, amongst others are mainly found in south-western Nigeria (Illoh, 1986; Illoh and Olorode, 1991; Aguoru et al., 2016). According to the FAO report of 2004, Nigeria is the largest mango producing country in Africa and seventh in the world, but on the contrary not listed among the 10 leading mango fruit exporters (Ugese et al., 2012). However, information on the exact number of cultivars in Nigeria has not been accurately documented leading to a lack of accurately named germplasm and cultivars.

This has been a major limitation on the effective study and communication regarding the general biology of the cultivars. The common names used are often misleading, confusing and taxonomically inconsistent (Aguoru et al., 2009; 2016; ICBN, 2015). In addition, despite its popularity, limited scientific attention has been directed towards the characterization of the numerous cultivars found in Nigeria (Aguoru et al., 2009; 2016). Research to date has mainly focused on the relative food crop value and time of maturity of mango fruits (Eghareyba, 1975; Bruno and Golberg, 1963); Illoh (1986) recorded the anatomical and electrophoretic mobility of seed proteins of Mangifera indica. Other studies include: numerical taxonomic studies of mango (Mangifera indica L.) varieties in Nigeria Illoh and Olorode, (1991); Fruit production and production constraints of Mangifera indica in Gboko Local Government Area of Benue State (Ugese et al., 2012); micro-anatomical investigation of four varieties of Mangifera (Aguoru et al., 2016) and phytochemical screening for active compounds and chemosystematics studies on six cultivars of Mangifera indica L. (Aiyelagbe and Omamusiamen, 2009; Aguoru et al., 2017). Hence, this study aims to assess and characterize cultivars of Mangifera indica from south-west Nigeria employing a morphological approach.

MATERIALS AND METHODS

Plant materials:

Seven cultivars of Mangifera indica were used in this study (Table 1). Fresh leaves and fruits were collected from the National Horticultural Research Institute (NIHORT), Ibadan in the south-western part of Nigeria. Leaves from cultivars were plucked freshly from the trees at the mango orchard in NIHORT and were examined for morphometric analysis.

Table 1. List of Mangifera indica Varieties Used in the Study

S/N	Mango Cultivars
1	Mangifera indica var saigon
2	Mangifera indica var Julie
3	Mangifera indica var lipen
4	Mangifera indica var kent
5	Mangifera indica var edward
6	Mangifera indica var palmer
7	Mangifera indica var madoe

Morphometric analysis:

In this study, thirteen morphological characters were investigated and used to characterize the cultivars. Both qualitative and quantitative characters were recorded and coded as binary state. The readings of morphometric analysis were taken from the leaf length, leaf width, fruit length, fruit width and petiole length. A white thread placed on a line ruler was used for accurate measurement following standard protocols (Soladoye et al. 2010a). The corresponding mean values of the recorded sizes and standard deviations were also determined. All values were inputted into a SPSS version 23 analysis sheet. Principal component analysis (PCA) and cluster analysis were performed using unweighted pair group method with arithmetic mean (UPGMA) and a dendogram was constructed to show the relationship among the cultivars (Sneath and Sokal, 1973). The objective of using principal component analysis is to determine the characters that contribute strongly to the delimitation of the taxa while cluster analysis and others were aimed at determining how closely related the species or varieties are to one another employing phenetic similarities.

RESULTS

Seven Mangifera indica varieties were examined with numerical methods (Plates 1) in this study. The leaf and fruit morphological characters, expressed in the form of quantitative and qualitative characters are as summarized on tables 2 and 3 respectively. The values of mean and standard deviation for eight characters viz. leaf length, leaf width, leaf apex, petiole length, fruit shape, width, length, and colour are given on table 3.

