DRY SEASON CONSERVATION AND MULTIPLICATION OF SWEET POTATO [IPOMOEA BATATAS (L) LAM.] PLANTING MATERIAL IN THE COASTAL SAVANNAH ZONE OF GHANA

BY
EMELIA OBERYE MONNEY

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF M. Phil. DEGREE IN "CROP SCIENCE"

DEPARTMENT OF CROP SCIENCE
FACULTY OF AGRICULTURE
UNIVERSITY OF GHANA
LEGON

MAY 2003

DECLARATION

I hereby declare that this thesis is a product of my own original work and has not been submitted to another university for the award of a degree. Any help received in the compilation of this thesis and all sources have been duly acknowledged.

....EMELIA OBERYE MONNEY

(STUDENT)

....PROF. J. C. NORMAN

(SUPERVISOR)

DEDICATION

To Kweku, my husband.

ACKNOWLEDGEMENTS

Many are those who have contributed in divers ways to make this thesis possible. I am grateful to all for the contributions made. While I cannot mention every one's name here, it is important for me to acknowledge the contributions of those without whose help this work would not have been possible.

To the Lord my God who has brought me this far I bring all praise and adoration, and acknowledge that but for him, this work would not have been.

I am most grateful to Dr. Francis Ofori, Director of Crop Services for his support and encouragement, and to the Root and Tuber improvement Programme for providing the funds that made this work possible.

My deepest appreciation goes to Prof. J. C. Norman, my supervisor for the comments, constructive criticisms and for reading through this thesis. And also to Prof. Essie Blay, Prof. Oduro, Dr. K Ofori and Dr, Kumagah of the Crop Science Department, and Dr. Wilson of the Zoology Department for their advice and helpful suggestions.

My warmest appreciation is to Dr. Papanii Johnson, Dr. Vowortor and Mr. Noamesi of the Food Research Institute, for reading through my proposals and helping with literature sources. I am also grateful particularly to Mr. Noamesi for granting me access to the improved storage barn used in the study.

I am grateful to Mr. Tonyigah, Mr. Ankrah, Mr. Asante, and Mr. Adgyekum and all the other staff in the Department of Crop Science and workers of the University Farm, and to Larry my colleague.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

ABSTRACT

Three experiments were conducted during the dry season from October 2001 to April 2002 at the University of Ghana Farms and the Food Research Institute, to evaluate two methods of conservation of sweet potato planting material and one method of multiplication of vines were evaluated in this study using two cultivars – Sauti and Okumkom released to farmers by the Crops Research Institute. The study was aimed at developing a technology to ensure the availability of adequate quantities of sweet potato planting material at the beginning of the planting season.

In Experiment 1, small unmarketable tubers were stored in an improved barn for 0, 5, 10 and 15 weeks and then planted in the nursery. Sprouts from tubers planted were used to generate planting material for field planting of sweet potatoes. In Experiment 2, small unmarketable tubers of two sweet potato cultivars, Sauti and Okumkom, were planted at three different planting distances; 25cm x 10cm, 25cm x 15cm and 25cm x 20cm and evaluated for their vine yields. In Experiment 3 the effect of the conservation of vines of Sauti and Okumkom in the nursery and early initiation of vine multiplication were evaluated.

Except for sweet potato weevil (*Cylas puncticollis* (Sum)) damage in tubers in which significant differences (P=0.05) were observed between the cultivars, results obtained from storage of tubers showed that differences between the cultivars were not significant for percentage weight loss, percentage shriveling, percentage sprouting and percentage rotting. However, for the different periods of storage, the percentage weight loss,

percentage shriveling, percentage rotting, percentage insect damage and percentage sprouting increased significantly with increased period of storage. The resultant number of 30 cm apical, middle basal and total number of 30cm vines obtained from the remaining tubers planted, decreased significantly with increase in storage period.

Although differences observed among the different planting distances studied were not significant at P=0.05, planting both cultivars at 25cm x 15cm gave the highest number of planting material followed by 25cm x 10cm and then 25cm x 20cm.

Early initiation of multiplication of planting material after conservation of vines in the field - 14 weeks before field planting, gave the highest number of 30 cm apical, middle, basal and total vines available for field planting, followed by 10, 8, 6, 4, and 0 weeks in decreasing order. Differences observed were significant at P=0.05.

CHAPTER ONE

1.0 INTRODUCTION

Sweet potato (*Ipomoea batatas [L]*) is grown throughout the tropics for the tubers (an important source of carbohydrate) that are usually eaten boiled or baked, or used as a raw material in the starch, alcohol, carotene-juice, glue, and syrup industries. The tender tops and leaves are used as a pot-herb and the vines are widely used as a fodder for livestock. (Setijati *et al.* 1981; Purseglove, 1968; Onwueme and Sinha, 1991; Chukwu, 1995). The crop has a tremendous potential to be an efficient and economic source of food energy (Ambe, 1997). It has a relatively short growing season and a wide adaptability to different agro-ecologies (Hahn, 1977 and Ambe, 1997).

In Ghana, sweet potato cultivation and utilization is very prominent particularly in the savannah agro-ecologies (with an average annual rainfall of between 700-900 mm and a long dry season of up to about six months from November to April) where it is produced both as a food and cash crop (Missah and Kissiedu, 1994). There is also the potential for increased production both as food and animal feed in the other agro-ecologies (Otoo *et al.*, 1998). Recent market surveys have indicated an opening for the crop on the international market. In the year 2000, 6.873 tons of the tubers amounting to $8,534 were exported to Europe. This increased in the year 2001 to 24,244 tons amounting to $12,396 - GEPC (2002).

