

Agromorphological Characterisation of 29 Accessions of Okra (Abelmoschus spp L.)

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Abstract
The West African sub-region is indisputably the region of greatest diversity of Okra (*Abelmoschus* spp L.) germplasm as it currently hosts some 1,769 accessions of Okra (representing 77.49%) out of the 2, 283 reported world-wide. These are largely uncharacterised, making it practically impossible to ascribe specific attributes to known accessions to facilitate breeding for further improvement to meet specific demands by end-users or industrial-scale production. Twenty six (26) local accessions and three (3) exotic lines of Okra were collected from eight geographic regions of Ghana. Their agro-morphological traits were evaluated under field conditions on the research farm of the Biotechnology and Nuclear Agriculture Research Institute. Hierarchical cluster analysis of results grouped the accessions into two major clusters and subsequently into five sub-clusters based on the qualitative characters studied. The pattern of clustering did not indicate any relationship with geographic origin of collection. The two most divergent accessions were Cs-Legon (local accession) and Clemson spineless (exotic line). There were no duplicates among the accessions which exhibited great variability with respect to all vegetative as well as reproductive characters, except one.
Keywords: Okra; accession; characterisation; phenotypic variation; cluster analysis; genetic similarity index.

1.0. Introduction

Okra (*Abelmoschus* spp L.) also known as Okro, is a tropical vegetable crop, grown throughout Africa [Schippers, 2000; Norman, 1992], Asia and the Americas [Siemonsma & Kouame, 2004; Tindall, 1983] for its immature fruits, and seeds. In West Africa, the fruits, leaves, buds and flowers are eaten as vegetable (boiled fresh or fried) [Oppong-Sekyere et al., 2012; Siemonsma & Kouame, 2004] and often dried for storage during bumper harvests. It provides dietary fibre, distinct proteins [Kumar et al., 2010; National Academies Press, 2006], edible oil [Tindall, 1983], assorted minerals and vitamins [Ahiakpa et al., 2014b; Lamont Jr., 1999; Norman, 1992] as well as mucilage for thickening soups and stews [Ahiakpa et al., 2014a; Woofe et al., 1977]. It has extensive culinary [Oppong-Sekyere et al., 2012; Akintoye et al., 2011; Calisir et al., 2005; Moekchantuk&Kumar, 2004; Doijode, 2001], medicinal [Ahiakpa et al., 2013b; Indah, 2011; Collins, 2010; Dan & Gu, 2010; Adetuyi, 2008; Lengsfeld et al., 2004], and industrial [Kumar et al., 2010; Omonhinmin&Osawaru, 2005; Norman, 1992] properties.

Of 2, 283 accessions reported world-wide [Anonymous, 2010; Hamon&van Sloten, 1989], some 1,769 (77.49%) are currently found in West Africa [Oppong-Sekyere et al., 2012; Hamon&van Sloten, 1989], making it the region of greatest diversity [Ahiakpa et al., 2013a] represented by a wide variation in agro-morphological characteristics displayed in different eco-geographical areas [Amoatey et al., 2015; Ahiakpa et al., 2013a]. These are largely uncharacterised making it impossible to ascribe specific attributes to known accessions to facilitate industrial-scale production or breeding for further improvement to meet specific demands by end-users.

The value of germplasm depends not only on the number of accessions, but also upon the diversity present within [Omonhinmin&Osawaru, 2005; Ren et al., 1995]. Diversity based on phenotypic characters usually varies with environment and their evaluation requires growing plants to full maturity prior to identification [Doku et al., 2013; Aladele et al., 2008]. The almost absence of readily available information on agro-morphological characters of Okra germplasm for breeders and researchers is a limitation to Okra improvement [Amoatey et al., 2015; Ahiakpa et al., 2013a]. The objective of this paper was to assess phenotypic diversity among a collection of 29 Okra accessions, establish any duplications among them and identify superior ones with desirable characteristics for further breeding work.

