UNIVERSITY OF CAPE COAST

DIVERSITY OF BUSH YAM (*DIOSCOREA PRAEHENSILIS*) IN GHANA AND THE PROSPECTS OF RAPID MULTIPLICATION THROUGH YAM MINISETT TECHNIQUE

EDITH AWO FIANU

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BY

EDITH AWO FIANU

Thesis submitted to the Department of Crop Science of the School of Agriculture, College of Agriculture and Natural Sciences, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy degree in Crop Science

AUGUST, 2017

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:.. Date:..........................

Name: Edith Awo Fianu

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature:................................... Date:........................

Name: Prof. Jonathan Padi Tetteh

Co-Supervisor's Signature: .... Date:........................

Name: Dr. Michael Osei Adu

ABSTRACT

Bush Yam (*Dioscorea praehensilis*), a wild type of yam species, is an important food crop in Ghana. It thrives well under artificial secondary forest hence it is able to grow under cocoa plantations in the forest zones. It is suspected that there is great diversity in the gene pool of bush yam but there is limited information on the existing germplasm. This project was undertaken to make a collection of the yam germplasm, characterize and select superior lines for further improvement. A total of ninety accessions were collected from the major production communities in Ghana and they were established in the field at two locations for morphological characterization and assessment for their culinary values. Prospects of planting material production through the minisett technique was assessed. Diversityof both qualitative and quantitative traits were observed. Flowering ability of bush yam were male, female, absent of flowers and haemaphrodite flowers. The leaf shape were cordate long and broad and saggitate long. Purplish green, pale green and dark green leaf colours were also observed. Cluster analysis grouped the accessions into 4 clusters. Sensory analysis suggested that the accessions vary in some sensory attributes. Fracturability was observed not to influence the choice of accession by consumers. Accessions varies in their ability to perform under the minisett technique. Performance of the accessions were better in the mulch and top soil media than in sawdust. The minisett performance of accession were not significantly different from each other except with DJA-067 which performed poorly in all data collected.

KEYWORDS

Bush Yam

Germplasm

Cocoa Plantation

Morporlogical Characterisation

Qualitative traits

Quantitative traits

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Finally, I wish to thank my family, especially my mother, for their support and prayers.

DEDICATION

I dedicate this work to daughter Kekeli, my mother Miss Georgina, my father Mr. Fianu and to my late great grandmother, Madam Felicia.

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LIST OF ACRONYMS

FAO	-	Food and Agricultural Organization
IFT	-	The Institute of Food Technologists
IITA	-	The International Institute of Tropical Agriculture
IPGRI	-	International Plant Genetic Resources Institute
MEDA	-	Mennonite Economic Development Associate
NRCRI	-	National Root Crops Research Institute
PC	-	Principal Componet
PCA	-	Principal Component Analysis
PGRRI	-	Plant Genetic Research and Resource Insttitute
RCBD	-	Randomized Complete Block design
RTIMP	-	The Root and Tuber Improvement and Marketing Programme
WAAPP	-	The West African Agricultural Productivity Programm

CHAPTER ONE

INTRODUCTION

Background to the study

Yams (*Dioscorea spp*) are important source of dietary energy, livelihoods and incomes in West Africa (Mensah, 2005). International Institute of Tropical Agriculture (IITA), (2004) described yam as an annual or perennial climbing plant with an edible underground tuber native to warmer regions of both southern and northern hemispheres. Ammirato (1984), also indicated that yam plants produce edible tubers, bulbils, corms or rhizomes. The so-called 'West African Yam Belt' accounts for over 90% of global yam production, with Nigeria, Ghana and Cote d'Ivoire being the top three producers respectively (IITA, 2014; Anokye, Tetteh, & Otoo, 2014; Mensah, 2005). In 2013, production in the yam belt was approximately 55 million tons on 4.4 million hectares of land (IITA, 2014), giving an average yield of 12.5 tons per hectare. In contrast to other food crops, yams are almost entirely consumed as food.

Yam has a cultural value in West Africa as it symbolizes wealth and influence and is the food for celebration of some social ceremonies and festivals in West Africa (Tetteh & Saakwa, 1994).According to Ammirato (1984), the proximate composition of edible yam tubers is water (65-75%), carbohydrates, mainly starch (15-25%), protein (1-2.5%), fibre (0.5-1.5%), ash (0.7-2.08%), and fat (0.05-0.20%), vitamin A is present in yellow flesh varieties. Calcium, iron, and phosphorus contents are high among the materials. According to Asiedu and Sartie, (2010), yam is a major source of food for millions of people in tropical and sub-tropical regions, especially in West and Central Africa where at least 60 million people depend on it.

There are over 600 species of the genus Dioscorea, out of which six are cultivated for food in the tropics, namely, *D. alata* (water yam), *D. rotundata* (white guinea yam), *D. esculenta* (Chinese or lesser yam), *D. cayenensis* (yellow guinea yam), *D. bulbifera* (aerial or bulbils yam) and *D. dumetorum* (trifoliate or bitter yam), (Degras 1993; Tetteh & Saakwa, 1994). In the West African yam belt, the white guinea yam is commonly grown (Coursey, 1996). Apart from the commercial yam species, there are other edible wild yams such as *D. burkilliana*, *D. minutiflora* and *D. praehensilis* (bush yam), which are grown on subsistence basis. These wild yams are mostly found in forest areas and were previously the main energy food for hunter-gatherers (Sato, 2001). Among the edible wild yams, bush yam is said to be the most reliable staple food in Africa (Sato, 2006). Yields of these underutilized species could be three to seven-folds greater than that of the known commercial species of yam (Treche & Guion, 1979; Brillouet et al., 1981).

There have been initiatives to increase yield, minimize losses, and increase profitability of yams in Ghana and West Africa. Some of such interventions or initiatives include the Root and Tuber Improvement and Marketing Programme (RTIMP) and in 2008, the West African Agricultural Productivity Programme (WAAPP) was initiated to develop improved technologies for root and tubers in close collaborations with RTIMP (World Bank, 2007). However, these efforts have largely been targeted at the known commercial species and failed to exploit the potential of edible wild yams in the yam value chain. In Ghana, bush yam (known locally as '*Kokooase* *bayerɛ'*) has been an important food and income security crop for cocoa farmers for ages but is currently known to be disappearing (Anokye *et al.*, 2014; Gyasi & Uitto, 1997).

Ecologically, bush yam thrives well under artificial secondary forests that allow considerable penetration of sunrays within its canopy (Dumont, Dansi, Zoundjihékpon & Vernier, 2005; Hart & Hart, 1986; Hladik, Bahuchet, Ducatillion & Hladik, 1984), hence its ability to grow under cocoa plantations in the rainforest zone of Ghana. Cocoa is a shade-loving crop, hence small to medium-sized trees whose canopies grow above that of the cocoa are left in the field to provide the needed shade for the cocoa trees (Adelusi & Lawanson, 1987). These trees also serve as the live stakes for bush yam grown under cocoa plantations. Beside cocoa plantations, bush yam can grow in other tree crop plantations that provide some shade and serve as live stakes in the semi-deciduous and transitional zones of Ghana (Ajibola *et al*., 1988).

The production of bush yam bears several advantages over the known commercial species of yam.

- First, there are no known pests that have been documented.
- Second, it is environmentally friendly to cultivate as it does not require elaborate land preparation, agronomic management or additional land as it can grow under established tree crop plantations.
- Additionally, bush yam**,** when mature, can remain wholesome in the soil for several months if not harvested.
- Again, the yield per mound of bush yam is much greater than that of the known commercial species and it is a delicacy or premium yam, preferred to the commercial species, in localities where it is grown.

- Finally, there is a great diversity to be exploited and it readily flowers and produces seeds profusely, making it amenable to crop improvement through hybridization.

However, a major limitation to the commercial and wider cultivation and consumption of bush yam is the short postharvest shelf-life. A few days after harvesting, the tubers become hardened when cooked and therefore difficult to eat (Dumont *et al*., 2005). This restricts the consumption and marketing of freshly harvested tubers to mainly the production areas in the cocoa belt, hence, limiting supplies to urban markets.

This notwithstanding, this yam can remain wholesome and be harvested bit by bit (piece meal) over several weeks or months after maturity. This makes it a potential food security crop for most part of the year and a source of income for cocoa farmers during the cocoa off-season. Moreover, bush yam produces seeds that naturally disperse and germinate in the wild. It is probable that the cultivars might have hybridized and segregated in the wild to create diversity in the population with regard to yield, quality and post-harvest shelf-life. This possibility has not been explored.

Statement of the problem

In Ghana, bush yam largely grows under cocoa plantations and has been an important food and income security crop for cocoa farmers for ages but is currently known to be disappearing as reported by (Anokye, Tetteh & Otoo, 2014; Gyasi & Uitto, 1997). The production, consumption and marketing of bush yam in Ghana are restricted to the cocoa belt largely due to its short postharvest shelf life. Knowledge and information on bush yam in Ghana is scanty.

Research questions

- Is it possible to have diversity in bush yam?
- Do consumers have preferences for bush yam?
- Is it possible to use yam minisette technique to multiply bush yam?

Significance of the study

Bush yam is a semi-domesticated crop and have been given any serious attention. Interactions with farmers and stakeholders incates that the germplasm of bush yam is disappearing due to changes in the farming systems. Norman, Tongoona and Shanahan, (2011), observed that yams are food security crops that sustain many livelihoods in the tropics and subtropics especially in West Africa, where large commercial scale production is practised (Dansi *et al*., 2009). The yam crop serves as a source of food, medicine and income for many small-scale farmers in Africa.

This project, therefore, seeks to create baseline knowledge on the distribution, diversity and morphological characteristics, and variations in the shelf life of *D. praehensilis* to support scientific exploitation and production as a commercial and food security crop. It also seeks to gather information on the consumer acceptability through culinary evaluation and to make planting materials available to farmers through the yam minisett technique.

Bush yam is important as a source of genetic variation in yam breeding work. Further genetic improvement to reduce the bitter constituents may render this yam more palatable and popular. Elite accessions that show high yield and good tuber characteristics and consumer preference would be selected in this project.

Objectives

General objectives

The general objective is to assess the diversity of bush yam (*Dioscorea praehensilis*) accessions in Ghana, and the prospects of rapid multiplication through yam minisett technique.

Specific objectives are:

- To investigate the diversity among bush yam accessions;
- To assess consumer acceptability of bush yam; and
- To assess the prospects of using the yam minisett technique for the multiplication of bush yam.

Delimitation

This work considers the diversity of bush yam in Ghana and prospects of yam multiplication.

Limitation

The influence of wearther (rainfall, temperature, light) was not measured.

Organisation of the study

The thesis is organised as follows: Chapter one (introduction), chapter two (literature review), chapter three (Methodology), chapter four (results), chapter five (discussion), chapter six (conclusion and recommendation) and references

CHAPTER TWO

LITERATURE REVIEW

Description, origin and distribution of yam

Yam, (*Dioscorea* spp) is a genus of over 600 species of usually herbaceous (but sometimes woody) perennial or annual vines that produce starchy, edible tuberous roots that are economically important in terms of food and medicine (IITA, 2014). Yam belongs to the genus Dioscorea and family Dioscoreaceae. Yams are agronomically rain-fed crops which grow for 6-12 months depending on the cultivar, ecology and soil properties in the production area (NARP, 1994). The vines of yam often have cordate leaves that may be alternate, opposite, or whorled. The flowers, arranged in spikes or racemes, are small and generally unisexual (Shanthakumari, Mohan & Britto, 2008). The fruits are 3-angled or winged capsules (in some species, berries), containing winged seeds. The roots of most species are rhizomatous or produce tubers (Shanthakumari *et al*. 2008).

Yam tubers can grow up to 1.5 m (4.9 feet) long and weigh up to 70 kg (154 pounds). The yam tuber has a rough skin which is difficult to peel, but which softens after heating. The skins vary in colour from dark brown to light pink (Shanthakumari *et al*. 2008). They are mostly composed of starch with significant amounts of vitamin C (Akoto & Safo, 1987). Yams must be cooked to be safely eaten, because raw yams contain various natural compounds, including phenols, tannins, hydrogen cyanide, oxalate, amylase inhibitor activity and trypsin inhibitor, that can cause illness or lead to nutritional deficiencies if consumed, also contact with uncooked yam fluids can cause skin irritations (Shanthakumari *et al*., 2008)

Some species of yam in which numerous cultivars have been developed are *D. rotundata* (white yam) and *D. cayenensis* (yellow yam), which originated in Africa, and *D. alata* (water yam), which originated in Southeast Asia (Alexander & Coursey, 1969). Yams are usually grown in tropical regions and mostly produced in the Savannah region of West Africa, where rainfalls are divided into wet and dry seasons (FAO, 2007). Chaïret *et al*., (2005), reported that the species status of West African yams is poorly defined, as cultivars of both yellow yam and white yam may have arisen through independent hybridization of wild or feral parents, including *D. abyssinica* and *D. praehensilis*, with little genetic exchange occurring naturally among members of either group. Lebot, (2009), submitted that the cultivation of these yam species in Africa is believed to have started at least 7,000 years ago (perhaps much earlier), and domestication of wild types continues today. According to FAO (2007), yam is also grown in Latin American and Caribbean countries like Colombia, Brazil, Haiti, Cuba and Jamaica. Yams are often marketed as fresh tubers and prepared for consumption (Asiedu *et al*., 1997).

Yam as a food security crop

Yam contributes substantially to household food security (Akromah & Bennett-Lartey 1993; Kenyon & Fowler, 2000). In Ghana, yam occupies about 11.6% of the total cropped area and annual production is estimated to be 5.8 million metric tonnes in 2009 (FAO, 2007). Income generation from yam improves the livelihood of resource poor farmers especially women (Bennett-Lartey & Akromah, 1996). Yam is a favoured food and a food security crop in some Sub-Saharan African countries (IITA, 2014). Yam could be eaten as boiled yam or fried in oil and can also be processed into yam flour or pounded yam (Ayensu & Coursey, 1972). Moreover, yam is also a source of industrial starch, the quality of which varies with the species, although the quality of starch of some species is said to be comparable to cereal starchy (Osisiogu &Uzo, 1973). It can be stored for four to six months without refrigeration and provides an important food safety net between growing seasons (Babaleye, 2003).

Bitter yams such as *Dioscorea dumetorum* have unpleasant taste and sometimes toxic properties and are eaten in times of food scarcity as a characteristic "famine crop" (Bhandari *et al*., 2003). Varieties with such properties need to be detoxified by soaking and cooking before eating. The West African yellow yam (*Dioscorea cayenensis)* gets its colour from the presence of carotenoids, and it is a good source of vitamin A (Bradbury& Holloway, 1988). Cooked yam also has about 2% protein which is about twice that in cassava. Yams therefore generally can provide nutritional security in West Africa where it is estimated to provide more than 200 dietary calories each day for over 60 million people (Nweke, Ugwu, Asadu & Ay, 1991; FAO, 2002).

Cultivars of yams grown in Ghana

During his study, Kumar & Chacko, (1979), reported that species of yams primarily grown in Ghana are the white yams (*Dioscorea rotundata*), bulbil bearing yams (*Dioscorea bulbifera*), yellow yam (*Dioscorea cayenensis*) and water yam (*Dioscorea alata*). The cultivars that are grown have significant dissimilarities that separate them into varieties. Kumar & Chacko, (1979), reported that these cultivars have local names in the northern part of Ghana, some of which are “Laribakor” “Pona” “Dundubanza” “Chenchito” “Sola” and “Tantapurika”. In the southern part of Ghana, these same varieties are called “Bayere” (Twi); “Yele” (Ga); and “Ete” (Ewe). Bush yam is known as “kokoase bayere” or “Asobayere” because it is mostly found within cocoa growing areas of Ghana.

According to Ayensu (1972), there are no universally accepted names and detailed descriptions of the distinguishing features of yams are lacking. Tetteh and Saakwa, (1994) also reported in a survey that, there are about 26 varieties of white yams grown in Ghana. The varieties are given local names which more or less describe certain attributes they have or are named after whoever introduced them to the area. During a study, Ayensu (1972) concluded that some varieties are sometimes given different names in different localities and hence some of the different varieties may, therefore, be the same.

Diversity of yam

Kumar & Chacko, (1979), submitted that genetic diversity refers to the amount of genetic variability among individuals of a variety, population or species, and provides the basis for adaptation to changing environmental conditions and for developing new varieties. This variation can be expressed in differences such as the morphological characters, physiological properties, biochemical characteristics, or in DNA sequence as described by (Ramanatha & Hodgkin 2002). Bush yam is considered one of the wild relatives or even one of the parents, of the cultivated yellow yam (*Dioscorea cayenensis)* and therefore may be used as a source of resistance and other useful properties (Brown, 2000).

Six main species of yams are cultivated in Ghana with the collection of large numbers of varieties (FAO, 2007). They are in order of importance: *Dioscorea rotundata* (White (Guinea)), *Dioscorea cayenensis* (Yellow (Guinea)), *Dioscorea alata* (Water yam), *Dioscorea esculenla* (Chinese yam), *Dioscorea dumetorum* (Three leafed yam), and (6) *Dioscorea bulbifera*. (Aerial yam).