Although yields of up to 40 tons per hectare have been reported (Missah and Kissiedu, 1994), Otoo *et al.*, (1998) indicated that yields obtained by farmers tend to be low and the quality reduced due to the low genetic potential of varieties, diseases (fungal and viral) and pests (*Cylas* sp. and *Acidodes* sp.) infestations. There is also little or no information on appropriate agronomic practices and increased production is further limited by the availability of planting materials (Okoli, 1988; Carey *et al.*, 1997; Kakraba, 2001; Yankey, 2001).

Sweet potato vines do not store for more than seven days (Okoli 1988). Onwueme and Sinha. (1991) and Otoo (1998), reported that there is always a shortage of planting materials at the beginning of the farming season because, during the long dry season preceding the growing season the vines dry up. Sometimes, farmers are able to save only a small quantity of planting material for the following season by planting a few vines in backyard gardens, dam sites, valley bottoms and the banks of rivers. This practice restricts the expansion of small farms, large-scale cultivation and the establishment of new fields (Okoli, 1988; Otoo, 1998; Kakraba, 2001; Yankey, 2001). It is therefore important to conserve planting material during the dry season, and special arrangements made to provide planting materials for sweet potato, which is harvested at a time when a new crop is not being planted (Okoli, 1988).

The Crops Research Institute of the Council for Scientific and Industrial Research in Ghana is promoting the use of the rapid vine multiplication technique, to produce vine cuttings for planting by farmers. Farmers using this technique, plant available vines at 10cm x 10cm intervals in the nursery at the onset of the rains, apply nitrogen fertilizer and harvest vines for planting five weeks after nursing. Apart from this not much work has been done on the conservation and multiplication of planting materials for the crop – (CRI, 2000).

This study therefore aims at developing a technique that would ensure the availability of adequate quantities of sweet potato planting materials at the beginning of the planting season for both local and export farmers.

The objectives of the study were to determine the:

- Possibility of, and the optimum time for storing unmarketable sweet potato tubers in an improved barn for the early part of the dry season and using them to generate planting material for the planting season.
- Optimum spacing for tubers planted in the nursery.
- Optimal time for maintaining sweet potato vines in mulched nursery beds prior to the initiation of their multiplication for planting material production.
- Yield of planting material produced from tubers and vines after different periods of storage during the dry season.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Origin and Distribution

The Sweet potato - *Ipomoea batatas (L)* Lam of the family Convolvulaceae is native to Central America (Hahn, 1977; Ambe, 1997), although it has been cultivated throughout the warm islands of the Pacific Ocean for an equally long time (Sowley, 1999). It ranks seventh in total production among the world's food crops (Opena *et al*., 1989), and is grown in areas reaching 40°N and 40°S latitudes and as high as 2000 m above sea level (Hahn, 1977) in more than 100 countries. Among the world's root crops, it is second only to white potato (*Solanum tuberosum*) in importance (Horton, 1989).

World production in 2001 was 135,918,673 metric tons of which 10,203,169 metric tons was produced in Africa and 90,000 metric tons produced in Ghana (FAO, 2001). Roughly 80% of the world's production is grown in Asia and just under 15% in Africa with only about 5% grown in the rest of the world. Developing countries grow nearly all the world's sweet potatoes. China alone accounts for about 80% and also has much higher yields and production per head (Horton, 1989). The largest producing countries in Africa are Rwanda and Uganda. In West Africa, it is important in Liberia and Sierra Leone (Otoo *et al*., 1998) Its introduction to Ghana (Gold Coast) is believed to have been in the second half of the 17th century (M.O.A., 1988).

2.2 Botany

Setijati *et al.*, (1981); Cobley and Steele, (1983); and Purseglove (1987) describe the sweet potato as a self incompatible, short day, dicotyledonous perennial herb cultivated as an annual with trailing or twining stems 1-5 m in length with latex in all its parts. The stems are mainly prostrate, sometimes twining and light green to purple. The leaves are spirally arranged and either simple or deeply lobed. They are up to 15 cm long with pointed tips and may be green to purple. The root system is extensive and roots grow from the stem nodes where stems contact the soil. Tuber structure is mainly globular and smooth or ridged. The tuber surface may be white, yellow, orange, purple or brown and the flesh is white, yellow, orange, red or purple. The flowers may be single or in clusters (cymes); the calyx is five lobed, the corolla is funnel shaped or tubular and the petals are purple with pale margins.

2.3. Sweet Potato Propagation

Sweet potato is clonally propagated as well as by seed. Sexual multiplication is exclusively reserved for the production of new cultivars (Cobley and Steele, 1983; Sihachakr *et al.*, 1997; Daisy, 1998). Cuttings of stem fragments 20-25cm long with 3-5 nodes are traditionally planted in family farms while roots bearing numerous adventitious buds are used as clonal propagation for commercial production (Sihachakr *et al.*, 1997). Between 400,000 and 1,250,000 vines are planted per hectare depending on the cultivar (Du Plooy *et al.*, 1988).