Plate 1: A= Mangifera indica var saigon; B= Mangifera indica var edward;
C= Mangifera indica var kent; D= Mangifera indica var palmer; E= Mangifera indica var Julie

Table 2: Leaf and Fruit Morphological Characters and States of the Different M. indica Varieties

Variety name	Leaf apex	Fruit shape	Fruit colour
Saigon	Apiculate	Oval	Green
Julie	Apiculate	Oval	Yellowish green with dark spots
Kent	Acute	Round-ovate	Green
Palmer	Apiculate	Oblong-oval	Reddish green
Edward	Aristulate	Oval	Green
Madoe	Acute	Oval	Green
Lipen	Aristulate	Oval	Green

Table 3: Quantitative Characters of M. indica Varieties (in cm.)

Variety name	Leaf length (cm)	Leaf width(cm)	Leaf petiole (cm)	Fruit length (cm)	Fruit width(cm)
Saigon	19.5±2.1	5.8±0.5	22.8±2.9	7.3±0.8	5.3±0.8
Julie	19.4±2.2	4.6±0.5	21.1±2.6	10.1±1.4	7.6±1.5
Kent	18.4±0.9	5.4±0.1	20.6±1.0	13.2±0.8	10.3±0.6
Palmer	19.7±1.6	5.5±0.6	22.0±1.8	11.5±1.2	8.0±0.4
Edward	20.0±1.3	5.4±0-4	22.6±1.6	10.8±1.5	7.8±0.5
Lipen	24.8±3.2	5.5±0.7	28.0±4.2	9.5±1.2	8.9±0.45
Madoe	21.9±2.2	6.2±0.8	24.6±2.7	8.8±0.9	6.7±0.39

*Values are mean±standard deviation

Similarities matrix on correlation of the mango varieties (Table 4) revealed significantly that close resemblance of varieties could be observed using few characters. For instance, when leaf length was correlated with petiole length, the degree of affinity was 0.982; fruit width and fruit length was correlated at 0.871 whereas fruit length and shape revealed a similarity matrix on correlation at 0.779. Results revealed highly significant positive correlations among most of the analysed features, however a few negative correlations were observed among some characters. A negative correlation of -0.461 was observed between leaf length and fruit shape.

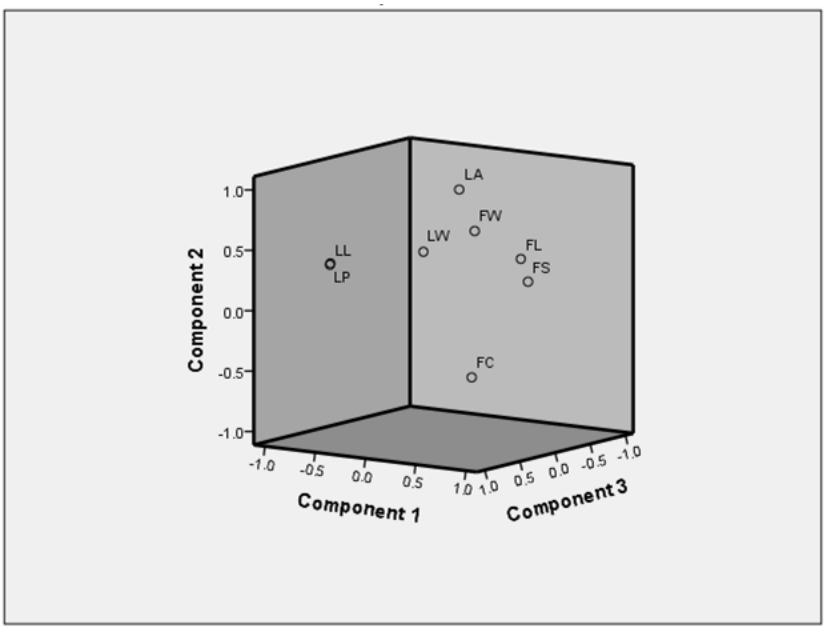

Figure 1: Component Plot for the Nine Morphological Traits Examined Among M. indica Varieties

Table 4: Correlation Matrix based on Quantitative Traits of the Studied M. indica Varieties

