https://dx.doi.org/10.4314/ijs.v24i1.12

VARIABILITY STUDIES ON QUALITATIVE AND QUANTITATIVE CHARACTERS OF *Mangifera indica* Linn. (MANGO) IN OYO STATE, NIGERIA

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(Received: 25th May, 2021; Accepted: 28th April, 2022)

ABSTRACT

Mango is one of the edible tree crops cultivated globally. Therefore, this study investigated the variation among 36 accessions of mango collected from genebank and selected locations in Oyo State, Nigeria. The field experiment was conducted in a Complete Randomized Design (CRD) with three replicates. A total of 17 quantitative and 43 qualitative characters were evaluated on mango stem, leaf and fruit. Analysis of hierarchical cluster was performed on the characters scored. The results showed that the fruit length (18.18 cm), fruit weight (751.75 g) and fruit width (18.23 cm) performed best in Big Mango (BIGMCB Acc-1), while Ogbomosho Mango (OGBM Acc-10) had the highest for leaf area (198.79 cm^2), petiole length (6.54 cm), lamina length (32.68 cm) and stone width (6.36 cm). Moreover, leaf length had strong positive correlation with leaf width (r= 0.87), petiole length (r= 0.74), internodal length (r= 0.60), plant height (r= 0.71), lamina length (r= 0.99) and leaf area (r= 0.56) at $p \leq 0.05$. However, BUTM Acc-1 (fruit ground colour), PALMER (pulp colour), BIGMCB Acc-1 (fruit weight), SHRIM Acc-2 (fruit beak), OGBM Acc-3 (stone dry weight), OGBM Acc-8 (fruit thickness) and OGBM Acc-10 (fruit stone width) accessions varied morphologically, thereby enhanced characterization which could be recommended for future breeding of mango.

Key words: Mango, morphology, variation, traits, clusters.

INTRODUCTION

Mango (*Mangifera indica* Linn.) is a tree crop belonging to the family Anacardiaceae in the order Sapindales (Mukherjee, 1951; Kittiphoom, 2012; Krishnapillail and Wilson, 2016). The genus *Mangifera* L. consists of 69 species, that have been classified into two sub-genera with several sections based on morphological characters (Bompard, 1993). Among the species, mango is the most important, although there are other species that also produce edible fruits such as *Mangifera altissima* Blanco*, Mangifera lagenifera* Griff.*, Mangifera macrocarpa* Blume*, Mangifera odorata* Griff. and *Mangifera sylvatica* Roxb.(Kostermans and Bompard, 1993). Mango is an important tropical fruit believed to have emanated in the Himalayan hills of Indo-Myanmar region (Mukherjee, 1951; Yonemori *et al*., 2002; Fowomola, 2010; Akinyemi *et al.,* 2017) and continuously spread to other regions of the world. Fifty-eight (58) listed species of the genus *Mangifera* are further classified into definite sections, based on their flower morphologies (Kittiphoom, 2012). Mango and some other species of this genus are diploid with somatic number (2*n*) of chromosomes 40 (Roy and Visweswaraiya, 1951). India accounts for primary center of distribution for mango (NBPGR, 2007) and the largest mango germplasm in the world with over 1000 mango accessions (Karihaloo *et al*., 2003). There are many commercially grown cultivars that have been propagated vegetatively and cultivated over a wide area. Large cultivars of mango are the result of open pollination leading to chance seedling which are then further maintained asexually (Bally *et al.,* 2009; Rajwana *et al.,* 2011)

Mango is a perennial edible fruit crop, cultivated in most ecological zones particularly in Africa and in the tropics (Akinyemi *et al.,* 2017). Nigeria is the 9th largest mango producer with about 850,000 tons/year contributing 3% of the world market (Akinyemi *et al.,* 2017). The following mango varieties Alphonso, Zill, Julie, Palmer, Keitt, Saigon, Edward, Lippens, Haden and Early gold have been found promising and are available at National Horticultural Research Institute

(NIHORT), Ibadan Nigeria (Akinyemi *et al.,* 2017).

However, characterization of mango is essential for its improvement and conservation of genetic resources (Rajwana *et al.,* 2011). Morphological (quantitative and qualitative) characterization is the most common method evaluated in different crops. It is often used extensively as a tool for identification and differentiation of varieties including mango (Galvez–Lopez *et al.,* 2010; Rajwana *et al.,* 2011; Barua *et al.,* 2013; Ribeiro *et al.,* 2013; Toili *et al.,* 2013). The International Plant Genetic Resources Institute (IPGRI) had provided universally accepted list of descriptors of morphological traits of plants leaves, flowers, seeds and fruits for characterization of mango varieties (IPGRI, 2006; IBPGR, 2015). The application of morphological trait markers is one of the simplest approaches of assessing crop genetic variation (Brettell *et al.,* 2002; Gibert *et al.,* 2009; Begum *et al.,* 2012; Mhamed and Ahmed, 2015).

The cytological and morphological characterization of mango accessions in Nigeria had been reported by Illoh and Olorode (1991) and Akinyemi *et al.* (2017). Yet, there are limited studies on the morphological variability of selected accessions. Therefore, there is need for further characterization of mango accessions from both germplasm and wild sources in order to utilize mango genetic resources effectively. Hence, the study aimed at characterizing mango morphologically.

MATERIALS AND METHODS

Sources of Mango accessions and their locations

Ten (10) matured leaves and 10 ripe mango fruits were randomly collected from 36 accessions of mango obtained from five (5) locations (Oyo, Saki, Ogbomosho, Iseyin, and Ibadan) based on the method described by Biodiversity International IPGRI (2006). The coordinates of locations of the sampled trees were taken using a hand-held Global Positioning System (GPS) along with local names of the trees as shown in Table 1A. Qualitative and quantitative characters of mango accessions accessed are represented in Table 1B.

Table 1A: Sources of mango, their locations and coordinates

Accessions	Local Names	Locations	Coordinates
JULIE	JULIE	NIHORT, IBADAN	N 07⁰ 24´ 33.40" E 003⁰ 51´ 09.80"
EDWARD	EDWARD	NIHORT, IBADAN	N 07⁰ 24´ 33.50" E 003⁰ 51´ 14.80"
ZAIGON	SAIGON	NIHORT, IBADAN	N 07⁰ 24´ 33.20" E 003⁰ 51´ 11.20"
OGBOM NIHORT	OGBOMOSHO	NIHORT, IBADAN	N 07⁰ 24´ 35.10" E 003⁰ 51´ 17.10"
PALMER	PALMER	NIHORT, IBADAN	N 07⁰ 24´ 37.30" E 003⁰ 51´ 18.70"
HARDEN	HARDEN	NIHORT, IBADAN	N 07⁰ 24´ 35.00" E 003⁰ 51´ 17.50"
KEINT	KEINT	NIHORT, IBADAN	N 07⁰ 24´ 36.30" E 003⁰ 51´ 16.80"
OGBM Acc -2	OGBOMOSHO	LAUTECH	N 08⁰ 10´ 09.20" E 004⁰ 16´ 52.90"
OGBM Acc-3	OGBOMOSHO	LAUTECH	N 08⁰ 10´ 09.40" E 004⁰ 17´ 53.20"
OGBM Acc-5	OGBOMOSHO	LAUTECH	N 08⁰ 10´ 06.00" E 004⁰ 16´ 50.90"
OGBM Acc-8	OGBOMOSHO	SURULERE LGA	N 08⁰ 12´ 39.00" E 004⁰ 18´ 23.10"
OGBM Acc-9	OGBOMOSHO	SURULERE LGA	N 08⁰ 14´ 49.00" E 004⁰ 23 ´ 18.10"
OGBM Acc-10	OGBOMOSHO MANGO - AJUWA	OGBOMOSHO SOUTH	N 08⁰ 03´ 10.50" E 004⁰ 08´ 51.70"
OGBM Acc-13	OGBOMOSHO MANGO	ATIBA SOUTH	N 08⁰ 05´ 18.20" E 004⁰ 12´ 58.40"
BUTM Acc-1	BUTTER	OGO OLUWA	N 08⁰ 12´ 42.10" E 004⁰ 25 ´ 15.90"
BIGMCB Acc-1	BIG MANGO	MCB DEPT. UI, IBADAN	N 07⁰ 26´ 37.70" E 003⁰ 53´ 47.50"
SWM UI Acc-1	SWEET MANGO	UI, IBADAN	N 07⁰ 21´ 28.90" E 003⁰ 50 ´ 11.70"
SWM UI Acc-3	SWEET MANGO	UI, IBADAN	N 07⁰ 26´ 23.30" E 003⁰ 53´ 11.40"
SWM UI Acc-4	SWEET MANGO	AWBA DAM UI, IBADAN	N 07⁰ 26´ 40.00" E 003⁰ 52´ 22.90"
SWM Acc-6	SWEET MANGO	IBADAN	N 07⁰ 25´ 22.60" E 003⁰ 51´ 14.70"
SWM Acc-7	SWEET MANGO	IBADAN	N 07⁰ 29´ 21.90" E 003⁰ 57´ 11.80"
SWM Acc-4	SWEET MANGO	IBADAN	N 07⁰ 29´ 20.70" E 003⁰ 58´ 14.60"
OROM Acc-1	ORO MANGO	OKE ADAGBA, SAKI WEST	N 08⁰ 40´ 30.80" E 003⁰ 23´ 02.00"
OROM Acc-2	ORO MANGO	BSH, SAKI WEST	N 08⁰ 19´ 37.50" E 003⁰ 23´ 53.40"
OROM Acc-4	ORO MANGO	SAKI	N 08⁰ 13´ 13.10" E 003⁰ 27´ 27.10"
SHRIM Acc-2	CHERRY MANGO	AFRICAN BAPTISH CHURCH	N 08⁰ 39´ 33.40" E 003⁰ 23´ 43.10"
OYOM Acc-1	OYO	OYO	N 08⁰ 10´ 41. 90" E 004⁰ 23 ´ 17.60"
OYOM Acc-3	OYO	OYO	N 08⁰ 16´ 44.40" E 004⁰ 26 ´ 18.60"
OYOM Acc-5	OYO	OYO	N 08⁰ 11´ 39.30" E 004⁰ 23 ´ 12.80"
OGBSHEM Acc-1	OGBOMOSHO CHERRY	SAKI	N 08⁰ 40´ 40. 80" E 003⁰ 23´ 43.30"
SAKM Acc-2	SAKI	SAKI	N 08⁰ 40´ 13.80" E 003⁰ 24 ´ 43.80"
SAKM Acc-3	SAKI	SAKI	N 08⁰ 35´ 33.50" E 003⁰ 46 ´ 48.60"
SAKM Acc-4	SAKI	SAKI	N 08⁰ 07 ´ 36.50" E 003⁰ 30´ 30. 20"
BIGM (IPAPO)	BIG MANGO	IPAPO, ITESIWAJU	N 08⁰ 26´ 18.30" E 003⁰ 23´ 50.70"
SWMUI IDIA Acc-1	SWEET MANGO	IDIA UI, IBADAN	N 07⁰ 26 18.30" E 003⁰ 53 47.90"
SWMUI IDIA Acc-2	SWEET MANGO	IDIA UI, IBADAN	N 07⁰ 26 18.30" E 003⁰ 53 47.90"