2.0. Materials and Methods

2.1. Collection of Accessions

Twenty-nine (29) accessions of Okra (*Abelmoschus* spp L.) were collected from eight different geographic regions of Ghana using passport data [IPGRI, 1991]; eight (8) were collected from the Greater Accra, six (6) from Ashanti, five (5) from Brong Ahafo, three (3) from Eastern, three (3) from Upper East, two (2) from Volta, one (1) each from Central and Western regions. The study was conducted at the Nuclear Agriculture Research Centre (NARC) of the Biotechnology and Nuclear Agriculture Research Institute (BNARI), Ghana Atomic Energy Commission (GAEC). The soil at the site is the Nyigbenya-Haatso series, which is a typically well-drained savannah Ochrosol (Ferric Acrisol) derived from quartzite Schist [FAO/UNESCO, 1994].

2.2. Experimental Design and Field Layout

A total land area of 60m x 33m was cleared; all stumps were removed and ploughed to a fine tilth for planting. The Randomised Complete Block Design (RCBD) was used with four replications; each replicate measured 30m x 12.5m, separated by a distance of 2m from each other with 30 subplots within a block. Each subplot had a dimension of 3.5m x 2.5m and spaced from one another by 1m.

Seeds were sown to a depth of 2cm, at a spacing of 0.70m x 0.50m between and within rows with three to four seeds per hole and thinned to two per hill after germination. No fertiliser was applied, but weeds were controlled fortnightly and water was supplied uniformly to all plots weekly during the dry season (November 2011-February 2012) using a watering can.

2.3. Data Collection and Analysis

Data were collected using the International Plant Genetic Resources Institute (IPGRI) [IPGRI, 1991], Descriptor List for okra. Data on qualitative characters were grouped into four growth stages of the plant. Hierarchical cluster analysis based on similarity matrix was also employed to obtain a dendrogram. Genstat Statistical Software Programme [Payne et al., 2007] and Microsoft Excel Software were used for all the data analyses.

3.0. Results and Discussion

3.1. Variation in Vegetative and Reproductive Characteristics of 29 accessions of Okra

The accessions varied extensively in vegetative and reproductive characteristics as shown in Plates I & 2 and also in Tables 1 & 2. Stems were generally erect and slightly branched with colour ranging from greenish through yellowish green to purplish, which were glabrous or pubescent. The leaves exhibited typical maple to cordate shape with variation in number of lobes, pubescence, petiole colour and venation. Flower colour also varied from cream, yellow to purple.

Fruits invariably exhibited pubescence (downy or rough) but varied in shape, size, colour, general conformation as well as presence or absence of ridges (most prominent on the dry fruits).There was also variation among accessions with respect to maturity duration ranging from early, midseason, late to very late. These agree with other results for okra morphological diversity studies [Amoatey et al., 2015; Oppong-Sekyere et al., 2012; Nwangburuka et al., 2011; Khanorkar & Kathiria, 2010; Omonhinmin & Osawaru, 2005; Dhankar & Dhankar, 2002; Norman, 1992; Mishra & Chhonkar, 1979].

The significant phenotypic variation observed within the qualitative characters of the accessions corresponds to the diverse collection sites (eight geographical regions). It may also signify a preponderance of out-crossing among accessions [Ahiakpa et al., 2013a; Lim & Chai, 2007; Adeniji, 2003] as there is no intraspecific barrier to crossability in okra [Ahiakpa et al., 2013a; Anonymous, 2010; Omonhinmin & Osawaru, 2005].