Planting materials usually consist of sprouts, vine cuttings or root cuttings. Sprouts are produced by placing "seed roots" in beds (often later covered with sash or polythene film), covering the roots with 5-8 cm of sand, then pulling the sprouts when they reach a height of 20-25 cm. Vine cuttings, obtained from established plantings or nursery gardens are used primarily for production of disease-free seed, or for main crop production in areas with long growing seasons (Bouwkamp, 1982; M.O.A., 1988; Gibson *et al.*, 1997; Hoa, 1998; Sihachakr *et al.*, 1997; Nair, 2000). Root cuttings are taken from secondary rather than main roots and should have up to six nodes per cutting.

According to Du Plooy *et al.*, (1988), the sweet potato is propagated by means of vines cut into 30 to 40 cm slips. The authors stated that it is important to use healthy, insect-free propagation material since diseases and pests can be spread through propagation material. Long vines are cut into slips and divided into top or apical vines (growth point portions) and stem vines (rest of the vine). The use of planting material cut from the vines of old sweet potato lands should be avoided as these vines are usually from the voluntary growth of smaller and inferior sweet potatoes left in the ground after the crop was lifted. Moreover, this volunteer growth often arises from poor or diseased plants thus resulting in the continual selection of poor planting material.

Three types of transplants: sprouts, cut sprouts and vine cuttings are normally used in the sub-tropical and warm temperate areas (Edmond, 1971a; Daisy, 1998).

Sprouts: these are entire plants, which arise and are pulled from the bedded roots. At the time they are ready for pulling, the above ground portion of the stems is 15-20cm, has 4-6 physiologically active leaves, and an underground portion with a developed extensive root system. Although they require somewhat shorter time for their development than do cut-sprouts and vine cuttings, their main disadvantage is that sprouts spread Fusarium wilt, black rot and soil rot or scurf from infected soils to the field.

Cut sprouts are essentially the above ground portions of sprouts. The stems of individual plants are cut usually at or just below the level of the bedding media when the aboveground portion is about 18-25cm long.

Vine cuttings are the terminal portions of plants growing in the plant bed or in the field. Usually, the stems are cut at the fifth or sixth node back from the terminal. In general, vine cuttings are used for the establishment of new plantings in tropical and subtropical regions, and in warm temperate regions adjacent to subtropical regions (Edmond, 1971).

Nair *et al.*, (1989) reported that in India, sweet potato is propagated through vine cuttings obtained from either freshly harvested plants or a nursery. In Indonesia, farmers meet their planting material needs by taking apical vines from a previous crop or from stored roots (Jusuf *et al.*, 1998).

2.3.1. Production of planting material:

Different methods are employed in different countries in the production of planting material. To obtain vine cuttings, Indian farmers raise nurseries either from healthy tubers or from selected vines. Vines obtained from nurseries are healthy and vigorous resulting in maximum tuber production (Nair *et al*., 1989). In North Carolina, U.S.A., transplants are produced by pre-sprouting seed stock (roots) at curing temperatures (30°C) for approximately 4 weeks after a period of storage dependent on the cultivar (some cultivars stored longer than others). The transplants are pulled and planted out, or where disease infestation is suspected, sprouts are cut off above the ground to avoid transmitting diseases onto the field (Wilson *et al*., 1992).

Rice *et al*., (1991) and Alvarez, (1992) observed that in general, optimal use of healthy good quality planting material in Africa is rare due to the lack of adequate quantities when it is most needed. Seedlings vary in performance, and propagation from tubers and tuber shoots is also rare. Stem cuttings are most frequently used. Akoroda *et al*., (1992) listed a number of methods employed by Cameroonian farmers to conserve planting material during the dry season, and generate material for planting at the beginning of the season. These were

1. Harvesting vines from re-growth of un-harvested small tubers from previous farms. However, because of slow re-growth, farmers have to wait until after two months of rain before enough vines become available.
2. Vines cut from the main crop a few weeks before the end of the seasonal rains are planted in a nursery by a stream, watered as and when necessary, and cut for planting at the start of the rains.

3. Soon after harvest small unmarketable tubers are planted densely in nursery beds and mulched lightly. This method produces a lot of vines that are cut for planting at the onset of the rains.
4. Ridges and beds of vines or tubercles are established under bananas or sugarcane in sites near streams or wetlands. These give reliable amounts of planting material depending on the water regime, soil fertility, and field maintenance to control shading from other crops.
5. Beds of small tubers are prepared, and over these, shelters are constructed with stick supports and grass thatch. Watering is highly regulated to control vine growth.
6. A large bunch of old vines from the harvested field is kept near a stream or in a wetland and protected against animals.

They concluded that adoption of methods 2,3,4, or 5 was adequate for conserving planting material, but the use of small tubers and vines was better.

In East Africa, villagers typically leave some roots in the ground during the dry season, and months later, when the rains start, the roots re-sprouted and after a few weeks the vines are strong enough for farmers to take cuttings that they use to re-establish the crop. However, an early cessation and late on-set of rains in 1997 resulted in a six-month long drought which killed off most of the plants. To prevent a recurrence of another production crisis, healthy cuttings were planted in small 1.5 square meter beds in advance and watered as needed throughout the dry season. Cuttings were taken from these vines immediately the rains started without waiting for old roots to re-sprout. The added advantage of this method was that with cuttings from such a nursery, farmers begun the season with fresh clean planting material less likely to be infested with weevils (CIP, 1998).