Table 1B: Qualitative and Quantitative Characters of Mango Accessions

S/N	Qualitative Traits	Quantitative Traits
1	Fruit Shape	Fruit Weight(g)
2	Fruit Ground Colour	Fruit Length (cm)
3	Fruit Shape of Apices	Fruit Width (cm)
4	Fruit Skin Surface Texture	Fruit Length to Width Ratio
5	Fruit Beak	Fruit Thickness (cm)
6	Fruit Beak Type	Number of Leaves
7	Fruit Groove	Leaf Length (cm)
8	Fruit Sinus Type:	Leaf Width (cm)
9	Fruit Stalk Insertion	Leaf Area (cm^2)
10	Fruit Attractiveness	Petiole Length (cm)
11	Fruit Basal Cavity	Internodal Length (cm)
12	Depth of Fruit Stalk Cavity	Lamina Length (cm)
13	Fruit Stalk Attachment	Stone Length (cm)
14	Slope of Fruit Ventral Shoulder	Stone Width (cm)
15	Fruit Neck Prominence	Stone Thickness (cm)
16	Fruit Skin Colour of Ripe	Stone Weight Dry (g)
17	Pulp Colour of Ripe Fruit	Stone Weight Wet (g)
18	Pulp Texture of Ripe Fruit	
19	Pulp Juiciness	
20	Present of Turpentine Flavor	
21	Quality of Fiber in Stone	
22	Adherence of Fruit Skin to Pulp	
23	Quality of Fiber in Pulp	
24	Adherence of Fiber to Skin	
25	Pulp Aroma	
26	Seed Shape	
27	Stone Shape	
28	Stone Pattern of Venation	
29	Stone Veins	
30	Texture of Stone Fiber	
31	Adherence of Fiber to Stone	
32	Leaf Attitude in Relation to Branch	
33	Colour of Young Leaf	
34	Leaf Fragrance Strength	
35	Colour of Fully Mature Leaf	
36	Leaf Margin Type	
37	Leaf Pubescence	
38	Leaf Texture	
39	Leaf Blade Shape	
40	Leaf Apex	
41	Leaf Base	
42	Growth Habit	
43	Crown Shape	

Experimental Layout and Planting of Mango Seed

The experiment was laid out in Complete Randomized Design with three replicates in the nursery farm of the Department of Botany, University of Ibadan, Nigeria. The mango seeds were planted using the method described by Verheij (2004). The growth related characters of mango were evaluated weekly till the 12th week after planting.

Determination of Qualitative and Quantitative Characters

A total of 60 morphological characters (17 quantitative and 43 qualitative) were evaluated on the stem, leaf and fruit using descriptors as

documented by IPGRI (2006) and El Kheshin *et al.* (2016).

Statistical Analysis

The data collected from mango accessions were analysed using the 2003 version of the SAS 9.1 program to generates Analysis of Variance (ANOVA) at $P<0.05$. The differences among quantitative and qualitative characters were also determined using Pearson Correlation Coefficient, Principal Component Analysis (PCA) and dendrogram.

RESULTS

The results in Tables 2A and 2B showed the qualitative fruit characters of the 36 mango accessions. For 18accessions, the fruit shape was oblong, while 4 accessions oblique and 5 accessions were ovate, with the exception of BUTM Acc-1, which was rounded in fruit shape. The fruit skin when ripe was greenish-yellow for 15 accessions, while 8 accessions were yellowish-green, 2 accessions were reddish-yellow, 3 accessions were green, and 1 accession was dark-green, 1 reddish yellow, 5 yellow while BUTM Acc-1 had Red Blush throughout. For 15 accessions, the fruit ground skin was greenish-yellow, 9 accessions yellow-green, 6 accessions yellow, 2 accessions reddish-yellow, 3 accessions was green, 1 accession brownish-green, and BUTM Acc-1 had Red Blush allover. The fruit apices shapes of 25 accessions were acute, 8 accessions were obtuse and 3 accessions were rounded. In 11 accessions including PALMER, ZAIGON, EDWARD, JULIE, SWM Acc-4, SWMAcc-7, SWM Acc-8, OROM Acc-2, SAKM Acc-2, OYOM Acc-5 and BIGM (IPAPO), the fruit skin surface texture was rough and smooth in other accessions, except for SWM Acc-6 and BUTM Acc-1. The fruit beak was present in 34 accessions, in 18 accessions the fruit beak was pointed, perceptible in 13 accessions, prominent in 3 accessions and mammiform in SHERIM Acc-2. In 34 accessions, mango fruit grooves were observed and absent in accessions such as OGBOM NIHORT and ZAIGON. In 32 accessions the fruit sinus was shallow but deep in a few accessions such as OGBOM NIHORT, Keint, SWM UI Acc-1, OROM Acc-4. The insertion of fruit stalks of 20 accessions were vertical, while 16 others were oblique. The fruit attractiveness was excellent for 7 accessions, 17 accessions were fine, and 12 accessions were average. The fruit basal cavity were observed in 25 accessions but was absent in 11 accessions. Twelve (12) accessions, were shallow to the depth of the fruit stalk cavity, 11 accessions were average, deep in SWMUI IDIA Acc -2 while in 12 accessions it was absent. For 21 accessions, the fruit stalk attachment character was intermediate, strong for PALMER, KEINT, BIGMCB Acc-1, SWM Acc-7, SAKM Acc-2, OYOM Acc-1, OYOM Acc-3 and BIGM (IPAPO) and weak for seven other accessions. Fruit stalk attachment character was intermediate for 21 accessions, strong in PALMER, KEINT, BIGMCB Acc-1, SWM Acc-7, SAKM Acc-2, OYOM Acc-1, OYOM Acc-3 and BIGM (IPAPO) and weak for others 7 accessions. The Slope of Fruit Ventral Shoulder were slopped abruptly in 15 accessions and ended in a long curve for the other 21 accessions. The fruit neck prominence of 19 accessions were mildly prominent, prominent in 6 accessions, rising and rounding in 6 accessions, and very prominent in SWM UI Acc-4 but absent in BUTM Acc-1, OGBM Acc-2, ZAIGON and PALMER.

The results in Table 3A and 3B showed the morphological characters of the seed and pulp of Mango. The Seed shape and Stone shape of 22 accessions were reniform, accessions such as KEINT, ZAIGON, BUTM Acc-1, SWM UI Acc-3, SWMUI IDIA Acc-1, BIGMCB Acc-1, SAKM Acc-3, SAKM Acc-4 and BIGM (IPAPO) were oblong, while SWM Acc-6, SWM Acc-7, SWM Acc-8, OYOM Acc-1 and OYOM Acc-3 were ellipsoidal. The venation pattern of the seeds was all parallel, while the Stone vein in 19 accessions were level with the surface and depressed in 17 accessions. The stone fiber texture was coarse in 23 accessions, but soft in JULIE, BUTM Acc-1, SWM UI Acc-3, SWM UI Acc-4, SWMUI IDIA Acc-1, SWMUI IDIA Acc-2, BIGMCB Acc-1, SWM Acc-7, SWM Acc-8, OYOM Acc-1, OYOM Acc-3 and OYOM Acc-5. The stone fiber quality was medium in 17 accessions, while low in 13 accessions and strong OGBOM NIHORT, OGBM Acc-8, SHRIM Acc-2, SWM UI Acc-1, SWMUI IDIA Acc-1 and OROM Acc-1. Adherence of fiber to stone was weak in 20 accessions, moderate in 12 accessions and high in

HARDEN, KEINT, ZAIGON and EDWARD accessions. The ripe fruit pulp colour was yellow in 31 accessions, orange-yellow in palmer, light-orange in OGBM Acc-13, gold-yellow in SWMUI IDIA Acc -1, SAKM Acc-3 and SAKM Acc-4. The pulp texture was smooth in 33 accessions, except for HARDEN, OGBM Acc-10 and OGBM Acc-13. The juiciness of the pulp was juicy in the 18 accessions, mild Juicy in the 6 accessions and very juicy in the other 12 accessions. The presence of turpentine flavor was strong in 17 accessions, absent in BIGMCB Acc-1 and intermediate in 18 accessions. Fruit skin adherence to pulp was weak in 20 accessions, moderate in 13 accessions and strong in PALMER, KEINT and BIGMCB Acc-1. The aroma of pulp was strong in 17 accessions, intermediate in 14 accessions and mild in 5 accessions. Fiber adherence to skin was low in 26 accessions, medium in 9 accessions and strong in Keint. The quality of fiber on stone was intermediate in 27 accessions and scare in other accessions.

The morphological relationship among the accessions based on the quantitative characters of the fruits are shown in Table 4A and 4B. The overall mean value of the fruit weight of the BIGMCB Acc-1 was 751.75 ± 66.29 g, while the minimum value of the Oyo mango Acc-3 (OYOM Acc-3) was 92.28±11.77 g. The BIGMCB Acc-1 fruit length also had the highest mean value of 18.18 ±0.81cm with OYOM Acc-6 having the lowest value of 9.46±0.72cm. Similarly, the overall mean value was 18.23±0.49cm for the fruit width of the BIGMCB Acc-1, while the minimum value was 5.46±0.48cm for the OGBSHEM Acc-1. OGBM Acc-8 had the highest mean value of 2.02±0.12 for fruit length / width ratio while BIGMCB Acc-1 has the lowest value of 0.99±0.02. Similarly, the highest mean value for fruit thickness of 11.13±0.26 mm was obtained from OGBM Acc-8, while OYOM Acc-3 had the lowest value of 4.99±0.22mm.

