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Full Length Research Paper

Characterization of okra (*Abelmoschus spp.* L.) germplasm based on morphological characters in Ghana

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Twenty five accessions of okra collected in Ghana were evaluated for phenotypic identity, diversity and quality based on morphological characters. Qualitative and quantitative characteristics were measured and scored as specified by the standard international crop descriptor for okra. A dendrogram was generated for morphological data based on the simple matching coefficient, and four cluster groups were observed. The distribution of the accessions into the groups, based on the morphological traits had no unique geographical relationship. The results of the matrix of similarity among the 25 accessions performed by NTsys pc programme placed two accessions in a tie, suggesting that, they were identical. Eight accessions were placed at above 80% similarity, meaning that, the accession pairs were closely related, and three accessions were 50% similar, which means they matched at half the characters measured. Six pairs of accessions measured were somewhat diverse, which can be exploited by plant breeders for further improvement. The genetic affinity between the accessions from different regions and ethnic groups could however be due to the selection and exchange of okra between farmers from different regions and ethnic groups. Distinct morphotypes exist in the Ghanaian okra germplasm, depicted by variation in petal colour, pubescence of the leaf and stem, fruit shape, anthocyanin pigmentation and number of days to 50% flowering.

Key words: Dendrogram, diversity, morphotypes, pubescence, vegetables.

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is a warm-season annual herbaceous vegetable crop which can be found in nearly every market in Africa. It is grown primarily for its young immature green fruits and fresh leaves used in salads, soups and stews. The crop, which is generally self-pollinated (Martin, 1983), belongs to the Malvaceae (mallow) family and has its origin in West Africa (Joshi et al., 1974).

The okra provides an important source of vitamins and minerals (Lamont, 1999). Grubben et al. (1977) have also reported significant levels of carbohydrate, potassium and magnesium. The seeds of okra are reported to contain between 15 and 26% protein and over 14% edible oil content (NARP, 1993). The crop is the fourth most popular vegetable in Ghana after tomatoes, capsicum peppers, and garden eggs (Sinnadurai, 1973), and its production is widespread across all the major regions. About 10-15 t /ha of yield can be obtained under good management (NARP, 1993). The world okra production was estimated at 4.8 million tons (Gulsen et al., 2007). In Ghana, okra is found in its fresh state in almost all markets in Ghana during the rainy season and in a dehydrated form during the dry season, particularly in Northern Ghana due to its strong commercial value. Okra has vital importance as food diet among the inhabitants of the cities and villages.

Characterization of crops is a very essential first step in any crop improvement programme (De Vicente et al., 2005). Characterization of genetic resources, therefore,

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refers to the process by which accessions are identified, differentiated or distinguished according to their character or quality (traits) (Merriam-Webster, 1991). Characterization provides information on diversity, within and between crop collections. This enables the identification of unique accessions essential for curators of gene banks (Ren et al., 1995). Moreover, information obtained on genetic relatedness among genetic resources of crop plants is useful, both for breeding and for the purposes of germplasm conservation (Brown et al., 1990).

Notwithstanding the potential of the crop, there is no improved variety for cultivation in Ghana (Kumar et al., 2010). More so, there has not yet been any previous reported attempt by breeders at improving vegetable in terms of developing core collections for higher yield and quality. The accessions under cultivation, over the years in the various regions across the country are landraces. Nevertheless, these landraces are associated with challenges such as, high susceptibility to diseases and pests, for example, nematodes. In addition, these landraces have long maturity periods yet short harvesting duration. They are of poor nutritional quality, non-standard in shape, colour and size, making them unfit for the Ghanaian vegetable export market. This has a consequential effect of causing a reduction in the per capita income of the nation. It is therefore important that plant breeders developed improved varieties of the okra vegetable, which seems to be the last concern in their research programmes for adoption by Ghanaian vegetable farmers and for the export market. Varieties that are perennial in growth habit and at the same time, combine higher yields and early maturity with longer harvest duration and more so resistant to diseases and pests, would be ideal to the okra vegetable industry in Ghana. Improved varieties in terms of fruit size, shape and colour are also very much desired in the Ghanaian okra export market. It is against this backdrop that this characterization and genetic diversity study was necessitated. More importantly, the Ghanaian ecotypes as an important first step should improve the crop in Ghana by providing the foundation to enhance their potential use. This study sought to afford us the opportunity to assess qualitative and quantitative variations among collections of the Ghanaian okra landraces through morphological evaluation and thus exploit such variations in breeding programmes to develop improved, high yielding varieties.

MATERIALS AND METHODS

Twenty-five accessions of okra were used as experimental materials to assess the differences in morphological traits. Among the accessions, twelve were collected from the Plant Genetic Resources Research Institute (PGRRI) of CSIR, twelve from College of Agricultural Science, University of Education, Winneba-Mampong, and one from the Department of Horticulture, KNUST-Kumasi. The study was conducted in the major and minor cropping seasons of 2008 at the experimental field of the Department of Crop and Soil Sciences, KNUST. The land, which had been allowed to lie uncultivated for one year after a previous harvest of groundnut was slashed, ploughed and harrowed to a fine tilt for the experiment. Randomized complete block design (RCBD) was used as experimental design with four replications. The total experimental area was 14 m x 83 m. Seeds were sown directly in the field at a rate of two seeds per hill. Seedlings were thinned to one plant per stand two weeks after germination. There were a total of 100 plots with each plot measuring 2.4 m by 1.8 m. Each plot had sixteen plants with a spacing of 60 cm by 45 cm. Standard agronomic practices including thinning, weeding and watering were adopted. Compound fertilizer in the form of N.P.K. 15:15:15 at a rate of 250 kg/ha and urea at a rate of 125 kg/ha were applied to the plants at 30 days after sowing.

Data were collected on plant growth habit, general growth appearance/branching, flowering characteristics, pigmentation and pubescence of the various plant parts, fruit characteristics and leaf characteristics. Data were recorded from the four tagged plants in each plot.

A standardized crop descriptor for okra (IBPGR, 1991) was used to measure the various parameters studied (Tables 1 and 2). A dendrogram showing the distinct clusters among the 25 okra accessions was constructed using Numerical Taxonomy and Multivariate Analysis System (NTSYS version 2.11s; Rohlf, 2005) and similarity coefficients were calculated by simple matching produced by UPGMA (Rohlf, 2005).