Agric short fruit

Agric type I

Akrave

Amanfrom

Asante type II

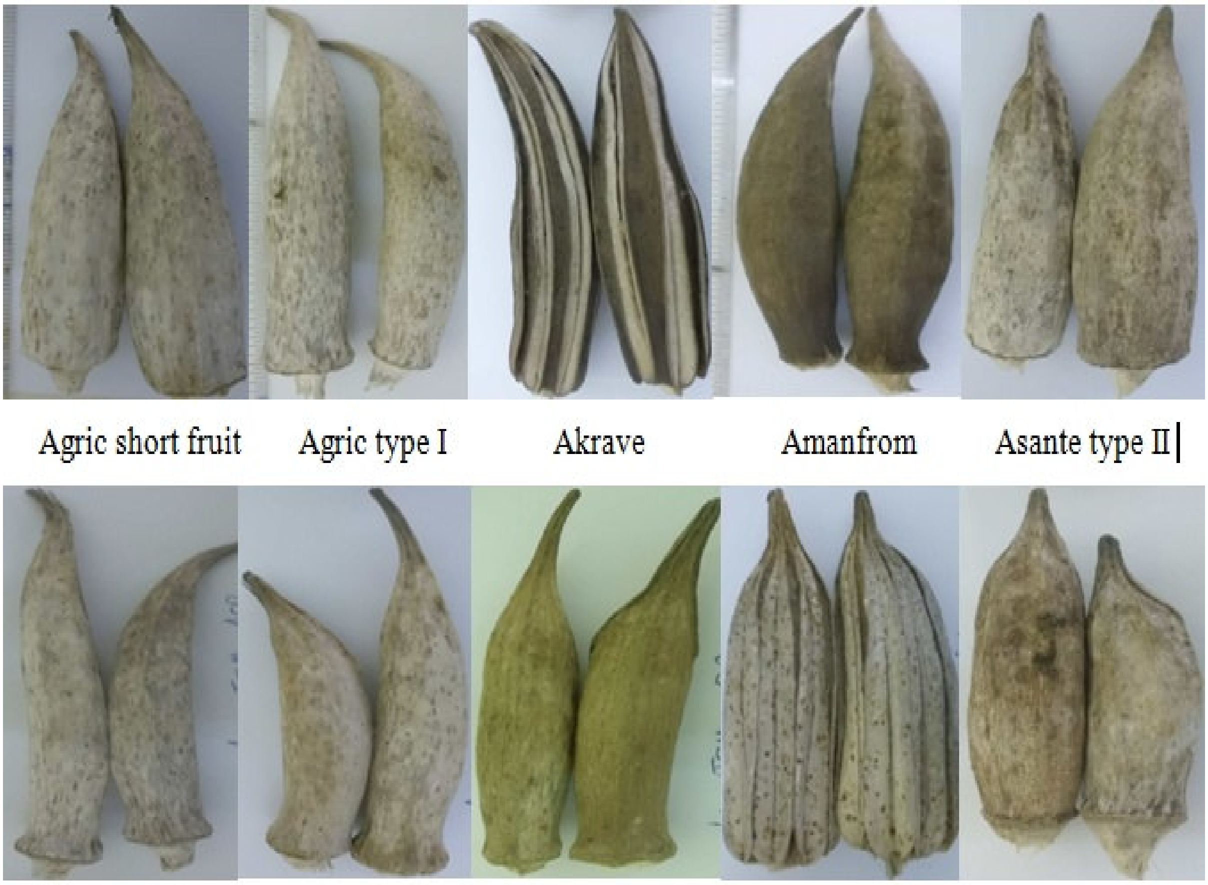
Asontem-ER

Asontem NV.

Atomic

Cape

Plate 1: Variation in Vegetative and Reproductive Characteristics of some Accessions of Okra.