The Stone dry weight of Ogbomosho mango Acc-8 (OGBM Acc-8) accounted for the highest Mean value of 56.41±1.39g with Ogbomosho mango Acc-3 (OGBM Acc-3) having the least value of 32.13±2.99g. Also, the stone length of SWM UI Acc-3 had the highest mean value of 9.98±0.77cm while, OROM Acc-4 had the least value of 5.74±0.45cm. Similarly, the Stone wet weight of OGBM Acc-4 produced the highest mean value of 39.04±3.40g and OYOM Acc-3 has the least value of 10.48±3.14g. OGBM Acc-10 had the highest stone width mean value of 6.36±0.56cm, while SWM UI Acc-3 had the least value of 1.78±0.09cm. Similarly, the stone thickness of SWM UI Acc-3 accounted for the highest Mean value of 5.26±4.66mm, while SAKM Acc-3 had the least value of 1.70±0.52mm.

The result of the interactive effects of location, replicate, accessions and weeks on the growth related characters of mango are shown in Table 5. The sprouting days, number of leaves per seedling, leaf length, leaf width, leaf area, petiole length, internodal length, plant height, and lamina length were significantly influenced by the impact of locations and growth stages (weeks). The effect of accessions was highly significant ($p<0.01$) on sprouting days, number of leaves per seedling, leaf length, leaf width, leaf area, petiole length and internodal length. The effect of locations, replicates, accessions, first order interaction of location x replicate, location x week, accessions x replicate, week x replicate and week x accessions, second order interaction of location x accessions x replicate, location x week x accessions, week x accessions x replicate had high significant effect on leaf length (Table 5). Moreover, locations, replicates, accessions, first order interaction of location x replicate, location x accessions, location x week, accessions x replicate, week x replicate and week x accessions, second order interaction of location x accessions x replicate, location x week x replicate and location x week x accessions all produced high significant effect on leaf width and leaf area. The petiole length was significantly influenced by the impact of locations, accessions, weeks, first order interaction of location x accessions, location x week, second order interaction of location x accessions x replicate and location x week x accessions. In addition, the locations, replicates, accessions, first order interaction of location x accessions, location x week, accessions x replicate, week x accessions, second order interaction of location x accessions x replicate and location x week x replicate produced highly significant effect

on the internodal length. The locations, accessions, first order interaction of location x replicate, location x accessions, location x week, week x accessions, second order interaction of location x accessions x replicate, location x week x accessions had high significant effect on plant height. It was also observed that locations, replicates, weeks, first order interaction of location x replicate, location x accessions, location x week, accessions x replicate, week x replicate and week x accessions, second order interaction of location x accessions x replicate, location x week x replicate and location x week x accessions produced highly significant effect on lamina length. However, locations, accessions, weeks, first order Interaction of location x replicate, location x accessions, location x week, week x replicate and week x accessions, second order interaction of location x week x accessions, week x accessions x replicate produced highly significant effect ($p<0.01$) on the sprouting days. Also, location, accessions, week, first order interaction of location x replicate, location x accessions, location x week, week x accessions, second order interaction of location x accessions x replicate, location x week x accessions and week x accessions x replicate had highly significant effect on the number of leaves per seedling (Table 5).

The results of the quantitative characters of Mango based on locations revealed significant difference at $p<0.05$ as shown in Table 6. Locations 1 (NIHORT), 2 (OGBOMOSHO), 3 (SAKI), 4 (IBADAN), 5 (ISEHIN), 6 (OYO) accessions were significantly different for the sprouting days, number of leaves per seedling, leaf length, and leaf width. Location 1 produced the highest mean value of 2.67 for sprouting days, location 2 accounted for the highest mean values of 18.53 cm for leaf length, 4.40cm for leaf width, 2.14cm for petiole length and 18.53cm for lamina length. Leaf area of location 4 and 5 were not significantly different from each other, while location 1, 2, 3 and 6 were significantly different. For petiole length and lamina length there was no significant difference ($P>0.05$) in location 3 and 4 while there were significant differences in locations 1, 2, 5 and 6. Intermodal length of location 3 and 6 are not significantly different from each other while location 1, 2, 4 and 5 were significantly different. Plant height in locations 2, 5, 4 and 6 were not significantly different whereas there was significant difference in locations 1 and 3 respectively.

The Principal Component Analysis (PCA) documented for the morphological characters of mango accessions account for variation in Eigen values and Proportion as 4.13 (45.90%), 1.67 (18.57%), 0.93 (10.36%), 0.69 (7.51%), 0.55 (6.10%), 0.47 (5.18%), 0.41 (4.58%) and 0.16 (1.79%) (Table 7). The first PCA (Prin 1) had the highest eigen value of 4.13 with proportion of 45.90%, while Prin 8 had the least eigen value (0.16) with proportion of 1.79%. The leaf length (0.47), leaf width (0.41) and lamina length (0.47) were closely related, while petiole length (0.35) and plant height (0.33) were closely associated to one another in Prin 1. The sprouting days and number of leaves per seeding were closely related, while petiole length and internodal length were also related. In Prin 3, sprouting days and leaf length were positively associated, while petiole length, plant height and lamina length were negatively related. Again, in Prin 4, petiole length, plant height and lamina length were negatively related, while sprouting days and petiole length characters were positively related in Prin 5. The sprouting days and leaf length were closely associated in Prin 7. The leaf width, number of leaves, petiole length, internodal length and plant height were positively associated, while leaf length and lamina length were negatively related in Prin 8.

The results of correlation of growth related characters in Mango accessions at $P<0.05$ in Table 8 showed that leaf length had strong positive significant association with leaf width ($r=0.87$), petiole length ($r=0.74$), internodal length ($r=0.60$), plant height ($r=0.71$), lamina length ($r=0.99$) and positive correlation with leaf area ($r=0.56$). The number of leaves had strong positive association with plant height ($r=0.70$) and positive correlation with petiole length ($r=0.50$). Leaf width produced strong positive significant correlation with petiole length ($r=0.62$), lamina length ($r=0.88$) and positive correlation with plant height ($r=0.56$). Also, petiole length had positive relationship with internodal length ($r=0.53$) and strongly positive correlation with lamina length ($r=0.72$) and plant height ($r=0.64$). The Internodal length had strong positive association with lamina

length (r=0.60) and positive correlation with plant height (r=0.59), while plant height had strong positive correlation with lamina length (r=0.70) P<0.05.

The results in Figure 1 showed the dendrogram based on qualitative characters in fruit, leaf, seed and pulp. At cluster distance/point of 16, there were five (5) main clusters. All accessions in the same clusters were similar and closely related to one another. It was observed in cluster 1 that LAUTECH 3 (OGBM Acc-3) and BUTM Acc-1 were related. LAUTECH 4 (OGBM Acc-4) and SAKM Acc-2 were closely related to each other, SWM Acc-7 and SWM Acc-8 as well as OGBM Acc-13 and BIGM (IPAPO) were closely associated as shown in Cluster 2. KEINT and JULIE Mango were closely related, OGBOM NIHORT and SWM UI Acc-1 were also associated in sub-cluster 5.

The results showing the relationships among accessions based on quantitative characters in fruit, leaf, seed and pulp is shown in Figure 2. The Dendrogram consists of 3 main clusters and all accessions in the same clusters were similar or closely related to each other. At the base of the main cluster, BIG Mango MCB breached out from their base which had distance relationship with other accessions. LAUTECH 2 (OGBM Acc-2) and LAUTECH 3 (OGBM Acc-3) were closely related, Ogbomosho Acc-9 (OGBM Acc-9) and Oyo Mango 5 (OYOM Acc-5) as well as (OGBM Acc-8) Surulere 8 and Ogbmosho NIHORT (OGBOM NIHORT) were closely related as shown in sub-cluster 1. Cluster 2a has KEINT and PALMER Mango closely related while for cluster 2b, Butter Mango (BUTM Acc-1) and Saki Mango 4 (SAKM Acc-4) were closely related. Oyo Mango 1(OYOM Acc-1) and Oyo Mango 2 (OYOM Acc-2) were related, while SWM UI Acc-7 and SWM UI Acc-8 are closely related in sub-cluster 3. Saki Mango 4 (SAKM Acc-4), SWMUI IDIA Acc-1, Saki Mango 3 (SAKM Acc-3) were more related. Also, KEINT and Ogbomosho NIHORT were closely related while SWM UI Acc-3 and BUTM Acc 1 are distinct related to each other.