RESULTS

General observations

In general, all the okra accessions showed relatively wide ranges of variations for all morphological characters observed. Most of the plants showed erect growth habits while leaf and stem colours were predominantly green. Petal or flower colour was mostly golden yellow among the okra, whereas fruit orientation was largely intermediate for all accession studied. Majority of the fruits produced green and smooth fruits. Most of the accessions showed symptoms of okra mosaic virus and okra leaf curl disease.

Vegetative characters

Plant growth habit, general appearance and branching

Branching position-at-main-stem (general growth appearance) of okra accessions were 60% in occurrence for unique orthotrop axis (UOA). Densely branched all over (DBO) and densely branched base (DBB) characters were 20% in frequency (Figure 1). Figure 2 shows the DBB, UOA and DBO growth habits observed in this study.

Fruit characters

Fruit colour

The results showed that fruit colour displayed five distinct variations that ranged from common green, green with

Table 1. Evaluated characteristic of okra collection. Coding of qualitative characters is according to IBPGR, 1991 descriptors for okra.

Code for character		Parameter measured	Character codes
S/N	Qualitative		
1	SC	Seed colour	1=dark, 2=black, 3=whitish to dark, 4=purple to black
2	SSh	Seed shape	1=Roundness, 2=Kidney, 3=Spherical
3	SS	Seed size	1=Small, 2=medium, 3=large
4	BPMS	Branching position at main stem	1=UOA-unique orthotrop axis, 2=DBO-densely branched all over, 3=DBB-densely branched base
5	MLC	Mature leaf colour	1=Green, 2=Green+red veins
6	LSh	Leaf shape	From types 1 to 11
7	LBr (cm)	Length of branches	0= no branches, 1= branches rarely > 10cm
8	LRC	Leaf rib colour	1=Green, 2=Green+red veins
9	PtC	Petiole colour	1=Green, 2=Green+red veins, 3=purple
10	PC	Petal colour	1=Golden yellow, 2=yellow
11	CDR	Colour of the darkest ridges	1=light, 2=dark, 3=light to dark
12	StC	Stem colour	1=green, 2=green+purple tinge, 3=purple
13	NES	Number of epicalyx segments	1=8 to10, 2=5 to 7, 3=>10
14	FSp	Flowering span	1=Single flowering, 2=grouped flowing
15	NSfS	Number of segments from the stigma	From 5 to 12 segments
16	FC	Fruit colour	1 =Green, 2=green+red spots, 3=dark green to black, 4=green to yellow, 5=purple
17	FP	Fruit pubescene	1=Smooth, 2=little rough, 3=downy+hairs
18	FSh	Fruit shape	From types 1 to 15
19	NR/F	Number of ridges per fruit	1=0, 2=b/n 5 and 12, 3=5ridges
20	PFMS	Position of fruit from the main stem	1=intermediate, 2=slightly falling, 3=horizontal, 4=Erect, 5=Drooping
21	LFP	Length of fruit peduncle	1=1 to 3cm, 2=>3cm
22	SI	Susceptibility to insects	Scale: 1 to 9; (*Podagrica* spp, Aphids, Cotton stainer): NS=0-1,WS=1-3,IS=3-5, HS=6-9
23	Sdi	Susceptibility to diseases	Scale: 1 to 9; (OMV, OLCV): NS=0-1, WS=1-3, IS=3-5, HS=6-9

Table 2. Qualitative traits that varied among okra collection studied.

S/N	Accession	SC	SSh	SS	BPMS	MLC	LSh	LBr (cm)	LRC	PtC	PC	CDR	StC	NES	FSp	NSfS	FC	FP	FSh	NR/F	PFMS	LFP	SI	Sdi
1	GH 4487 Muomi	1	1	3	1	1	2	0	1	1	1	1	1	1	1	9	1	1	2	1	1	1	2	2
2	GH 4482 Muomi	2	2	2	1	2	1	0	2	2	1	1	2	1	1	9	1	1	2	1	1	1	2	2
3	GH 4499 Fetri	3	1	2	1	1	2	0	1	2	1	1	1	1	1	12	1	1	8	2	1	1	2	2
4	GH 1169 Fetri	3	1	3	1	2	2	0	2	2	1	1	2	1	1	7	1	1	8	2	1	1	2	2
5	GH 4376 Atuogya	2	2	2	1	2	2	0	2	2	2	1	1	2	1	9	1	1	2	2	2	1	2	2
6	GH 4490 Fetri	4	1	1	1	2	7	0	2	3	1	1	3	3	1	6	1	1	8	2	1	1	2	2
7	GH 3801 Pora	3	3	1	1	2	7	0	2	3	1	1	3	1	1	9	5	2	3	2	3	1	9	9

Table 2. Contd.

8	GH 6102 Fetri	3	2	1	1	1	2	0	1	1	1	1	1	1	1	6	1	1	8	2	1	1	2	2
9	GH 4964 Muomi	2	2	2	1	2	1	0	1	2	1	1	2	1	1	6	1	1	2	1	1	1	2	2
10	GH 5793 Gyeabatan	2	2	1	1	2	1	0	1	2	2	1	3	2	2	5	2	2	4	2	1	2	2	2
11	GH 5787 Asontem	2	3	2	1	2	2	0	2	1	1	1	1	1	1	9	1	2	8	2	4	1	0	0
12	GH 3736 Fetri	3	3	1	1	1	2	0	1	1	1	1	1	1	1	5	1	2	8	2	1	1	5	5
13	Atuogya-tiatia	4	3	1	3	1	3	1	2	2	2	1	1	2	2	6	2	2	4	2	3	2	5	2
14	DA/08/001Wun mana	3	3	2	2	1	3	0	2	1	2	2	2	1	2	9	3	3	6	2	1	2	0	0
15	DA/08/02Sheo mana	4	1	1	3	2	3	0	2	2	1	2	1	1	1	5	1	2	14	2	1	1	0	0
16	DA/08/02 Ason-Wen	4	3	1	1	2	2	0	1	1	1	1	1	1	1	7	1	1	8	2	1	1	2	2
17	Atuogya-Asante	2	2	2	2	2	3	1	1	1	2	1	2	2	2	10	1	2	1	2	1	2	2	2
18	Asontem	4	3	1	1	1	4	0	1	1	1	1	1	2	1	9	1	1	8	2	4	1	2	2
19	DA/08/04Wun mana	2	2	2	2	1	2	1	2	1	2	2	2	2	2	9	3	3	15	2	3	2	2	2
20	DA/08/004 Agbodro	3	3	2	2	1	4	1	2	2	2	1	2	1	2	5	1	1	7	1	5	2	0	0
21	Gbodro-wild	2	2	2	2	1	2	0	2	2	2	1	2	2	2	9	4	2	3	3	1	2	2	2
22	DA/08/02Dikaba	3	3	1	3	1	2	0	1	3	2	1	1	1	1	6	1	1	13	2	4	1	0	0
23	DA/08/03Sheo mana	4	1	1	3	1	2	1	1	1	1	3	1	1	1	10	4	3	15	2	4	2	0	0
24	Atuogya-tenten	1	2	3	3	1	2	0	1	1	2	2	1	1	2	5	1	2	1	3	1	2	5	2
25	KNUST/SL1/07Nkrumahene	1	3	1	1	1	2	0	1	1	1	1	1	1	1	9	1	1	2	2	4	1	0	0