	LL	LW	LP	FL	FW	LA	FS	FC
LL	1	.278	.982**	-.376	.041	.164	-.461	-.264
		.547	.000	.406	.930	.725	.298	.567
LW	.278	1	.418	-.382	-.346	.453	-.050	-.375
	.547		.351	.398	.447	.307	.915	.408
LP	.982**	.418	1	-.474	-.066	.177	-.488	-.353
	.000	.351		.283	.888	.705	.266	.437
FL	-.376	-.382	-.474	1	.871*	.317	.779*	.287
	.406	.398	.283		.011	.488	.039	.533
FW	.041	-.346	-.066	.871*	1	.457	.583	.027
	.930	.447	.888	.011		.303	.169	.955
LA	.164	.453	.177	.317	.457	1	.108	-.605
	.725	.307	.705	.488	.303		.817	.150
FS	-.461	-.050	-.488	.779*	.583	.108	1	.496
	.298	.915	.266	.039	.169	.817		.257
FC	-.264	-.375	-.353	.287	.027	-.605	.496	1
	.567	.408	.437	.533	.955	.150	.257	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Key: LL=leaf length; LW=leaf width; LP=length of petiole; FL=fruit length; FW=fruit width; LA=leaf apex; FS=fruit shape; FC=fruit colour

The cumulative Principal Component Analysis as presented in tables 5 and 6, indicated that three characters (leaf length, petiole length and fruit length) contributed greatly to the delimitation of the studied cultivars. Figure 1 revealed the components plot on rotated axis for the eight quantitative morphological traits employed. It also indicated that fruit length, fruit width, fruit shape, leaf length and petiole length of the leaves and fruits were contributing most to the separation among the cultivars. Table 7 shows agglomeration schedule of the mango varieties as viewed from the perspective of clusters; as further explained on table 8, the similarities among the different cultivars were expressed. For instance, Saigon is most closely similar to Madoe; Julie is closely similar to Edward. Dendrogram based on farthest neighbour, mean character difference and constrained clustering strategy (Figure 2) revealed that the Mangifera indica cultivars are distinctly divided into two groups. Cluster A comprises Julie, Edward, and Palmer, whereas cluster B comprises Saigon, Madoe and Lipen.

Table 5: Variance in the Observed Traits using Principal Component Analysis

Total Variance Explained						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.478	43.469	43.469	3.478	43.469	43.469
2	2.188	27.355	70.824	2.188	27.355	70.824
3	1.247	15.584	86.408	1.247	15.584	86.408
4	.890	11.131	97.539			
5	.160	1.995	99.533			
6	.037	.467	100.000			
7	3.333E-16	4.166E-15	100.000			
8	-7.126E-18	-8.907E-17	100.000			

Table 6. Factor Loading of the M. indica Varieties Quantitative Traits

	Component		
	1	2	3
LL	-.715	.346	.594
LW	-.544	.314	-.491
LP	-.800	.330	.465
FL	.853	.484	.118
FW	.565	.721	.364
LA	-.092	.895	-.355
FS	.811	.267	-.044
FC	.562	-.485	.403

Table 7. Agglomeration Schedule of the M. indica Varieties Viewed from the Perspective of Clusters

Agglomeration Schedule						
	Cluster Combined			Stage Cluster First Appears		
Stage	Cluster 1	Cluster 2	Coefficients	Cluster 1	Cluster 2	Next Stage
1	2	5	5.780	0	0	2
2	2	4	6.410	1	0	4
3	1	7	16.020	0	0	5
4	2	3	21.733	2	0	5
5	1	2	33.718	3	4	6
6	1	6	70.930	5	0	0