Importance of Bush Yam

Apart from the commercial yam species, there are edible wild yams such as *D. burkilliana*, *D. minutiflora* and *D. praehensilis* (bush yam), which are grown on subsistence basis (Doku, 1966). These wild yams are mostly found in forest areas and were previously the main energy food for hunter-gatherers (Sato, 2001). Among the edible wild yams, bush yam is said to be the most reliable staple food in Africa (Sato, 2006). Yields of these underutilized species could be three to seven-folds greater than that of the known commercial species of yam (Brillouet *et al*., 1981). Bush yam is the most important edible wild yam of Africa, and is harvested quite extensively, for example in Ghana, from cocoa farms, forest and forest-margin habitats (Akromah & Bennett-Lartey, 1993). A piece of tuber and the crown is often replanted to produce a yam for subsequent years (Hladik *et al*., 1984). The leaves may also be eaten. Sometimes termed forest yam or white yam in English, this type of yam though common is not cultivated on large scale in Ghana. Bush yam (commonly known as '*Kokooase bayerɛ'* in Ghana, which literally means 'yam grown under cocoa plantation') has been an important food and income security crop for cocoa farmers for ages but is currently known to be disappearing (Anokye, Tetteh, & Otoo, 2014; Gyasi & Uitto, 1997). Coursey, (1967), revealed that many wild yam species contain toxic or bioactive chemicals, and some of these are cultivated for pharmaceutical products.

Morphology of Yam

Yam is a flowering plant and although a monocot has many features normally associated with dicots. According to Kumar & Chacko, (1979), there is the presence of two cotyledons in West Africa Dioscorea species. Some cultivars flower only rarely and even more rarely set fertile seeds (Coursey, 1969). All the Dioscorea are dioecious, although occasionally both male and female flowers are borne on the same plant (Chukwu & Ikweue, 2000).

The root system of yam

Yam plants has a fibrous root system which grows horizontally thereby lying close to the soil surface. These fibrous roots system according to Onwueme, (1978) are concentrated within the top 0.3m of the top soil; and only a few of these fibrous roots penetrate deeper than 1m. The root system develops elaborately during the early part of the plant's life (Dounias, 2001). If tubers are planted, the roots arise from the corm-like structure at the base of the stem (Domout & Vernier 2000). These roots which are adventitious roots are relatively fat and elongated rapidly to become the main feeder roots of the plant (GEPC, 1995). Roots arise at the same base of the stem even if the tuber sprouted in storage without being planted (Onwueme & Charles, 1994)

Yams have a second type of roots arising from the body of the tuber (Onwueme, 1978). These are however thin and short and develop as the tuber grows. During the development of a tuber, these roots are alive and may function for a short period as feeder roots but they become non-functional eventually as reported by (Onwueme, 1978). They are fewer in number but probably serve the same function of mineral absorption as do the ordinary feeder roots (Onwueme, 1978).

The stem of yam

A typical Dioscorea consists of a twining vine, which is annually renewed. The stem develops from the rhizome end of the tuber at the beginning of the growth period and dries away with the onset of dormancy (Girardin *et al*., 1998). There are no tendrils or other specialised organs for climbing and the twining stem branches freely in most species (Girma *et al*., 2012). The twining of vines is specific either belonging to the section Enantiophyllum circumnutate (clockwise in an upward direction) or yams belonging to the sections Opsophyton, Psilophyton, Cymbidium and Macroconidium which circumnutate anticlockwise (Onwueme 1978). For example, species such as *rotundata*, *alata*, *cayenensis* and *japonica* twine in a clockwise direction when viewed from the ground upwards while species such as *dumetorium*, *hispida*, *bulbifera*, *esculenta*, *trifida* and *praehensilis* twine to the left direction. The stem may be armed with spines as in *D. rotundata*or with wings as in *D. alata*to assist in supporting the stem on the host plant (Onwueme, 1978).

Bush yam hasvines that twine anticlockwise and possess spines too for support and protect against predators (Hooker & Niger, 1849). A report by Okonkwo, (1985) suggest that vines of many species of yam have spines which provide support in the twining habit while also deterring animal predators.The shape of the yam stem also depends on the species (Onwueme, 1978). The stem anatomy of yam is typical of the angiosperms. The outermost cell layer of the stem, the epidermis, may have stomata and glands (Gurma, 1974). According to Onwueme, (1978) the stem cortex of 3 to 7 layers of cells may also contain chlorophyll, which gives the green colouration of the stems.

The leaf of yam

According to Hladik & Dounias, (1993), the leaves of *D. praehensilis* are opposite, rarely alternate, the blades are entire, the apex acuminate to long-acuminate, somewhat thickened (distal 3–4 mm), usually longitudinally folded along midrib in herbarium specimens. Cataphylls are present on basal stems, usually to 2 cm long (Hladik & Dounias, 1993). The leaves are ovate, acuminate, thick and leathery in texture with a thinner translucent margin (Igwelo, 1989).

The flower of bush yam

Hladik & Dounias, (1993), stated that, the inflorescence of bush yam is spicate, simple. Male flowers patent to axis and 1–2 mm apart. The outer tepals of the flowers are 1.4–2.1 × 0.8–1.6 mm. The outer tepals are elliptic to elliptic oblong or ovate, sometimes broadly or thinly papery, rigid and somewhat translucent when dry, basal half often thicker but more translucent, especially in older flowers where base may appear grey in herbarium specimens. The inner tepals are 1.1–1.9 × 0.6–1.4 mm. The inner tepals are elliptic or ovate to broadly so, occasionally obovate, erect and concave, thickly papery and opaque and the stamens (Onwueme, 1978).

Yam flowers are inconspicuous yet their pollination is by insects. The female flower is, however, larger than the male flower. The sex ratio is in favour of male plants (Hladik & Dounias, 1993). In a research of yam specimens conserved in 10 national or university herbaria, Hladik & Dounias,

(1993) noted a male/female ratio, among flower-bearing plants, of 33/1 for bush yam**.** Thus 33 males to 1 female bearing plant. In the wild, the plants are often randomly thrown in various directions and are pollinated by insects, especially by Larothrips dentipes *thrips* (Hladik & Dounias, 1993). The problem associated with under-representation of the female sex, means that allelic diversity is limited.

The fruit and seed of bush yam

According to Hladik & Dounias, (1993), the fruit of bush yam when formed are in the form of a capsule.The yam seed is small and winged either completely or partially. The embryo is small and surrounded by much larger endosperm. The maturation of the fruit and seeds continues long after the plant has senesced (Okoli, 1975). Female plants of bush yam produce several dozen to several thousand flowers, each with six ovules (Hladik & Dounias, 1993).

The tuber of bush yam

The tubers are annual organs, which produce shoots and shrivel away and remain dormant in the dry season and produce new shoots again when the rains break (Purseglove, 1972). In addition to environmental conditions, the genotype and species differences influence the tuber growth and development are of different shapes, size, skin colour and level of grooving depending on the cultivar. The yam tuber has conventionally been classified as a stem structure. Earlier reports by Degras (1993), have described the tuber as a root but currently the accepted view is that, it is neither a root nor a stem structure but rather has its origin as a hypocotyl structure between the stem and root (Degras, 1993).

Constraints of yam production in Ghana

According to farmers, the main constraint to the production of bush yam is the short postharvest shelf life due to hardening of the tubers few days after harvest. Mignouna, Abdoulaye, Alene, Asiedu and Manyong (2014) stated that, the unavailability and high cost of high-quality, disease-free seed yam emerged as the first constraint, followed by the high levels of on-farm losses of tubers (almost 30%) during harvesting and storage, low soil fertility, and high labour costs associated with land preparation and staking. Manyong, Asiedu & Olaniyan, (2001), attributed the declining trend in yam production to deteriorating soil structure and low fertility, prevalence of noxious weeds such as spear grass, and low yield of varieties grown by farmers.

Increasing intensification of yam cultivation has also raised the incidence and severity of field pests and diseases (Mignouna *et al*., 2014). Pests such as nematodes, mealy bugs, and scale insects are transferred from the field into storage where they continue to multiply and cause damage leading to higher rates of tuber loss and reduced market value (Ampofo, Kumar &Seal,2010; MEDA 2011).

Maroya (2014), submitted that high production costs arise from the high incidence of destructive yam pests and diseases such as nematodes, viruses, fungi, scale insects, beetles, etc. at both pre-harvest and postharvest stages; the high labour input associated with land preparation, planting, staking, weeding, and harvesting; and the increasing shortage of virgin land suitable for production of the crop.

In the Derived Coastal Savannah Zone, Otoo, Asiedu, Ennin and Ekpe, (2005), found that farmers ranked staking as the most important and costly constraint after availability and cost of planting materials. Ninety percent of the farmers indicated that staking limits the scale of production especially when one cultivates *Dioscorea rotundata*. Farmers also indicated that since *D. cayenensis* and *D. alata* are hardy, farmers can afford not to stake and yet get good results.

Tuber dormancy and sprouting process

Coursey (1967), describes tuber dormancy process as the aerial growth of yam plants which normally cease with the onset of the dry season and most of the dry matter in the vine is then translocated into the tuber, which subsequently enters a resting or dormant state i.e. a physiological rest period of the yam tuber during which sprouting is suppressed. The ability of yam tubers to germinate after variable and often prolonged periods of dormancy is a vital quality characteristic which could be manipulated to improve the flexibility of storage duration and date of planting. A long dormant period, without loss of viability, enables the tubers to be used in propagation and is a factor in the perenniality of yams (Onwueme, 1973).

The whole process of sprouting, from cell division to emergence of the shoot, occurs in about 1 to 2 weeks (Onwueme, 1973). Varieties of *D. alata* and *D. cayenensis* may sprout a little earlier than *D. rotundata*. The physiological significance of apical dominance (the tendency to sprout from the head of the tuber) is not clear, particularly for whole tubers (Onwueme 1973). Even among cut setts taken from the middle and the tail region, the sprouting locus often develops on the part near the head region.

Factors that affect sprouting

Temperature is known to affect sprouting in yam. The optimum temperature for tuber sprouting is between 25 and 30^{o}C. Any appreciable change more than 5^{o}C below or above this range delays sprouting as reported by (Onwueme, 1973). Moisture stress may not prevent sprouting entirely but may inhibit bud elongation on the tuber. Any factor that helps to break tuber dormancy is likely to favour sprouting in yam. This explains the significance of mulching the mounds or yam ridges after sowing during the hot planting season.

Agronomic characteristics

Coursey (1967), reported that yam is a plant of the tropical climates and does not tolerate frosty conditions. Temperatures below 20 °C impede the growth of the plant which needs temperatures between 25 and 30 °C to develop normally. Light intensity is known to affect growth and tuber formation. This is usually the reason why yam vines are staked to ensure maximum interception of light by the leaves to promote yield (Coursey, 1982; Okezie, 1987).

According to IITA (2014), an annual rainfall of about 1000 mm spread over five to six months and deep, fertile, friable, and well-drained soils are ideal for yam cultivation. Most food yams give the highest yields in areas where long rainy seasons prevail. Yam is also able to survive long dry periods, though yields are reduced considerably (IFT, 1975). The cultivation is like other yams; *Dioscorea praehensilis*is grown in well-weeded plots, often in mounds of soil and trained against a support (Onwueme, 1973).

Planting materials

Traditionally, yams are grown from tubers or pieces of tuber from the previous crop (Okoli, 1978). The planting piece is called a 'sett' or 'mother tuber' (Okezie *et al*., 1981). The size of sett used varies, from around 100g to 500g or more, with 300g being a fairly typical size (Bakang, 1998). Seed rates may range from 2– 6t or more per ha depending on the plant space (Bakang, 1998). In addition to size, the part of the mother tuber that is used for a sett also affects the timing and strength of initial growth. 'Head setts', from the top of the tuber, sprout most strongly, followed by middle and tail setts. However, the influence on final yield has not been well studied. Small whole tubers are comparable or superior to head setts, and are preferred if available (Okigbo, 2005).

Mounding and Planting

The traditional method of land preparation for yams production is making mounds (Nweke *et al*., 1992). The size of the mounds varies depending on the ecology, zone of production, cultivar, purpose of production and sett size (Norman *et al*., 2011). Small mounds 50cm-60cm in diameter are made for traditional seed yam production, larger mounds of 0.5m to 1.0m by 1.0m to 1.5m high are used for ware yams (Ng & Ng, 1997). Mounds are made with hoes and shovels. (Onwueme, 1978). However there is no known document pertaining to the preparation of mounds for bush yam.

Staking material

Staking is done when the yam is about 1m tall. This involves providing a support on which the vine will twine (NARP, 1994). It is done after emergence before the vines trails on the ground (Mozie, 1988). In production environments, most yam genotypes yield better when the vines are provided with support than when they are not (King & Risimeri, 1992). Staking performs two functions; to increase the light interception of the leaf canopy and to increase ventilation around the leaves. Thus staking is carried out especially in the humid forest to help the twining yam stems display their leaves to capture adequate photosynthetic active radiation (PAR) for efficient photosynthesis (Moore, 1972). It also facilitates weeding, especially with thorny varieties (King & Risimeri, 1992). The type of staking may depend on local conditions and available materials. A typical method is to provide one vertical stake per stand. However, where stakes are less available, one stake may be provided for 2–6 stands. According to Ndegwe (1992), the yield of *D. rotundata* increased with stake density (two stands per stake was the highest number tested), but that the increased yield may not justify the increased cost. There are several types of staking which includes pyramid staking, individual staking and trellisings (Mignouna *et al*., 2003).

Ecological areas and characteristics of varieties of yam cultivated

Bush yam (*Dioscorea praehensilis*) is quite common in West Africa (Meige, 1957). Bush yam will grow for as long as three years if they are continually milked. It is considered one of the wild relatives or even one of the parents of the cultivated *Dioscorea cayenensis* and therefore may be used as a source of resistance and other useful properties (Meilgaard *et al*., 1991). The many genetically different populations are being studied. Physiologically, *D. cayenensis* differs from *D. rotundata* in having a shorter period of dormancy and a longer growing season (Mayes *et al*., 2012). Thus it can only be grown in areas where the rainy season is slightly longer than the minimum required for *D. rotundata*. It takes about twelve months to grow and mature (Martin & Degras, 1978).

Germplasm collection

According to Thomas & Mathur, (1991), not until a collection has been properly evaluated and its attributes become known to breeders, it has little practical use. Field surveys which were recently undertaken in Benin and Nigeria have shown that the process of domestication is still ongoing (Mignouna and Dansi 2003). Small-scale farmers mainly acquire new cultivars from their neighbours, during travels or by collecting tubers found in fallows or forests (Martin & Sadik, 1977).

The demand for germplasm (ranging from individual genes to co-adapted gene complexes to entire genotypes or even populations) is unpredictable and dynamic (Engels *et al*., 2004). There is no way of telling what tomorrows needs may be, and what plants may be able to fulfil them. The more diversity is conserved and made available for future use, the better the chances of fulfilling future demand. Germplasm collecting can be expensive, and funds are usually limited.

Engels, Arora and Guarino (2004) stated that the main reasons for collecting germplasm of a given gene pool in a given area are:

- The diversity it represents is missing from, or insufficiently represented in, existing ex situ germplasm collections;
- Germplasm is in danger of genetic erosion or even extinction;
- A clear need for it has been expressed by the users, at national level or internationally;
- A lot more needs to be known about it

The following are not mutually exclusive. It is imperative to know that germplasm may be both threatened and useful, and there may be gaps both in collections of a gene pool and in what is known about it (Irving, 1956). Important as germplasm collecting may be, it is essential to remember that it is not the end of the story. It needs to be seen as simply one facet of a conservation strategy that may also include an *in situ* component, for example. A successful collecting programme does not mean that one can stop worrying about conservation of the target gene pool (King & Risimeri, 1992).

Characterisation of yam

Characterization of germplasm involves traits that are highly heritable, expressed in different environments and can be easily seen by the eye (Kolo, 1995). Characterization information along with passport data provides an indication of the range of diversity in the collections and is of considerable help to the breeders to narrow the selection of potential breeding stocks (Kordylas, 1990).

Proper characterization and evaluation of germplasm and dissemination of the information to the plant breeders and others is a priority area in any germplasm management programme (IITA, 2014). Through characterization, variations that exist in a germplasm collection in terms of morphological and phenological characteristics of high heritability can be estimated (Lex & Shriver, 1998). This means that the diversity in a germplasm collection is studied when characterization is done (Manly, 1994). Such variation may also include characteristics whose expression is little influenced by the environment. That is variability expressed by molecular markers (King & Risimeri, 1992).

Morphological characterization

Morphological characterization is important in the identification of duplicate accessions, identification of unique traits and the structure of the population to be conserved, in so doing saving on storage space and simplifying selection by plant breeders (IITA, 2014) whose phenotypic expression is the product of the combined effect of the environment and the genotype. Morphological characterization studies this process, its causes and results.

Yam minisett technique

Techniques have been developed for the rapid multiplication of yams using minisetts (tuber pieces around 30 g) (IITA, 2014), from vine cuttings (Singh, Bordoloi & Nag, 1991) and from true seed (IITA, 2014). These techniques are not relevant to the production of the ware tubers as the tubers produced by such plants are generally small and suited mainly for use as planting materials. Larger setts produce larger, more vigorous plants that yield larger tubers a study by Lyonga, Fayemi and Agboola (1973) revealed. This is apparently due to earlier germination, and quicker growth of roots and vines in the earliest phase of crop development (Manyony *et al*., 1996). However, smaller setts are generally used to multiply planting material, but larger setts are preferred ware tuber for production (Onwueme, 1978).

According to IITA (2014), minisetts cut from various sections of the tuber have varying rates of sprouting. Marfo (2002) reported that setts planted with adequate moisture support better sprouting and initial growth and also less rot whilst minisetts planted in hot weather without mulching rotted more and reduced sprouting (Marfo, 2002).