SC, See colour; SSh, seed shape; SS, seed size; BPMS, branching position at main stem; MLC, mature leaf colour; LSh, leaf shape; LBr, length of branches; LRC, leaf rib colour; PtC, petiole colour; PC, petal colour; CDR, colour of the darkest ridges; StC, stem colour; NES, number of epicalyx segments; FSp, Flowering span; NSfS, number of spines from the stigma; FC, fruit colour; FP, fruit pubescence; FSh, fruit shape; NR/F, number of ridges per fruit; PFMS, position of fruit from the main stem; LFP, length of fruit peduncle; SI, susceptibility to insects; Sdi, susceptibility to diseases.

red spots, dark green to black, green-to-yellow to completely purple (Figure 3). In total, 72% of the accessions produced green fruits while 8% displayed green-with-red-spotted fruits, dark green to black fruits and green to yellow-fruits. A small portion (4%) of the accessions had tinged purple fruits. Variety GH3801 Pora had a unique purplish pigmented fruit colour. Figure 4 gives a pictorial view of variations in fruit colour among the okra studied.

Fruit pubescence

Fruit pubescence showed wide variation among the okra accessions. Sixty-four percentages of okra accessions showed fruits with no hairs (Figure 5), while the rest had rough, downy or little hairs on their fruits representing 4, 12 and 20% occurrences, respectively. From these results, one can conclude that the okra fruit has no hairs.

Fruit shape (form)

Fruit shape showed the greatest diversity among the okra accessions; from short and triangular to long straight or long curved. From the results in Figure 6, 8% of total accessions bore fruits with shape scores of 1, 3, 4, and 15, respectively, according to the descriptor (IBPGR, 1991; Plate 1). Twenty percent accessions bore fruits with a shape score of 2, while 4% bore fruit with shape scores 6, 7, 13 and 14. Fruit shape scores 5, 9, 10, 11 and 12, did not show any occurrence (zero percentages) while shape score of type 8 recorded the highest occurrence of 32% of the okra accessions. Figure 7 shows variations in fruit shape among accession studied.

Number of fruit ridges

Number of fruit ridges and position of fruits on main stem are useful only for cultivated forms of

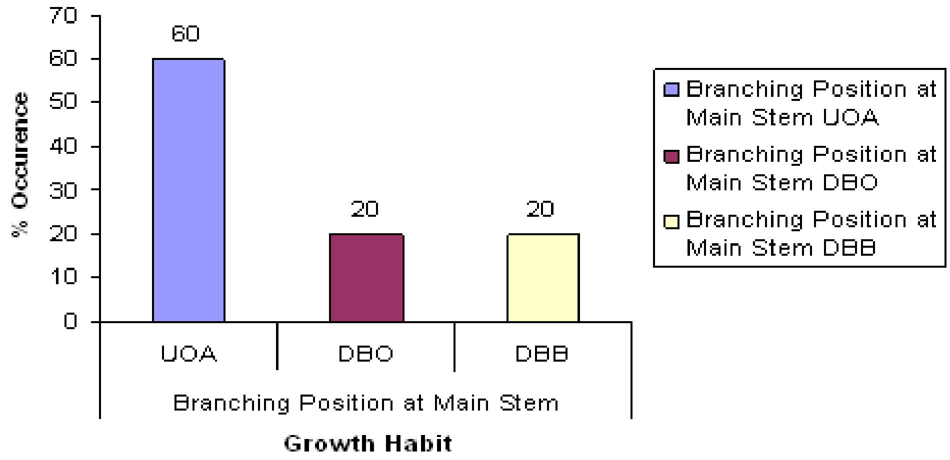

Figure 1. Variations in growth habit among okra accessions.

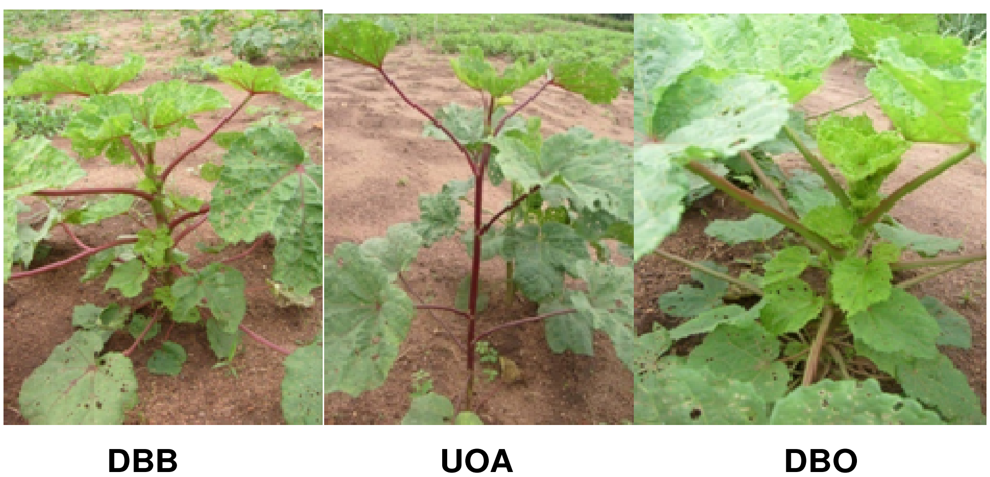

Figure 2. Variations in growth habit among okra accessions.