Of all the different types of planting material used in sweet potato production, the tender apical vines have been found to give the highest planting material and tuber yields followed by the older woody vines, then the tubers. Nair, (2000) and Nair *et al.* (1989) indicated that use of terminal vine cuttings had given the highest tuber yields at the Central Tuber Crops Research Institute. Hossain and Mondal (1994) and Hoa (1998) also reported that apical vines gave significantly higher tuber yields than middle and basal vines. Although middle vines gave higher yields than basal vines, the differences were not significant.

Du Plooy *et al.*, (1988) and Onwueme and Sinha (1991), reported that the top 30 cm vines produced higher yields than the stem vines, probably because the former have a better percentage take. Since only one top vine can be cut from each vine, top vines are fairly scarce and therefore more expensive. Plooy *et al.*, (1992) further showed that the same potential existed for storage root formation in apical vines of six different cultivars of sweet potato planted vertically or horizontally with 3-5 nodes beneath the soil surface provided that the planting material had been cut in between two nodes.

Ravindran and Mohankumar, (1989) found out that planting sweet potato vines after keeping under shaded conditions for two days gave the highest percentage yield followed by vines kept under shade for four days and freshly cut vines. They also reported that vine cuttings with leaves intact prior to planting had better establishment, sprouting and higher tuber yield than those without leaves. Hoa (1998) supported this when he reported that fresh undefoliated cuttings produced higher yields than defoliated or wilted cuttings. A vine length of 20-40 cm was found to be optimum for tuber production.

2.3.2. Plant Tissue Culture:

Progress has been made in the improvement of sweet potato by using conventional breeding methods for the transfer of resistance to diseases, nematodes and insects and also for increasing protein content and nutritional quality. Nevertheless, the selection process is time consuming and requires a high number of individuals and improved breeding systems (Sihachakr *et al.*, 1997). Fuglie et al. (1999) stated that sweet potato yields were significantly reduced due to diseases and pests in the planting material. The development and transfer of new methods and technologies for producing clonal seed could overcome these constraints and help unlock the significant yield potential of the crop. One of such techniques is the use of the tissue culture technique to supplement and complement conventional breeding methods and also to clean up sweet potato of viral diseases that account for the crop producing well below its potential.

Some successes have already been made in the conservation and multiplication of planting materials using this technique. Dodds (1989) reported that it is possible to regenerate de novo in vitro plantlets from almost all plant parts when placed into culture. He further reported that several scientists have successfully regenerated plantlets of sweet potato from cultured stems, petioles, roots and leaf discs. In all cases the first step is the formation of callus at the cut surface.

Martin (1982) reported that callusing and rooting occurred rapidly when young but nearly full sized leaves of sweet potato were planted in sterile sand covered with a transparent chamber and partially shaded. Rooted leaves showed unusual growth phenomena including leaf enlargement, petiole swelling and storage roots that may sprout and generate normal plants. Schultheis *et al.*, (1994) reported that vegetative growth, larger-sized storage roots (6cm in diameter), and total yields were consistently reduced when plants were derived from somatic embryos compared with propagules from stock plant origin. Kozai *et al.*, (1998) reported that leafy node or shoot cuttings from disease-indexed, micro-propagated plantlets are widely used for vegetative propagation and transplant production of sweet potato under natural light in the greenhouse in Japan.

Nelson and Mantel (1989) demonstrated that micro-propagated plantlets of sweet potatoes could be rapidly established in the nutrient film technique system, and concluded that large quantities of vigorously growing stem cuttings could be produced throughout the year to provide disease-free planting material, particularly for sweet potato stock and cultivar introduction programs. Silva *et al.*, (1991) also reported yield increases in tuber production when six different sweet potato cultivars grown from stem culture were compared with the same cultivars produced by traditional field multiplication methods. Vine yield and commercial class tubers were also greater with planting material derived from stem culture.

When sweet potato production from true seed culture was compared with production from stem cuttings, Iwama *et al.*, (1990) reported that with cultural practices that improved early top growth, crops grown from true seeds could yield as well as those conventionally grown from cuttings. Increasing the plant density in field plantings of cultivars raised in-vitro from 20 plants/m^2 (0.25 x 0.2m), 36 plants/m^2 (0.15 x 0.15m) and 54 plants/m^2 (0.15 x 0.12m) resulted in increases in tuber numbers but decreases in tuber weight per m^2 (Ekanayake *et al.*, 1990). Wang *et al.*, (1990) reported that virus-free sweet potato planting material had better dry matter accumulation when compared to controls and could be used extensively in sweet potato production.

Although most of these findings are still at the research level, China has moved further by using the virus clean up technique to produce disease free plants which are regenerated in greenhouses where they form small roots used to grow virus-free vine cuttings for farmers' use (Fuglie *et al.*, 1999).

2.4. Storage of sweet potato tubers

Du Plooy *et al*., (1988) stated that a number of practices must be followed to multiply sweet potato vines. The practice followed would be mainly determined by the climatic conditions in which the multiplication is to be done. As already stated, sweet potato tubers are also used for propagation either by direct planting or by using the tubers to produce sprouts or vines as planting material. Where the tubers are not immediately planted after harvest, i.e., in the temperate regions and regions with long dry seasons, it becomes necessary for the tubers to be stored for a while.