CHAPTER THREE

THE DIVERSITY OF BUSH YAM (*DIOSCOREA PRAEHENSILIS*) ACCESSIONS IN GHANA

Introduction

Yams cultivated in Ghana belong to six major species. Each species is represented by many landraces, some with several strains. Many studies have been conducted on the existing commercial species of yams but few researches have been done on the wild yams especially *Dioscorea praehensilis*. Edible wild yams such as bush yam has thus become under-researched, underutilized and restricted to a small geographic area. Earlier interactions with farmers have indicated that, there is the existence of great diversity among the bush yam germplasm that are cultivated with regard to shelf life, cooking quality, yield and consumer preference. This reinforces the belief that there could be variants in the wild that have the potential to be cultivated commercially and as a food security crop. It is suspected that there is great diversity in the gene pool of bush yam but there is limited information on the existing germplasm.

In other to accertain the findings of these farmers, it is important to conduct an experiment to determine whether or not there is diversity in bush yam. Determination of the genetic diversity of yam is complicated by the fact that farmers with different ethnicity have different vernacular names possibly for the same genotypes. Thus, an extensive germplasm assessment and characterization involves measurement of more than one traits.

Genetic diversity refers to the variety of genes in all organisms from human beings to crops, fungi and viruses (Thijssen, Van der Heijden & Rocco, 2008). It determines the uniqueness of each individual, or population, within the species. There are four methods of measuring genetic diversity namely ethino-botanical classification, morphological, biochemical and molecular characterization (Hoogendijk & Wiliams, 2001).

Characterization of information along with passport data provides an indication of the range of diversity in the collections and is of considerable help to the breeders to narrow the selection of potential breeding stocks (Martin, 1976). Through characterization, variations that exist in a germplasm collection in terms of morphological and phenological characteristics of high heritability can be estimated (Onayemi & Idowu, 1988). This means that the diversity in a germplasm collection is studied when characterization is done (Onueme & Sinha 1991).

This would aid in selecting accessions that are superior for further crop improvement programmes.

Methodology

Germplasm collection

Accessions were collected from regions within Ghana noted for bush yam production. Extension agents of the Ministry of Foods and Agriculture and some stakeholders in the identified regions were consulted to identify specific communities engaging in the production of bush yam. Eventually, 3 regions and out of the 3 regions, 30 communities were identified. The regions were Eastern, Ashanti and Western regions.

A trip was then made to those proposed places to ascertain the information obtained. The visits to the various communities were done on the following dates: 1st to 2nd October, 2015 and 17-18th December 2015 (Eastern region), 13th -14th October 2015 and 26th November (Western Region) 2015 then 14th October 2015 (Ashanti Region). Through these visits, germplasm of bush yams were obtained at the farmers' fields and in markets. Communities in Western Region where germplasm were collected were; Sefwi Wiawso, Bekwai and Bibiani. In the Ashanti region, materials were collected from; Nyinahin, Mampong, and Fumso. Some materials were also collected from the Plant Genetic Resource and Research Institute (PGRRI) Bunso in the Eastern Region of Ghana. Passport data of each accessions were taken for easy identification of the accessions.

Location for morphological characterization

The morphological characterization was conducted at two locations, which were; Asuansi Research Station, and the University of Cape Coast Teaching and Research farm. The Asuansi field was under a cocoa plantation while the University of Cape Coast was an open field.

Asuansi Research Station is located at Asuansi in the Abura/Asebu/Kwamankese District of the Central Region of Ghana. It is about 30km North of Cape Coast. The station is close to the Asuansi Technical Institute. The Asuansi Agricultural Station lies in the southern fringes of the semi-deciduous rainforest. It experiences a mean rainfall of about 980mm. The rainfall pattern follows the traditional double maxima (bimodal) distribution experienced in most parts of southern Ghana. However, the minor dry season in August is ill-defined and may be assumed to be a continuous raining season with two peaks. The rains starts in March and ends in early December. January and February are the clear dry months. Temperatures are generally warm and uniform throughout the year. Mean monthly temperature is about 26.90^{o}C.

The topography of the area consist of low hills and small knolls. Gradients are almost becoming on the knolls. The Kakum River and the Chichiwere Stream are the main drainage ways of the stations land. However, a few isolated upland depressions (dry valleys), are scattered over the site. Cape Coast granites that are known to be very rich in micas underline the area. It gives rise to porous gravelly sandy loams over gritty sandy clay soils that are often rich in minerals especially potassium if they are not over-cropped or severely leached.

The University of Cape Coast Teaching and Research farms falls within the Savannah Thickets of Ghana. It lies between latitude 05^{o} 03'N and 05^{0} N and Longitude 01^{o} 13' W and is characterized by annual rainfall of about 750 mm to 1200mm (Boamah, 2008). There are two main seasons in the area; wet season and dry season. The wet season is divided into major and minor seasons. The major season starts from May to July and Peaks in June while the minor season begins from September to November and peaks in October. The main dry season in the area is from December to February. Temperature throughout the year are usually high, with maximum usually between 30-36^{o}C and minimum between 22-26^{o}C (Marfo, 2002). The relative humidity in the area ranges from 70% to 90%, this reduces to 70% in the afternoon (meteorological station Cape Coast, 2002). At each location, the experimental design used was the randomized complete block design (RCBD). There were 3replications for Asuansi Research Farms and two (2) replications for the School of Agriculture Teaching and Research Farms.

Field work

Accessions

There were 90 accessions collected in the form of ware tubersand regenerated tubers from the three major cocoa growing area of Ghana. Accessions with numbers ending001 to 062, and 080 to 090 were ware tubers while 063 to 079 were regenerated tubers. In all instances, accessions were collected on the day of harvest except for accessions 042 and 043 which were harvested about a week before collection.

Mound preparation and planting

Mounds were prepared on each field. A mound of about 60cm long, 60cm wide and 60cm deep were prepared. Distance between mounds was 1m. A pit was dug to pulverize the soil. The pit was then filled with soil and it was then heaped to form a mound.

Before planting, the yams were prepared by cutting them into sizeable units of approximately 2cm and weighing 25g. These cut yams were treated against insects and pathogens using a fungicide (Mencozeb). The planting materials were then air dried under shade. The weight of each cut tuber was then recorded and each cut tuber was bagged using polythene and then labelled.

The prepared yams were then planted on each mound. Planting was done on the 11th November 2015 and 28th December, 2015 at the School of Agriculture Teaching and Research farms. Planting was done on the 16th and 19th December 2015 respectively at the Asuansi Research Station. Each mound was then staked with bamboo stakes where necessary at the Asuansi Research Station but at the School of Agriculture Teaching and Research Farms, all mounds were staked with bamboo stakes. There were 2 replications for the School of Agricultural Teaching and Research farm whilst the Asuansi Research Station had 3 replications. In all, there were 174 and 266 mounds for the School of Agriculture Teaching and Research and the Asuansi Research Station respectively.

Routine agronomic practices such as weed control, earthening-up, watering were carried out where necessary. No chemical amendments were applied to the soil.

Data collection

The IPGRI descriptor for yam was used as a guide to determine the parameters or traits to be observed. The following parameters were measured after Days planting was done:

- to emergence [d]
- Number of days between planting and emergence
- Sprouting percentage.
- Stem colour (young and matured),
- Spine position, spine shape, absence/presence of coalescent spines.
- Internode number to fully expanded leaf (number).
- Leaf colour (young and matured).
- Flowering and sex (female or male).
- Tuber flesh colour, before and after oxidation, and ease of peeling and colour of cooked tuber.

Evaluation of Morphological Traits

Days to emergence

On two days intervals the mounds were observed to see whether there were any visible sign of sprouts. Each sprouted mound was recorded. This was done until there was no more sprouts.

Vine characteristics

Colour of young vines and old vines were noted after sprouting. It was evaluated 7 days after sprouting had begun. The Munscell colour chart was used to determine the colours of each sprouted vine. Appropriate colours which matched but young and matured vines both were selected and recorded. Each colour observed was coded to make data entry simple.

Leaf characteristics

Colour and shape of young leaves (10 days after sprouting) and matured leaves (60 days after sprouting) of sprouted plant were recorded. The Munscell Colour chart was used. Each leaf was matched with the chart and the appropriate colour was then selected. Codes were used to identify each colour observed.

The various leaves shapes were determined using the descriptor and the shape that best fits the leaf was selected.

Spine characteristics

This was done to ascertain whether the accessions have spines on their vines or not. Visual appraisal and the feel of spines using the hand were used to collect this data.

Abundance of spines above and below the vines were also measured

Spines were being designated as being few or more on the vines. When they are few above or below the vine, it was designated by 1 and if the spines are many then they were designated as 2.

Another feature of the spine that was evaluated was the shape of the spine. Appropriate shapes are then matched to the right accessions.The number of spines at the 3rd internode from the mound was measured. Visual counts and the abundance of spines were recorded at the 3rd internode. The number of spines counted were then recorded.

A pair of callipers was used to measure the girth of the vine. It was taken at the 3rd internode from above the mound level.

Flowering

Parameters measured included the sex of the flowers and the ability of the vine to produce flowers. The sex of the flowers (males or females, whether it was male dominated or female dominated or whether they were hermaphrodites). The relative lengths of the flowers peduncles were measured using a ruler and the number of florets per peduncle on the female inflorescence were counted.

Number of internodes from ground to the first fully expanded leaf

The number of internode to the first fully expanded leaf was done by counting the number of internode on a vine. The first leaf spotted suggest that counting should stop and the number is the recorded.

Harvest parameters

Yield data

The bush yams were harvested after the leaves on the vines were completely senesced. The harvested yams from each mound were weighed and the value obtained was recorded. A top loading scale was used in carrying out this exercise.

Tuber flesh colour, and colour change from oxidation

Tuber flesh colour was observed during the sensory analysis process. Harvested yam tubers were peeled for cooking. During peeling, the initial tuber flesh colour, and the colour change after five minutes of peeling, were noted. The colour change was the result of oxidation.

Thorns on Tuber

The thorns on tuber was taken after harvesting was done. Thorns which were seen on the yam tuber were counted.

Ease of peeling

The ease with which the peels comes off the yam tuber was determined during peeling.

Data Analysis

Excel spreadsheet was used for data input and presenting. Frequencies were determined using SPSS. PAST was sed for Cluster analysis. Cluster analysis was used to estimate pairwise genetic similarity or dissimilarity values among accessions. Further, selected traits were subjected to Principal Component Analysis (PCA) to examine the percentage contribution of each trait to total genetic variation. Principal Component Analysis (PCA) of the characterization results will identify a few key or minimum descriptors that effectively account for the majority of diversity observed.

Results

A total of ninety accessions in (Table 1) were collected from thirty eight communities in three regions. The accessions were in the form of tubers. The number of accessions collected was 39, 7 and 44 accessions from the Western, Ashanti and Eastern regions respectively. The assessions collected from market places did not have any local names, but those obtained directly from farmers had local names.

Table 1: *Regions and Communities of Collection and Local Names of Bush Yam Assessions Collected*

Accession Numbers	Regions	Communities	Local Names
AGO-001	Eastern	Klo Agogo	Nil
AKY-002	Eastern	Akyemateng	Nil
NS-A-003	Eastern	Nsuta-Apirede	Nil
NS-A-004	Eastern	Nsuta-Apirede	Nil
NS-A-005	Eastern	Nsuta-Apirede	Nil
AKY-006	Eastern	Akyemateng	Nil
NKU-007	Eastern	Nkurakan	Nil
ABO-008	Eastern	Aboa	Nil
ABO-009	Eastern	Aboa	Nil
DJA-010	Eastern	Djamam	Odorno
DAW-011	Eastern	Dawatrim	Kati
ABE-012	Eastern	Abesre	Odorno
ASE-013	Eastern	Asempanaeye	Odorno
TAK-014	Eastern	Takorase	Ogyam
TAK-015	Eastern	Takorase	Odorno
DJA-016	Eastern	Djamam	Tsomatsor
BET-017	Western	Bethlehem	Nil
AMA-018	Western	Amafie	Afu
AMA-019	Western	Amafia	Nil
ABO-020	Western	Aboboyaa	Nkaseè Bayere
ABO-021	Western	Aboboyaa	Nil
AMA-022	Western	Amafie	Asobayerepa
AHW-023	Western	Ahwia	Nil

Table 1 conitnued

AMA-024	Western	Amafie	Nil
AMA-025	Western	Amafie	Kokoase Mankeni
AMA-026	Western	Amafie	Nil
AMA-027	Western	Amafie	Nil
AMA-028	Western	Amafie	Nil
AMA-029	Western	Amafie	Kokoase Bayerepapa
AMA-030	Western	Amafie	Kokoase Bayerepapa
SE-W-031	Western	Sefwi Wenchi	Asobayere
SE-W-032	Western	Sefwi Wenchi	Akyekyere
SE-W-033	Western	Sefwi Wenchi	Forking bayere
SE-P-034	Western	Sefwi Paboase	Kokoase Bayere Pa
SE-A-035	Western	Sefwi Adobawura	Forking Bayere
SE-A-036	Western	Sefwi Adobawura	Asobayere
SE-A-037	Western	Sefwi Adobawura	Asobayere
SE-S-038	Western	SefwiSowodadeam	Kokoase pona
NYI-039	Ashanti	Nyinahin	Dabreko Kokoase
NYI-040	Ashanti	Nyinahin	White type
NYI-041	Ashanti	Nyinahin	Nil
MAM-042	Ashanti	Mampong	Asobayere
MAM-043	Ashanti	Mampong	Asobayere
FUM-044	Ashanti	Fumso	Nil
FOM-045	Ashanti	Fomena	Nil
SE-B-046	Western	Sefwi Bethlehem	Bono Bayere
SE-B-047	Western	Sefwi Bethlehem	Osono Keseè
SE-B-048	Western	Sefwi Bethlehem	Bobidieè (Kokoase Afun)
SE-B-049	Western	Sefwi Bethlehem	Kokoase Kartre
SE-B-050	Western	Sefwi Bethlehem	Serwaa Bayere
SE-B-051	Western	Sefwi Bethlehem	Asobayere Ketewa
SE-B-052	Western	Sefwi Bethlehem	Nkaseè Bayere
SE-B-053	Western	Sefwi Bethlehem	Afun Tenten
SE-B-054	Western	Sefwi Bethlehem	Bayere fufuo
SE-B-055	Western	Sefwi Bethlehem	Akyekyedeè
SE-B-056	Western	Sefwi Bethlehem	Bootaa/Koometa
SE-B-057	Western	Sefwi Bethlehem	Kokoase Pona
SE-B-058	Western	Sefwi Bethlehem	Kokoase kootibre
SE-B-059	Western	Sefwi Bethlehem	Bootaa Asobayere
SE-A-060	Western	Sefwi Ankra-Muano	Brobidieè
SE-A-061	Western	Sefwi Ankra-Muano	Afum
SE-A-062	Western	Sefwi Ankra-Muano	Asobayere
DJA-063	Eastern	Djamam	Sackitey

Table 1 conitnued

DJA-064	Eastern	Djamam	Obobe
DJA-065	Eastern	Djamam	Bale tuu
DJA-066	Eastern	Djamam	Bale hior
DJA-067	Eastern	Djamam	Odornor kpawayo
DJA-068	Eastern	Djamam	Kati hior
DJA-069	Eastern	Djamam	Odornor kpangua
DJA-070	Eastern	Djamam	Ojam
DJA-071	Eastern	Djamam	Amalo
DJA-072	Eastern	Djamam	Ologojo
DJA-073	Eastern	Djamam	Ojeoblai
DJA-074	Eastern	Djamam	Kpayumu
DJA-075	Eastern	Djamam	Otim bale
DJA-076	Eastern	Djamam	Kati Hior 2
DJA-077	Eastern	Djamam	Kati yumu
DJA-078	Eastern	Djamam	Ologojo
DJA-079	Eastern	Djamam	Odornor kpangua
BUN-080	Eastern	Bunso	Nil
BUN-081	Eastern	Bunso	Nil
BUN-082	Eastern	Bunso	Nil
BUN-083	Eastern	Bunso	Nil
BUN-084	Eastern	Bunso	Nil
BUN-085	Eastern	Bunso	Nil
BUN-086	Eastern	Bunso	Nil
BUN-087	Eastern	Bunso	Nil
BUN-088	Eastern	Bunso	Nil
BUN-089	Eastern	Bunso	Nil
BUN-090	Eastern	Bunso	Nil

Source: Field work, Fianu (2015)

Table 2: *Duration of Storage and Sprouting Percentage of Accessions*

Accessions	Harvest date of collection	Days of storage before planting	Days from planting to sprouting	Percentage sprouting
001-007	1-10-15	71	46-104	78.6
008-016	2-10-15	70	45-115	77.8
018-030	13-10-15	59	46-115	88.5
031-043	14-10-15	58	46-100	96.2
044-046	15-10-15	57	46-68	100
047-062	26-11-15	30	29-83	100
062-079	17-12-15	11	29-89	97.1
080-090	18-12-15	10	63-97	80.0

Source: Field work, Fianu (2015)

Vine colour

Sixty-nine (69) accessions had green colour, 13 accessions also had purplish green and 8 accessions, however, had their young vine colour to be purple.

With regard to mature vines, four different colours were observed. The frequency distribution of the various vine colours are shown in Figure 1. The vine colours include: green, brownish green, purple, and black. Out of the 90 accessions planted, 54 of them had green matured vine colour, 33 accessions also had their matured vine colour being brownish green, while 2 were purple and one was black in colour.

