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Agro-morphological Characterisation of Twenty-Nine (29) Accessions of Okra (*Abelmoschus* sp. L) from Eight Regions of Ghana

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Abstract: About twenty six (26) local accessions and three (3) exotic lines of okra were collected from 8 geographic regions of Ghana. Their agro-morphological traits were evaluated under field conditions on the research fields of the Biotechnology and Nuclear Agriculture Research Institute (BNARI), using the International Plant Genetic Research Institute (IPGRI) descriptor lists for okra. Hierarchical cluster analysis of results groupedthe accessionsinto 2 major clusters and subsequently into 5 sub-clusters based on the qualitative characters studied. The pattern of clustering did not indicate any relationship with geographic origin of collection. The 2 most divergent accessions were Cs-Legon (local accession) and Clemson Spineless (exotic line).

Key words: Okra, accession, characterisation, phenotypic variation, clusters analysis, genetic similarity index

INTRODUCTION

Okra (*Abelmoschus* sp. L) also known as okro, is a tropical vegetable crop, grown throughout Africa (Schippers, 2000; Norman, 1992), Asia and the Americas (Grubben, 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;Grubben, 2004; Tindall, 1983, Oyolu, 1977) and often dried for storage during bumper harvests. It provides dietary fibre, distinct proteins (Kumar *et al.*, 2010, NRC, 2006), edible oil (Tindall, 1983), assorted minerals and vitamins (Lamont, 1999; Norman, 1992; Tindall, 1983), as well as mucilage for thickening soups and stews (NRC, 2006; Woolfe *et al.*, 1977).

It has extensive culinary (Oppong-Sekyere *et al.*, 2012; Akintoye *et al.*, 2011; Kumar *et al.*, 2010; Torkpo *et al.*, 2006; Calisir *et al.*, 2005; Moekchantuk and Kumar, 2004; Oyelade *et al.*, 2003; Doijode, 2001), medicinal (Amin, 2011; Collins, 2010; Dan and Gu, 2010; Adekunle *et al.*, 2008; Lengsfeld *et al.*, 2004) and industrial (Kumar *et al.*, 2010; Norman 1992; Charvan, 1991) properties.

Of 2,283 accessions reported world-wide (Oppong-Sekyere *et al.*, 2012; Hamon and Sloten, 1989) some 1,769 (77.49%) are currently found in West Africa (Oppong-Sekyere *et al.*, 2012; Hamon and Sloten, 1989), making it the region of greatest diversity (Omonhinmin and Osawaru, 2005) represented by a wide variation in agro-morphological characteristics displayed in different eco-geographical areas. 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 (Ahiakpa *et al.*, 2013; 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. The objective of this study was to assess phenotypic diversity among a collection of 29 okra accessions, establishany duplications among them and identify superior ones with desirable characteristics for further breeding work.

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MATERIALS AND METHODS

Collection of accessions: About twenty-nine (29) accessions of okra (*Abelmoschus* sp. L) were collected from 8 different geographic regions of Ghana using IPGRI (1991) passport data, 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 Centraland Western regions. The study was conducted at the Nuclear Agriculture Centre (NAC) 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).

Experimental design and field layout: A total land area of 60×33 m 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 30×12.5 m, separated by a distance of 2 m from each other with 30 subplots within a block. Each subplot had a dimension of 3.5×2.5 m and spaced from one another by 1 m.

Seeds were sown to a depth of 2 cm, at a spacing of 0.70×0.50 m between and within rows with 3-4 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 to February, 2012) using a watering can.

Data collection and analysis: Data were collected using the International Plant Genetic Resources Institute, (IPGRI, 1991) descriptor list for okra. Data on characters were grouped into 4 growth stages of the plant. Hierarchical cluster analysis based on similarity matrix was also employed to obtain a dendrogram. Genstat Statistical Software Programme (Gilmour *et al*., 2007) and Microsoft Excel Software were used for all the data analyses.

RESULTS AND DISCUSSSION

Variation in vegetative and reproductive characteristics: The accessions varied extensively in vegetative and reproductive characteristics as shown in Fig. 1 and 2 and

Fig. 1: Continue

Fig. 1: Variation in vegetative and reproductive characteristics of accessions: a) Indiana; b) Mamolega; c) Cape; d) Labadi; e) Atomic; f) Debo; g) Agric short fruit; h) Volta; i) Kortebortor-ASR; j) DKA; k) Akrave; l) Amanfrom; m) Asontem nv; n) Asontem-ER; o) Mapelega; p) Yeji-Local; q) Agric type 1; r) Asante type 2

Fig. 2: Variation in dry fruits of accessions: a) DKA, Yeji-Local, asontem NV, labadi Cs-Legon; b) Mapelega cape, debo akrave, volta agric type 1; c) Kpeve' asontem-ERJuaboso, legon fingers asontem-BAR; d) Asante type 2, amanfrom agric short fruit asontem-ASR, Atomic

also in Table 1 and 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, mid season, late to very late. These agree with results found in okra morphological diversity studies by Ahiakpa *et al.* (2013), Oppong-Sekyere *et al.* (2012), Nwangburuka *et al.* (2011), Khanorkar and Kathiria (2010), Dhankar and Dhankar (2002), Norman(1992) and Michra and Chchonkar (1977).