However, in contrast to cereals, which have good natural properties for making them suitable for storage, sweet potato like other tropical roots and tubers is a perishable crop. The factors determining the storage properties of tropical roots and tubers include high moisture content, mostly between 50-80%, and high to very high respiratory activity of stored crops (Knoth, 1993).

In temperate countries, sweet potatoes are usually stored in cold storage rooms where the temperature and relative humidity are controlled. Optimum storage conditions reported by Data *et al*., (1989) and Onwueme and Sinha (1991) are 15°C and 85-90% RH. Below this, chilling injury, decay, internal breakdown and impaired edibility may occur because lower temperatures favour the growth of fungi that cause decay in sweet potato. On the other hand temperatures above 15.5°C reportedly shortens the storage life of sweet potato because it causes considerable weight loss. Dry matter content of sweet potatoes generally decreases during storage. The decrease is generally higher at 18.5°C than at lower temperatures and is attributed to the increase in respiration rate as manifested by increased moisture loss of sweet potatoes stored at higher temperatures.

Sowa (2000) reported that in the production of planting material using tubers, storing tubers at 14°C and 90% RH delayed emergence of seed potatoes and increased number of stems per plant. Gasiorowska and Zarzecka (2000) reported reduction in storage losses when maleic hydrazide was applied at 5kg/ha in 400l of water to potato tubers stored in cellars and clamps. The lowest losses were recorded when the inhibitor was applied four weeks before tuber harvest.

In tropical countries, cold storage for sweet potatoes is not economically feasible. Hence researchers have studied different methods of maintaining high relative humidity and low temperature conditions during storage. Kamalam, *et al*., (1998) reported that keeping the tubers in wooden boxes in layers with sand was effective in controlling storage pests and post-harvest deterioration for up to two months and beyond.

Storage of fresh tubers in moist sawdust, sand, and under ambient conditions have been studied, and results have shown weight losses of 11.4, 9.88 and 40.71% respectively after 6 weeks of storage (Data *et al*., 1989). Roots stored in sand and moist sawdust were still acceptable after six weeks of storage while those stored at ambient conditions were no longer marketable. Storage in this system must however not last longer than the dormancy period of sweet potato after which sprouting and rotting may take place because of the high relative humidity (Data *et al.*, 1989). Sowley (1999) reported fresh weight losses of up to 22.69% in sweet potatoes stored for 8 weeks in storage barn.

Clamp and pit storage have also been studied and recommended for use in some countries like Uganda, Tanzania and Philippines. In Uganda, research has shown that it is possible to keep tubers in good condition for as long as five months during the dry season (Data *et al.*, 1989). In certain areas of India, farmers store tubers in pits, sand beds, earthen pots or in heaps and covered with paddy straw or dry grass (Kamalam *et al.*, 1998).

According to Data *et al.*, (1989), other village level storage structures with adequate ventilation, and temperatures and relative humidity lower than the outside have been developed in countries like the Philippines. Some of these have additional slated walling to provide diffused light which inhibits sprouting to some extent. Care must however be taken to avoid over ventilation as it can result in excessive weight loss.

Any storage structure designed for holding perishable produce at the rural level must afford protection from the prevailing weather conditions, allow adequate air circulation and ventilation and attain the lowest practical temperature (Bani and Josiah, 1995). Satish *et al.*, (2000) observed shrinkage in 7-12 weeks of storing potatoes and sprouting 3-8 weeks after storage when they tested four non-refrigerated storage methods i.e. passive-draft evaporatively cooled storage, radioactively cooled storage, farm level (brick and sand) storage and evaporatively cooled storage. Assuming 10% total weight loss as the safe and economical limit, the potatoes could be stored for up to 10-13 weeks in non-refrigerated storage structures while under ambient conditions potatoes can only be stored for up to 8 weeks.

The condition of the material before storage is one of the most important factors governing the success of the storage method used. Harvesting roots from flooded and/or cold soils adversely affected keeping quality and increased storage rots. Both conditions resulted in abnormal respiratory responses in roots tested (Ahn *et al.*, 1980). To ensure good storage, only top quality roots free from insect damage, rots and rodent damage should be selected for storage.

Varietal effects have also been recognized as important for the successful storage of sweet potatoes (Data *et al.*, 1989). Wide varietal differences in weight loss were observed among sweet potato roots stored at 21°C. Variations were also observed in the ability of tubers to retain fresh quality during storage among different varieties used as parent material in developing new sweet potato genotypes). The storability of roots was limited by the onset of sprouting, greening, shriveling and susceptibility to decay causing pathogens.

The effectiveness of a storage method also depended to some extent on the variety owing to differences in susceptibility to diseases, length of dormancy period, and transpiration rate. Thus, the storage method for a variety with a potentially short shelf life may not be as effective when used for one with a longer shelf life (Data *et al*., 1989).

In storage, sweet potatoes are subjected to several types of post harvest losses like physiological damage, weight loss, pathological decay, sprouting, and sweet potato weevil infestations (Kamalam *et al*., 1998). Losses due to diseases, particularly soft rots can be very substantial. Soft rot, ring rot or collar rot caused by *Rhizopus stolonifer* is of considerable economic importance. Under favourable conditions, it can destroy the entire tuber in a few days. Other storage rots and their causal organisms are *Erwinia chrysanthemi*, black rot (*Ceratocystis fimbriata*), surface rot (*Fusarium oxysporum*), dry rot (*Diaporthe phaseolorum var batatatis*), charcoal rot (*Macrophomina phaseolina*) and java black rot (*Botryodiplodia theobromae*), (Daisy, 1998; Sowley, 1999). *B. theobromae* has an optimum growth temperature of about 28°C and is often a serious problem in the tropics.