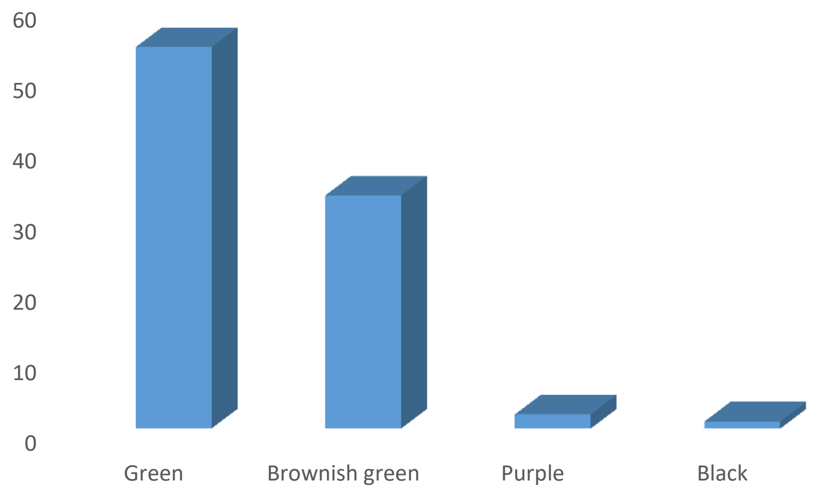

Figure 1: Frequency distribution of matured vine colour

Leaf colour

Two colours were observed (pale green and purplish green). It was observed that, out of the 90 accessions planted, 81 of the accessions had pale green young leaf colour whilst 9 of the accessions produced purplish green young leaf colour.

Leaf shape

The frequency distribution of the leaf shape among the 90 accessions collected is shown in Figure 2. Three leaf shapes were observed. They include: cordate long, cordate broad and sagittate long. Out of the 90 accessions that were characterized, 30% had a cordate long shape, 55% had cordate broad leaf shape and 5% had sagittate leaf shape.

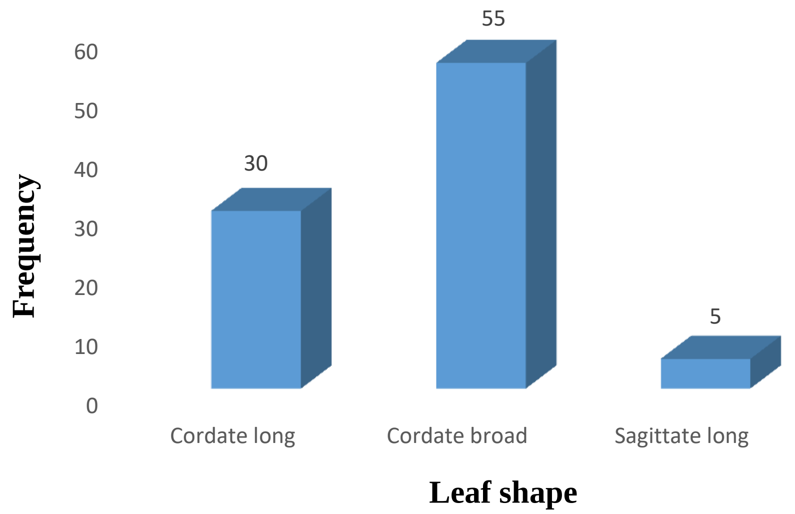

Figure 2: Frequency distribution of leaf shape ofbush yam accessions

Spine shape and number

The frequency distribution of the spine shape among the 90 accessions collected are presented in Figure 3. Three spine shapes were observed. They include curved upward, curved downward and straight. Out of the 90 accessions that were accessed, 40 accessions had a curved upwards spine shape, 36 of the accessions had their spine shape curved downwards and 14 had straight spine shape (Figure 3).

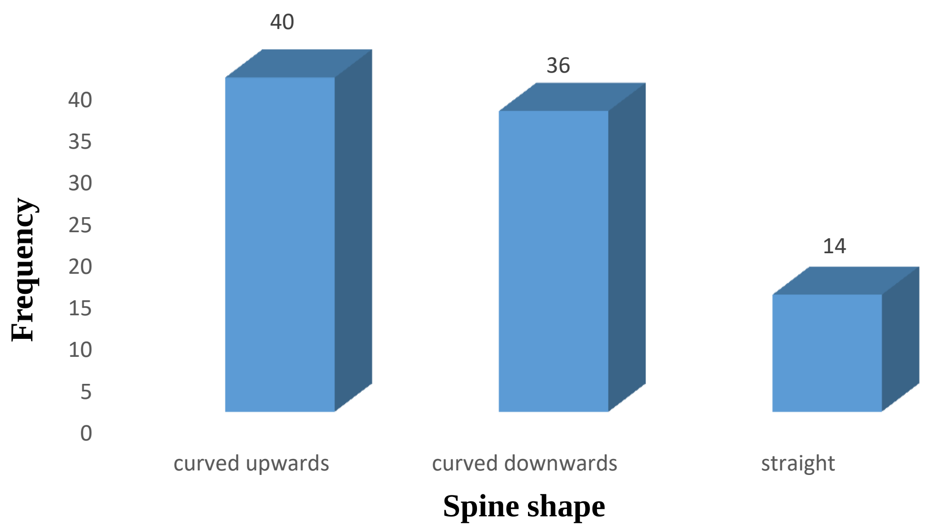

Figure 3: Frequency distribution of spine shape of bush yam

Flowering characteritics

Four main flowering abilities were observed (Figure 4). No flowers (absent), male flowers only, female flowers only, and both male and female flowers present. There were 8 out of the 90 that did not produce any flowers (Figure 4). Only 5 of the accessions produced female inflorescence. In all, 73 of the accessions produced male flowers only, and 4 accessions produced both male and female inflorescence (Figure 4).

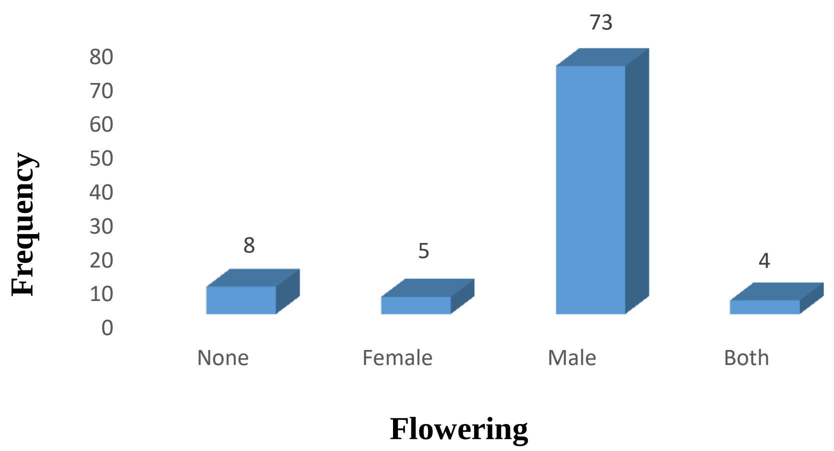

Figure 4: Frequency distribution of flowering ability of bush yam

Peduncle length

On the basis of peduncle length of female inflorescence, three different types were observed. These were short, medium and long respectively (Plate 2).

A

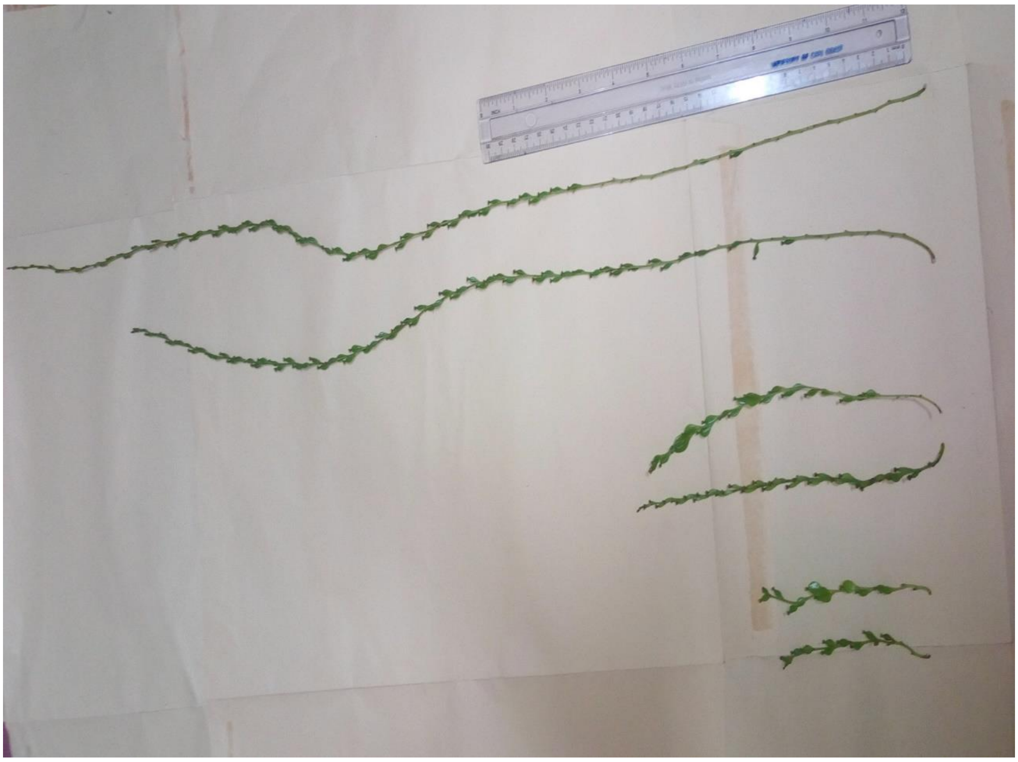

Plate 1: Female inflorescence of bush yam

The short flower measured about 20cm, the medium one also measured about 30cm and the longest one measured about 80cm. The longest finflorescence had up to 126 florets per peduncle, while the medium and short ones had about 50 and 30 florets respectively.

The bush yam produced male inflorescence (Plate 3) that appears in a pair, two pairs, three pairs and more than three pairs in a spike. The male inflorescence measured about 20cm just like the short inflorescence of female bush yam flowers.

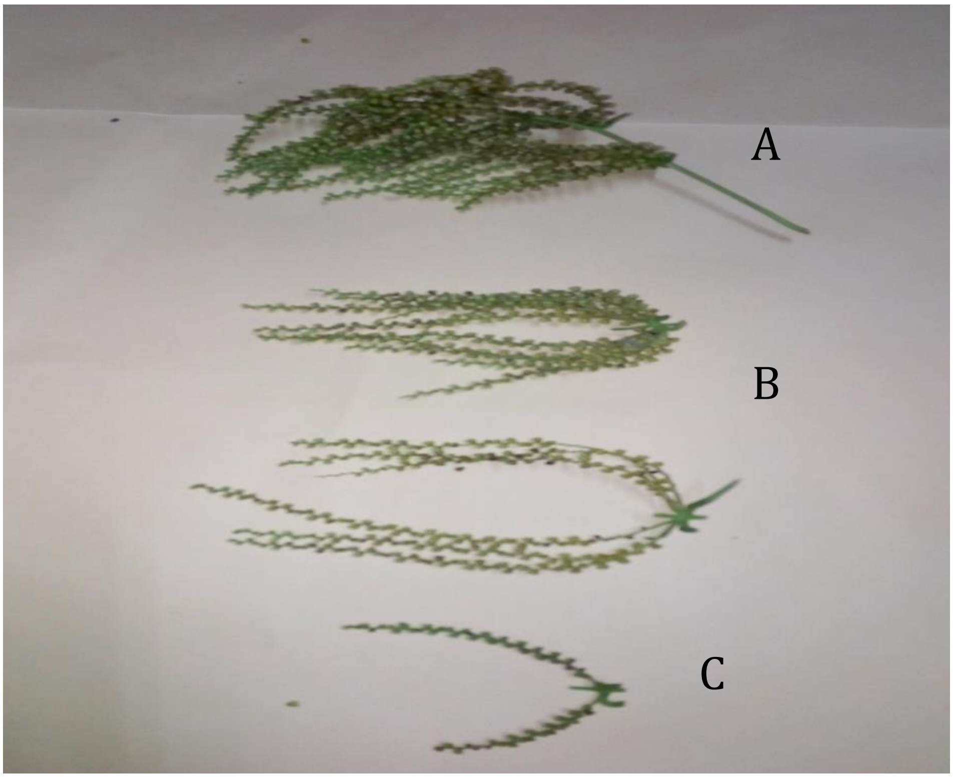

Plate 2: Male inflorescence of bush yam

Tuber characteristics

Seventy seven (77) accessions of the harvested tubers had no thorns on them. However, 10 accessions of the harvested tubers had thorns on them. Out of the 84 accessions harvested 21 of them changed colour of the flesh from white to orange while 63 of them remained unchanged.

With regards to hairs on tuber, there are 72 of accessions with no hairs on the tubers that were harvested. 14 of the accessions had hairs on the tubers that were harvested.

Flesh tuber colour was taken after harvesting of the tuber was done. In Figure 5, the graph shows the various distribution of the fresh tuber colour observed. In all, 5 different tuber colour was recorded. Out of the 68 accessions that were assessed, the colours observed were; white, yellow, purple, white with purple and yellowish white. One accession recorded the tuber with purple colour, 10 out of the 68 accessions were yellow fleshed fresh tuber colour and white with purple fleshed fresh tuber colour. However the white fleshed fresh tuber colour recorded the highest number of accessions of 27. It was followed by the yellowish white fleshed fresh tuber colour.

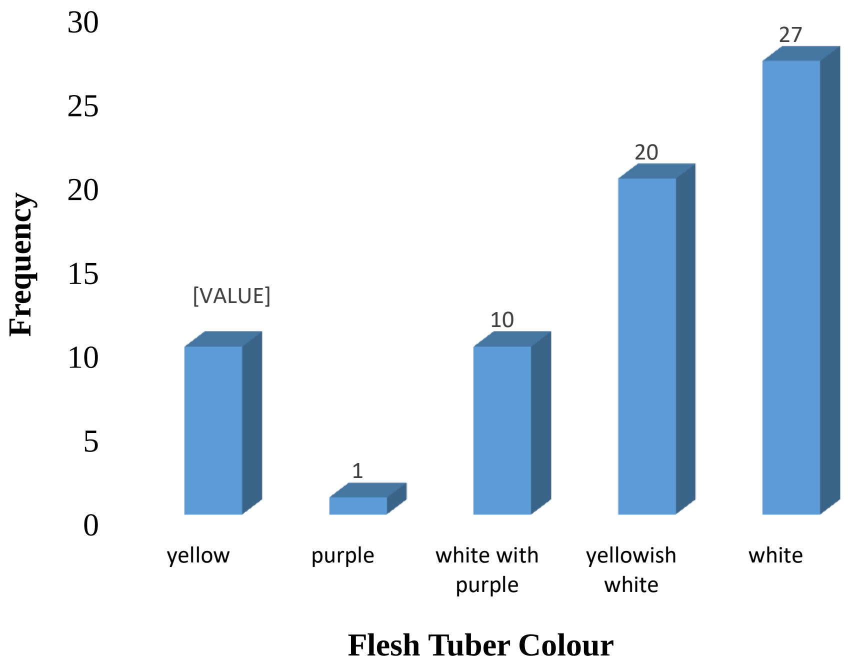

Figure 5: Frequency distribution of flesh tuber colour

In all, 68 accessions were observed for their cooked tuber colour. Out of the 68, 5 different colours were observed (Figure 6). They included; purple, white not coloured, white with purple, yellow and yellowish white. Majority of the tubers were white, not coloured. This amounts to 58.8% of the total tuber assessed. The yellowish white tuber colour recorded the second highest number of accessions of 16. White with purple, purple and yellow cooked tuber colour also recorded 16, 6 and 1 accession respectively.

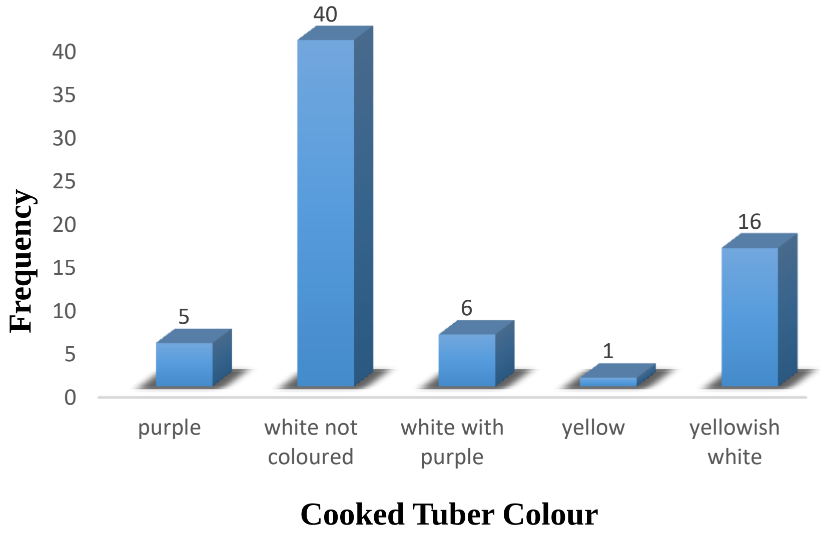

Figure 6: Frequency distribution of cooked tuber colour

Results for principal component analysis of morphological traits

The first 4 Principal Components (PC) explained collected 94.22% of the total variation among the accessions. Principal Component 1, 2, 3, and 4 accounted for 60.35, 15.20, 12.64, and 6.03% of the variation respectively (Table 3). PC 1 was explained mostly by yield, spines at the 3rd internode and growth of vine (Table 3). The 2nd PC was explained by yield, spines at 3rd internode and number of internode (Table 3). PC 3 was explained by number of internode and spines at 3rd internode (Table 3). The last PC was explained by girth of vine, flesh tuber colour and cooked tuber colour (Table 3).