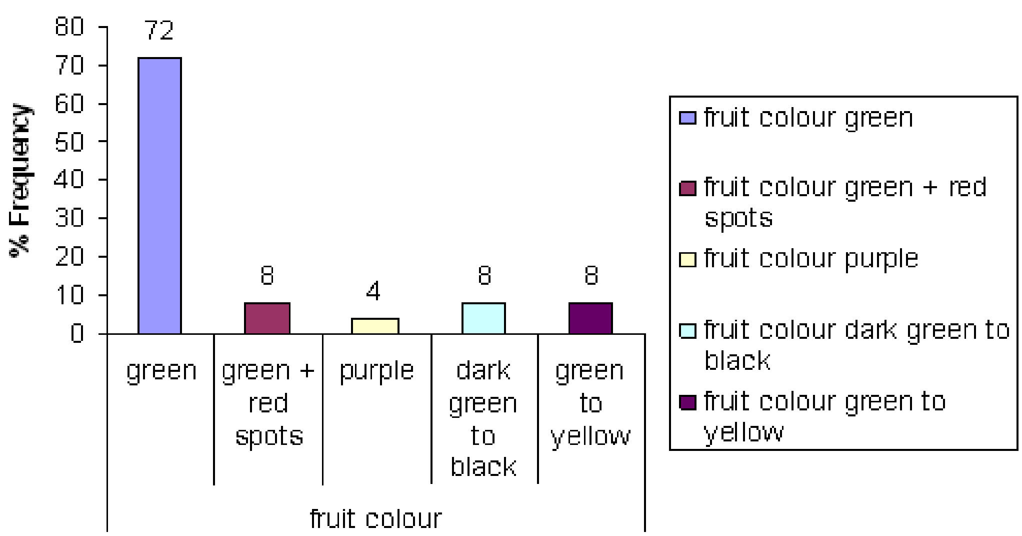

Figure 3. Variation in fruit colour among okra accessions.

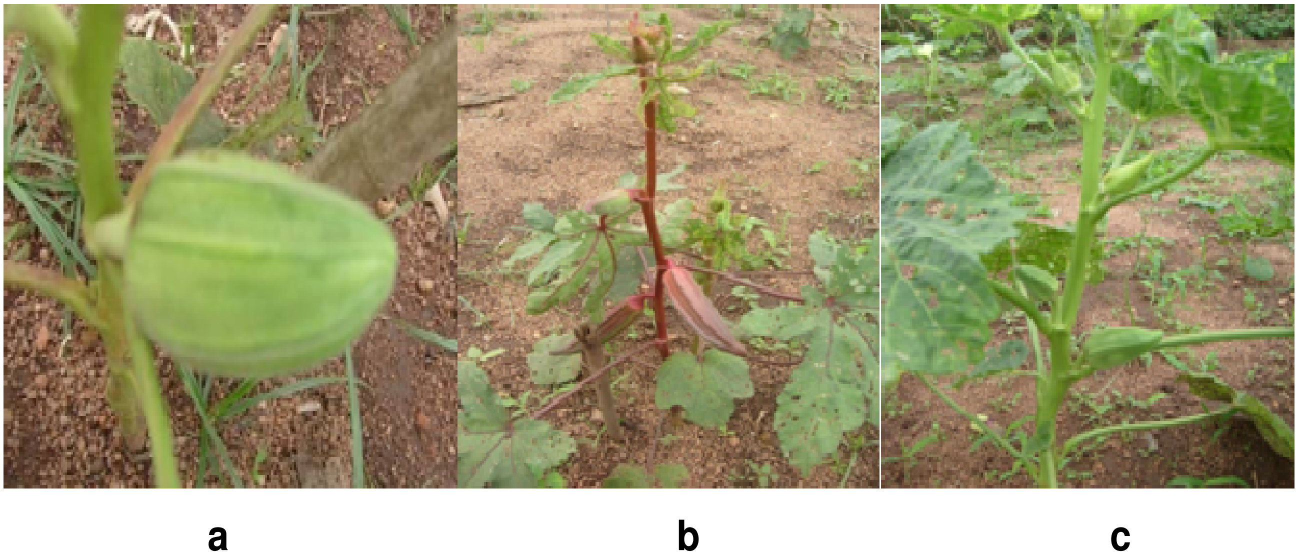

Figure 4. Variation in fruit colour among okra accessions. a, Yellowish-green okra fruits; b, Purple (GH3801 Pora) okra fruit; c, Okra with green fruits.

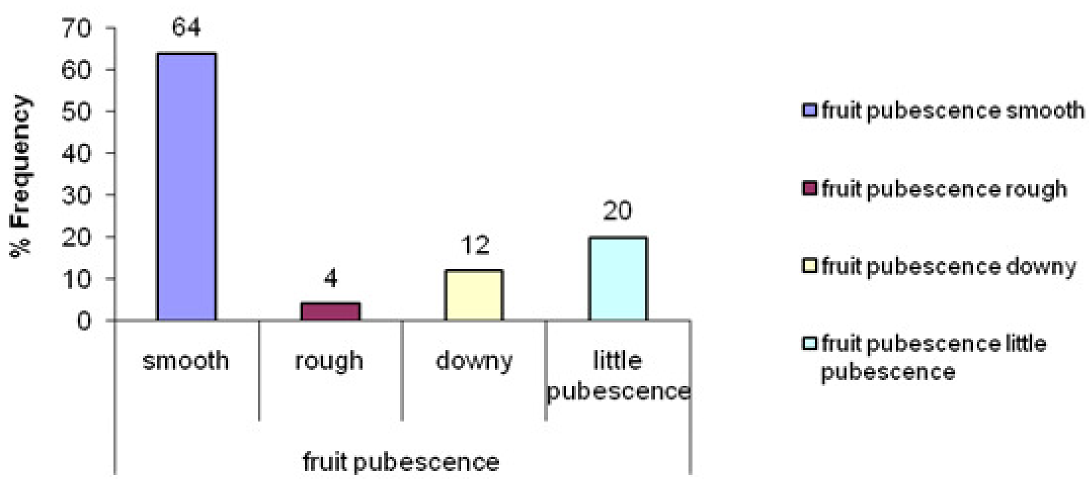

Figure 5. Variation in fruit pubescence among okra accessions.

okra. The number of ridges per fruit of the 25 entries ranged from 0-12 ridges. Accessions DA/08/004 Agbodro, GH 4964 Muomi, GH 4482 Muomi, GH 4487 Muomi recorded had no well-marked ridges on their fruits while Gbodro and Atuogya-tenten had five ridges on their fruits. The rest of the okra accessions, representing about 80% had very conspicuous ridges per fruit between 8 and 12 (Figure 8).