The sweet potato weevil, *Cylas formicarius (Fab)*, is a major pest in most countries, where the larvae feed on the sweet potato roots in the field (Purseglove; 1987; Capinera; 1998). Another sweet potato weevil, *C. puncticollis* (Sum), is a serious pest on susceptible varieties planted in soils, which have previously carried infested crops. Exposed tubers or tubers near the soil surface are heavily attacked. The weevil attack is also serious during long periods of drought (Sowley, 1999). Adult weevils feed on leaves and vines as well as on storage roots but the most severe damage is caused by the larvae which tunnel the roots (Lema, 1992), and leave frass which render the fleshy roots unfit for food and feed (Edmond, 1971b). Early planting and harvesting greatly reduce weevil damage (Lema, 1992). To maximize yields and reduce pest damage, Missah and Kissiedu (1994) recommended that sweet potatoes should be harvested early; between three to five months after planting. Other practices like farm sanitation i.e. removal of discarded and unharvested tubers and the destruction of alternate hosts especially *Ipomoea* weeds are recommended (Capinera (1998)). Irradiation of tubers prior to storage is also potentially effective in the control of the insect although its older stages are less susceptible to destruction.

Advanced technology improvements have been developed for the extension of shelf life of most agricultural produce. These include food irradiation, which is the process by which products are exposed to ionizing radiation to sterilize or kill insects and microbial pests by damaging their DNA (USEPA; 2002). Gamma irradiation is known to induce lesions on nucleic acids and cellular proteins thus preventing them from multiplying. In addition it inhibits sprouting in tubers, bulbs and root vegetables (USEPA; 2002). When applied at doses of about 7.5 per head, gamma irradiation has been reported to inhibit sprouting of yams, potatoes and sweet potatoes. However, this technique has not yet been applied on a commercial scale in the tropics although it has been tested on yams where sprouting was inhibited for six months when tubers were irradiated before storage (Adesiyan; 1977; Diop 1998)

The effect of irradiation on potato tuber yield and quality depended to a great extent on the physiological conditions of the irradiated tubers in addition to the level of irradiation dose (Avakyan *et al.,*; 1974). In addition to its effects on tuber yield and quality, Maghrabi and El-Sayed (1988) reported that gamma radiation inhibited sprouting of potato tubers in storage but, the incidence of rotting during storage increased with increased dosage. Adesiyan (1977) reported that dosages of 5 to 15krad of gamma irradiation on yams entirely suppressed sprouting and signs of deterioration but did not entirely eliminate nematodes.

In stores using natural ventilation, with relatively high ambient temperatures (20°C to 30°C) such as are normally experienced in tropical and subtropical lowlands) and for any period of storage beyond the normal or natural end of the dormancy period, the use of sprout inhibiting chemicals like CIPC (isopropyl-N-chlorophenylcarbamate) is the only practical means of controlling sprouting. This treatment has proved effective on potatoes and sweet potatoes (Diop, 1998).

2.4.1. Planting material production from tubers

Yamashita (2000) studied the differences between propagation using 10g cut pieces of sweet potato roots treated with growth regulators and cut sprouts. Growth of the transplants was vigorous with no transplanting injury after field planting. Plantlets nurtured for 50 days achieved the highest yield and best quality and did not show the thickening of mother roots observed in direct planting using whole storage roots.

Pre-sprouting of Georgia Jet Sweet Potato seed roots accelerated emergence from the plant bed and enhanced early, mid-season and total plant production. Small pre-sprouted roots produced as many as were produced by large pre-sprouted roots, or more than, early and mid-season plants. However, small pre-sprouted roots produced lighter weight plants. Cutting roots before bedding did not affect plant weight nor enhance early or mid-season plant production (Hall, 1986). Hall (1990) also reported earlier harvests and increases in total number of plants produced from tubers immersed in ethephon before planting.

Villamayor (1988) showed that the number of accumulated cut sprouts increased linearly with number of days from planting. Slicing roots transversely in half reduced cut sprout production by 33% while application of 30kg N or N, P and K each at 30kg/ha increased sprout production by 43 and 46% respectively. Cut sprouts and vine cuttings gave similar yields.

Martin (1986) developed a technique for re-sprouting sweet potatoes for propagation purposes. Pieces of or whole tubers were planted in a well drained growing medium in 6-inch plastic pots, thoroughly watered and maintained in the shade at temperatures of 24-28°C until several sprouts 10cm in length had been produced, and then moved into full sunlight. Fifteen centimeters long shoots were removed from plants for planting directly in the field or in containers. In trials with 17 sweet potato cultivars, sprouts were produced in 7-18 days. A minimum of 14 sprouts was produced per pot in 30 days, and the number of sprouts per pot ranged from 16 - 38 in 90 days.