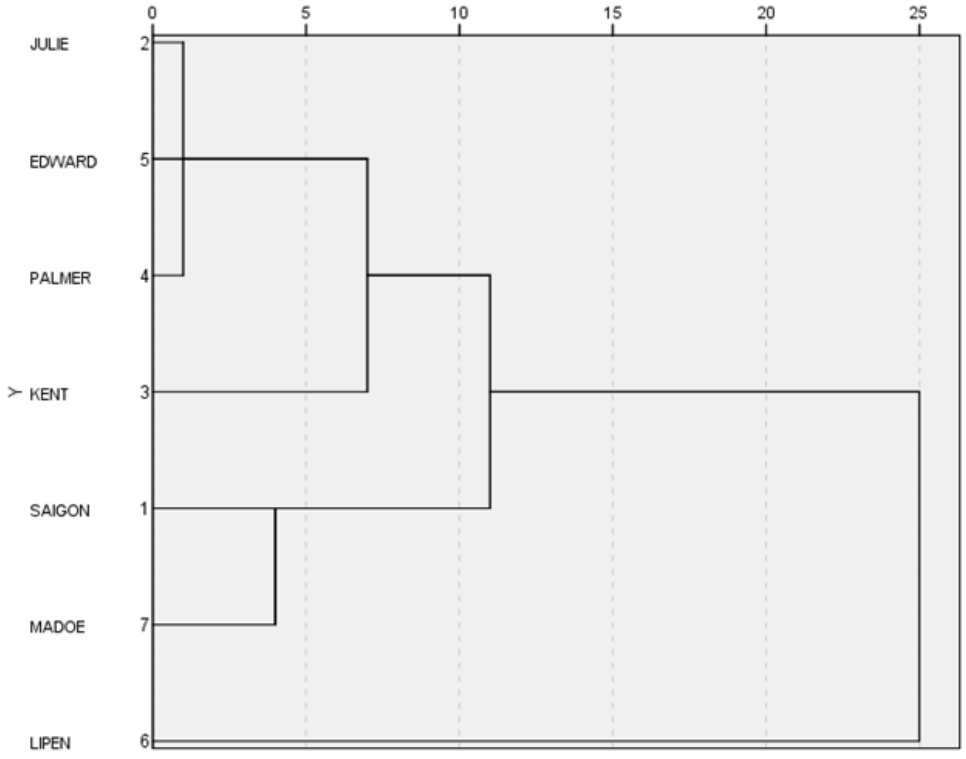

Figure 2: Cluster Analysis Showing the Relationship among M. indica Varieties Based on Quantitative Morphological Trait

Table 8. Cluster Analysis Revealing Relationship Between Seven M. indica Varieties

Distance Matrix	Saigon	Julie	Kent	Palmer	Edward	Lipen	Madoe
Saigon	0						
Julie	4.297674	0					
Kent	8.427337	3.978956	0				
Palmer	5.540758	5.414539	6.454212	0			
Edward	4.466542	5.424163	4.535416	5.643861	0		
Lipen	8.603488	2.034932	1.648010	1.533464	1.423611	0	
Madoe	4.002499	2.210566	3.758866	2.170289	3.861967	5.349766	0

DISCUSSION

Morphometrics use the information of characters and character states of organisms to arrange and group them into clusters, allowing the generation of a thorough similarity index within a genus or between varieties. In this study, morphological features of the seven M. indica varieties were evaluated using 13 morphological features, and revealed that mango varieties exhibited some variability in shapes and sizes of leaves and fruits resulting in reliable discriminating characters. Our results revealed that morphological characters of the cultivars expressed little differences from each other except in leaf length and petiole length. The fruit morphological features (fruit length, width and shape) exhibited the highest variability. However, leaf colour, fruit colour, leaf apex and others showed very little or no differences at all and cannot be used as a strong characterization tool for the seven cultivars of Mangifera indica used in this study.

These results are consistent with the report of Sennhenn et al., (2013) and Agouror et al., (2016) who reported that leaf morphological characters do not display significant variation between the phenotypes of M. indica cultivars, exhibiting low variation amongst all cultivars. This was evident from the uniformity of leaf shape, margin and veination of all the different varieties of mango examined. Conversely, leaf length and leaf width and their ratio were previously suggested to contribute significantly to species delimitation of Ficus (Sonibare et al., 2004), Acalypha (Soladoye et al., 2008), Senna (Soladoye et al., 2010a; Rahman et al., 2013) and Indigofera (Soladoye et al., 2010b).

However, our results are in line with Illoh, (1986); Illoh and Olorode, (1991); Gálvez-López et al., (2010) and Aguoru et al., (2016) who argued that fruits had the most significant characters to influence morphological variability among mangoes. In addition, there could be a chance of the cultivars to differ morphologically due to probable genotypic variation among the different cultivars (Mitra, 2016; Krishnapillai and Wijeratnam, 2016).