Fruit position on the stem

The position of fruits on the main stem of the accessions showed five distinct variations; erect intermediate, slightly falling, horizontal and drooping positions. Figure 9 showed that, 60% of the accessions had fruits that were intermediate on the stem, which means that they were half upright on the stem, 20% of the accessions bore fruits which were in erect (upright) position, 12% of the okra accessions bore fruits which were positioned horizontally on the stem while only 4% bore fruits which were slightly falling and drooping (fruits in an almost upside down position).

CLUSTERING

General clustering of okra accessions into groups

A cluster diagram obtained from the morphological

Figure 6. Variation in fruit shapes (forms) within accessions studied.

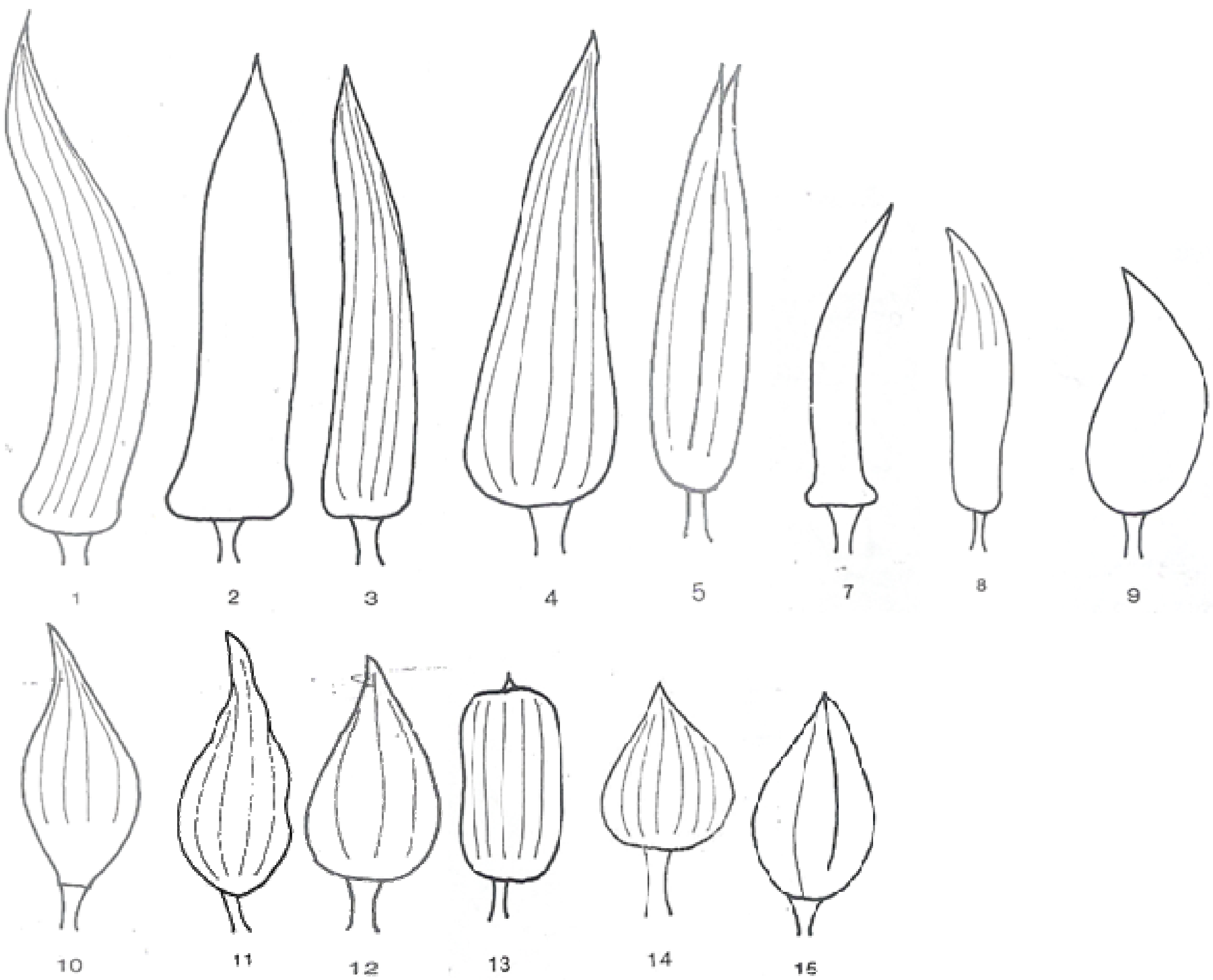

Plate 1. Variation in fruit shapes (IBPGR, 1991).

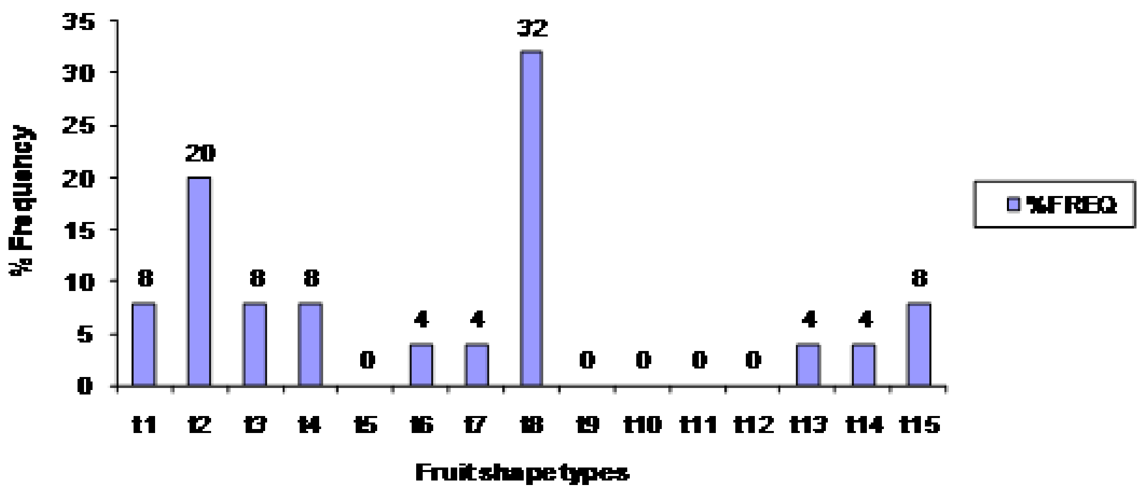

Figure 7. Variation in fruit shape among okra accessions.