Mid-storage heating increased plant production from bedded sweet potato roots. Increasing the length of time of curing decreased emergence time and increased number of early and mid-season plants produced, but had no effect on total number of plants produced (Hall, 1993). Hall (1994) tested the effects of combined heating applications on the Red Jewel cultivar of sweet potato seed tubers cured at 32° ±1°C and 85% RH for seven days immediately after harvest, and then subjected to additional curing before storage. The author reported that mid-storage heating or pre-sprouting, or a combination of these treatments resulted in earlier emergence of sprouts, and yielded more cumulative early, mid-season and total sprouts than non-heated tubers.

The cost of transplants is a major expense in the commercial production of sweet potato. Sparse plant production from bedded roots of some cultivars further increased propagation costs. Small roots produced more plants than large roots however small roots produced fewer plants per root. Pre-sprouting for three weeks or longer at 32° ± 1°C and 85%±5% RH promoted early plant production and an increased number of plants from bedded roots (Hall, 1986).

2.4.2. Maintenance and multiplication of vines

According to Lewthwaite and Triggs (1999), the amount of planting material is limited in the early stages of cultivar development. Wholey and Cook (1973) also stated that crop improvement programmes frequently encountered problems associated with the rate of multiplying planting material. A low rate of planting material multiplication impeded agronomic testing of new varieties, and delayed distribution to farmers. The problem was more acute with vegetatively propagated crops. It is important therefore that improvement programmes should have an organized procedure for rapidly multiplying improved cultivars. A successful programme must be able to multiply rapidly from an initial stock of a small number of plants.

Lewthwaite (1999) and Lewthwaite and Triggs (1999) tested the use of plug transplants which allow production of robust and uniform plant stands from small amounts of plant material, and reported that transplants held in air to allow root initiation suffered less transplant shock than those planted directly into the field, and concluded that for now, plug transplants may be useful for research purposes but are not recommended for general commercial use on the basis of trials conducted.

In order to ensure that high quality planting materials of superior sweet potato varieties are available for farmers use at the beginning of the planting season, Carey *et al*., (1997) multiplied pathogen tested in vitro cultures of selected superior sweet potato varieties using 2-node cuttings in beds at a density of 100 plants/m^2. Depending on farmers' preferences, between 4,900 and 20,600 apical vines were harvested from the varieties and distributed to various locations to serve as nuclear stocks for subsequent multiplication and distribution to farmers. A study undertaken to examine differences in sprouting ability among International Potato Center bred clones showed significant cultivar variation in sprouting ability. In addition, clones found to produce the highest number of sprouts sprouted earliest.

Another method used for plant material production in sweet potatoes is the topping of vines after crop establishment to promote branching (Hoa, 1998). Villamayor and Perez (1988) studied the effect of topping on storage tuber and stem cutting production and reported that regardless of the time of topping, a single topping did not reduce total number, marketable and total tuber yield, herbage yield and harvest index. However, the number of cuttings per plant increased with delay in date of topping. Also, the number of cuttings/m^2 depended on the stage of sweet potato growth and increased with the frequency of topping. The number of total and marketable yield on the other hand decreased with increase in the frequency of topping.

Nakatani and Komeichi (1988) reported that the number of roots decreased when cut sprouts of sweet potatoes were held for 5-10 days under low light intensity at 16°C and 85% RH, and planted under soil conditions of 30°C and 70% soil moisture. However, the elongation of roots was accelerated and the length of roots increased about 10% by holding. Rooting of cut sprouts was restricted by low temperature or moisture. The optimum soil temperatures for total root length of 12 different cultivars of sweet potatoes cuttings tested by Nakatani *et al.*, (1989) under controlled environmental conditions ranged from 30-35°C.

The application of nitrogen fertilizer, the type of planting material used, and the mode of planting and the kind of substrate used to hold the planting materials have all been shown to affect the vine yield. Ruiz-Martinez *et al.*, (1992) reported an increase in planting material production when 80kgN/ha and 2% foliar nitrogen was applied after each vine harvest for three consecutive harvests. The total yield of 32.63t/ha fresh shoots obtained, represented an increase of 34% over stands grown without nitrogen, and 20% over stands given a basal application of 60kgN/ha and two applications of 30kgN/ha as top-dressings.

The depth of ploughing, maturity of cutting (apical, middle and basal vines) and planting method was found to affect tuber dry matter (Biswas and Singh; 1990). Sweet potato tuber starch and non-reducing, reducing and total sugar contents were highest in plants grown from apical vines in soil ploughed to a depth of 20cm; while tuber dry matter percentage was highest from plants grown from apical cuttings in soil ploughed to 10cm depth. Nzima and Banga (1999), investigated inexpensive techniques of maintaining and multiplying sweet potato vines during the dry season using three different cultivars grown on three different soils in three different types of containers. Significant differences between the varieties and substrates tested, and different costs of production for the different kinds of containers used were reported.

During establishment, drought significantly reduced the stem weight, and leaf weight and area, and similar but non-significant trends were also evident for root number and weight. Pardales *et al.*, (2000) studied the effect of fluctuations of soil moisture on root development during the establishment of sweet potato i.e. from planting to about one month. Findings from this study indicated that the number of leaves, shoot dry weight and vine length were suppressed significantly by deficient moisture but were markedly increased by excessive moisture regardless of the time of occurrence relative to the initial development of the plant. However, Holwerda and Ekanayake (1991) reported that when drought stressed, a stem length of 30cm with 10-15cm of the stem covered by soil produced the most vigorous growth. The advantages of dipping cuttings into a dissolved root hormone were cultivar dependent, but pre-rooted cuttings of the two cultivars tested had no advantage in terms of survival and growth.