Table 2A: Qualitative Fruit Characters of Mango Accessions

Accessions	Fruit Shape	Fruit Colour of Skin When Ripe	Fruit Ground Colour	Fruit Shape of Apices	Fruit Skin Surface Texture	Fruit Beak	Fruit Beak Type	Fruit Groove
OGBOM NIHORT	Oblique	Greenish Yellow	Greenish Yellow	Obtuse	Smooth	Present	Pointed	Absent
PALMER	Oblong	Brownish-Green	Brownish-Green	Obtuse	Rough	Present	Pointed	Present
HARDEN	Obvoid	Greenish Yellow	Greenish Yellow	Rounded	Smooth	Present	Pointed	Present
KEINT	Oblong	Dark Green	Greenish yellow	Acute	Smooth	Present	Pointed	Present
ZAIGON	Oblong	Green	Green	Acute	Rough	Present	Pointed	Absent
EDWARD	Oblong	Greenish-Yellow	Greenish-Yellow	Rounded	Rough	Present	Perceptible	Present
JULIE	Oblong-Oval	Green	Green	Obtuse	Rough	Present	Pointed	Present
OGBM Acc-2	Oblong	Yellow	Yellow	Acute	Smooth	Present	Pointed	Present
OGBM Acc-3	Ovate	Greenish yellow	Yellow	Acute	Smooth	Present	Pointed	Present
OGBM Acc-5	Oblong	Yellow	Yellow	Acute	Smooth	Present	Pointed	Present
OGBM Acc-8	Oblong	Yellow	Yellow	Acute	Smooth	Present	Perceptible	Present
OGBSHE Acc-1	Oblong	Yellowish green	Yellowish green	Obtuse	Smooth	Present	Pointed	Present
OGBM Acc-9	Obvoid	Green	Greenish yellow	Acute	Smooth	Present	Pointed	Present
OGBM Acc-10	Oblong	Yellowish green	Yellowish green	Acute	Smooth	Present	Prominent	Present
OGBM Acc-13	Ovate	Yellow	Yellowish green	Acute	Smooth	Present	Perceptible	Present
SHRIM Acc-2	Oblong	Yellowish green	Yellowish green	Acute	Smooth	Present	Mammiform	Present
BUTM Acc-1	Roundish	Red blush allover	Red blush allover	Rounded	Smooth	Absent	None	Present
SWM UI Acc-1	Oblique	Greenish yellow	Greenish yellow	Obtuse	Smooth	Present	Perceptible	Present
SWM UI Acc-3	Obvoid	Greenish yellow	Greenish yellow	Acute	Smooth	Present	Perceptible	Present
SWM UI Acc-4	Elliptic	Greenish yellow	Greenish yellow	Acute	Rough	Present	Pointed	Present
SWMUI IDIA Acc-1	Oblique	Greenish yellow	Greenish yellow	Acute	Smooth	Present	Pointed	Present
SWMUI IDIA Acc-2	Oblique	Greenish yellow	Greenish yellow	Acute	Smooth	Present	Pointed	Present
BIGMCB Acc-1	Obvoid	Greenish yellow	Greenish yellow	Acute	Smooth	Present	Perceptible	Present
SWM Acc-6	Obvoid	Yellow	Yellow	Obtuse	Smooth	Present	Perceptible	Present
SWM Acc-7	Ovate	Greenish yellow	Greenish yellow	Acute	Rough	Present	Pointed	Present
SWM Acc-8	Ovate	Greenish yellow	Greenish yellow	Acute	Rough	Present	Pointed	Present
OROM Acc-1	Oblong	Greenish yellow	Greenish yellow	Acute	Smooth	Present	Perceptible	Present
OROM Acc-2	Oblong	Yellowish green	Yellowish green	Acute	Rough	Present	Prominent	Present
OROM Acc-4	Oblong	Yellowish green	Yellowish green	Acute	Smooth	Present	Perceptible	Present
SAKM Acc-2	Obvoid	Reddish yellow	Reddish yellow	Acute	Rough	Present	Perceptible	Present
SAKM Acc-3	Oblong	Yellowish green	Yellowish green	Acute	Smooth	Present	Pointed	Present
SAKM Acc-4	Oblong	Yellowish green	Yellowish green	Acute	Smooth	Present	Prominent	Present
OYOM Acc-1	Oblong	Greenish yellow	Yellow	Acute	Smooth	Present	Perceptible	Present
OYOM Acc-3	Oblong	Yellowish green	Yellowish green	Acute	Smooth	Present	Perceptible	Present
OYOM Acc-5	Oblong	Greenish yellow	Greenish yellow	Obtuse	Rough	Present	Prominent	Present
BIGM (IPAPO)	Ovate	Reddish yellow	Reddish yellow	Obtuse	Rough	Present	Perceptible	Present

Table 2B: Qualitative Fruit Characters of Mango Accessions Contd.

Accessions	Fruit Sinus	Fruit Stalk Insertion	Fruit Attracti-veness	Fruit Basal Cavity	Depth of Fruit Stalks Cavity	Fruit Stalk Attachment	Slope of Fruit Ventral Shoulder	Fruit Neck Prominess
OGBOM NIHORT	Deep	Oblique	Average	Present	Shallow	Weak	Ending in a long curve	Slightly prominent
PALMER	Shallow	Vertical	Good	Present	Shallow	Strong	Slopping abruptly	Absent
HARDEN	Shallow	Oblique	Excellent	Present	Shallow	Intermediate	Ending in a long curve	Slightly prominent
KEINT	Deep	Vertical	Average	Present	Medium	Strong	Ending in a long curve	Prominent
ZAIGON	Shallow	Oblique	Good	Absent	Absent	Intermediate	Slopping abruptly	Absent
EDWARD	Shallow	Oblique	Excellent	Present	Shallow	Weak	Ending in a long curve	Slightly prominent
JULIE	Shallow	Oblique	Average	Present	Medium	Intermediate	Ending in a long curve	Prominent
OGBM Acc-2	Shallow	Vertical	Good	Present	Absent	Intermediate	Ending in a long curve	Absent
OGBM Acc-3	Shallow	Vertical	Average	Present	Shallow	Intermediate	Ending in a long curve	Slightly prominent
OGBM Acc-5	Shallow	Vertical	Average	Present	Shallow	Intermediate	Ending in a long curve	Slightly prominent
OGBM Acc-8	Shallow	Vertical	Good	Present	Shallow	Intermediate	Ending in a long curve	Slightly prominent
OGBSHE Acc-1	Shallow	Oblique	Good	Present	Shallow	Intermediate	Ending in a long curve	Prominent
OGBM Acc-9	Shallow	Vertical	Good	Present	Shallow	Intermediate	Slopping abruptly	Slightly prominent
OGBM Acc-10	Shallow	Vertical	Good	Present	Shallow	Intermediate	Slopping abruptly	Slightly prominent
OGBM Acc-13	Shallow	Vertical	Good	Absent	Absent	Intermediate	Ending in a long curve	Slightly prominent
SHRIM Acc-2	Shallow	Vertical	Good	Present	Shallow	Intermediate	Slopping abruptly	Slightly prominent
BUTM Acc-1	Shallow	Oblique	Excellent	Absent	Absent	Weak	Ending in a long curve	Absent
SWM UI Acc-1	Deep	Oblique	Good	Present	Shallow	Weak	Ending in a long curve	Slightly prominent
SWM UI Acc-3	Shallow	Vertical	Excellent	Present	Medium	Intermediate	Slopping abruptly	Slightly prominent
SWM UI Acc-4	Shallow	Vertical	Average	Absent	Absent	Intermediate	Slopping abruptly	Very prominent
SWMUI IDIA Acc-1	Shallow	Oblique	Good	Present	Medium	Weak	Ending in a long curve	Rising and rounded
SWMUI IDIA Acc-2	Shallow	Oblique	Good	Present	Deep	Weak	Ending in a long curve	Rising and rounded
BIGMCB Acc-1	Shallow	Vertical	Average	Absent	Absent	Strong	Ending in a long curve	Slightly prominent
SWM Acc-6	Shallow	Vertical	Excellent	Absent	Absent	Intermediate	Ending in a long curve	Rising and rounded
SWM Acc-7	Shallow	Oblique	Average	Present	Medium	Strong	Slopping abruptly	Rising and rounded
SWM Acc-8	Shallow	Oblique	Average	Present	Medium	Weak	Slopping abruptly	Rising and rounded
OROM Acc-1	Shallow	Oblique	Excellent	Present	Absent	Intermediate	Slopping abruptly	Slightly prominent
OROM Acc-2	Shallow	Oblique	Good	Absent	Absent	Intermediate	Slopping abruptly	Prominent
OROM Acc-4	Deep	Oblique	Excellent	Present	Absent	Intermediate	Ending in a long curve	Slightly prominent
SAKM Acc-2	Shallow	Vertical	Average	Absent	Medium	Strong	Ending in a long curve	Slightly prominent
SAKM Acc-3	Shallow	Vertical	Good	Absent	Absent	Intermediate	Slopping abruptly	Slightly prominent
SAKM Acc-4	Shallow	Vertical	Good	Present	Medium	Intermediate	Slopping abruptly	Slightly prominent
OYOM Acc-1	Shallow	Vertical	Good	Absent	Medium	Strong	Ending in a long curve	Rising and rounded
OYOM Acc-3	Shallow	Vertical	Good	Absent	Absent	Strong	Slopping abruptly	Prominent
OYOM Acc-5	Shallow	Oblique	Average	Present	Shallow	Intermediate	Slopping abruptly	Slightly prominent
BIGM (IPAPO)	Shallow	Vertical	Average	Present	Medium	Strong	Ending in a long curve	Prominent