Figure 8. Variation in fruit ridges among okra accessions.

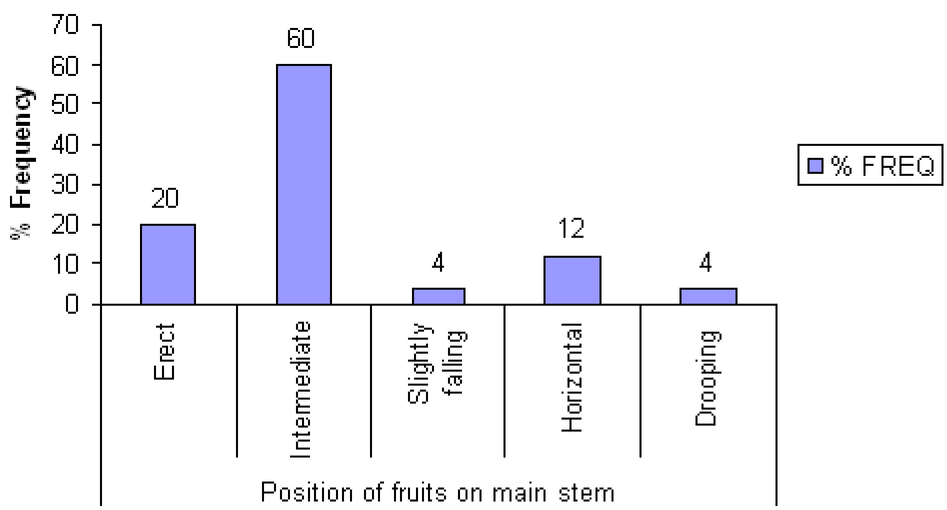

Figure 9. Variation in fruit position among okra accessions.

descriptors produced four main sub-cluster groups of okra accessions at a coefficient of 0.63. Accessions were put into cluster groups based on certain qualities unique to them. Cluster A, recorded the highest number of accessions (16) while cluster B consisted of only one accession.

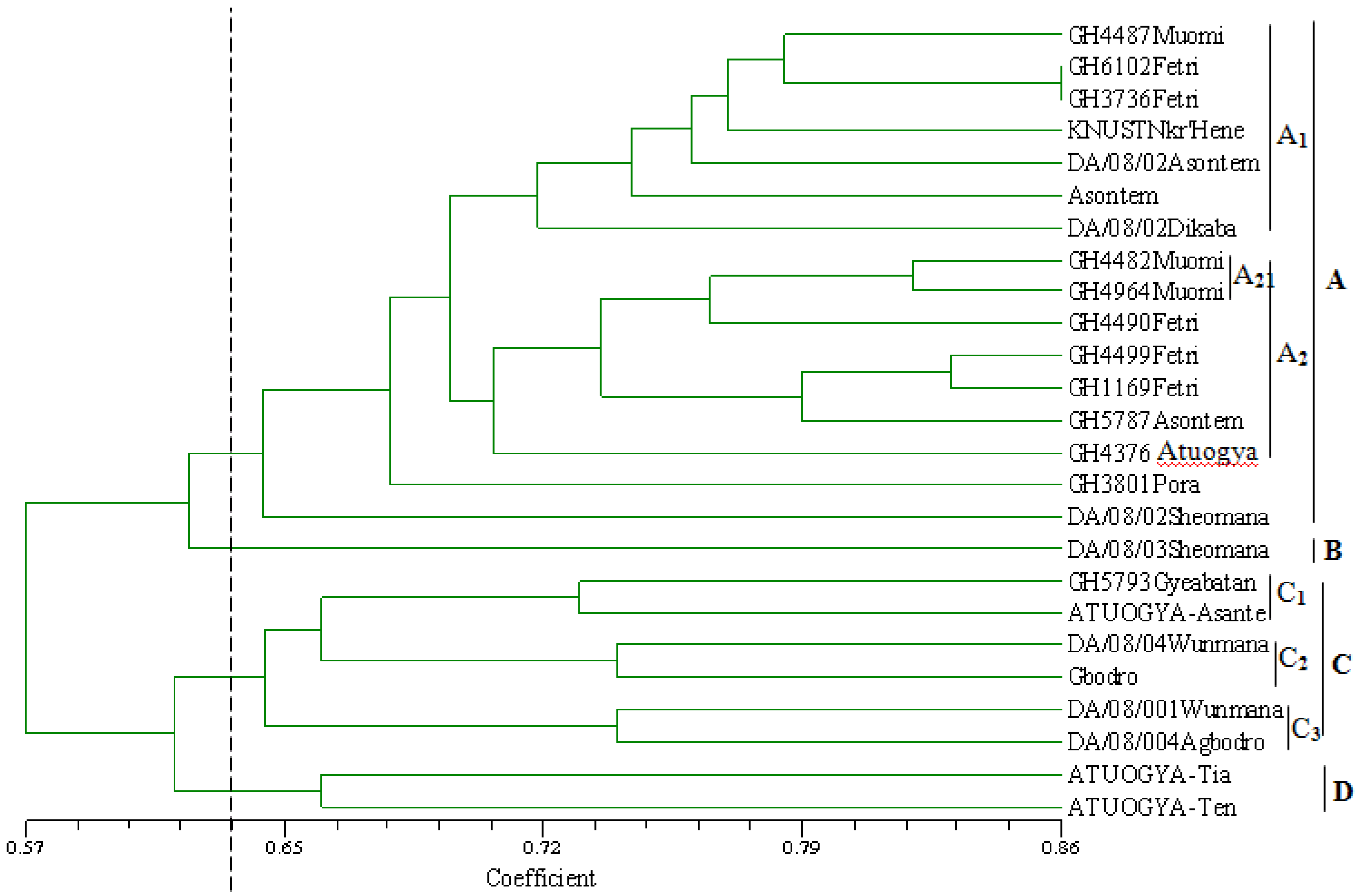

Figure 10. Dendrogram showing the relationship among 25 okra accessions revealed by UPGMA cluster analysis based on morphological characters.