Agric short fruit | Agric type I | Akrave | Amanfrom | Asante type II

Asontem-ASR | Asontem-BAR | Asontem-ER | Asontem-NV. | Atomic

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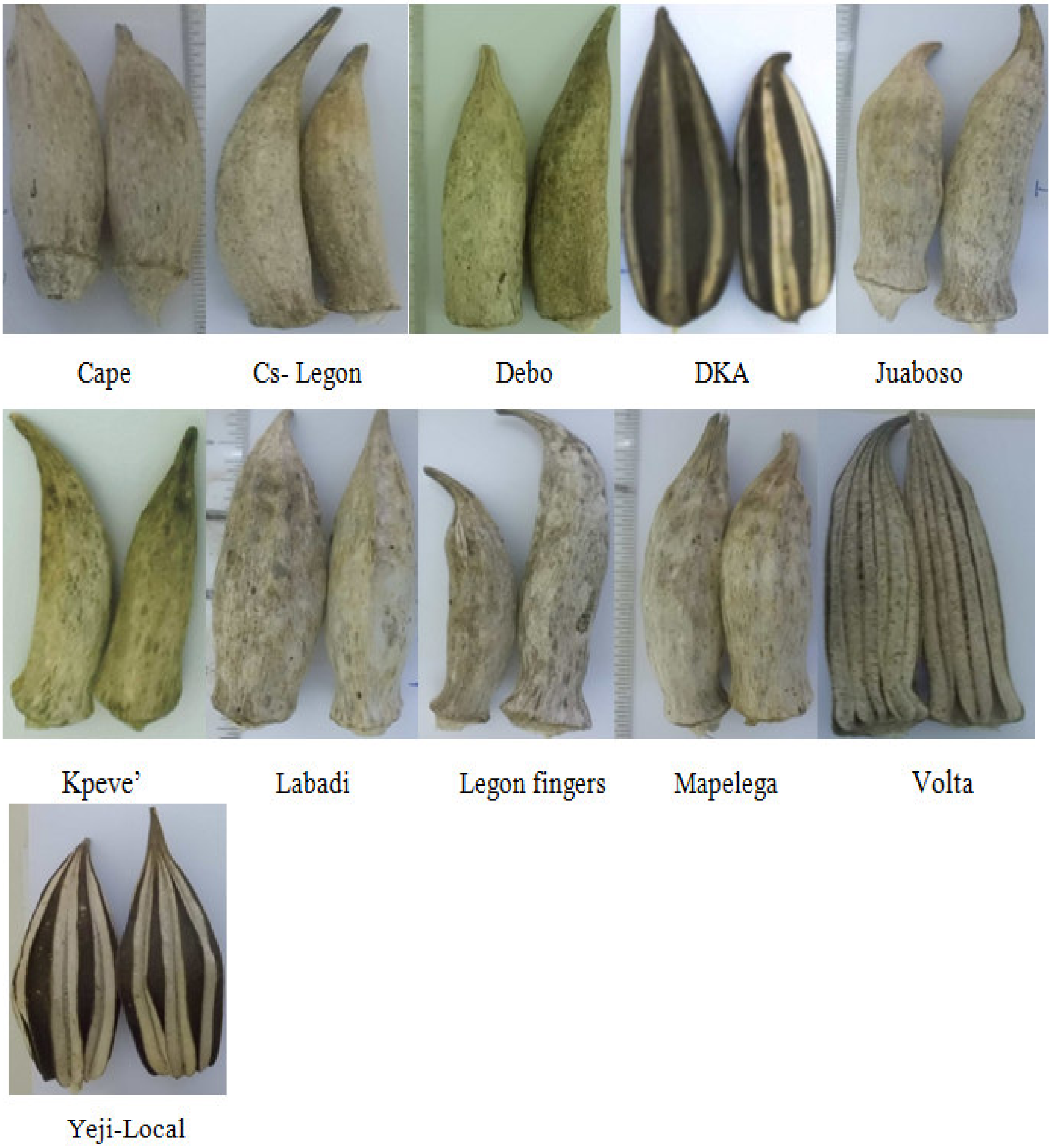

Plate 2: Variation in Morphology of Dry Fruits of some Accessions of Okra

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Table 1: Variability in Qualitative Traits of 29 Accessions of Okra (*Abelmoschus* spp L.)