Table 3: *Rotated component matrix of four factor model explaining 94.22% of the total variance for traits*

Variables	**PC1**	**PC2**	**PC3**	**PC4**
Cooked tuber colour	-0.00717	-0.03260	-0.03547	**0.34833**
Flowering	-0.00922	-0.00984	-0.01262	-0.03234
Flesh oxidation colour	0.01133	-0.00397	-0.00232	-0.02679
Fresh tuber colour	0.01849	-0.08183	-0.09650	**0.61564**
Girth of vine	**-0.24526**	0.07138	-0.02943	**0.67543**
Leaf shape	-0.00933	-0.01424	-0.01192	0.01417
Matured vine colour	-0.01007	0.00630	-0.06449	0.06215
Number of internode	-0.17248	**0.11703**	**-0.96770**	-0.12245
Spines at 3rd internode	**-0.90668**	**0.26616**	**0.20855**	-0.12941
Spine shape	-0.00148	-0.01463	-0.02468	-0.03494
Hairs on tuber	-0.01120	-0.01186	0.00712	-0.00499
Thorns on tuber	-0.01401	-0.00400	0.00489	0.00008
Yield	**-0.29480**	**-0.94963**	-0.05358	-0.06417
Young leaf colour	0.00055	-0.00622	0.01687	-0.00082
Young vine colour	-0.00269	-0.00738	0.01797	-0.02265
Latent root	6913	1741	1448	691
Percentage variation	60.35	15.20	12.64	6.03
Cumulative percentage variation	60.35	75.55	88.19	94.22

Source: Field work, Fianu (2015)

Cluster analysis

The accessions were clustered into 4 groups (Figure 7). The materials were not clustered according to the location of germplasm collection. For example, in cluster 1 were; AMA-024, SE-A-036, NYI-039, AMA-027, AMA-028, AMA-029, SE-W-031, SE-P-034, AMA-026, SE-B-047, MAM-043, MAM-042, FUM-044, NYI-041, NYI-042, SE-A-035, SE-A-037, SE-S-038, NYI-040 and these materials were collected from across the three regions. Similar kind was observed in cluster 2 and 3, except in cluster 4 where all the accessions were collected from one region (Figure 7).

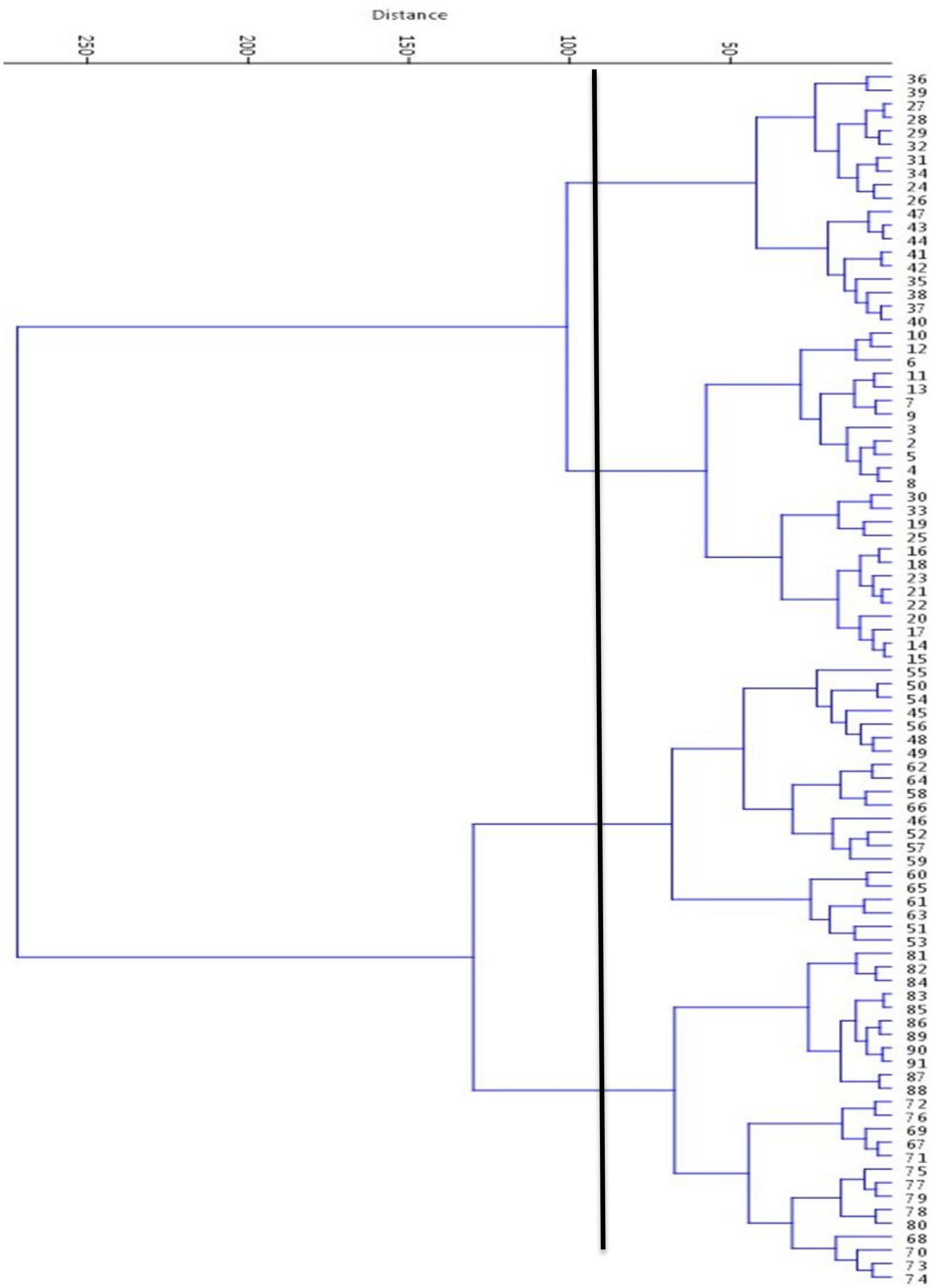

Figure 7: Dendrogram of Dioscorea prahensilis accessions based on morphological characters cut at 100. All accession numbers can be referred from Table 1.

Discussion

Morphological variation on both quantitative and qualitative date

The yam tubers were stored for a while before planting in order for them to break dormancy. Some tubers, however, did not break dormancy before rotting started resulting in the loss of some planting materials of such accessions. About 50% of the accessions did not show any sign of rot and this could be attributed to handling of the tuber of tuber by the farmers. Nevertheless, the extent of rot varied among tubers that were equally damaged during harvest and this suggest that there was variability among the accessions for rot. Accessions number 1-46 which were stored for between 57-71 days before planting suffered most from rot. The regenerated tubers sprouted earlier relatively than most of the ware tubers. Sprouting is affected by the type of tuber used than the duration of storage before planting. The regenerated tubers even though stored for a shorter time sprouted quite early (Table 2). During interaction with farmers, they indicated that the regenerated tubers are better planting materials than the ware tubers. The genotype of the planting materials also seem to have an effect on the sprouting and this is evidence from the fact that among the ware tubers, some accessions sprouted earlier than others.

Morphological characteristics are characters that can be observed using the human eyes. Marfo (2002), reported that Morphological trait characterization will enable breeders to assess genetic diversity in the crop, from based population and help in the assemblage of good attributes to the germplasm. Morphological trait characterization of genetic resource collections are based on the physical attributes the environment have got on the crop.

The Principal Components analysis also grouped the characters into four factors which accounted for a total of 94.22%. The Principal components values recorded were PC1, PC2, PC3 and PC4. The variations recorded were 60.35, 215.20 12.64 and 4 6.03 respectively. The factors loading indicates that the highest and major contributor recorded from PC1 came from number of spines at the 3rd internode from the soil level. This was followed by the yield and girth of vine, yield and the number of internode to fully expanded leaf. It would important to know that all these contributing factors vary with respect to the vine (stem) of the bush yam. All these characters are quantitative traits. The yield at PC2 contributed to the highest character. The next contributing factor was recorded by the number of spines from the 3rd internode and the third value was recorded by the number of internode to the first leaf. These factors are correlated in that they are more of quantitative factors than qualitative traits.

Again at PC3 the number of internode to first leaf gave a highest contributing factor. It was followed by the number of spine at 3rd internode and this was followed by flesh tuber colour. These are traits related to vine characters and the tuber character. The girth gave the highest contribution for PC4. It was followed by the flesh tuber colour and cooked tuber colour. The flesh tuber colour and cooked tuber are characters related to harvested tubers. These factors encompasses both qualitative and quantitative traits unlike PC1, PC2 and PC3 whose difference came from quantitative characters.

Young vine colour

On young vine colour out of the 90 accessions observed, 69 accessions had green colour of their young vine which contributed to almost 80% of plants observed, 13 accessions also had purplish green as being their young vine colour and 8accessions, however, had their young vine colour to be purple. A similar work carried out by Marfo (2002), on *D. alata* and *D. bulbifera* indicates that they (*D. alata* and *D. bulbifera*) possess stem colour from purplish green to green.

Young leaf colour

The accessions with purplish green young leaf colour includes: ABO-009, ASE-013, SE-B-049, SE-B-053, SE-B-062, DJA-063, DJA-066, BUN-082 and BUN-090.

Matured leaf colour

Yams changes their leaf colouration during their growth and development. All the ninety accessions had green leaf colouration. Thus 100% was recorded for matured leaf colour. It is important to note that leaves that were purplish green during their young stages turned green. This will enable the plant species to intercept sunlight for the process of photosynthesis to take place. The leaves of bush yam are not hairy in nature. This is in agreement with Onwueme, (1978) and Fragaria, (1992), that yam venations are non-pubescent.

Matured vine colour

Four different colours were observed and these include green, brownish green, purple, and black. Two accessions (AMA-019 and DJA-074) possessed purple matured vine colour and one accession (DJA-016) had black matured vine colour.

Leaf shape

The germplasm accessions exhibited alternate, opposite, and alternate at base and opposite above in leaf position. The three leaf shapes were observed includes: cordate long, cordate broad and sagittate long. This is in agreement with similar experiment conducted by Marfo (2002) on *D. alata* and *D. bulbifera*. In Marfo (2002), findings, it was observed that D. alata possesses a cordate and a sagittate leaf shape. It was observed that accessions with cordate leaf shape had large leaf area index and can, therefore, aid in photosynthesis process.

Spine characteristics

High phenotypic diversity was obtained from spininess of the vines. It was observed that all the 90 accessions collected had spines on their stems. Most of the spines observed were prominent and can be seen with the naked eye except DJA-016; which possesses spines which were not prominent. The accessions also showed three shapes of spines which includes; curved upward, curved downward and straight. The spines of many species as reported by Okonkwo (1985), provides support in the twining habit while also deterring animal predators. The coalescencing of spines was also observed. It was realized that all the germplasm accessions collected had their spines coalescencing.

Flowering

In many elite clones of the major edible Dioscorea spp, flowering has been reported to be sparse, irregular or absent which is a limiting factor in yam hybridization according to Marfo (2002). In the present study, four main flowering abilities were observed. They included absent, male, female or both. Three types of female inflorescence were observed. There were those with long spikes, (up to 85 cm in length with up to 126 flowers per spike). The medium spike types were about 20 to 25 cm long and 25 to 30 flowers per spike, while the short ones were 10 to 12 cm long with up to 15 flowers per spike.But only the short spike types were observed to produce fruits that developed to maturity and yielded seeds.It was observed from the study that the female inflorescence were 10x longer than the average male inflorescence. Each fruit has 3 lobes and posses 2 seeds per lobe making it 6 seeds in all. The seeds are light in weight which is suitable for wing dispersal. The male inflorescence had about 2 to 6 spikes in a whorl, but the spike lengths were about the same, 10 to 15 cm in length.The flowers, fruits and seeds are similar to those of *D. rotundata* according to Onwueme (1978). In his study, he observed that white yams had winged seeds and the fruits are tri-locular capsule.

Thorns on tuber

Onwueme (1978), in his study observed that the wild relatives of yams has spiny roots more than their cultivated ones. In the present study, during germplasm accession collections, i some farmersreported that most of the yam tubers of bush yams are not thorny in nature. The farmers suggested that some environmental conditions could have affected the yams to possess thorns on them. In agreement to Onwueme (1978), the farmers reported that some bush yams possess thorns on the roots. In addition, the farmers suggested that the thorns on the roots of the growing yam deters thieves from stealing those type of yam. An example is the (ABO-020, Nkaseé Bayere). With this type of yam, the yams are thory in nature.

Hairs on tuber

Tuber pubescent were present in some accessions while it was absent in some. The hairs arise from the fibrous roots that were produced by the yam species. During germplasm collection, some farmers reportedthat most of the bush yam do not produce hairs. However, there were only thirteen accessions that produced hairs out of the 86 accessions harvested.

Flesh tuber colour

White coloured flesh colour dominated in the studies, followed by yellowish white, then white with purple, purple and yellow respectively. In a similar study conducted by Onwueme (1978) on white and yellow yams, the tuber of *D. rotundata*and *D. cayenensis* are white and yellow respectively and these white and yellow colours will attract consumers to also consume bush yams.

Yield

Yield is an important element in the commercialization of a particular crop. The higher the yield, the better. From the experiment, it was realised that lower yields were obtained from the Asuansi Research Station. The lower yield could be attributed to the delays in the onset of rain during the planting season. Also the cocoa plantation is an old field which could have lost most of its vital nutrients to support plant growth. The yield on the open field was far better than that of the under cocoa plantation. It could also be due to the fact that the land was applied with manure before the mounds were prepared and these manure could provide some essential nutrients to the crops for its growth and production. Also irrigation was done and this could also help to obtain those yields.

Cluster analysis of bush yam

The dendrogram shows four major different clusterswhen cut at a distance of 100.Both qualitative and quantitative morphological traits put the accessions into clusters without any unique relationship with the collection regions or pairs. In cluster one all the accessions are found from the three region of collections. Apart from MAM-042 and MAM-043 which had yellowish green matured leaf colour, the rest of the accessions had dark green matured leaf colour.

The same is seen for cluster two, where the location involved occurs in different regions. In cluster 3, the 2 locations involved; the Ashanti region and the Western region. With the exception of SE-B-053, DJA-063 which have purplish green young leaf colour, the rest of the accessions in that cluster had pale green young vine colour. The leaf shape in this cluster is either cordate long or cordate broad. It is important to know that though both points of collection are from the same region, they are apart in terms of locations. It can also be observed that in cluster 3 almost all accessions came from 2 regions of collections though majority of them were from the western region. This suggests that there are diversity in the accessions of bush yam that were collected. It is also important to note that cluster was not based on locations and or agro-ecological zones and points to the fact that on a whole, differences observed among the samples were not related to the locations from which they were picked. This can be elaborated by the fact that the PCA analysis gave spine at the 2nd internodes as the most important variable and this was seen not significant different with location and or agro-ecological zones.

Conclusion

There is a great diversity that exist among the bush yam germplasm. The various cultivars can be identified by their tubers during storage or by their shoot characteristics while they are growing on the field. Identification may be based on tuber shape, tuber-skin colour and structure, tuber-flesh colour and tuber-flesh texture; or on the colour of sprout and shoot tips, quantity and distribution of spines and bloom on the stem, and leaf shape, size, and colour (Onwueme, 1978). Morphological markers enable the detection of genetic variation based on individual phenotypic variations. Three leaf shapes and spine shapes were identified. Four distinct clusters were identified. The clustering suggest that variations observed from the agro-ecological zones from which accessions were collected did not contribute to the clustering.

CHAPTER FOUR

CONSUMER PREFERENCE FOR BUSH YAM (*DIOSCOREA PRAEHENSILIS*) ACCESSIONS

Introduction

Yam is produced in the forest zone of Ghana especially in the cocoa growing areas. The consumption of bush yam is confined only to these production areas. However, the urban population in Ghana are not familiar with the crop. The problem associated with bush yam is the short shelf life due to rapid decline in quality after harvest (Treche & Agbor-Egbe, 1996).

There are diversity that is known to exist in the bush yam germplasm for quality attributes (Smith, 2002). This diversity can be exploited for the commercialization and cultivation of bush yam and can also be used as a source of food security crop. There is therefore a need to know about the quality attributes preferred by consumers. The quality attributes of freshly harvested bush yam could be evaluated through a sensory analysis. Research has been conducted especially on food beverages and there is no empirical evidence of sensory analysis performed on bush yam.

Methodology

There were 90 accessions that were collected and evaluated for morphological characteristics (in an open field and under a cocoa plantation). However sixty-eight accessions (Table 4) were used for the sensory evaluation and this was due to low yield of some of the accessions grown on the field.Bush yam samples were collected from the field on the day of harvest. Ten to fifteen accessions were cooked and evaluated on a daily basis. The bush yam samples were then peeled and washed and put in a cooking utensil.

Water and a little salt to taste was then added to the peeled yam sample. These utensils werelabelled for easy identification. They were then placed on the cooking stove and then cooked for 10 to 15 minutes.

The cooked bush yam samples were then served to 25 untrained panellists consisting of students of the University of Cape Coast. A 9-point Hedonic scale (1=very low, 6=extremely high) was used for the assessment. The Hedonic scale was modified to suit this exercise. The samples were served warm and assessed for appearance, flavour, taste, mouth feel, and overall acceptability.