It was observed that 23 out of 25 okra accessions under study were distinct accessions. A tie was recorded between accessions GH6102Fetri and GH3736Fetri. Similarity coefficient ranged from 45.8 to 86.5%. There was no unique relationship between the cluster groups and the regions of collection. Accessions with similar quantitative and qualitative morphological characters appeared well grouped in the same cluster. Okra accessions with common local names were also found in the same cluster (Figure 10).

Similarity per cluster group

Cluster A comprised of 16 accessions, differing from accession in the other clusters by having green fruit colour and golden yellow petal colour. Within cluster A, sub-cluster A_1 produced accessions with green stem colour as against A_2 with green-with-purple tinge stem colour. Within sub-cluster A_2, sub-sub-cluster A_{21}, consisting of accessions GH4482Muomi and GH4964Muomi, produced the same fruit shape (type 12) and leaf shape (type 1).

Okra genotypes, GH3801 Pora and DA/08/02 Sheo mana were singled out of the two unique sub-cluster groups A_1 and A_2 due to the fact that, GH3801 Pora formed a unique fruit colour/pigmentation (purple), and leaf shape (type 7) while DA/08/02 Sheo mana had fruits with green colour and a leaf shape of type 3.

Cluster B comprises of only one okra accession, DA/08/03 Sheo mana, and this differed from accessions in the other clusters mainly in its fruit pubescence or the presence of hairs on its fruits (downy plus hairs), and fruit colour (green to yellow).

Cluster C, the second largest cluster with 6 okra accessions, composed of okra genotypes that were different from the others by their reduced fruit pubescence, yellow petal colour with stem colour having a combination of green with purple tinge. The orientation of fruits on main stem was drooping. Within cluster C, sub-cluster C_1 formed fruit with shape of type 4, and combined green with red-spotted fruits while sub-cluster C_2 showed fruits with a combination of dark green plus red and dark green-to-black as well as leaf shape of type

2. Sub-cluster C_3 included fruits with dark green-to-black colour only.

Cluster D consisted of 2 okra accessions, Atuogya-tiatia and Atuogya-tenten. These were different from accessions in the other clusters by their branching position-at-main-stem; being DBB and fruit pubescence being little rough with dark hairs. The orientation of fruits-at-main-stem of these okra varieties was horizontal.

DISCUSSION

Extent of variation in qualitative and quantitative morphological characteristics

Variation is an important attribute in breeding programmes (Hazra and Basu, 2000; Omonhinmin and Osawaru, 2005). The okra genotypes characterized in this study (IBPGR, 1991) showed a broad variation for most traits, which allows for the identification of promising accessions for okra breeding in Ghana and beyond. The variation in leaf shape, leaf rib colour, petal colour, petiole colour, stem colour, fruit colour and pubescence and fruit shape, among others, were easily recognizable with visual appraisal (by the use of a colour chart and in accordance with IBPGR, 1991 descriptor list for okra).

Vegetative characters

Growth habit

Different genotypes have different growth habits, as a result of selection or a natural adaptation mechanism. The commonest growth habit among all the landraces observed indeterminate growth habit with erect general growth appearance.

Erect plant type is advantageous to okra production, since it allows maximum and uniform exposure or distribution of all leaves and other vegetative parts for better interception of sunlight, and would also result in an increase in dry matter production and a subsequent increase in yield. This is similar to findings by Hanson (2005). Moreover, there is less chance of fruits touching the ground or soil thereby causing fruit rot.

The indeterminate nature of the okra landraces is a character which might have been selected for over the years by researchers and farmers because it allows for longer and continuous fruit harvest. This is an advantage when prices of the vegetable fluctuate. Farmers do not want these plants to produce long branches and would rather opt for more plants per area unit. Previous studies in Tomatoes by Hanson (2005) suggested this to be advantageous because it allows the combination of large numbers of fruit with many plants per unit space, which is an indicator of high yield.

Okra genotypes such as ‘Wun mana’ and ‘Sheo mana’ types produced dense branches with fruits closer to the soil, yet gave higher total fruit yields. This could be selected for and incorporated into other ‘Asontem’ varieties which had the typical UOA branching (erect) but moderate in plant height, in order to develop elite okra types that are less lodging with higher yields and can therefore pass for commercial production.

Fruit characters and production

Fruits displayed great diversity in size-shape and length. Earliness, expressed by the lower leaf axil in which flower buds appear is partly due to varietal characteristic.

Fruits with characteristics such as smooth, spineless, slender with green (light or dark) skin are very desirable in the Ghanaian local and export markets (Sinnadurai, 1992). Varieties such as KNUST/SL1/07Nkrumahene, DA/08/004 Agbodro and Asontem were among the landraces that displayed such traits. These can therefore be selected for breeding by crossing them with other local materials such as ‘Atuogya’, ‘Sheo mana’ or ‘Wun mana’ accessions which were comparatively high yielding with longer harvest duration and also highly resistant to environmental stresses such as diseases and pests, and drought but revealed undesirable fruit shape and colour.

Variation revealed in this study for fruit colour was highest for green and appreciably high for green-to-yellow as well as green-to-red spots. This is different from the results of Myanmar (1995) in which fruit colour was observed to be either green or yellow-to-green, though green fruit colour was found to be highest in the okra accessions studied. These results were expected, because Myanmar (1995) might have examined improved okra collections that were more uniform. The okra genotypes used in this study were landraces, and hence more variable or diverse.

Results obtained in this study show that the okra accessions exhibited varying degrees of fruit pubescence including smooth, rough, downy or little hairs on fruits but with the majority having smooth fruits. This result is in contrast to those of Bish et al. (1995) and Thomas (1991) who found downy type of fruit pubescence to be highest, followed by slightly rough while prickly fruits was the least in the okra accessions they studied. This shows that farmers in Ghana have selected the smooth fruit types as their preferred fruit and discarded the hairy types.