The considerable phenotypicvariation observed within the characters of the accessions corresponds to the diverse collection sites (8 geographical regions). It may also signify a preponderance of out-crossing among accessions (Oppong-Sekyere *et al.*, 2012; Lim and Chai, 2007; Adeniji, 2003) as there is no intraspecific barrier to crossabilityin okra (Ahiakpa *et al.*, 2013; Anonymous, 2010).

Table 1: Variability in qualitative traits of accession

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

NES = No. 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

Accession	Traits and description										
	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	1-3 cm	Medium	Medium	Straight	Medium	Early	Medium	Reniform	Glabrous
Agric type 1	4	Green with red veins	>3 cm	Medium	Mixed	Straight	Medium	Midseason	Medium	Round	Glabrous

Table 2: Continue

	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
Akrave'	7	Mixed	1-3 cm	Short	Big	Curved	Strong	Late	Medium	Round	Downy
Amanfrom	7	Mixed	>3 cm	Long	Mixed	Curved	Strong	Late	Medium	Round	Downy
Asante type 2	10	Green	1-3 cm	Medium	Mixed	Stocky	Orthotropic stem only	Late	Mixed	Round	Glabrous
Asontem NV	4	Green	1-3 cm	Very long	Mixed	Mixed axes	Medium	Midseason	Medium	Round	Downy
Asontem-ASR	4	Green with red veins	1-3 cm	Medium	Mixed	Stocky	Mixed	Midseason	Erect	Round	Downy
Asontem-BAR	4	Green with red veins	1-3 cm	Medium	Mixed	Stocky	Mixed	Midseason	Erect	Round	Downy
Asontem-ER	4	Green with red veins	>3 cm	Medium	Medium	Stocky	Mixed	Midseason	Erect	Round	Downy
Asontem-GAR	4	Mixed	>3 cm	Medium	Big	Stocky	Mixed	Late	Erect	Reniform	Glabrous
Atomic	6	Green	1-3 cm	Short	Small	Stocky	Medium	Midseason	Erect	Round	Glabrous
Cape	6	Green	1-3 cm	Short	Small	Stocky	Medium	Midseason	Erect	Round	Glabrous
Clemson Spineless	10	Green	>3 cm	Long	Medium	Curved	Medium	Early	Procumbent	Reniform	Glabrous
Cs-Legon	8	Green	1-3 cm	Medium	Mixed	Stocky	Medium	Early	Erect	Round	Glabrous
Debo'	9	Green	1-3 cm	Medium	Medium	Stocky	Strong	Late	Medium	Reniform	Downy
DKA	10	Green	>3 cm	Medium	Mixed	Stocky	Orthotropic stem only	Late	Mixed	Round	Glabrous
Indiana	10	Green	1-3 cm	Very long	Medium	Straight	Orthotropic stem only	Early	Erect	Reniform	Downy
Juaboso	3	Green	1-3 cm	Medium	Medium	Mixed axes	Medium	Midseason	Erect	Reniform	Glabrous
Kortebortor-ASR	4	Green	>3cm	Mixed	Medium	Straight	Strong	Very late	Erect	Reniform	Downy
Kortebortor-BAR	4	Green	>3cm	Medium	Medium	Straight	Strong	Very late	Erect	Reniform	Downy
Kpeve'	7	Mixed	1-3 cm	Very long	Big	Curved	Strong	Late	Medium	Round	Downy
Labadi	7	Green	1-3 cm	Very long	Big	Mixed axes	Medium	Late	Mixed	Reniform	Downy
Legon Fingers	8	Green	>3cm	Short	Medium	Stocky	Medium	Early	Erect	Round	Glabrous
Mamolega	9	Green with red veins	>3 cm	Medium	Medium	Mixed axes	Medium	Very late	Mixed	Reniform	Glabrous
Mapelega	11	Green with red veins	1-3 cm	Medium	Mixed	Mixed axes	Orthotropic stem only	Midseason	Procumbent	Reniform	Downy
Nkran Nkuruma	6	Green with red veins	>3 cm	Mixed	Big	Mixed axes	Medium	Very late	Mixed	Reniform	Glabrous
Volta	2	Green	1-3 cm	Long	Medium	Curved	Medium	Early	Erect	Round	Glabrous
Wune mana	11	Green with red veins	1-3 cm	Medium	Medium	Mixed axes	Orthotropic stem only	Midseason	Procumbent	Reniform	Downy
Yeji-Local	9	Green with red veins	1-3 cm	Mixed	Medium	Mixed axes	Strong	Very late	Mixed	Reniform	Downy