Table 3A: Qualitative Seed and Pulp Characters of Mango Accessions

Accessions	Seed Shape	Stone Shape	Pattern of Venation	Stone Vein	Texture Of Stone Fiber	Quality of Fiber on the Stone	Adherence of Fiber to Stone	Pulp Colour Of Ripe Fruit
OGBOM NIHORT	Reniform	Reniform	Parallel	Level with surface	Coarse	High	Weak	Yellow
PALMER	Reniform	Reniform	Parallel	Level with surface	Coarse	Medium	Intermediate	Orange-yellow
HARDEN	Reniform	Reniform	Parallel	Depressed	Coarse	Medium	Strong	Yellow
KEINT	Oblong	Oblong	Parallel	Level with surface	Coarse	Medium	Strong	Yellow
ZAIGON	Oblong	Oblong	Parallel	Level with surface	Coarse	Low	Strong	Yellow
EDWARD	Reniform	Reniform	Parallel	Depressed	Coarse	Low	Strong	Yellow
JULIE	Reniform	Reniform	Parallel	Level with surface	Soft	Low	Intermediate	Yellow
OGBM Acc-2	Reniform	Reniform	Parallel	Depressed	Coarse	Medium	Weak	Yellow
OGBM Acc-3	Reniform	Reniform	Parallel	Depressed	Coarse	Medium	Intermediate	Yellow
OGBM Acc-5	Reniform	Reniform	Parallel	Depressed	Coarse	Low	Weak	Yellow
OGBM Acc-8	Reniform	Reniform	Parallel	Level with surface	Coarse	High	Weak	Yellow
OGBSHE Acc-1	Reniform	Reniform	Parallel	Level with surface	Soft	medium	Weak	Yellow
OGBM Acc-9	Reniform	Reniform	Parallel	Level with surface	Coarse	Medium	Weak	Yellow
OGBM Acc-10	Reniform	Reniform	Parallel	Depressed	Coarse	Medium	Intermediate	Yellow
OGBM Acc-13	Reniform	Reniform	Parallel	Level with surface	Coarse	Low	Intermediate	Light orange
SHRIM Acc-2	Reniform	Reniform	Parallel	Depressed	Coarse	High	Weak	Yellow
BUTM Acc-1	Oblong	Oblong	Parallel	Level with surface	Soft	Low	Weak	Yellow
SWM UI Acc-1	Reniform	Reniform	Parallel	Level with surface	Coarse	High	Weak	Yellow
SWM UI Acc-3	Oblong	Oblong	Parallel	Level with surface	Soft	Medium	Intermediate	Yellow
SWM UI Acc-4	Reniform	Reniform	Parallel	Level with surface	Soft	Low	Weak	Yellow
SWMUI IDIA Acc-1	Oblong	Oblong	Parallel	Depressed	Soft	High	Weak	Golden yellow
SWMUI IDIA Acc-2	Reniform	Reniform	Parallel	Depressed	Soft	Medium	Weak	Yellow
BIGMCB Acc-1	Oblong	Oblong	Parallel	Depressed	Soft	Low	Weak	Yellow
SWM Acc-6	Ellipsoid	Ellipsoid	Parallel	Level with surface	Coarse	Medium	Intermediate	Yellow
SWM Acc-7	Ellipsoid	Ellipsoid	Parallel	Depressed	Soft	Low	Weak	Yellow
SWM Acc-8	Ellipsoid	Ellipsoid	Parallel	Depressed	Soft	Low	Intermediate	Yellow
OROM Acc-1	Reniform	Reniform	Parallel	Depressed	Coarse	High	Weak	Yellow
OROM Acc-2	Reniform	Reniform	Parallel	Depressed	Coarse	Medium	Weak	Yellow
OROM Acc-4	Reniform	Reniform	Parallel	Depressed	Coarse	Medium	Weak	Yellow
SAKM Acc-2	Reniform	Reniform	Parallel	Level with surface	Coarse	Low	Weak	Yellow
SAKM Acc-3	Oblong	Oblong	Parallel	Level with surface	Coarse	Medium	Weak	Golden yellow
SAKM Acc-4	Oblong	Oblong	Parallel	Level with surface	Coarse	Low	Weak	Golden yellow
OYOM Acc-1	Ellipsoid	Ellipsoid	Parallel	Depressed	Soft	Medium	Intermediate	Yellow
OYOM Acc-3	Ellipsoid	Ellipsoid	Parallel	Depressed	Soft	Medium	Intermediate	Yellow
OYOM Acc-5	Reniform	Reniform	Parallel	Level with surface	Soft	Low	Intermediate	Yellow
BIGM (IPAPO)	Oblong	Oblong	Parallel	Level with surface	Coarse	Medium	Intermediate	Yellow

Table 3B: Qualitative Seed and Pulp Characters of Mango Accessions Cont.

Accessions	Pulp Texture	Pulp Juiciness	Present Turpentine flavor	Adherence of Fruit Skin to Pulp	Pulp Aroma	Adherence of Fiber To Skin	Quality of Fiberon Stone
OGBOM NIHORT	Smooth	Very juicy	Strong	Weak	Strong	Low	Scare
PALMER	Smooth	Slightly juicy	Intermediate	Strong	Intermediate	Medium	Scare
HARDEN	Rough	Juicy	Strong	Intermediate	Intermediate	Medium	Scare
KEINT	Smooth	Juicy	Intermediate	Strong	Mild	Strong	Scare
ZAIGON	Smooth	Very juicy	Intermediate	Weak	Strong	Low	Intermediate
EDWARD	Smooth	Juicy	Intermediate	Intermediate	Intermediate	Medium	Intermediate
JULIE	Smooth	Juicy	Strong	Intermediate	Intermediate	Medium	Intermediate
OGBM Acc-2	Smooth	Juicy	Intermediate	Weak	Strong	Low	Intermediate
OGBM Acc-3	Smooth	Juicy	Intermediate	Week	Strong	Low	Intermediate
OGBM Acc-5	Smooth	Juicy	Intermediate	Weak	Strong	Low	Intermediate
OGBM Acc-8	Smooth	Very juicy	Strong	Weak	Strong	Low	Intermediate
OGBSHE Acc-1	Smooth	Juicy	Intermediate	Intermediate	Intermediate	Medium	Intermediate
OGBM Acc-9	Smooth	Very juicy	Strong	Weak	Strong	Low	Intermediate
OGBM Acc-10	Rough	Very juicy	Strong	Weak	Strong	Low	Intermediate
OGBM Acc-13	Rough	Juicy	Strong	Intermediate	Strong	Low	Intermediate
SHRIM Acc-2	Smooth	Very juicy	Intermediate	Weak	Strong	Low	Intermediate
BUTM Acc-1	Smooth	Slightly juicy	Intermediate	Intermediate	Mild	Medium	Intermediate
SWM UI Acc-1	Smooth	Very juicy	Strong	Intermediate	Strong	Low	Intermediate
SWM UI Acc-3	Smooth	Very juicy	Strong	Weak	Strong	Low	Intermediate
SWM UI Acc-4	Smooth	Very juicy	Strong	Weak	Strong	Low	Intermediate
SWMUI IDIA Acc-1	Smooth	Slightly juicy	Intermediate	Intermediate	Mild	Low	Intermediate
SWMUI IDIA Acc-2	Smooth	Juicy	Strong	Weak	Strong	Low	Scare
BIGMCB Acc-1	Smooth	Slightly juicy	Absent	Strong	Mild	Low	Scare
SWM Acc-6	Smooth	Juicy	Strong	Intermediate	Intermediate	Low	Intermediate
SWM Acc-7	Smooth	Juicy	Strong	Weak	Intermediate	Low	Intermediate
SWM Acc-8	Smooth	Juicy	Intermediate	Intermediate	Intermediate	Low	Intermediate
OROM Acc-1	Smooth	Slightly juicy	Intermediate	Intermediate	Mild	Medium	Intermediate
OROM Acc-2	Smooth	Juicy	Strong	Intermediate	Strong	Low	Intermediate
OROM Acc-4	Smooth	Slightly juicy	Intermediate	Weak	Intermediate	Medium	Intermediate
SAKM Acc-2	Smooth	Very juicy	Strong	Weak	Strong	Low	Intermediate
SAKM Acc-3	Smooth	Very juicy	Intermediate	Weak	Strong	Low	Intermediate
SAKM Acc-4	Smooth	Juicy	Intermediate	Intermediate	Intermediate	Medium	Intermediate
OYOM Acc-1	Smooth	Juicy	Intermediate	Weak	Intermediate	Low	Scare
OYOM Acc-3	Smooth	Juicy	Intermediate	Weak	Intermediate	Low	Scare
OYOM Acc-5	Smooth	Juicy	Strong	Weak	Strong	Low	Scare
BIGM (IPAPO)	Smooth	Very juicy	Strong	Weak	Strong	Low	Intermediate

Table 4A: The Quantitative Fruit, Leaf, Pulp and Seed Characters of Mango Accessions

ACCESSIONS	FRUIT WEIGHT (g)	FRUIT LENGTH (cm)	FRUIT WIDTH (cm)	FRUIT LENGTH TO WIDTH RATIO	FRUIT THICKNESS (cm)	No of Leaves	Leaf Length (cm)	Leaf Width (cm)	Leaf Area (cm^2)
SHRIM Acc-2	111.79	10.30	8.56	1.27	5.25	5.00	23.02	4.56	104.98
BIGM (IPAPO)	455.78	15.63	13.33	1.17	8.84	4.00	19.38	4.55	88.79
BIGMCB Acc-1	751.75	18.18	18.23	0.99	10.13	4.00	28.48	5.05	139.17
BUTM Acc-1	247.90	12.04	11.50	1.05	6.66	4.00	26.28	4.72	123.74
EDWARD	470.40	15.68	14.25	1.10	7.94	5.00	26.74	6.64	177.67
HARDEN	443.00	16.68	16.25	1.19	7.28	5.00	18.44	4.16	77.49
JULIE	442.00	15.34	13.97	1.10	7.71	5.00	20.00	5.84	116.32
KEINT	669.50	18.00	14.75	1.29	9.18	4.00	16.23	6.28	100.11
OGBM Acc-2	190.09	12.90	13.33	1.04	6.14	5.00	27.80	6.67	187.70
OGBM Acc-3	247.16	12.93	12.82	1.30	6.56	4.00	20.95	3.55	74.98
OGBM Acc-4	242.98	12.32	13.65	1.04	6.42	5.00	18.80	4.40	83.86
OGBM Acc-10	216.57	12.16	11.03	1.13	6.45	5.00	39.22	5.00	198.79
OGBM Acc-13	233.53	12.66	10.73	1.17	6.62	5.00	25.56	4.52	115.79
OGBSHEM Acc-1	167.87	10.08	5.46	1.86	9.25	5.00	21.02	4.98	103.87
OGBOM NIHORT	201.40	11.80	10.93	1.08	6.43	5.00	16.04	4.26	69.57
OROM Acc-1	218.134	12.28	10.71	1.15	6.52	5.00	20.02	4.34	87.222
OROM Acc-2	136.30	10.76	8.97	1.20	5.63	5.00	20.02	4.34	94.43
OROM Acc-4	207.06	12.22	10.23	1.19	6.29	5.00	19.82	4.72	97.7
OYOM Acc-1	140.78	11.36	9.64	1.17	5.86	5.00	19.24	4.24	80.42
OYOM Acc-3	92.28	10.24	8.71	1.18	4.99	5.00	19.86	5.52	109.89
OYOM Acc-5	138.38	9.83	9.28	1.06	5.64	5.00	18.82	4.52	86.08
OYOM Acc-6	131.252	9.46	8.98	1.05	5.39	5.00	20.48	4.40	90.46
PALMER	466.67	17.47	13.62	1.28	7.45	5.00	19.00	4.53	86.64
ZAIGON	207.00	13.30	10.76	1.24	5.91	5.00	19.54	7.10	166.23
SAKM Acc-2	203.26	11.78	10.50	1.12	6.74	5.00	19.24	4.22	83.16
SAKM Acc-3	231.622	12.24	10.85	1.13	7.08	5.00	22.66	4.70	106.83
SAKM Acc-4	249.22	11.76	10.90	1.08	7.28	5.00	30.18	4.50	135.51
OGBM Acc-8	224.07	12.24	6.08	2.02	11.13	5.00	25.60	5.26	134.83
SWM UI Acc-1	228.3	13.28	10.61	1.25	6.28	5.00	30.06	5.42	162.94
SWM UI Acc-3	146.25	10.66	9.64	1.11	8.78	5.00	22.18	4.78	107.5
SWM UI Acc-4	195.18	13.03	9.69	34.5	6.39	4.00	30.03	4.48	134.97
SWM Acc-6	142.5	10.68	9.64	1.11	5.70	5.00	19.58	5.02	97.8
SWM Acc-7	214.15	12.04	11.55	1.04	7.09	5.00	23.46	4.12	98.95
SWM Acc-8	293.82	14.08	12.41	1.14	7.40	5.00	20.48	4.90	102.53
SWMUI IDIA Acc-1	197.56	12.10	10.82	1.13	6.50	5.00	19.98	5.28	106.66
SWMUI IDIA Acc-2	171.86	12.64	10.33	1.23	6.17	5.00	21.76	4.66	99.73

Table 4B: The Quantitative Fruit, Leaf, Pulp and Seed Characters of Mango Accessions Contd.