Table 4: *Accessions of Bush Yam for Sensory Evaluation*

Accession codes	**Region**	**Community**	**Local Name**
AKY-002	Eastern	Akyemateng	Nil
NS-A-003	Eastern	Nsuta-Apirede	Kat
NS-A-004	Eastern	Nsuta-Apirede	Nil
AKY-006	Eastern	Akyemateng	Nil
NKU-007	Eastern	Nkurakan	Nil
ABO-008	Eastern	Aboa	Nil
ABO-009	Eastern	Aboa	Nil
ABE-012	Eastern	Abesre	Odorno
TAK-014	Eastern	Takorase	Ogyam
DJA-016	Eastern	Djamam	Tsomatsor
SE-B-017	Western	Sefwi Bethlehem	Asobayere ketewa
AMA-018	Western	Amafie	Afu
AMA-019	Western	Amafia	Nil
ABO-020	Western	Aboboyaa	Nkaseè Bayere
ABO-021	Western	Aboboyaa	Nil
AMA-022	Western	Amafie	Asobayerepa
AHW-023	Western	Ahwia	Nil
AMA-024	Western	Amafie	Nil
AMA-025	Western	Amafie	Kokoase Bayerepapa
AMA-027	Western	Amafie	Nil
AMA-028	Western	Amafie	Nil
AMA-030	Western	Amafie	Kokoase Bayerepapa
SE-W-031	Western	Sefwi-Wenchi	Asobayere
SE-W-032	Western	Sefwi-Wenchi	Akyekyere
SE-W-033	Western	Sefwi-Wenchi	Forking bayere

Table 4 Continued

Accession Code	Region	Community	Local Name
SE-P-034	Western	Sefwi Paboase	Kokoase bayere Pa
SE-A-035	Western	SefwiAdobawura	Forking bayere
SE-A-036	Western	Sefwi Adobawura	Asobayere
SE-A-037	Western	Sefwi Adobawura	Asobayere
SE-S-038	Western	Sefwi Sowodadeam	Kokoase pona
NYI-039	Ashanti	Nyinahin	Dabreko kokoase
NYI-040	Ashanti	Nyinahin	White type
NYI-041	Ashanti	Nyinahin	Nil
FUM-044	Ashanti	Fumso	Nil
FOM-045	Ashanti	Fomena	Nil
SE-B-046	Western	Sefwi Bethlehem	Bono bayere
SE-B-047	Western	Sefwi Bethlehem	Osono keseè
SE-B-048	Western	Sefwi Bethlehem	Bobidie (Kokoase afun)
SE-B-049	Western	Sefwi Bethlehem	Kokoase kartre
SE-B-050	Western	Sefwi Bethlehem	Serwaa bayere
SE-B-051	Western	Sefwi Bethlehem	Asobayere ketewa
SE-B-052	Western	Sefwi Bethlehem	Nkaseè bayere
SE-B-053	Western	Sefwi Bethlehem	Afun tentan
SE-B-054	Western	Sefwi Bethlehem	Bayere fufuo
SE-B-055	Western	Sefwi Bethlehem	Akyekyedeè
SE-B-056	Western	Sefwi Bethlehem	Bootaa/Koometa
SE-B-057	Western	Sefwi Bethlehem	Kokoase pona
SE-B-058	Western	Sefwi Bethlehem	Kokoase kootibre
SE-B-059	Western	Sefwi Bethlehem	Bootaa Asobayere

Table 4 Continued

Accession code	Region	Community	Local name
SE-A-060	Western	Sefwi Ankra-Muano	Brobidieè
SE-A-061	Western	Sefwi Ankra-Muano	Afum
SE-A-062	Western	Sefwi Ankra-Muano	Asobayere
DJA-063	Eastern	Djamam	Otim
DJA-064	Eastern	Djamam	Obobe
DJA-065	Eastern	Djamam	Bale tuu
DJA-066	Eastern	Djamam	Bale hior
DJA-067	Eastern	Djamam	Odornor kpawayo
DJA-068	Eastern	Djamam	Kati hior
DJA-069	Eastern	Djamam	Odornor kpangua
DJA-072	Eastern	Djamam	Ologojo
DJA-073	Eastern	Djamam	Ojeoblai
DJA-074	Eastern	Djamam	Kpayumu
DJA-076	Eastern	Djamam	Kati hior 2
DJA-077	Eastern	Djamam	Kati yumu
DJA-078	Eastern	Djamam	Ologojo
DJA-079	Eastern	Djamam	Odornor kpangua
BUN-082	Eastern	Bunso	Nil
BUN-084	Eastern	Bunso	Nil

Source: Field work, Fianu (2015)

Attractiveness of cooked tuber

Participants assessed the cooked tuber using visual appraisal. The participants assessed the appearance of flesh tuber after cooking, colour of flesh tuber after cooking and attractiveness of cooked tuber.

Stickiness of cooked tuber

Pieces of the cooked tuber were placed between two fingers of panallists to crush and assessed the texture and the stickiness of the tuber. The options for the texture ranged from smooth to grainy to fibrous. For stickiness, non-sticky, slightly sticky, sticky, very sticky and extremely sticky were the options the panellists were to chose from.

Sweetness of cooked tuber

Panellists took a bite into their mouths, unmunched on, swallowed it and then assessed the sweetness of the bush yam. On the basis of bitterness, the options were: not bitter, slightly bitter, bitter and very bitter. For sweetness, the options were: slightly sweet, sweet and very sweet.

Fracturability of cooked tuber

After biting, panellist assessed the cooked tuber whether it was crumbly or brittle for its fracturability.

Denseness of cooked tuber

In the first chew, panellist assessed the tuber for its denseness. The options of whether the cooked tuber is airy (denseless soft to chew) and dense (hard to chew).

Flavour of cooked tuber

This was done by assessing the flavour of the cooked tuber. The options to be chosen from were: not acceptable, acceptable and very acceptable.

Colour of cooked tuber

This was done by assessing the colour of the cooked tuber. The options to be chosen from were: not acceptable, acceptable and very acceptable.

Data analysis

The sensory scores obtained were analysed using SPSS and by a Kruskal-Wallis One-Way Nonparametric Analysis of Variance. The Least Significant Difference (LSD) test and Statistix 8.0 were used to determine significant differences between means and separate means respectively at $p<0.05$ levels.

Results

A Kruskal-Wallis One-Way Nonparametric Analysis of Variance showed that there was a statistically significant difference in attractiveness, colour, stickiness, sweetness and the overall assessment of the cooked yam between the tested accessions of Bush yam (Table 5).

Attractiveness of cooked tuber

The rankings of cooked tubers for attractiveness ranged from about 100 to 690. TAK-014 recorded the highest rank of 619.6 and it was followed by DJA-067 (616.7) (Table 5). The following also recorded ranks close to the highest means; DJA-065, DJA-072, DJA-016, BUN-084, DJA-064, Nku-007, SE-A-061, DJA-075, SE-B-017and DJA-063. They recorded ranks of 571.0, 556.6, 555.7, 544.9, 547.2, 541.3, 539.8, 531.4, 516.0 and 505.4 respectively. The following accessions however recorded the least in the ranks in terms of attractiveness; SE-A-036 (186.6), AHW-023 (177.3), ABO-021 (147.4), NYI-039(147.7) and AB0-009 (145.5).

Colour of cooked tuber

With accessions ranking: TAK-014 (635.9), SE-B-052, DJA-079, and DJA-065 all recorded 610.5, DJA-073 and SE-B-059 both recorded amean of 569.9. NKU-007 also recorded 554.8. Again, DJA-076, SE-A-062 also recorded a mean of 545.3. SE-B-054 and BUN-082 both recorded a total rank of 542.2. However, the following accession also recorded the lowest rank in terms of colour. These accessions include~~s~~: SE-A-028 (186.8), SE-A-023 (174.5), SE-A-036(145.0) and SE-B-047 (158.5).

Stickiness of cooked tuber

The mean rankings for stickiness of cooked tuber by the panellists' are shown in Table 5. Stickiness was found highest in the following accessions. They includes: SE-A-036 and SE-B-058 both obtained (635.0), SE-B-053(581.0), SE-A-035 (563.8), DJA-069(543.6), SE-B-049(530.5), DJA-064 (521.9), AB0-009 (519.0), SE-B-054 (516.0) and DJA-072 (505.8). Surprisingly however, the following gave the lowest ranks. NS-A-003, NS-A-004, ABE-012, AMA-019, SE-W-031, SE-W-032, DJA-067, DJA-073, DJA-077, DJA-078 and BUN-082. Their ranks were 244.4, 285.9, 286.2, 244.0, 253.2, 250.7, 295.8, 283.3, 214.3, and 271.8 respectively.

Sweetness of cooked tuber

Means of sweetness of accessions tested by panellists gave varying results in Table 5. From the table, it can be observed that out of about 68 accessions that were tested, eight of the accessions gave ranks which were high and two accessions also produced tubers which were not sweet according to the panellist judgement. The accessions are; SE-B-017, TAK-014, SE-A-036, FUM-044, SE-B-051, SE-B-053, SE-B-056, DJA-077 and BUN-084. The means obtained were 501.6, 516.5, 704.0, 520.8, 520.8, 518.2, 512.5 and 549.7 respectively. However DJA-016 recorded the lowest ranks of 179.0. There was significant difference between the highest and the lowest means.

Flavour of cooked tuber

Amongst the means recorded in Table 5, three accessions gave highest means of 537.4 for BUN-084, DJA-065 had504.7 and SE-B-053 recorded 500.0. However, AMA-022, SE-A-037and SE-B-055 recorded a least of 282.0 in terms of ranking. AKY-006 also gave a mean of 252.8 and DJA-073 recorded 273.1. It can be noted that from the Table 5, the results shows that there was a significant difference between the highest and the lowest ranking values.

Overall assessment of cooked tuber

From Table 5, it can be observed that out of about 68 accessions that were tested, nine of the accessions recorded high ranks according to the panellist judgement. These accessions included: BUN-084 (610.6), NKU-007 (506.6), TAK-017 (561.1), FOM-045 (564.8), SE-B-053 (522.5), SE-B-058 (572.2), DJA-067 (529.9), DJA-068 (526.8) and DJA-076 (564.8).

Table 5: *Sensory Evaluation of Various Accessions of Bush Yam*

Accession	Attractiveness	Colour	Flavour	Stickiness	Sweetness	Overall Assessment
AKY-002	376.9	289.7	456.3	396.3	337.5	358.6
NS-A-003	285.4	290.8	290.4	244.4	382.1	278.5
NS-A-004	468.8	405.4	466.2	285.9	410.8	359.4
AKY-006	329.4	315.6	252.8	412.2	398.6	257.8
NKU-007	541.3	554.8	484.9	324.7	403.1	506.6
ABO-008	440.3	398.2	397.8	409.3	390.3	421.1
ABO-009	145.5	422.1	399.0	519.0	468.8	207.8
ABE-012	357.9	395.6	328.8	286.2	399.6	260.5
TAK-014	619.6	635.9	459.6	375.4	516.5	561.1
DJA-016	555.7	495.9	340.5	389.5	179.0	409.0
SE-B-017	516.0	552.9	463.4	460.7	501.6	498.7
AMA-018	394.0	333.8	456.3	422.0	334.4	411.7
AMA-019	363.9	371.6	427.6	244.0	422.1	360.6

Table 5 Continued

Accession	Attractiveness	Colour	Flavour	Stickiness	Sweetness	Overall Assessment
ABO-020	382.0	424.0	398.2	445.6	355.1	432.4
ABO-021	149.4	212.8	335.2	360.5	360.9	343.1
AMA-022	281.8	325.8	282.0	350.8	266.5	271.8
AHW-023	177.3	174.5	311.3	358.7	271.3	177.0
AMA-024	346.9	303.3	418.3	384.4	479.2	384.4
AMA-025	302.6	269.3	456.3	493.3	319.3	313.2
AMA-027	387.6	405.5	420.5	473.4	463.9	399.6
AMA-028	294.7	283.2	366.7	437.5	289.3	308.4
AMA-030	221.7	186.8	420.0	407.0	350.9	270.2
SE-W-031	288.1	257.5	371.4	253.2	381.7	311.2

Source: Field work, Fianu (2015)

Table 5 Continued

Accession	Attractiveness	Colour	Flavour	Stickiness	Sweetness	Overall Assessment
SE-W-032	426.0	443.0	398.3	250.7	387.1	420.0
SE-W-033	186.8	269.3	340.5	396.3	231.8	271.8
SE-P-034	391.5	345.4	398.6	366.0	482.6	345.7
SE-A-035	211.9	200.2	340.5	563.5	365.7	351.0
SE-A-036	375.0	145.0	399.0	635.0	704.0	354.5
SE-A-037	147.7	238.1	282.0	434.9	284.7	317.3
SE-S-038	421.1	472.0	377.1	394.7	359.2	377.7
NYI-039	415.8	434.3	360.0	458.7	401.3	464.3
NYI-040	242.9	264.9	371.4	312.8	416.1	353.1
FUM-044	509.2	362.0	399.0	403.0	520.8	354.5
FOM-045	234.5	547.5	397.6	370.7	444.7	564.8
SE-B-046	231.4	158.5	399.0	319.4	224.3	251.7

Source: Field work, Fianu (2015)

Table 5 Continued

Accession	Attractiveness	Colour	Flavour	Stickiness	Sweetness	Overall Assessment
SE-B-047	474.9	234.0	399.0	313.6	389.9	283.6
SE-B-048	422.2	465.5	399.0	317.7	309.5	360.6
SE-B-049	376.9	496.1	370.8	530.5	321.9	362.9
SE-B-050	433.6	325.8	340.5	344.1	406.8	358.6
SE-B-051	405.3	416.3	399.0	392.9	520.8	422.6
SE-B-052	686.1	354.0	358.2	456.1	349.3	387.2
SE-B-053	599.1	610.5	500.0	581.0	518.2	577.8
SE-B-054	349.9	542.2	467.7	430.3	465.8	522.5
SE-B-055	528.8	426.1	282.0	516.0	422.6	378.8
SE-B-056	377.3	362.0	399.0	490.6	520.8	422.6
SE-B-057	565.1	405.4	327.3	635.0	452.4	450.2
SE-B-058	328.8	569.9	471.3	478.6	456.9	572.2
SE-B-059	291.0	347.7	348.3	343.9	455.8	399.8

Table 5 Continued

Accession	Attractiveness	Colour	Flavour	Stickiness	Sweetness	Overall Assessment
SE-A-060	539.8	380.5	345.0	316.0	390.1	273.9
SE-A-061	327.0	545.3	420.0	472.8	448.9	484.7
SE-A-062	505.4	325.8	298.7	521.9	375.0	351.3
DJA-063	547.2	416.3	456.3	402.7	468.8	435.3
DJA-064	571.0	354.0	340.5	473.6	231.8	408.1
DJA-065	335.7	610.5	504.7	378.7	477.0	421.6
DJA-066	616.7	542.2	311.3	364.1	492.8	324.8
DJA-067	469.5	426.1	441.9	295.8	468.8	592.9
DJA-068	247.9	362.0	461.5	455.7	473.5	526.8
DJA-069	371.1	405.4	267.4	543.6	415.5	425.7
DJA-072	336.5	569.9	423.5	505.8	397.6	417.4
DJA-073	347.8	347.7	273.1	283.3	224.3	227.9
DJA-074	531.4	380.5	397.5	412.4	326.6	410.6

Source: Field work, Fianu (2015)

Table 5 Continued

Accession	Attractiveness	Colour	Flavour	Stickiness	Sweetness	Overall Assessment
DJA-076	395.7	545.3	484.3	306.8	462.5	510.0
DJA-077	287.7	325.8	311.3	214.3	512.5	222.9
DJA-078	418.7	416.3	398.3	271.8	313.2	286.3
DJA-079	556.6	354.0	335.2	325.0	265.5	330.4
BUN-082	544.9	610.5	484.9	422.1	466.3	483.7
BUN-084	447.3	542.2	536.4	360.1	549.7	610.6
Kruskal Wallis statistics	253.980	238.110	126.661	130.682	117.607	177.233
P (using χ^2 Approx.)	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000
F (df $_{68,\ 713}$)	5.02	4.75	2.03	2.10	1.86	3.03

Source: Field work, Fianu (2015)

A cross tabulation of the nominal parameters are measured in Table 6. All the parameters except fracturability show a highly significant difference among the accessions that was tested using the Chi-square test of independence. The likelihood ratio obtained from the analysis were 0.15, 0.00, 0.00, and 0.00 for fracturability (first bite and first chew), Denseness, hardness and texture (Table 6).

Table 6: *Chi-Square Test and Cross Tabulation of Nominal Parameters*

Nominal parameters	χ^2	Df	Likelihood ratio
Fracturability	0.51	69	0.15
Denseness	0.000	69	0.00
Hardness	0.000	69	0.00
Texture	0.000	69	0.00

Source: Field work, Fianu (2015)

Discussions

Attractiveness of cooked tuber

There were significant difference among some accessions whilst other were not. A critical Z = 4.251, at 0.05, SE-B-053 ranked highest and SE-B-053 was significantly differenet from AHW-023, AMA-028, ABO-009, AMA-018, NYI-39, NYI-040, SE-B-059 SE-B-058, SE-W-031 and DJA-074. TAK-014 was also significantly different from ABO-021, AMA-025, AHW-028, AHW-023, AMA-028, ABO-009, AMA-018, NYI-040, SE-B-059 SE-B-058, SE-W-031 and DJA-074. TAK-14 ranked second to SE-B-053. The 3rd ranking accession is DJA-068. This accession was significantly different from AHW-028, ABO-021, AMA-025, and NYI-039. However, ABO-021, AHW-023, AMA-028, SE-W-031, SEF-037 NYI-040 are also significantly different from DJA-059. These accessions could have features such as whiteness of their cooked tubers, sweet aroma which made them attractive to the panellists.