The relationship between fruit length and shape could be associated with the effect of length on the shape of the different mango varieties as most mango possess ovate fruit shape with different modifications (Ritu et al., 2013). The traits that resulted in the separation of the different varieties into clusters were specifically the leaf length, petiole length, fruit length and shape. However, this result may also be attributed to the limited number of characters used in the analysis. Although thirteen parameters were recorded, but due to the redundant variability in the recorded features, nine characters were eventually useful for the analysis. To tackle this, future research will focus on the inclusion of more features to obtain a more robust dataset to allow discrimination of other varieties of M. indica. Also, molecular characterization of the different mango cultivars will be useful to differentiate and identify each cultivar even when distinctive morphological features are absent.

Our study has morphologically characterized mango cultivars from south-west Nigeria. It has provided new insight in the characterization of M. indica assigning a key role to leaf length and petiole length for cultivar discrimination. These results could be of interest in breeding programs to produce desirable and consistent quality of mango and also identify mango trees when in their non-fruiting state. In conclusion, the study has

provided the morphological differences within the different varieties of M. indica that abound in southwestern Nigeria, providing a baseline for further characterization of the different mango cultivars in Nigeria, and could be useful for germplasm management and crop breeding.

ACKNOWLEDGEMENT
We thank the National Horticultural Research Institute (NIHORT) for providing the mango cultivars used for this research.

CONFLICT OF INTEREST
The authors declare that they have no conflict of interest.

REFERENCES

Aguoru, C.U., Manyi, M. and Okoh, T. (2009). Problems of common names in plant taxonomy. Undergraduate Practical Manual: University Basic Biology. 1st ed. Pp12-15.

Aguoru, C.U., Okoli, B.E. and Olasan, J.O. (2016). Taxonomic investigation of four cultivars of mangifera using micro-anatomical features. International Research Journal of Natural Sciences, 3(5): 21-32.

Aguoru, C.U., Ogbodo, C. and Olasan, J.O. (2017). Chemosystematics studies on six cultivars of Mangifera indica L. Agricultural Sciences, 8: 253-259.

Aiyelaagbe, O.O. and Omamudiamen, P.M. (2009). Phytochemical screening for active compounds in Mangifera indica leaves from Ibadan, Oyo State. Plant Sciences Research, 2(1): 11-13.

Bompard, J.M. (1993). The genus Mangifera rediscovered: the potential contribution of wild species to mango cultivation. Acta Horticulturae, 341: 69-77.

Bruno, A. and Golberg, P.H. (1963). The morphology and chemical composition of some Nigeria mangoes (Mangifera indica L.). Journal of Imperial Collections of Tropical West Indies, 19(2): 143-152.

Egharevba, R.K. (1975). Consumption patterns and preference for fruits and vegetables in Nigeria. In: P.A. Town. Proceedings of National Seminar on fruits and vegetables. Ojehomon O.O. (Ed.) NIHORT Ibadan Publisher.

EOL (2015). Encyclopedia of Life, Information on Mangifera indica. Retrieved from: www.eol.org. Accessed 16th September, 2017.

FAO (2004). Food and Agricultural Organisation, Retrieved from: www.faostat.org/fruit_crop Accessed 8th September, 2017.

Gálvez-López D., Salvador-Figueroa, M., Adriano-Anaya, M.D.L., Mayek-Pérez, N. (2010). Morphological characterization of native mangos from Chiapas, Mexico. Subtropical Plant Science, 62:18-26.

Hutchinson, J. and Dlaziel, J.N. (1963). Flora of tropical West Africa. Vol. 2. Crown Agents, London. 727 pp.

Illoh, H.C. (1986). Taxonomic evaluation of mango (Mangifera indica L.) cultivars in Nigeria. Ph.D. Thesis submitted to University of Ife, Ile-Ife, Nigeria.