Accessions	Petiole Length (cm)	Intermodal Length (cm)	Lamina Length (cm)	Stone Dry Weight (g)	Stone Length (g)	Stone Wet Width (g)	Stone Width ratio (cm)	Stone Thickness (cm)
SHRIM Acc-2	3.10	0.84	19.92	20.59	8.48	23.04	2.05	2.44
BIGM (IPAPO)	1.80	1.78	17.58	27.76	8.73	29.78	2.40	2.31
BIGMCB Acc-1	3.95	2.35	24.53	20.33	9.30	32.40	5.08	2.76
BUTM Acc-1	4.82	2.44	21.64	17.89	7.40	23.00	5.33	2.78
EDWARD	4.64	3.34	22.10	24.80	7.86	28.88	4.49	2.75
HARDEN	5.22	3.76	13.22	28.67	7.86	32.32	5.45	3.01
JULIE	4.78	4.10	15.22	23.80	7.26	34.26	5.75	3.03
KEINT	4.10	3.78	12.13	23.00	7.85	30.99	5.10	2.90
OGBM Acc-2	3.18	2.17	24.63	25.62	7.58	28.30	5.74	2.10
OGBM Acc-3	3.00	1.78	17.95	32.13	0.43	34.17	6.17	2.78
OGBM Acc-4	2.26	0.82	16.54	28.83	7.88	39.04	5.67	2.45
OGBM Acc-10	6.54	2.10	32.68	30.22	8.14	33.72	6.36	2.93
OGBM Acc-13	4.52	2.54	21.04	28.07	8.26	32.27	5.68	2.86
OGBSEM Acc-1	1.98	1.22	19.04	25.07	8.14	28.71	1.93	2.23
OGBOM NIHORT	5.24	4.06	10.80	28.51	7.40	31.05	5.12	2.63
OROM Acc-1	3.16	0.70	16.86	26.35	6.00	32.95	5.91	2.33
OROM Acc-2	3.02	0.94	17.00	27.78	5.94	29.96	5.93	2.46
OROM Acc-4	2.46	0.92	17.36	28.36	5.74	31.34	5.77	2.56
OYOM Acc-1	4.22	2.68	15.02	28.50	7.06	17.07	5.41	2.78
OYOM Acc-3	4.18	3.94	15.68	28.76	6.90	10.48	4.44	2.80
OYOM Acc-5	2.44	1.12	16.38	20.16	7.18	14.98	5.21	2.68
OYOM Acc-6	2.48	2.24	18.00	22.12	6.48	12.85	5.3	3.14
PALMER	5.17	3.60	15.30	29.14	7.75	31.39	5.74	2.80
ZAIGON	3.74	2.70	19.70	28.16	7.70	22.46	4.95	1.99
SAKM Acc-2	2.42	0.72	16.82	27.72	5.94	30.93	6.02	2.28
SAKM Acc-3	2.06	0.88	20.60	28.00	8.20	29.58	2.48	1.70
SAKM Acc-4	2.48	1.68	27.70	34.324	8.44	36.74	2.632	2.29
OGBM Acc-8	5.24	2.08	20.30	50.41	7.52	32.13	5.85	2.37
SWM UI Acc-1	5.02	1.50	25.04	19.31	8.68	32.15	5.75	3.09
SWM UI Acc-3	1.66	0.84	15.14	18.43	9.76	21.84	1.78	5.26
SWM UI Acc-4	2.55	3.43	27.48	15.09	9.98	18.30	2.42	2.17
SWM Acc-6	4.44	2.20	15.14	23.70	6.44	26.80	5.33	2.33
SWM Acc-7	3.22	1.56	20.24	25.99	7.36	30.82	6.03	2.37
SWM Acc-8	3.67	1.54	16.81	27.04	6.68	30.11	5.37	2.56
SWMUI IDIA Acc-1	2.82	1.58	17.16	22.86	8.20	25.39	5.30	2.62
SWMUI IDIA Acc-2	2.84	1.40	18.92	19.55	8.12	21.30	21.30	2.37

Table 5: Mean Square Effects of location, replicate, accessions and weeks on the growth related characters of Mango

Source of Variation	Df (n-1)	Sprouting Days	No of Leaves per Seedling	Leaf Length (cm)	Leaf Width (cm)	Leaf Area (cm^2)	Petiole Length (cm)	Internodal Length (cm)	Plant Height (cm)	Lamina Length (cm)
Model	788	14.90**	14.90**	86.20**	5.40**	988.55**	0.92**	10.30**	241.99**	83.07**
Location	5	239.73**	78.82**	2529.15**	130.24**	48428.72**	20.32**	339.91**	4004.85**	2507.74**
Replicate	3	2.58	2.44	84.78**	4.94**	109.59**	0.39	2.31	39.82	86.05**
Accessions	6	36.93**	213.96**	457.18**	16.77**	13116.05**	6.27**	45.40**	670.3	377.79
Week	11	153.23**	1030.80**	2229.99**	97.88**	8134.23**	20.26**	171.73**	7763.01**	2072.55**
Location x Replicate	15	3.12**	6.25**	12.00*	1.03**	122.82**	0.24	2.64	68.85**	12.01**
Location x Accessions	21	14.33**	161.78**	479.09**	38.68**	7727.62**	5.57**	81.47**	1028.35**	453.22**
Location x Weeks	55	72.71**	42.43**	116.82**	13.39**	1267.73**	0.41**	8.93**	134.45**	453.22**
Accessions x Replicate	18	1.37	3.89	36.04**	1.87**	96.02**	0.21	7.48**	42.75	36.36**
Week x Replicate	33	4.50**	0.97	8.73**	0.98**	19.68**	0.35	1.43	16.39	8.24**
Weeks x Accessions	55	11.50**	24.07**	12.78**	1.72**	201.83**	0.3	3.70**	104.14**	12.72**
Location x Accessions x Replicate	54	1.25	7.69**	27.64**	1.37**	118.74**	0.38**	9.16**	111.58**	27.92**
Location x Weeks x Replicate	162	1.15	1.72	4.84**	0.43**	12.41**	0.18	1.06	19.5	78.82**
Location x Weeks x Accessions	185	7.78**	21.38**	22.10**	1.77**	261.94**	0.38**	4.02**	114.92**	21.60**
Weeks x Accessions Replicate	165	0.79**	2.23	2.29	2.27	11.35	0.15**	1.13	16.43	2.43
Error	533	0.96	1.93	2.19	0.26	21.53	0.17	1.06	19.86	2.3

Note: * P<0.05 significant, ** P<0.01 highly significant, *** P<0.001 highly significant.

Table 6: Quantitative Characters of Mango at different locations

Locations	Sprouting Days	Number of Leaves per Seedling	Leaf Length (cm)	Leaf Width (cm)	Leaf Area (cm^2)	Petiole Length (cm)	Internodal Length (cm)	Plant Height (cm)	Lamina Length (cm)
1	2.67^{a}	7.08^{d}	8.29^{e}	2.23^{f}	8.45^{e}	1.28^{e}	1.31^{e}	14.76^{d}	8.31^{e}
2	0.68^{b}	7.56^{bc}	18.53^{a}	4.40^{a}	18.53^{c}	2.14^{a}	3.56^{b}	25.17^{a}	18.53^{a}
3	0.311^{d}	7.31^{cd}	15.16^{bc}	3.77^{c}	26.53^{b}	1.82^{d}	2.59^{d}	21.43^{c}	14.49^{c}
4	0.56^{bc}	7.69^{b}	14.69^{d}	3.65^{d}	14.67^{d}	1.81^{d}	3.33^{c}	22.97^{b}	14.69^{c}
5	0.41^{cd}	8.56^{a}	15.38^{b}	4.05^{b}	14.66^{d}	2.02^{b}	4.70^{a}	25.43^{a}	15.31^{b}
6	0.00^{e}	7.51^{bc}	15.07^{c}	3.33^{e}	56.91^{a}	1.93^{c}	2.74^{d}	23.16^{b}	13.14^{d}

Mean with the same letter in the same column are not significant at $p<0.05$ according to Duncan Multiple Range Test (DMRT)

LOCATION KEY: 1: NIHORT, 2: OGBOMOSHO, 3: SAKI, 4: IBADAN, 5: ISEHIN, 6: OYO.