Variation in okra species has been investigated by several researchers (Bish et al., 1995; Akinyele and Oseikita, 2006; Duzyaman, 2005). They found that a large number of okra characters such as pigment colour and spines on the fruit surfaces are inherited in a simple fashion, suggesting that these characters are controlled by relatively few genes (monogenically inherited).

Ariyo (1993) indicated that the pattern of genetic variation observed in characters studied in West African okra suggests a lot of out crossing among the taxon. Wide morphological variation observed in okra characters studied could perhaps, be attributed to the preponderance of out crossing among different accessions of the okra studied.

Pattern of variation and description of the cluster groups

In cluster group A, the cluster analysis generally found accessions GH6102Fetri and GH3736Fetri (from Biakoye and Kpogadzi, respectively) in a tie. That is, the two accessions were placed at 100% similarity. These Fetri accession may therefore be identical. Perhaps, they may have been collected by the same farmer and misnamed due to the informal way of germplasm exchange from farmer to farmer, diverse languages or ethnic groups in the areas covered by the collection and marketing, which accounts for the differences in local names (Torkpo et al., 2006).

Within cluster group A other 'Fetri' accessions were also found (GH4490Fetri, GH4499Fetri and GH1169Fetri). These may again be the same accession but picked at different locations and time and named differently due to the informal means of germplasm collection, selection and dissemination by okra farmers. Similar reason could be ascribed to the three accessions of Muomi (GH4487, GH4482, and GH4964 from Bedoku, Prampram and Sutapong, respectively) also found in the same cluster group A.

Okra accessions, GH4376Atuogya and Atuogya-Asante were found in cluster groups A and C, respectively. One would expect these to be under one cluster group, however, they are not. Perhaps, the traits considered were inadequate or were not sufficiently discriminatory to permit their classification into one group. Similar results can be speculated of accessions such as DA/08/02 Sheo mana and DA/08/03 Sheo mana as well as DA/08/04 Wun mana and DA/08/001 Wun mana, which did not enter into one cluster group but were found in cluster B and sub-clusters C_2 and C_3, respectively.

The great difference in genetic relationship, particularly among the Atuogya, Wun mana, Sheo mana, Muomi and Fetri collections demand further classification of these collections by employing more discriminatory characters or by utilizing molecular markers.

It must be said that most of the okra genotypes found in the same cluster group, such as GH1169Fetri and GH4499Fetri (originally collected from Gabusa and Nyingutu respectively, both in the Northern region), Atuogya-tenten, Atuogya-tiatia, Atuogya-Asante, Asontem and KNUST/SL1/07 Nkrumahene (collected originally in the Ashanti region), DA/08/02 Sheo mana, DA/08/03 Sheo mana, and DA/08/04 Wun mana, DA/08/001 Wun mana (all from Sakogu in the Northern region), and scoring similar similarity indices may be eliminated from the germplasm collection. IBPGR (1991) reported that, repeated regional collections without proper documentation could account for duplication in germplasm collections.

From the analysis of the similarity matrix, similarity coefficient ranged from 45.8%, for the most distantly related accession, to 86.5% for those closely related. This is therefore indicative of a higher variability in the okra accessions studied.

From the similarity matrix, two pair of accessions, DA/08/03 Sheo mana and GH4482 Muomi, Atuogya-tiatia and GH4964 Muomi showed the widest variation in the characters measured, scoring 0.458 on the similarity matrix, meaning that these okra pairs are 45.8% similar and 54.2% dissimilar in the characters measured.

These variations are what plant breeders are very much interested in and therefore are suitable for further breeding purposes. This results is confirmed by Reid et al. (1998), who argued that, genetic diversity of crops in Africa have been naturally preserved for a longer time by virtue of the continent's relative traditional agriculture.

Four pairs of accessions; Atuogya-tiatia and GH4487 Muomi, DA/08/04 Wun mana and GH4487Muomi, DA/08/04 Wun mana and GH4490 Fetri and Atuogya-Asante and GH4499 Fetri showed a similarity matix of 0.49. This again implies that they were 49% similar. These okra accessions are therefore suitable for exploitation by breeders for further improvement of quality and yield. Mondal (2003) argues that genetic diversity is essential to meet the diversified goals of plant breeding which included increase in yield, diseases and pest toleance, wider adaptation and desirable consumer qualities.

Observation from the similarity matrix placed only three pairs of accessions; DA/08/03 Sheo mana and GH4376 Atuogya, DA/08/001 Wun mana and GH4376 Atuogya and Atuogya-Asante and GH 4490 Fetri at 50% similarity, meaning the two accession pairs matched at half the characters measured.

The similarity matrix again showed that of all the accessions measured, eight accessions gave a matrix score of 0.8 and above. This shows that the pairs are 80% or more similar, according to the similarity matrix. Studies by Irwin et al. (1998) affirmed that closely related accessions are normally located within 80-90% similarity. Crosses between accessions with similarity indices of 80-100% may, therefore, not be desirable; and that the potential for successful crossing of unrelated varieties may generate into an array of genotypes from which useful agronomic types may be selected, a similar observation was made by Gulsen et al. (2007). The large size of the accessions from a wide range of geographical areas is very essential for genetic distance estimation (Nei, 1978).

Findings Torkpo et al. (2006) indicate that the wide range of similarity indices, coupled with the clustering of accessions, suggested useful variability in the okra germplasm collection for genetic preservationists and plant breeders for improvement programmes.

Conclusion

Conclusively, the pubescence and pigmentation of various plant parts as well as fruit characteristics, among qualitative traits of the okra landraces studied, proved to be most significant in the analysis of variability and contributed significantly to the total variation observed. The study has established that, varietal names are often descriptive; 'the early one', 'the late one', 'the dry season type', 'the wet season type'. The genetic affinity between the accessions from different regions observed in this study could however be attributed to the selection and exchange of okra germplasm between farmers from different regions and also between ethnic groups. Migrant farmers often carry seeds from their homes to their new locations, thus creating duplications in the germplasm. Nevertheless, there are distinct morphotypes in the Ghanaian okra germplasm, depicted by variation in petal colour, pubescence of the leaf and stem, fruit shape, anthocyanin pigmentation and number of days to 50% flowering. The clustering pattern indicated the presence of diverse forms in collections made from the same location, indicating tremendous opportunity to select the most desirable lines for that eco-geographical location.

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