TRAITS AND DESCRIPTION

Accession	PES	SES	NES	RCPB	Petal colour	Fruit pubescence	Fruit colour	PFMS	Stem pubescence	NRpF	Fruit shape
Agric short fruit	Persistent	Triangular	More than 10	Both sides	Cream	Slightly rough	Green	Pendulous	Conspicuous	5 to 10	12
Agric type I	Persistent	Lanceolate	From 8 to 10	Inside only	Cream	Slightly rough	Yellowish green	Erect	Conspicuous	5 to 7	3
Akrave'	Persistent	Linear	From 7 to 10	Inside only	Cream	Downy	Green with red patches	Pendulous	Glabrous	5 to 10	11
Amanfrom	Persistent	Lanceolate	More than 10	Both sides	Yellow	Downy	Yellowish green	Pendulous	Slight	None (smooth)	1
Asante type II	Persistent	Lanceolate	From 8 to 10	Inside only	Cream	Slightly rough	Green	Erect	Glabrous	5 to 10	8
Asontem NV.	Persistent	Lanceolate	From 7 to 10	Both sides	Cream	Slightly rough	Green	Erect	Slight	5 to 10	14
Asontem-ASR	Persistent	Triangular	More than 10	Inside only	Cream	Slightly rough	Green	Erect	Slight	None (smooth)	2
Asontem-BAR	Persistent	Lanceolate	More than 10	Inside only	Cream	Slightly rough	Yellowish green	Erect	Slight	None (smooth)	3
Asontem-ER	Persistent	Triangular	More than 10	Inside only	Cream	Slightly rough	Yellowish green	Horizontal	Slight	5 to 10	2
Asontem-GAR	Persistent	Lanceolate	More than 10	Inside only	Cream	Slightly rough	Green	Erect	Conspicuous	5 to 7	11
Atomic	Non-persistent	Lanceolate	From 8 to 10	Inside only	Cream	Downy	Green	Erect	Slight	None (smooth)	9
Cape	Persistent	Triangular	More than 10	Inside only	Cream	Slightly rough	Green with red patches	Erect	Conspicuous	5 to 10	7
Clemson Spineless	Non-persistent	Linear	From 7 to 10	Both sides	Cream	Slightly rough	Green	Erect	Slight	8 to 10	5
Cs-Legon	Persistent	Lanceolate	More than 10	Inside only	Cream	Downy	Yellowish green	Erect	Slight	None (smooth)	1
Debo'	Non-persistent	Triangular	From 7 to 10	Inside only	Cream	Slightly rough	Green	Pendulous	Slight	5 to 10	10
DKA	Persistent	Lanceolate	More than 10	Both sides	Cream	Downy	Green with red patches	Horizontal	Glabrous	8 to 10	6
Indiana	Persistent	Lanceolate	More than 10	Both sides	Cream	Slightly rough	Yellowish green	Horizontal	Glabrous	8 to 10	3
Juaboso	Persistent	Lanceolate	More than10	Inside only	Cream	Slightly rough	Green	Erect	Slight	5 to 10	8
Kortebortor-ASR	Persistent	Lanceolate	More than 10	Inside only	Cream	Prickly	Green with red patches	Erect	Slight	None (smooth)	7
Kortebortor-BAR	Persistent	Lanceolate	More than 10	Both sides	Cream	Slightly rough	Yellowish green	Pendulous	Conspicuous	5 to 7	3
Kpeve'	Non-persistent	Linear	From 5 to 7	Inside only	Cream	Slightly rough	Green	Pendulous	Slight	5 to 10	2
Labadi	Persistent	Lanceolate	More than 10	Inside only	Cream	Prickly	Yellowish green	Horizontal	Slight	8 to 10	7
Legon Fingers	Persistent	Lanceolate	More than 10	Inside only	Cream	Downy	Yellowish green	Erect	Conspicuous	None (smooth)	9
Mamolega	Persistent	Lanceolate	From 5 to 7	Both sides	Cream	Prickly	Red	Pendulous	Conspicuous	8 to 10	4
Mapelega	Persistent	Triangular	More than 10	Inside only	Cream	Slightly rough	Yellowish green	Horizontal	Conspicuous	5 to 10	8
Nkran Nkuruma	Persistent	Triangular	From 8 to 10	Inside only	Cream	Slightly rough	Yellowish green	Horizontal	Slight	5 to 7	4
Volta	Persistent	Triangular	More than 10	Inside only	Cream	Prickly	Green with red patches	Pendulous	Slight	8 to 10	3
Wune mana	Persistent	Linear	More than 10	Both sides	Cream	Slightly rough	Green	Erect	Conspicuous	5 to 7	5
Yeji-Local	Persistent	Triangular	From 5 to 7	Inside only	Cream	Prickly	Green with red patches	Pendulous	Slight	None (smooth)	6

NES = Number of Epicalyx Segment; RCPB = Red Colouration of Petal Base; PES = Persistence of Epicalyx Segment; SES = Shape of Epicalyx Segment; PFMS = Position of Fruit on Main Stem; NRpF = Number of Ridges per Fruit.

Table 2: Variability in Reproductive Traits of 29 Accessions of Okra (*Abelmoschus* spp L.)