Table 7: Principal Component Axis showing the Growth Characters of Mango

Characters	Prin.1	Prin.2	Prin.3	Prin.4	Prin.5	Prin.6	Prin.7	Prin.8
SD	0.16	0.60	0.09	-0.05	0.30	0.70	0.17	0.01
NL	0.13	0.62	0.01	-0.2	-0.28	-0.51	0.45	0.07
LL	0.47	-0.10	0.08	-0.08	-0.06	0.16	0.17	-0.42
LW	0.41	-0.24	-0.25	-0.25	-0.04	0.24	0.25	0.75
LA	0.2	0.01	0.31	0.31	-0.09	-0.01	-0.05	0.18
PL	0.35	0.12	-0.11	-0.11	0.82	-0.34	0.22	0.05
IL	0.28	0.15	0.86	0.86	0.00	0.01	0.10	0.09
PH	0.33	0.36	-0.14	-0.14	-0.37	0.11	-0.76	0.07
LAL	0.47	-0.10	-0.12	-0.12	-0.06	0.18	0.19	-0.46
Eigen values	4.13	1.67	0.93	0.68	0.55	0.47	0.41	0.16
Proportion (%)	45.90	18.57	10.36	7.51	6.10	5.18	4.58	1.79

KEYS: Prin: Principal Component Axes, **SD:** Sprouting Days, **NL**: Number of Leaves per seedling, **LL:** Leaf Length, **LW**: Leaf Width, **LA:** Leaf Area, **PL**: Petiole Length, **IL**: Internodal Length, **PH**: Plant Height**,, LAL:** Lamina Length.

Table 8: Correlation coefficients among the growth related characters of Mango

	SD	NL	LL	LW	LA	PL	IL	PH	LAL	LOC	WEK	SAMP	REP
SD													
NL	0.19												
LL	-0.37	0.47											
LW	-0.44	0.30	0.87**										
LA	-0.20	0.29	0.56*	0.36									
PL	-0.17	0.50*	0.74**	0.62**	0.44								
IL	-0.15	0.46	0.60**	0.47	0.31	0.53							
PH	-0.06	0.70**	0.71**	0.56*	0.4	0.64**	0.59*						
LAL	-0.36	0.47	0.99**	0.88**	0.47	0.72**	0.60**	0.70**					
LOC	-0.26	0.05	0.23	0.19	0.45	0.23	0.22	0.21	0.17				
WEK	-0.08	0.69**	0.54*	0.42	0.31	0.49	0.46	0.65**	0.54*	0.01			
SAMP	-0.01	0.01	-0.1	-0.11	-0.05	-0.11	0.10	-0.01	-0.10	0.02	0.01		
REP	-0.02	0.00	-0.9	-0.08	-0.05	-0.08	-0.05	0.02	-0.09	-0.01	0.01	-0.01	

Note: * P<0.05 significant, ** P<0.01 highly significant, *** P<0.001 highly significant.

KEYS: SD: Sprouting Days**, NL**: Number of Leaves per seedling, **LL:** Leaf Length, **LW**: Leaf Width, **LA:** Leaf Area, **PL**: Petiole Length, **IL**: Internodal Length, **PH**: Plant Height, **LAL:** Lamina Length, **WEK**: Week, **SAM**P: Sample, **REP**: Replicate.

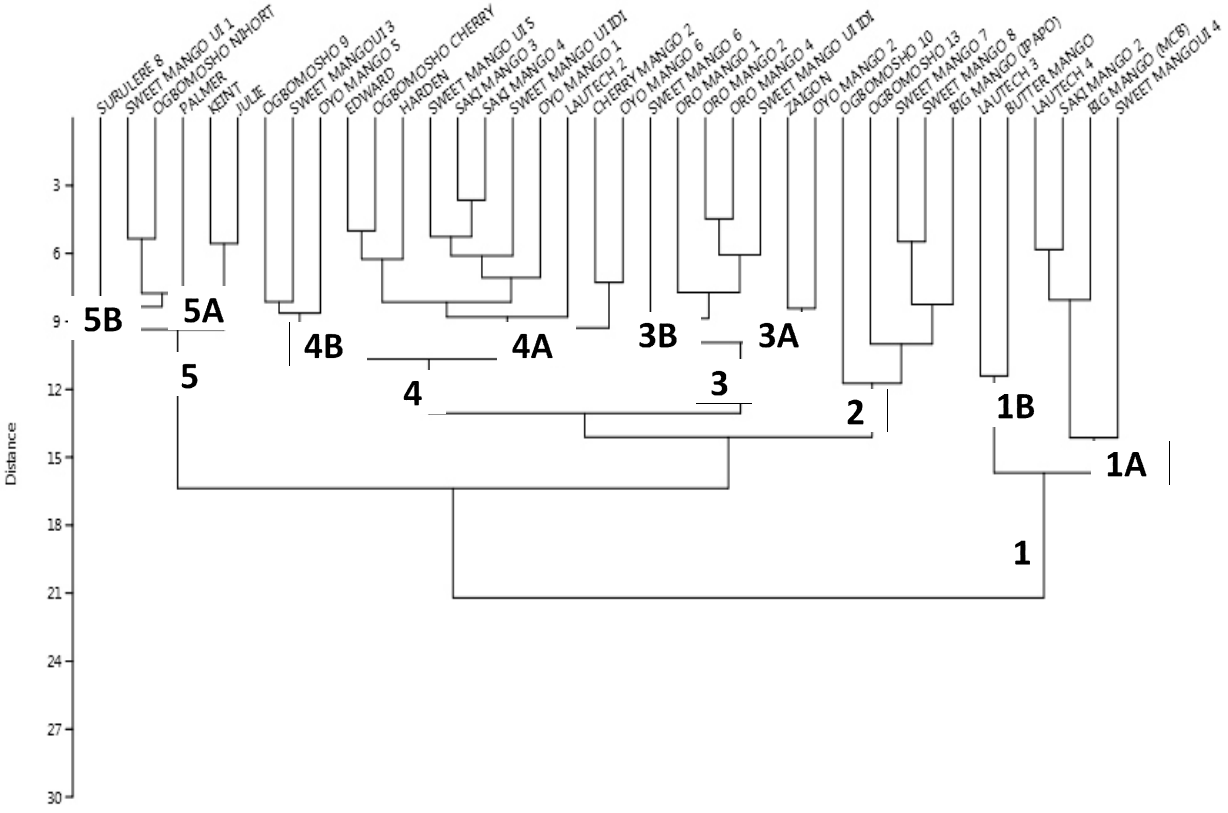

Figure 1: Dendrogram of Qualitative Characters in Fruit, Leaf, Seed and Pulp of *Mangifera indica*

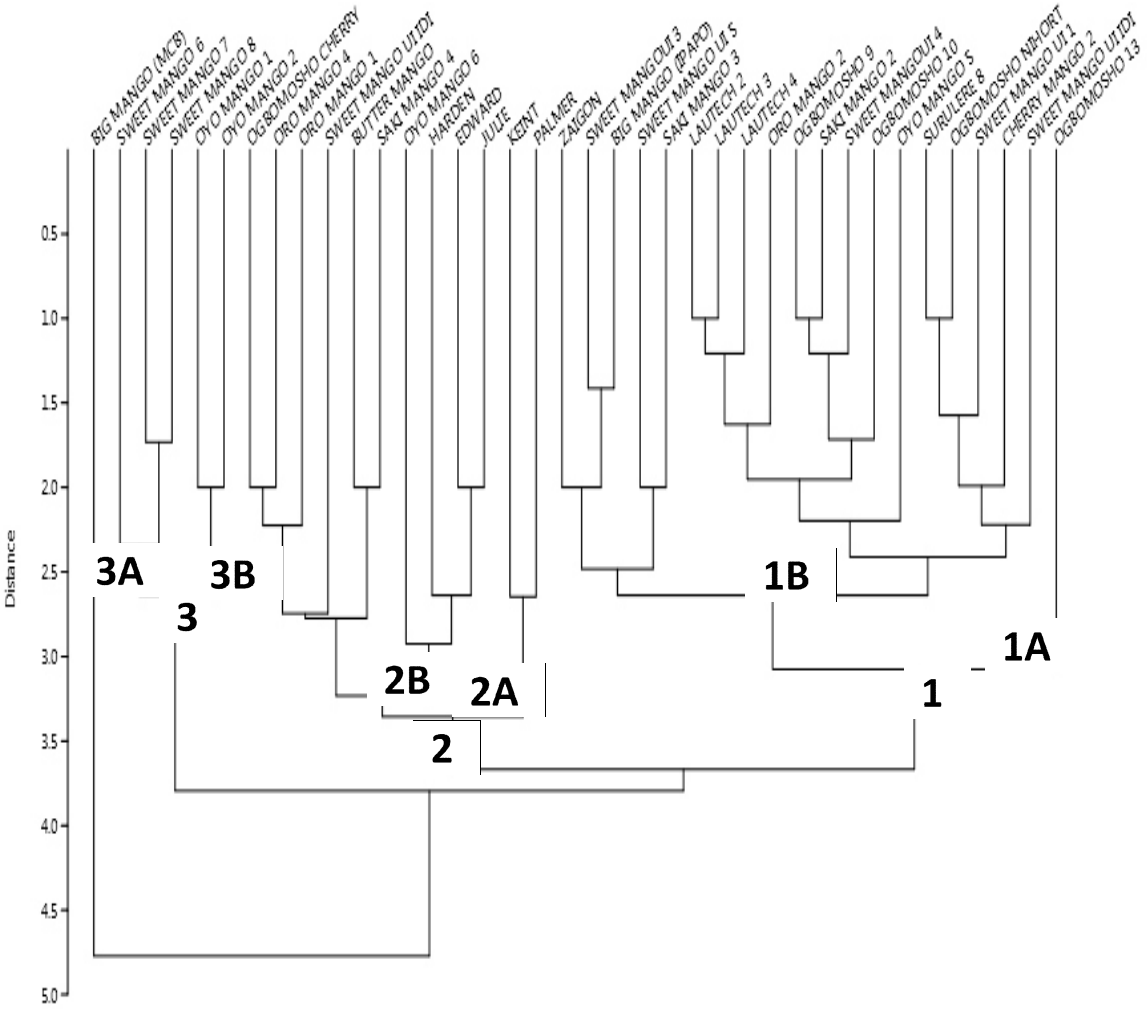

Figure 2: Dendrogram of Fruit, Leaf, Seed and Pulp Quantitative Characters of Mango

DISCUSSION

Morphological characterizations are easy to assess and widely applied by farmers and breeders. The fruit characters showed high diversity among different mango accessions. Therefore, these characteristics are important for identifying and differentiating mango accessions (Tables 2A and 2B). The findings of Illoh and Olorode (1991), Galvez-Lopez *et al.* (2010), Mussane *et al.* (2010) and Rajwana *et al.* (2011) confirmed the identified fruit characteristics with greatest discriminatory factors in mango identification. Palmer with orange-yellow pulp colour and other accessions of NIHORT with yellow colour agreed with the result of Akinyemi *et al.* (2017), who reported yellow pulp colour in Palmer mango. Moreover, characters such as fruit shape, fruit skin color when ripe and pulp colour of ripe fruit have multigenic characters in their expression (Akinyemi *et al.,* 2017).