Colour of cooked tuber

In terms of colour assessment, TAK-014 ranked first, and it was significantly different from ABO-021, AHW-023, AMA-028, FUM-044, SE-A-035, NYI-040, SE-B-046. It was due to the fact TAK-014 is white when cooked and so was somewhat similar to the white yam and so was preferred to the other accessions. Second ranked accessions were; SE-B-054, BUN-082 and DJA-067. The second ranked accessions were also significantly different from ABO-021, AHW-023, AMA-028, SE-A-035 and FUM-044. SE-B-058 and DJA-074 ranked third to TAK-014. Accessions SE-B-054, BUN-082 and DJA-067. SE-B-058 and DJA-074 were however significantly different from AHW-023, AMA-028 and SE-A-035. The fourth ranking accessions were (SE-B-053, and SE-A-060). These two were significantly different from SE-A-035 and AHW-023. SE-A-035 and AHW-023 were also significantly different from SE-B-017.

Stickiness and sweetness

The results suggested that the accession were not significantly different from each other. Interms of stickiness and sweetness all the accession were sweet. This sweetness could be due to the fact that the accessions were all cooked on the day of harvesting. This could also be in agreement to what farmers reported. Farmers indicated that the bush yams were sweet when they are cooked on the very first day of harvesting.

The accessions that were evaluated were not different from each other in terms of bitterness. According to some farmers during collection of accessions, some accessions becomes bitter at a point in time during cooking. But it should be noted that all the sensory evaluation was carried out on the very day harvesting of the tuber. With all accessions assessed, none of them were bitter.

From the Peasons Chi (χ^2) in Table 6, it can be observed that SE-B-053 ranked highest among the accessions. This may be due to the white nature of the cooked tuber. By comparing it to the other accessions, it was realized that SE-B-053wassignificantly different from accessions ABO-021, AHW-023, AMA-024, AMA-O28, AMA-025, SE-W-031, ABO-009, NYI-040, DJA-078 and DJA-065. Accessions NS-A-003 and SE-B-052 were the best ranked among the accessions. Accession SE-S-038 ranked second to ABO-020. It was also found out that SE-S-038 was significantly different from ABO-021, AHW-023, AMA-024, AMA-O28, AMA-025, SE-W-031, SE-W-033, NYI-040, DJA-065 and NS-A-003.

The fourth ranking accessions includes BUN-082 and DJA-065. These accessions were also significantly different from AHW-023 and AMA-028 and they ranked better than DJA-079 and TAK-014. It should be noted that the first and second best ranked accessions were collected from the same region (Eastern region).

Flavour

From the result of the sensory evaluation, all the accessions evaluated were not flavoured.This implies flavour does not influence the choice of selection of yam by consumers.

Fracturability, Denseness, Texture and Hardness

From the results obtained, it would be observed that fracturability does not have any influence on the choice of tuber by consumers. Consumers would opt for yams that are not crumbly or brittle. They would rather prefer those which are soft and easy to bite and chew. In the same vain, it can be observed that, there was a highly significant difference in denseness among the accessions. Again, the texture of yam is factor that would be considered by consumers during the choice of picking a particular kind of food. Smooth and fibrous textured yam would be preferred for easy absorption by the digestive system. There were also highly significant differences observed among the accessions.

Overall assessment

From the table of means, Table 6 the most highly ranked accessions included; BUN-084, SE-B-056, SE-B-052, SE-B-058, SE-B-054, DJA-063, Kati Hior, SE-B-053, DJA-077, SE-S-038 and ER-Nku-007. It was realised all these accessions were not significantly different from the other accessions but were different from AHW-023. These accessions may have features which might be closer to the known yam tuber (White yam) that made them ranked highby consumers. The top ranked accessions includes BUN-084, NKU-007, TAK-017, FOM-045, SE-B-053, SE-B-058, DJA-067, DJA-068 and DJA-076. These accessions have attributes almost like that of the white yam (*Dioscorea rotundata*).

Conclusion

From the analysis performed, taste and softness were the attributes used in determining the desired quality of yam by consumers. The most highly ranked accessions included BUN-082, DJA-067, SE-B-052, SE-B-058, SE-B-053, DJA-077, SE-B-057, FOM-045, SE-B-054, TAK-014, DJA-068, DJA-076 and Nku-007. Fracturability (first bite and first chew) does not influence the choice of accession by the consumer.

CHAPTER FIVE

THE PROSPECTS OF USING YAM MINISETT TECHNIQUE FOR THE RAPID MULTIPLICATION OF BUSH YAM

Introduction

According to Aidoo (2009), yam constitute about 13% of household food budget in urban centres in Ghana. Nutritionally, yam is a major staple food, providing food for millions of people in West Africa and many parts of the world.

Yam can be propagated by the use of whole tubers, bubils, vine cuttings and the use of true seeds (Prado *et al*., 2008). The use of true seeds as a propagule is restricted to research stations and mainly to crop improvement and breeding programmes. The use of tubers is the most commonly preferred practice for yam production. Regenerated tubers or the head portions of the tuber are used in this case (Peeters & Martinelli, 1989). However, there are limitations to the use of whole tuber method.These includes: scarcity of planting materials and high cost of planting materials. The multiplication ratio with the use of tubers is low. The tubers which are used for planting are usually used as food and this makes the use of whole tubers difficult.

According to Okoli *et al.*, (1982), the National Root Crop Research Institute, (NRCRI), Umudike successfully developed the yam minisett technology for rapid, high volume seed yam production. The yam minisett techniques are not relevant to the production of the food crop, as the tubers produced by such plants are generally small and suited mainly for planting material. The most common yam that has successfully responded to this technique is the white yam (*Disocorea rotundata*). No information on the use of bush yam for yam minisett has been recorded. The common sprouting media (sawdust) that is used for this technique is a problem in bush yam producing areas.

The minisett technique has the following advantages: It increases net returns by increasing the number of sett to seed yam ratio by about ten times as compared to the traditional method (IITA, 2014). It is a quick method of multiplying elite varieties generated from breeding programmes and it offers the opportunity of optimizing sett sizes to produce predetermined sizes of ware yams for export.

The objectives of this study is to find out whether bush yam would respond to the yam minisett technique and to find out the appropriate planting media for the bush yam minisett technique.

Methodology

Experimental design

A 4×6 factorial experiment with 3 replications was used. Factor A consisted of four sprouting media each made up of a bottom layer and a top layer material to cover the minisett. The sprouting media were: sawdust, top soil, mulch (Table 7). The sawdust was obtained from the saw mill in Abura in Cape Coast. The topsoil was obtained by scooping surface soil (up to 15cm deep) in the surroundings of the Technology Village of the School of Agriculture of University of Cape Coast. The mulch was obtained by gathering dry leaves under trees and bushes around the Technology Village School of Agriculture of University of Cape Coast.

Table 7: *Planting Media and the Media Combinations Used*

Media	**Bottom layer**	**Top layer**
A1	Topsoil	Topsoil
A2	Topsoil	Mulch
A3	Sawdust	Sawdust
A4	Mulch	Mulch

Source: Field work, Fianu (2015)

Factor B consisted of five accessions of bush yam used namely: DJA-077, SE-A-062, SE-B-054, DJA-067, DJA-068 and one variety of *Disocorea rotundata* specifically Dente as a check.

Preparation of Minisett

Clean healthy and disease-free mother yams of a month old after breaking dormancy (sprouted) were selected for the preparation of the yam minisett. The head, middle and the tail portions of the selected mother yams were used. These were cut into setts ranging from 30-40g each. Normal minisett size ranges between 25g-30g but 30-40g was used, based upon the recommendation by NARP to NRCRI to increase sett size for adoption. In all there were180 minisetts of each accessions.

The yam tuber were cut into discs of about 4cm thick and each was again cut longitudinally into many conical pieces. An average size regenerated mother yam gave between 8-20 setts. The freshly cut minisetts were put in small plastic baskets and dipped in a suspension of a suitable fungicide and wood ash for two minutes. The suspension was prepared by mixing 10mls of dursban and a handful of wood ash in 2 litres of water. The minisetts were treated for 2 hours before planting. A high level of sanitation was adhered to in the preparation of the minisetts. Infected tubers were discarded. Also all efforts were made to avoid using any unhealthy planting material for the experiment.

Nursing of minisetts

The minisetts were planted in concrete boxes of 60cm×60cm and 40cm deep filled with the sawdust sprouting mediamade up of combinations of; top soil and mulch. The specified bottom layer of media (Table 7) for each concrete box was spread to a depth of about 15cm. The treated minisett were spread (with the skin surface down) on the media. The specified upper layer of the media (Table 7) was spread over the minisett to a depth of about 8-10cm. Thirty minisetts were carefully arranged in each concrete box Watering was done immediately after nursing the minisetts.

The treatments were randomized three times under a shaded tree. Enough water was applied at intervals depending on how quickly the top soil, the mulch and the saw dust dried up.

The minisetts were nursed on the 17th, 20th and 21st of February, 2017. They were removed from the media 60 days later when about 10% of the minisetts have sprouted and emerged.

Data collection at the nursery

Thefollowing data were collected:

- Number of sprouted minisetts
- Number of rotten minisetts
- Number of intact minisett (minisetts that did not sprout)
- Number of roots per sprouted minisett
- Length of the longest root per sprouted minisett

- Longest shoot per sprouted minisett

Care was taken during handling to avoid damaging the shoots and roots of the spouted minisett.

Number of sprouted minisett (both start of sprout and emerged)

At the end of the experiment, (60 days after planting), Setts were removed from the various media and the number of setts that are just begining to sprout or have emerged fully were noted.

Number of intact minisett (neither rotten nor sprouted)

After the experiment was dismantled, each accessions was carefully examined. A minisett was considered intact if buds were not initiated on it and it was not rotten. These were counted at the end of the experiment for each accession.

Root parameters

The root parameters that were examined were the length of roots and the root numbers. A measuring rule was used to measure the root length of the longest root. The number of roots produced by the yam setts were also counted.

Field Establishment

The field was ploughed, harrowed and ridges made. The sprouted minisetts were transplanted. Sprouted yam setts were planted at a spacing of 1m × 0.5m. Good cultural practices including staking, weeding and remounding were carried out. Percentage establishment data were then collected. This was done by dividing the total number of planted setts by the total number of sprouted setts and multiplied by 100.

The sprouted minisetts from all the four nursery media were combined for each accession before transplanting in the field. The number of transplanted minisett that survived (were established) by 21 days after transplanting was obtained for each accession.

Data analysis

Data was subjected to statistical analysis using Excel spreadsheet (for data input and presenting frequencies) and GenStat for analysis of variance at P= 0.05. Count data were transformed using square roots transformation and percentage data were transformed using arcsine transformation.

Results

Percentage sprouting of bush yam minisetts from five accessions and in four nursery media

The Dente recorded the highest percentage sprouting of 84.9% in Table 8. It was followed by DJA-077, SE-B-054, and SE-B-062 which recorded 80.7%, and 72.4% of sprouted setts respectively. DJA-68 also recorded 64.5% of sprouted setts. The least percentage sprouted setts was recorded by DJA-067 which recorded 19.5% of sprouted setts. The best performing medium was the topsoil/topsoil combination which recorded a mean of 73.5%. However, it was not different from the mulch/mulch medium combination which recorded a mean percentage of (67.8%). The least performing medium was the sawdust/sawdust combination. This combination recorded a mean of 61.4%. In all, the media used recorded percentage sprouts which were more than 50% (Table 8).

The media and accession interactions from Table 8 indicated that DJA-077 performed better in the topsoil/topsoil medium combination. It recorded a mean of 87.1% and DJA-077 performed less in the mulch/topsoil media combination and mulch/mulch media combination. It can also be observed in Table 8 that, SE-B-062 performed very well in the topsoil/topsoil media of mean 78.8% and performed less in the mulch/mulch and mulch /topsoil media of mean 69.8%. There were no significant difference amongst them.

Again, SE-B-054 performed very well in the mulch/mulch medium than in the other media. SE-B-054 recorded the highest mean of 94.3% in the mulch/mulch medium.The mulch/topsoil medium and the sawdust/sawdust medium also recorded the least sprouting percentage of (71.7%). It can also be noted from Table 8 that DJA-067 recorded the lowest sprouting percentage (28.5%) in the topsoil/ topsoil medium: DJA-067 did not perform well in the other media combination.

DJA-068 recorded the highest sprouting percentage of 81.3% in the mulch/topsoil media. It however performed poorly in the sawdust/sawdust medium. The other media combination (topsoil/topsoil and mulch/mulch) also performed better than the sawdust/sawdust medium.

Dente performed very well in the sawdust/sawdust medium with a percentage sprouting mean of 89.6 and it performed less in the mulch/topsoil media. There were no differences among the other media that were used.

Additionally, it was realised from Table 8 that DJA-077 and Denteh performed well in the topsoil/topsoil medium combination percentage sprouting of 87.1. It was followed by SE-B-054 of mean 85.3%.SE-B-062 and DJA-068 also obtained a sprouting mean of 78.8% and 74.4. However, DJA-067 obtained the least sprouting percentage in the topsoil/topsoil medium of mean 28.5%. It can also be observed that Denteh, SE-B-054, SE-B-068, DJA-

077 and DJA-068 were not significantly different from each other but there were significant differences among them and DJA-06. Also, DJA-068 performed well in the mulch/topsoil medium with a percentage sprouting of 81.3%. The least performing bush yam in the mulch/topsoil media is the DJA-067 which recorded a mean sprouting percentage of 17.3. Denteh, DJA-077, SE-B-054 and SE-B-62 also obtained various sprouting means of 77.8%, 76.3%, 71.7% and 69.8% respectively.DJA-068, Denteh, DJA-077, SE-B-054 and SE-B-062 were all significantly different from DJA-067 with respect to the mulch/topsoil media.

Dente from Table 8 recorded the highest sprouting percentage for sawdust/sawdust medium of 89.65 and DJA-077 also recorded a mean of 83.0% for the sawdust/sawdust medium. Again, SE-B-054 and SE-B-062 recorded sprouting means of 71.7% and 71.4% respectively. DJA-067 recorded the least performing accession in the sawdust/sawdust medium combination. The DJA-067 was different from the other accessions significantly.

In the mulch/mulch media, SE-B-054 recorded the highest performing accession with a sprouting percentage of 94.3. Denteh, SE-B-054, DJA-077 and SE-B-063 also recorded means of 89.1%, 87.0%, 86.2% and 84.4% respectively. Again, DJA-068 recoreded a sprouting percentage of 73.9 in the mulch/mulch medium. However, DJA-067 was the accession that recorded the least sprouting percentage in this particular medium. DJA-067 obtained means 19.6%. All the accessions were significantly different from DJA-067.

Table 8: *Percentage Sprouting of Bush Yam Minisetts from Five Accessions and in Four Nursery Media*

		Nursery	Media		Accessions
Accessions	**A1**	**A2**	**A3**	**A4**	**Means**
DJA-077	87.1	76.3	83.0	76.3	80.7
SE-B-062	78.8	69.8	71.4	69.8	72.4
SE-B-054	85.3	71.7	71.7	94.3	80.7
DJA-067	28.5	17.3	15.3	16.8	19.5
DJA-068	74.4	81.3	37.5	64.8	64.5
Denteh (control)	87.1	77.8	89.6	85.3	84.9
Media means	73.5	65.7	61.4	67.8	
Lsd	5.09				14.96
Accessions×media:		Lsd=7.89			

Source: Field work, Fianu (2015)
A1= Topsoil/topsoil, A2=Mulch/Topsoil. A3 = Sawdust/sawdust
A4 = Mulch/mulch

Percentage rotten bush yam minisetts from five accessions and in four nursery media

DJA-067 recorded the highest percentage of rotten minisetts of 29.9%. This was significantly different from DJA-077, Denteh, SE-B-054 and SE-B-062. It was followed by DJA-068 which recorded 20.8% of rotten minisetts. DJA-077 and the Denteh recorded 10.1% and 8.1% of rotten minisetts respectively. SE-B-062 also recorded 6.0% of rotten minisetts. SE-B-054 also recorded the least percentage of rotten minisetts of 5.4%.

The percentage rotten minisetts in Table 9 indicates that DJA-067 recorded the highest rotten minisetts of 29.9% and SE-B-054 recorded the least of 5.4%. The mulch/mulch medium also recorded the highest of the rotten minisetts of 19.0%. It was followed by Sawdust/Sawdust medium and topsoil/topsoil medium which gave percentage means of 16.7% and 11.9% respectively. The topsoil/topsoil combination gave the least amongst the media of 5.9% means.

From Table 9, it was realized that DJA-077 recorded higher means in the sawdust/sawdust and mulch/mulch media by recording means of 19.8% and 16.8% respectively. The DJA-077 again gave the least rotten minisetts of 0.76%. SE-B-062 also gave higher rotten setts in the mulch/topsoil and sawdust media of percentage means 9.0 and 8.6 respectively but SE-B-062 recorded least means in the topsoil/topsoil medium of 0.76%. SE-B-054 recorded the highest rotten means in the mulch/topsoil media of 11.9% and recorded the least in the topsoil/topsoil medium of 0%.

Interestingly, DJA-067 recorded higher means in mulch/mulch medium of 55.4 rotten minisetts but recorded least rotten setts in the topsoil/topsoil medium of 12.5%. DJA-068 recorded high rotten setts in the sawdust/sawdust medium of 35.4% and produced least rotten setts in the mulch/topsoil media of means 9.0%. The sawdust medium was significantly different from mulch/topsoil media. However, the control (Denteh) recorded high rotten setts in the mulch/topsoil media of means 12.9% and least rotten setts in the mulch/mulch medium of percentage rotten setts of 3.0.