Illoh, H.C. and Olorode, O. (1991). Numerical taxonomic studies of mango (Mangifera indica L.) cultivars in Nigeria. Euphytica, 51: 197-205.

ICBN (2005). International Code for Botanical Nomenclature, Retrieved from: www.icbn.org. Accessed 8th September, 2017.

ITIS (2015). Integrated Taxonomic Information System, Retrieved from: www.itis.gov. Accessed 8th September, 2017.

Joshi. R., Kundu, M. and Singh, C.P. (2013). Efficient tool for identification on different mango cultivars. Environment and Ecology, 31(1): 385-388.

Krishna H, Singh S. (2007) Biotechnological advances in mango (Mangifera indica L.) and their future implication in crop improvement - A Review. Biotech Adv. 25: 223-243.

Krishnapillai, N. and Wijeratnam, R.S.W. (2016). Morphometric analysis of mango cultivars in Sri Lanka. Australian Journal of Crop Science, 10(6): 784-792.

Mitra, S.K. (2016). Mango production in the world-present situation and future prospect. Acta Horticulturae, 1111: 287-296.

Mukherjee, S.K. (1997). Introduction: Botany and importance. In: The mango: Botany, Production and Uses. Litz, R.E. (Ed.).

CAB International, Wallingford, UK. pp 1-19.

Rahman, R.O., Rahman, M.Z. and Begum, A. 2013. Numerical taxonomy of the genus Senna Mill. from Bangladesh. Bangladesh J. Plant Taxon., 20(1): 77-83.

Ribeiro, R.S.M., Queiroz, J.H., Queiroz, L.R.M.E., de Campos F.M. and Santana, P.H.M. (2007). Antioxidant in mango (Mangifera indica L.) pulp. Plant Foods for Human Nutrition, 6:13-21.

Ritu, J., Manoj, K. and Singh, C.P. (2013). Morphological characters: efficient tool for identification of different mango cultivars. Environment and Ecology, 31: 385-388

Sennhenn, A., Prinz, K., Gebauer, J., Whitbread, A., Jamnadass, R. and Kehlenbeck, K. (2013). Identification of mango (Mangifera indica L.) landraces from Eastern and Central Kenya using a morphological and molecular approach. Genetic Resources and Crop Evolution, 60(5): 96-112.

Singh, L.B. (1968). The mango, Botany, Cultivation and Utilization. Leonard Hill Publishers, London.

Sneath, P.H.A. and Sokal, R.R. (1973). Numerical Taxonomy: The Principles and Practice of Numerical Classification. W.H. Freeman and Company. San Francisco, Carlifonia, USA. 485pp.

Soladoye, M.O., Sonibare, M.A. and Rosanwo, T.O. 2008. Phytochemical and Morphometric Analysis of the Genus Acalypha Linn. (Euphorbiaceae). J. Appl. Sci,. 8(17): 3044-3049.

Soladoye, M.O., Onakoya, M.A., Chukwuma, E.C. and Sonibare, M.A. 2010a. Morphometric study of the genus Senna Mill. in South-Western Nigeria. African Journal of Plant Science, 4(3): 44-52.

Soladoye, M.O., Sonibare, M.A. and Chukuma, E.C. 2010b. Morphometric study of the genus Indigofera Linn. (Leguminosae-Papillionoideae) in South-Western Nigeria. International Journal of Botany, 6(3): 343-350.

Sonibare, M.A., Jayeola, A.A. and Egunyomi, A. 2004. A Morphometric analysis of the genus Ficus Linn. (Moraceae). Afr. J. Biotechnology, 3(4): 229-235

Ugese, F.D., Iyango, P.O. and Swem, T.J. (2012). Fruit production and production constraints in Gboko Local Government Area of Benue State. Production Agriculture and Technology, 8(1): 164-174.

Vasugi, C., Dinesh, M. R., Sekar, K., Shivashankara, K. S., Padmakar, B. and Ravishankar, K. V. (2012). Genetic diversity in unique indigenous mango accessions (Apemidi) of the western Ghats for certain fruit characteristics. Current Science, 103(2): 199-207.