The PCA and correlation matrix varied in character association in accordance with the reports made by Fayeun *et al.* (2012), Aremu *et al.* (2014) and Olawuyi *et al.,* (2022) which accounted for diversity in mango and other crops. This implies that promising characters such as leaf width, petiole length, leaf length, lamina length, and plant height showed variability in a specific characters and this can be utilized in crop improvement.

The results of correlation coefficient showed characters and positive correlation that can promote the selection and development of another character as similarly observed by Fayeun *et al.* (2012).

The leaf length, petiole length, internodal length, lamina length, plant height and leaf width are characters to be considered during selection for improvement of *Mangifera indica*.

The results from dendrogram showed the relationships among mango accessions based on qualitative and quantitative characters in fruit, leaf, seed and pulp. There were variability in morphological traits of mango, particularly in fruit length, fruit weight, fruit area, leaf length, leaf area, petiole length, stone width, fruit ground colour, fruit beak type and pulp colour. Also, there were similarities in the accessions collected from NIHORT orchard and that of the wild. These might have resulted from the frequent use of few parents in breeding of mango within the selected locations as similarly reported by Kumar *et al.* (2013).

Furthermore, BUTM Acc-1 (fruit ground colour), OGBM Acc-13 (fruit size), PALMER (pulp colour), BIGMCB Acc-1 (fruit weight), SHERIM Acc-2 (fruit beak), OGBM Acc-3 (stone dry weight), OGBM Acc-8 (fruit thickness) and OGBM Acc-10 (fruit stone width) accessions gave additional insights to morphological characteristics of mango, though different accessions from same locations showed some distinguishing factor. The level of relatedness in the mango accessions resulted from the method of propagation and /or the use of closely related parents.

CONCLUSION

There were morphological variations among the Mango accessions and these facilitated proper characterization of Mango. However, BUTM Acc-1, OGBM Acc-13, PALMER, BIGMCB Acc-1, SHERIM Acc-2, OGBM Acc-2, OGBM Acc-8 and OGBM Acc-10 were promising accessions to be considered in further breeding of Mango. The leaf length, petiole length, internodal length, lamina length, plant height and leaf width are also characters to be considered during selection for improvement of *Mangifera indica*.

ACKNOWLEDGEMENTS

We appreciate the assistance of Mr. Ishola and the authorities of the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. Thanks for all your support.

AUTHORS' CONTRIBUTIONS

AII wrote the protocol and the first draft of the manuscript. Author OOJ and AEA performed the statistical analysis and interpreted the analyses of the study. All authors managed the literature searches, read and approved the final manuscript.

FUNDING

This research did not receive any specific grant from individual or funding agencies.

COMPETING INTERESTS

Authors declared that no competing interests exist.

REFERENCES

Akinyemi, S.O., Arogundade, O.A., Akin-Idowu, P.E. Aderonmu, O.I, and Esuola, O.C. 2017. Molecular characterization of different mango *Mangifera indica* cultivar in South-West Nigeria using Random Amplified Polymorphic DNA (RADP) Markers. Lambert Academic Publishing. Translating Research Finding into Policy in Developing Countries. Contributions from Humboldt Kollege, Osogbo. Pp 195-206.

Aremu, M.O., Opaluwa, O.D., Bamidele, T.O., Nweze, C.C., Ohale, I.M. and Ochege, M.O. 2014. Comparative evaluation of nutritive value of okro (*Abelmoschus esculentus*) and bush mango (*Irvingia gabonensis)* fruits grown in Nasarawa State, Nigeria. *Food Science and Quality Management,* 27: 63-70.

Bally, I.S.E, Lu, P. and Johnson, P.R. 2009. Mango breeding. In: Jain, S.M., Priyadarshan, P.M. (eds) Breeding Plantation Tree Crops: Tropical Species. Springer, New York, 51–82.

Barua, H., Patwary, M. A. and Rahman, M. 2013. Performance of Bari mango *(Mangifera indica L.)* varieties in Chittagong region. *Bangladesh Journal of Agricultural Research,* 38(2): 203–209.

Begum, H., Reddy, T.M., Malathi, S., Reddy, B.P., Arcahk, S., Nagaraju, J. and Siddiq, E.A. 2012. Molecular analysis for genetic distinctiveness and relationships of indigenous landraces with popular cultivars of mango in Andhra Pradesh, India. *The Asian and Australian Journal of Plant Biotechnology,* 6(1): 24-37.

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

Brettell, R., Coulson, M. and González, A. 2002. Development of DNA markers ISSRs) in mango. *Acta Horticulturae,* 575: 139-143.

El Kheshin, M.A., Hossam, A.S. and Abdou, M. 2016. Morphological and molecular analysis of genetic diversity among some 'sukkary' mango (*Mangifera indica* L.) genotypes. *Journal of Horticultural Science and Ornamental Plants,* 8(1): 01-10.

Fayeun, S.L., Odiyi, A.C., Makinde, S.C. and Aiyelari, O.P. 2012. Genetic variability and correlation studies in the fluted pumpkin (*Telfairia occidentalis* Hook F.). *Journal of Plant Breeding and Crop Science,* 4(10): 156-160.

Fowomola, M.A. 2010. Some nutrients and antinutrients contents of mango (*Mangifera indica*) seed. *African Journal of Food Science,* 4(8): 472–476.

Galvez-Lopez, D., Hernandez-Delgado, S., Gonzalez-Paz, M., Becerra-Leor, E.N., Salvador-Figueroa, M. and Mayek-Perez, N. 2010. Genetic analysis of mango landraces from Mexico based on molecular markers. *Plant Genetic Resources*, 7: 244-251.

Gibert, O., Dufour, D., Giraldo, A., Sánchez, T., Reynes, M., Pain, J.P. and Díaz, A. 2009. Differentiation between cooking bananas and dessert bananas; morphological and compositional characterization of cultivated Colombian Musaceae (*Musa* sp.) in relation to consumer preferences. *Journal of Agricultural and Food Chemistry*, 57(17): 7857–7869.

Illoh, H.C. and Olorode, O. 1991. Numerical taxonomic studies of Nigerian mango varieties (*Mangifera indica* Linn.) *Euphytica,* 40: 197-205.

International Board for Plant Genetic Resources, 2015. Genetic resources, diversity and breeding. Retrieved from: www.cgiar.org and www.fao.org. Accessed on 5, February, 2022 at 1:10 pm.

International Plant Genetic Resources Institute, 2006. *Descriptors of Mango*, Pg 1-71.

Karihaloo, J.L., Dwivedi, Y.K., Archak, S. and Gaikwad, A.B. 2003. Analysis of genetic diversity of Indian mango cultivars using RAPD markers. *Journal of Hortricultural Science and Biotechnology,* 78: 285-289.

Kittiphoom, S. 2012. Utilization of Mango seed. *International Food Research Journal,* 19(4): 1325-1335.

Kostermans, A.J.G.H and Bompard, J.M. 1993. The Mangoes: Their Botany, Nomenclature, Horticulture and Utilization. Academic Press, Waltham.

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

Kumar, M., Ponnuswami, V., Nagarajan, P. and Jeyakumar, P. 2013. Molecular characterization of ten mango cultivars using simple sequences repeat (SSR) markers. *African Journal of Biotechnology,* 12: 6568-6573.

Mhamed, Z.M.A. and Ahmed, T.H.M. 2015. Diversity of Mango (*Mangifera indica* L.) Cultivars in Shendi Area: Morphological Leaf Characterization. *International Journal Resources of Agricultural Sciences*, 2(4): 2348–3997.

Mukherjee, S.K. 1951. Origin of mango. *Indian Journal of Genetics and Plant Breeding*, 11: 49-56.

Mussane, C.R.B., Biljon, A.V. and Herselman, L. 2010. Morphological and genetic characterization of mango varieties in Mozambique. Second RUFORUM Biennial Meeting 20 - 24 September 2010, Entebbe, Uganda: 991-995.

National Bureau of Plant Genetic Resources, 2007. State of plant genetic resources for food and agriculture in India (1996-2006). A Country Report. Indian Council of Agricultural Research, New Delhi,. p70.

Olawuyi, O.J., Ayodele, A.E., Ezekiel P.C. and Ajayi, I.I. 2022. Genetic assessment of Mangifera indica Linn.(Mango) from selected locations in Oyo State, Nigeria. *Journal of Biological Research and Biotechnology, Bio-Research*, 20(2): 1446-1460.

Rajwana, I.A., Tabbasam, N., Malik, A.U., Malik, S.A., Rahman, M. and Zafar, Y. 2011.

Assessment of genetic diversity among mango (*Mangifera indica* L.) genotypes using RAPD markers. *Scientia Horticulturae*, 117: 297-301.

Ribeiro, S. I.C., Lima-Neto, F.P. and Santos, C.A. 2013. Allelic database and accession divergence of a Brazilian mango collection based on microsatellite markers. *Genetic Molecular Resources,* 11: 4564–4574.

Roy, B. and Visweswariya, S.S. 1951. Cytogenetics of mango and banana, report. Maharashtra Association for the Cultivation of Sciences, Pune. India.

Toili, M.E.M., Rimberia, F.K., Nyende, A.B., Mutwiwa, U., Kaluli, J. and Sila, D. 2013. Electronic document delivery - Assessing morphological diversity of mango germplasm from upper Athi river (UAR) region of eastern Kenya. www.elearning.jkuat.ac.ke/journals/ojs/index.php/jscp/article/viewFile. Accessed on 09/08/2013.

Verheiji, E. 2004. Propagating and planting trees Agrodok-series. *Agromisa*/CTA.102.

Yonemori, K., Honsho, C., Kanzaki, S., Eiadthong, W. and Sugiura, A. 2002. Phylogenetic relationships of *Mangifera* species revealed by ITS sequences of nuclear ribosomal DNA and a possibility of their hybrid origin. *Plant System Evolution*, 231: 59–75.