TRAITS AND DESCRIPTION

Accession	Leaf shape	Leaf colour	Fruit Peduncle	Fruit Length	Fruit Diameter	Fruit axis type	Branching type	PMS 1-9	General plant type	Seed shape	Aspect of seed surface
Agric short fruit	8	Green	1-3cm	Medium	Medium	Straight	Medium	Early	Medium	Reniform	Glabrous
Agric type I	4	Green with red veins	More than 3cm	Medium	Mixed	Straight	Medium	Midseason	Medium	Round	Glabrous
Akrave'	7	Mixed	1-3cm	Short	Big	Curved	Strong	Late	Medium	Round	Downy
Amanfrom	7	Mixed	More than 3cm	Long	Mixed	Curved	Strong	Late	Medium	Round	Downy
Asante type II	10	Green	1-3cm	Medium	Mixed	Stocky	Orthotropic stem only	Late	Mixed	Round	Glabrous
Asontem NV.	4	Green with red veins	1-3cm	Very long	Mixed	Mixed axes	Medium	Midseason	Medium	Round	Downy
Asontem-ASR	4	Green with red veins	1-3cm	Medium	Mixed	Stocky	Mixed	Midseason	Erect	Round	Downy
Asontem-BAR	4	Green with red veins	1-3cm	Medium	Mixed	Stocky	Mixed	Midseason	Erect	Round	Downy
Asontem-ER	4	Green with red veins	More than 3cm	Medium	Medium	Stocky	Mixed	Midseason	Erect	Round	Downy
Asontem-GAR	4	Mixed	More than 3cm	Medium	Big	Stocky	Mixed	Late	Erect	Reniform	Glabrous
Atomic	6	Green	1-3cm	Short	Small	Stocky	Medium	Midseason	Erect	Round	Glabrous
Cape	6	Green	1-3cm	Short	Small	Stocky	Medium	Midseason	Erect	Round	Glabrous
Clemson Spineless	10	Green	More than 3cm	Long	Medium	Curved	Medium	Early	Procumbent	Reniform	Glabrous
Cs-Legon	8	Green	1-3cm	Medium	Mixed	Stocky	Medium	Early	Erect	Round	Glabrous
Debo'	9	Green	1-3cm	Medium	Medium	Stocky	Strong	Late	Medium	Reniform	Downy
DKA	10	Green	More than 3cm	Medium	Mixed	Stocky	Orthotropic stem only	Late	Mixed	Round	Glabrous
Indiana	10	Green	1-3cm	Very long	Medium	Straight	Orthotropic stem only	Early	Erect	Reniform	Downy
Juaboso	3	Green	1-3cm	Medium	Medium	Mixed axes	Medium	Midseason	Erect	Reniform	Glabrous
Kortebortor-ASR	4	Green	More than 3cm	Mixed	Medium	Straight	Strong	Very late	Erect	Reniform	Downy
Kortebortor-BAR	4	Green	More than 3cm	Medium	Medium	Straight	Strong	Very late	Erect	Reniform	Downy
Kpeve'	7	Mixed	1-3cm	Very long	Big	Curved	Strong	Late	Medium	Round	Downy
Labadi	7	Green	1-3cm	Very long	Big	Mixed axes	Medium	Late	Mixed	Reniform	Downy
Legon Fingers	8	Green	More than 3cm	Short	Medium	Stocky	Medium	Early	Erect	Round	Glabrous
Mamolega	9	Green with red veins	More than 3cm	Medium	Medium	Mixed axes	Medium	Very late	Mixed	Reniform	Glabrous
Mapelega	11	Green with red veins	1-3cm	Medium	Mixed	Mixed axes	Orthotropic stem only	Midseason	Procumbent	Reniform	Downy
Nkran Nkuruma	6	Green with red veins	More than 3cm	Mixed	Big	Mixed axes	Medium	Very late	Mixed	Reniform	Glabrous
Volta	2	Green	1-3cm	Long	Medium	Curved	Medium	Early	Erect	Round	Glabrous
Wune mana	11	Green with red veins	1-3cm	Medium	Medium	Mixed axes	Orthotropic stem only	Midseason	Procumbent	Reniform	Downy
Yeji-Local	9	Green with red veins	1-3cm	Mixed	Medium	Mixed axes	Strong	Very late	Mixed	Reniform	Downy

PMS 1-9 = Plant maturity on a 1-9 scale.

3.2. Genetic Relationships among 29 Accessions of Okra (*Abelmoschus* spp L.) using Qualitative Traits.

Cluster analysis of qualitative morphological traits of 29 accessions of okra using Euclidean Complete Linked Similarity Matrix (ECLSM) is displayed in Figure 1.