Table 9: *Percentage Rotten Bush Yam Minisetts from Five Accessions and in Four Nursery Media*

Accessions	**A1**	**A2**	**A3**	**A4**	**Accession means**
DJA-077	0.76	3.2	16.8	19.8	10.1
SE-B-062	0.76	9.0	8.6	5.6	6.0
SE-B-054	0.0	11.9	7.6	2.3	5.4
DJA-067	12.5	25.9	25.9	55.4	29.9
DJA-068	10.8	9.0	35.4	27.9	20.8
Denteh (control)	10.4	12.9	6.0	3.0	8.1
Media means	5.9	11.9	16.7	19.0	
Sed	3.95				4.84
Lsd	9.67				9.79
Accession×media	9.68				
Sed					
Lsd	19.50				

Source: Field work, Fianu (2015)
A1= Topsoil/topsoil,   A2=Mulch/Topsoil, A3= Sawdust/Sawdust
A4= Mulch/Mulch

Percentage intact bush yam minisetts from five accessions and in four nursery media

DJA-067 recorded the highest intact of minisett in Table 9 by giving 41.5% of minisett. SE-B-062 and SE-B-054 also recorded the second highest of intact minisett of 6.2% and 6.3% of intact minisett respectively and DJA-068 also recorded 3.7% intact sprouts whereas 3.2% was recorded by DJA-077 as the percentage of intact sprouts. The control (Denteh) recorded the least intact minisett of 2.7%. There were no significant difference among SE-B-054, DJA-068, DJA-077 and SE-B-062. There was a significant difference between DJA-067 and the rest of the accessions evaluated.

Additionally, the sawdust medium in Table 9 recorded the highest intact of 31.7%. The topsoil/topsoil medium combination also recorded percentage intact setts of 20.5%. Also the mulch/topsoil media gave an intact percentage of 16.2%. However, the mulch/mulch medium recorded the least of the intact setts of 6.5%. The mulch/mulch combination was significantly different from the rest of the media used.

The interactions in Table 9 indicates that DJA-077 performed less in the sawdust medium and the mulch/mulch medium than the rest of the media with means 0% and 1.5% but DJA-077 recorded best means in the topsoil/mulch and mulch/topsoil by recording percentage means of 10.9%. SE-B-062 also performed less in the mulch/mulch mediun of mean 7.0% but gave a high intact percentage means of 19.2%, 14.3% and 18.7% in the topsoil/topsoil, mulch/topsoil and sawdust media respectively. SE-B-054 gave a highest intact minisett in the sawdust medium of means 26.2% but gave the lowest intact minisett in the mulch/mulch medium of means 0.76%. Again, DJA-067 recorded the accessions with the intact minisett in the sawdust medium of means 56.0%. It was followed by the topsoil/topsoil and mulch/topsoil media which also gave an intact percentage means of 54.0% but the mulch/mulch medium recorded the least of intact minisett of means 21.1%. DJA-068 produced the highest intact minisett of 19.3% in the sawdust medium and recorded the least intact minisett in the mulch/mulch medium. However, the control (Denteh) recorded the highest intact minisett in the sawdust medium by 7.6%. The Denteh also gave least intact minisett values in the mulch/mulch and the topsoil/topsoil media of percentage means of 1.5% and 0.76%.

Table 10: *Percentage Intact Bush Yam Minisetts from Five Accessions and in Four Nursery Media*

Accessions	**A1**	**A2**	**A3**	**A4**	**Accession means**
DJA-077	10.9	10.9	0.0	1.5	5.8
SE-B-062	19.2	14.3	18.7	7.0	14.8
SE-B-54	14.7	12.0	26.2	0.76	13.4
DJA-067	54.0	54.0	56.0	21.1	46.3
DJA-068	7.6	7.6	19.3	4.4	9.7
Denteh (control)	0.76	6.3	1.5	7.6	10.4
Media means	17.9	17.5	20.2	7.1	
Sed	4.98				4.71
Lsd	12.18				9.52
Accession×media	9.94				
Sed					
Lsd	20.08				

Source: Field work, Fianu (2015)
A1= Topsoil/topsoil A2=Mulch/Topsoil A3= Sawdust/sawdust A4= Mulch/mulch

Mean root and shoot lengths of sprouted minisetts

The longest length of the roots (55.7cm) was recorded by white yam of. DJA-077 recorded the second highest of 48.5cm of longest roots. DJA-068, SE-B-062 and SE-B-054 also recorded 43.9cm, 39.1cm and 32.5cm of longest roots respectively. DJA-067 recorded the accession with the least length of longest roots of 23.2cm.

SE-B-062 recorded the minisett with the longest shoot of 5.42cm. It was followed by DJA-077 of shoot length 5.25cm. Denteh, DJA-067 and SE-B-054 recorded shoot lengths of 4.92cm, 4.33cm and 4.08cm respectively. However, DJA-068 recorded the least sett with the shortest root length of 3.97cm

The ratio of the root to the shoot length was also recorded. Denteh recorded 11.25cm which is the highest amongst the minisetts. Accession DJA-068 was the second accession to the Denteh and it recorded a root/shoot ratio of 9.12cm. DJA-077 also recorded a root/shoot ratio of 8.32cm. SE-B-054 and SE-B-062 recorded a root/shoot ratio of 7.68cm and 7.51cm respectively. DJA-067 however recorded the least of the root/shoot ratio of 5.04cm.

Table 11: *Mean Root and Shoot Lengths of Sprouted Minisett*

Accessions	**Longest root**	**Shoot length**	**Root Length/Shoot Length ratio**
DJA-077	48.5	5.25	8.32
SE-B-062	39.1	5.42	7.51
SE-B-054	32.5	4.08	7.68
DJA-067	23.2	4.92	5.04
DJA-068	43.9	3.97	9.12
Denteh	55.7	4.33	11.25
Sed	5.62	0.819	1.874
Lsd	11.37	1.66	3.79

Source: Field work, Fianu (2015)

Field establishment

Sprouted minisetts obtained from the nursery gave varying results when planted in the field. The number of minisett which survived on the field after transplanting is presented in Table 11. SE-B-062 recorded the highest minisett of 109 plants out of 144 minisett transplanted. It was followed by DJA-077 which recorded 103 plants out of 142 minisett. SE-B-054 and DJA-068also recorded 87 and 72 minisett respectively. However, DJA-067 recorded the least number of established minisett of 31. Again, the control recorded 74 plants after 152 setts were transplanted.

Table 12: *Number of Setts and Percent Establishment on the Field After 21 Days After Transplanting (DAT)*

Accession	**% sprouted**	**No. of misetts transplanted**	**No. established at 21 DAT**	**% establishment At 21 DAT**	**% of total minisetts established after transplanting ****
DJA-077	78.8	142	103	72.5	57.2
SE-B-062	80	144	109	75.7	60.6
SE-B-54	78.8	142	87	61.3	48.3
DJA-067	20	36	31	86.1	17.22
DJA-068	63.8	115	72	62.6	40.0
Denteh (Control)	84.4	152	74	46.7	41.1

Source: Field work, Fianu (2015)
*180 setts were nursed per accession   DAT= Days after transplanting,
** Total establishment of minisetts from nursery to field combined.

Discussions

Percentage sprouting of bush yam minisetts

Bush yam responded positively to the yam minisett technique. Most of the minisett had sprouted into various stages of sprouting (intact, rot, sprouted but not emerged and sprouted but has emerged. This indicated that the yams had broken dormancy before planting was done and for that matter had buds on the tuber surface. This was in agreement with a report by IITA, (2014) that minisetts cut from various sections of the tuber have varying rates of sprouting.

DJA-067 which recorded the highest intact minisett was however significantly different from the other bush yams accessions except the control. The control (Denteh) was also significantly different from the bush yam accessions and it recorded the least intact number of minisett. The intact minisett are sets with no visible signs of rots on them. It is important to note that the experiment was carried out in the dry season and could have accounted for the delay in the minisett to sprouts.

The experiment was conducted under a shed but due the hot weather, there were rotten tubers that were also recorded. This was in agreement to the report made by IITA (2014) that minisetts planted in hot weather without mulching rotted more and reduced sprouting.

The percentage sprouting of various accessions indicates that Dente recorded the highest sprouts. The control was not significantly different from SE-B-054, DJA-077, SE-B-062 and DJA-068. The control (Denteh) and the bush yam accessions (SE-B-054, DJA-077, SE-B-062 and DJA-068) were significantly different from DJA-067. The various sprouting percentage indicates that Dente performed better than some of the bush yams. This observation is in disagreement to a report by Marfo (2002) that white yam responds poorly to the minisett propagation technique.

It was observed that there was no significant differences in the rate of sprouting betwwen the growth media. All the accessions performed well in the various planting media used. This goes to suggest that farmers in the rural areas where sawdust are scarce could rely on mulch which is readily available to propagate their minisetts. The interaction between the bush yam and the planting media shows that all the accessions performed well in the various media except DJA-067 which performed poorly in all the media that were used. From the preparation of the minisetts, it was realised that the mother seed of DJA-067 was infested by nematodes. These nematodes could have led to the low performance of DJA-067in all media and this could have led to low sprouting percentage even though the minisetts were treated.

Percentage intact and rotten minisetts of bush yam minisetts

Sprouting of yam can be affected by so many factors including the age of the plant, quality of the mother plant, wound on the mother plant, planting media, temperature, portion of minisett planted and dormancy. The quality of mother sett affects the rate of sprouting. Any bruise on the tuber at harvest may render the tuber liable to infestation by microorganisms such as fungi and bacteria which can cause wet or dry rot. According to Otoo *et al*., (1984), nematodes (*Scutellonema spp*. and *Melodogyne spp*.) which infest tubers in the field before harvest and can subsequently affect sprouting. Temperature also affect sprouting in yam. The optimum temperature for tuber sprouting is between 25°C and 30°C. Onwueme, (1978), reported that any appreciable change more than 5°C below or above this range delays sprouting. These factors could have accounted for the number of intact and rotten setts.

The number of sprouts observed in the experiments were low due to the excessive rots and some factors such as planting media, temperature experienced during the conduct of the experiment. The hot weather could have heated the media that was used leading to lower sprouts. Sterilization of the media was also not done and so could have accounted for the number of rots that were produced. It was also observed that, mushrooms were seen growing on some of the media that was used especially the sawdust media.

Moisture in the planting media also played a significant role in the sprouting process of the minisett. Though some of them could not emerge from the media they showed signs of sprouting at the time of transplanting.

Mean roots and shoots of sprouted minisetts

Root length is an important factor in the lifecycle of any plant. Lateral root development is related to yield determination in root and tuber crops. This could be attributed the fact that both media were not compact leading to free movement and penetration of the roots. Longer roots may break when not handled with care during transplanting and this can impede field establishment. Thus shorter roots may aid establishment in the field than longer roots.

Establishment of minisetts on the field after 21 days of transplanting

Sprouted minisetts obtained from the nursery gave varying results when transplanted in the field. Also the percentage establishment taken after 21days was rather low. However, SE-B-062 and DJA-077 performed better than the control (Denteh) which is a white yam. It is difficult to explain this phenomenon but SE-B-062 and DJA-077 might have adjusted favourably to the environmental conditions in the field than the other bush yam and the control. Most of the minisetts though sprouted in the nursery failed to emerge after transplanted was done and this might be attributed to the roots failing to establish in the soil. Otoo *et al*, (1987) stated, for better establishment, the roots should not be too long before transplanting, suggesting that longer roots may cause breakages during transplanting. The plant will thus have to reuse its energy in producing new roots to survive on the field. It was also noted that some of the sprouted minisetts were partially rotten. These may carry rot-causing infection such that their vigour to emerge after planting on the field was reduced. The sprouting media that was used was not sterilized before use and could serve as a source of infections. Conditions in the field could have led to failure of the sprouted setts to establish on the field. High temperature, attack by insects and soil-borne organisms could result in the sprouted setts failing to emerge on the field.

Conclusion

From the experiment, it can be observed that bush yam (*Dioscorea praehensilis*) performed well as the Dente, white yam (*Dioscorea rotundata)***.*** The performance of each accessions were not significantly different from each other except with DJA-067 which performed poorly in all the data collected. The mulch media performed better than the traditional sawdust and so farmers in the cocoa growing area could use the mulch at the expense of sawdust.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The collected bush yam germplasm exhibited three types of leaf shapes and three types of spines shapes. Clusters analysis categorized the 96 accessions into four distinct groups but the grouping was not influence by location from where the materials were collected. Also the morphological characterization suggest that there is a great diversity of bush yam that can be exploited and this can serve as a source of food security for Ghana. Leaf shape, leaf colour, girth of vine, vine colour, flowering ability all contributed to the diversity that were observed.

Again, the outcome of the sensory analysis suggest that, consumers would choose food products that are sweet and smells good. Also colour, bitterness and fracturability does not play a role in the selection of food product by consumers. Thus the choice of a product selection depends on taste, smell and touch.

Finally, from the experiment, it was observed that, the bush yam (*Dioscorea praehensilis*)**,** when tested under the minisett performed better like the white yam did. The bush yam performed better in all the various media that were used except the sawdust. The mulch could be used as an alternative medium for the traditional sawdust.

Recommendations

- Multi-locational on-farm test should be carried out to confirm the outcome of the morphological characterization.

- Molecular and biochemical analysis should be carried out to ascertain the results of the morphological characterization performed.
- The tansplanted yam minisett technique should be allowed to stay on the field to assess its performance at harvest.
- Again the yam minisett should be carried out in the wet season where all environmental conditions are favourable to assess its performance.
- Varying the days of nursing of minisetts to improve field establishment should be carried out.

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APPENDICES

Appendix I: OUTPUT TO YAM MINISETT TECHNIQUE

Analysis of variance

Variate: Root Length to Shoot Length RATIO

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REPLICATION stratum	2	201.55	100.78	1.52	
REPLICATION.MEDIUM stratum					
MEDIUM	3	112.80	37.60	0.57	0.657
REPLICATION.MEDIUM.ACCESSION stratum					
ACCESSION	5	250.48	50.10	2.38	0.056
MEDIUM.ACCESSION	15	213.59	14.24	0.68	0.792
Total	71	2019.66			

Analysis of variance

Variate: Higher feeder roots

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REPLICATION stratum	2	0.02189	0.01095	0.12	
REPLICATION.MEDIUM stratum					
MEDIUM	3	0.49574	0.16525	1.83	0.242
Residual	6	0.54130	0.09022	0.90	
REPLICATION.MEDIUM.ACCESSION stratum					
ACCESSION	5	0.60717	0.12143	1.22	0.320
MEDIUM.ACCESSION	15	2.50995	0.16733	1.68	0.099
Residual	38	3.79149	0.09978		
Total	69	7.66624			

Analysis of variance

Variate: Least Feeder Root

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REPLICATION stratum	2	0.029772	0.014886	3.00	
REPLICATION.MEDIUM stratum					
MEDIUM	3	0.014886	0.004962	1.00	0.455
Residual	6	0.029772	0.004962	0.67	
REPLICATION.MEDIUM.ACCESSION stratum					
ACCESSION	5	0.029772	0.005954	0.80	0.556
MEDIUM.ACCESSION	15	0.119089	0.007939	1.07	0.415
Residual	40	0.297721	0.007443		
Total	71	0.521012			

Analysis of variance

Variate: intact minisetts

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REPLICATION stratum	2	781.1	390.5	1.75	
REPLICATION.MEDIUM stratum					
MEDIUM	3	1182.3	394.1	1.77	0.253
Residual	6	1337.4	222.9	1.67	
REPLICATION.MEDIUM.ACCESSION stratum					
ACCESSION	5	8260.5	1652.1	12.40	<.001
MEDIUM.ACCESSION	15	2727.7	181.8	1.36	0.212
Residual	40	5330.5	133.3		
Total	71	19619.4			

Analysis of variance

Variate: Rotten minisett

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REPLICATION stratum	2	800.8	400.4	2.85	
REPLICATION.MEDIUM stratum					
MEDIUM	3	1446.2	482.1	3.43	0.093
Residual	6	843.5	140.6	1.00	
REPLICATION.MEDIUM.ACCESSION stratum					
ACCESSION	5	4701.3	940.3	6.68	<.001
MEDIUM.ACCESSION	15	2681.7	178.8	1.27	0.265
Residual	40	5628.3	140.7		
Total	71	16101.6			

Analysis of variance

Variate: Sprouted minisett

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REPLICATION stratum	2	133.91	66.96	1.72	
REPLICATION.MEDIUM stratum					
MEDIUM	3	644.23	214.74	5.52	0.037
Residual	6	233.34	38.89	0.42	
REPLICATION.MEDIUM.ACCESSION stratum					
ACCESSION	5	14327.97	2865.59	31.31	<.001
MEDIUM.ACCESSION	15	1828.04	121.87	1.33	0.229
Residual	40	3660.72	91.52		
Total	71	20828.21			

Appendix II: OUTPUT FOR PRINCIPAL COMPONENT ANALYSIS

Principal components analysis

Latent roots

1	2	3	4
6503	1448	709	322

Percentage variation

1	2	3	4
69.21	15.41	7.55	3.43

Latent vectors (loadings)

	1	2	3	4
FOC	0.01207	-0.00213	0.02803	-0.00780
CTC	-0.00592	-0.03295	-0.34997	0.33024
FLOW	-0.00881	-0.01190	0.02364	-0.05429
FTC	0.02353	-0.09036	-0.61760	0.60509
GIRTH	-0.25700	-0.03246	-0.65360	-0.69034
LS	-0.00846	-0.01082	-0.01778	0.01813
MVC	-0.01066	-0.06467	-0.05985	-0.02394
NOI	-0.18127	-0.97306	0.12519	-0.00150
NOS_3RD	-0.94522	0.19429	0.15430	0.20534
SS	-0.00023	-0.02367	0.03093	0.01033
TH	-0.01050	0.00792	0.00255	0.00096
TT	-0.01396	0.00526	-0.00066	-0.01252
YIELD_1	-0.07968	-0.00179	-0.15231	-0.04357