PMS 1-9 = Plant Maturity on a 1-9 Scale

Genetic relationship among accessions using qualitative traits: Cluster analysis of qualitative morphological dataon 29 accessions of okra using Euclidean Complete Linked Similarity Matrix (ECLSM) is displayed in Fig. 3. From the dendrogram, the accessions can be put into 2 clusters at 58.4% genetic similarity and further regrouped into 7 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-groupsbeyond 65% genetic similarity. Cs-Legon and Clemson Spineless were the most distantly related accessions.

For any 2 or more accessions to be taken as genetically identical, their Genetic Similarity index (GS) should be ≥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 accession. Hence, there were no duplicates among the accessions collected. The broad genetic similarity indices recorded and clustering patterns displayed provide 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 (Torkpo *et al*., 2006; Singh *et al*., 1974).

Except for cluster 5 (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 observationswere made by Hien *et al*. (2007), Hanson (2005), Hazra and Basu (2000) and Martin *et al*. (1981).

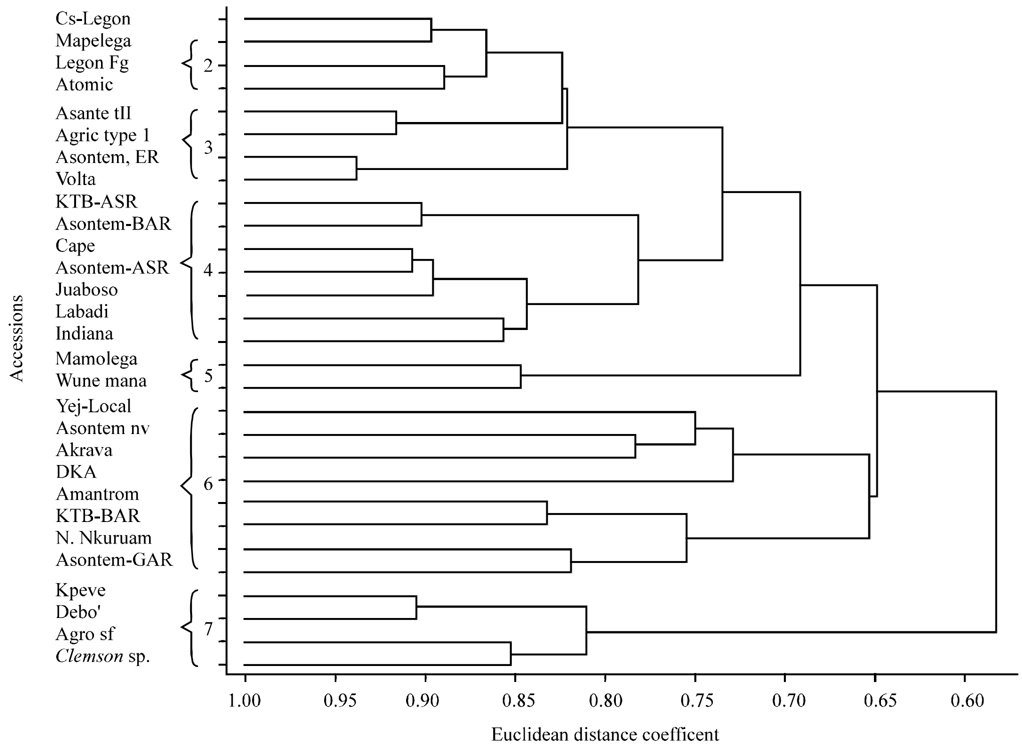

Fig. 3: A dendrogram showing genetic relationships among 29 accessions based on qualitative traits using coefficient of euclidean, complete linked similarity Matrix. KTB = Kortebortor; tII = type II; N = Nkuruma, Nv = Northern version, Sf = Short fruit, Sp = Spineless

CONCLUSION

The 29 accessions of okra exhibited great variability with respect to 20 agro-morphological characters studied. No duplicates were identified. Cs-Legon and Clemson Spineless were identified as the most diverse and 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 exploitthe benefits of heterosis, Cs-Legon may be crossed withall accessions in cluster 7 except Clemson Spineless (which has a number of undesirable traits-weak stem, curved fruit axes, rough fruit pubescence).

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