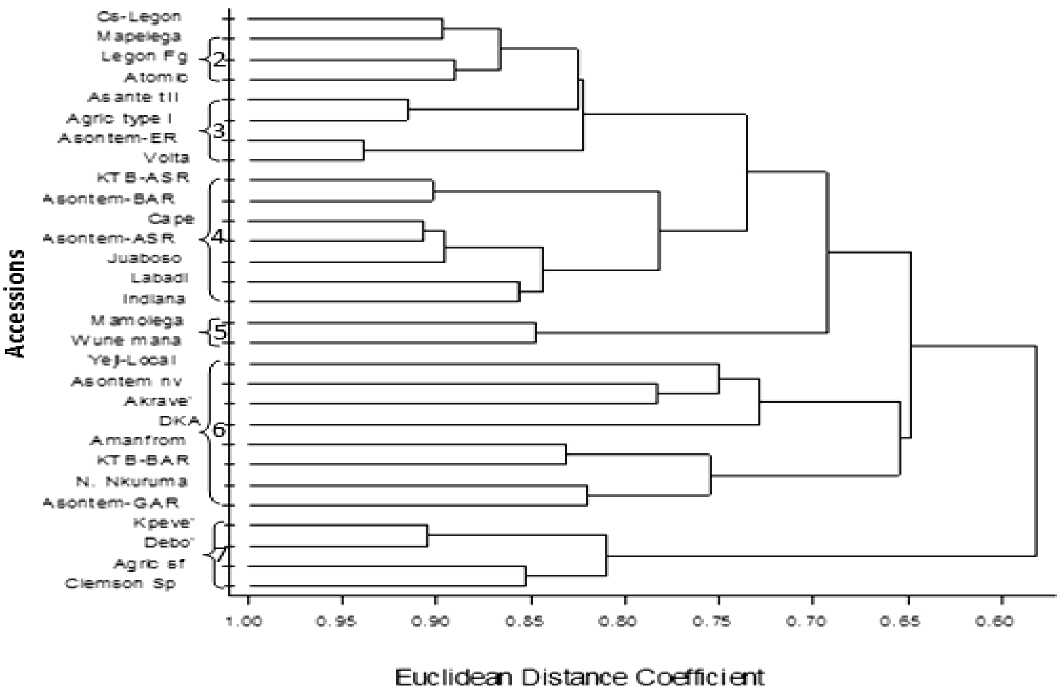

Figure 1: A Dendrogram Showing Genetic Relationship among 29 Okra Accessions based on Qualitative Traits using Coefficient of Euclidean, Complete Linked Similarity Matrix.

From the dendrogram, the accessions can be put into two clusters at 58.4 % genetic similarity and further regrouped into seven sub-clusters at levels up to 100 % similarity. Kpeve, Debo, Agric short fruit and Clemson spineless remained in one group up to a genetic distance of 81.1%, while the rest of the accessions were clustered into sub-groups beyond 65% genetic similarity. Cs-Legon and Clemson spineless were the most distantly related accessions.

For any two or more accessions to be taken as genetically identical, their genetic similarity index (GS) should be equal to or greater than 95% [Andersson et al., 2007]. In this study, the maximum genetic similarity index was 94.1% recorded between Asontem-ER and Volta, as the closest pair of accessions. Hence, there were no duplicates among the accessions collected. The broad genetic similarity indices recorded and clustering patterns displayed suggest useful variability within the collection for future genetic improvement of the crop through direct selection of accessions with the desired characteristics or hybridisation using genetically divergent ones as parents [Ahiakpa et al., 2013a; Torkpor, 2006].

Except for cluster five (which contains only two members), the pattern of clustering did not show distinct association between agro-morphological characters and geographic origin of the collections. Similar observations were made in earlier studies [Amoatey et al., 2015; Hien et al., 2007; Hanson, 2005; Hazra & Basu, 2000].

4.0. Conclusion

The 29 accessions of okra exhibited significant variability with respect to agro-morphological characters studied. No duplicates were identified. Cs-Legon and Clemson spineless were identified as the most diverse or distantly related accessions. Cs-Legon is a selection from a local breeder stock while Clemson spineless is an introduced line. Cs-Legon (with outstanding traits such as straight and stocky stem, medium height, early fruiting, uniform fruit size, and smooth pod shape) stands alone in cluster 1 which is most distantly related to cluster 7. In order to exploit the benefits of heterosis, Cs-Legon may be crossed with all accessions in cluster 7 except Clemson spineless (which has a number of undesirable traits such as weak stem, curved fruit axes, rough fruit pubescence).

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