On the other hand, improving conditions for holding and handling sweet potato planting material prior to field planting increased availability of planting material at planting. Bonte *et al.*, (2000) evaluated the effect of black polyethylene tunnel cover (BTC) on the quality and quantity of transplants of two sweet potato cultivars in plant beds and reported that the use of BTC increased production of transplants from 63% to 553% in one cultivar and 48% in the other in comparison with the bare ground control. Ahn *et al.*, (2000) also studied the optimum conditions for over winter culture of sweet potato stems to be used as transplant shoots instead of sprouts produced in polyethylene film house and reported that optimum conditions were mid October cutting time, planting density of 10 x 3cm and minimum maintenance temperature of 5°C. However, root yield produced by transplanted shoots from the stems was similar to the yield produced by shoots from roots. The survival rate was not different among varieties tested.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of Experiment

The study was conducted during the dry season from October 2001 to April 2002. The tubers were stored in an improved yam barn belonging to the Food Research Institute located at Taifa near Legon. The field study was carried out at the University of Ghana Farm on the Haatso series of soils (Brammer, 1967), which has been described as an entisol of quartzipsamment (U. S. D. A., 1992).

3.2 Climatic data

The climate under which the experiment was conducted is warm and dry Coastal Savanna with a mean annual rainfall of 800mm and two growing seasons (100- 110 days and 50 days per year). The major growing season occurs between April and July while the minor season occurs between September and November (Walker 1957; Doku 1988 and MOA 1991).

Five years (September – April 1996/97 to 2001/02) meteorological data for the period during which the experiment was carried out were taken and are presented in Appendices 1a-e. These data show the trend and give a history of the prevailing conditions as well as an estimation of what could be expected during the period of planting material conservation at Legon where the experiment was conducted.

3.3 Soil sampling and analysis

Before the establishment of the experiments the soils samples were collected and analyzed to determine the nutrient status of the field.

3.3.1. Soil sampling

The soil sample was collected from the Ap horizon at a depth of 0-15cm. The topsoil of the soil profile consisted of approximately 20cm of pale brown sand with weak, fine granular structure and had a loose and friable consistence. It contained fine and abundant common medium roots.

3.3.2. Soil analysis

The soil was analyzed to determine its nutrient levels by the following methods.

(i) The Macro - Kjeldhal (AOAC, 1975) method that is essentially a wet oxidation procedure, was used for nitrogen determination.

(ii)Total phosphorus and available phosphorus were determined using Bray and Kurtz (1945) method.

(iii) Organic phosphorus and soluble phosphorus was determined using Saunders and Williams (1955) (a modified Bray No. 1) method.

(iv) Flame photometry was used to determine potassium levels in the soil (Moss, 1961; Rayment and Higginson, 1992) after exchangeable cations (EC) or bases were determined using ammonium acetate (1.0MNH4OAC) method at pH 7.0

(v) Organic carbon content was determined using Walkley and Black Procedure (Nelson and Sommers; 1982).

The characteristics of the soil used in the study are as follows: the concentration of nitrogen was 0.084%, % phosphorus was 0.019, potassium was 0.48ppm, % organic carbon was 0.38 and % organic matter was 0.66.

3.4 Sweet potato cultivars

Description of the tubers and vines of the two sweet potato cultivars used in the experiments are shown in Table 1.

Table 1: Tubers and vines of two sweet potato cultivars, Sauti and Okumkom (after Otoo; 1998)

Cultivar	Pubescence	Leaf				Tuber		
		Young leaves colour	Leaf petiole colour	Leaf vein colour (abaxial view)	Leaf shape	Tuber skin colour	Tuber shape	Protein content
ıuti	Hairy at nodes	Green	Green	Green	Palmate	Green	Long irregular curved	5.3% protein
kumkom (TIS :66)	Profuse	Green	Green	Green	Cordate	Light purple	Round elliptical mixture	5.1% protein

(v) Organic carbon content was determined using Walkley and Black Procedure (Nelson and Sommers; 1982).

The characteristics of the soil used in the study are as follows: the concentration of nitrogen was 0.084%, % phosphorus was 0.019, potassium was 0.48ppm, % organic carbon was 0.38 and % organic matter was 0.66.

3.4 Sweet potato cultivars

Description of the tubers and vines of the two sweet potato cultivars used in the experiments are shown in Table 1.

Table 1: Tubers and vines of two sweet potato cultivars, Sauti and Okumkom (after Otoo; 1998)

Cultivar	Pubescence	Leaf				Tuber		
		Young leaves colour	Leaf petiole colour	Leaf vein colour (abaxial view)	Leaf shape	Tuber skin colour	Tuber shape	Protein content
Sauti	Hairy at nodes	Green	Green	Green	Palmate	Green	Long irregular curved	5.3% protein
Okumkom (TIS 8266)	Profuse	Green	Green	Green	Cordate	Light purple	Round elliptical mixture	5.1% protein

tubers of the Sauti (creamlike skinned) were long, irregular and curved. Not all the tubers were whole, some had been cut while the ends of others had been broken during harvest; therefore, each treatment was assessed for breakages and cuts. Table 2 describes the state of the tubers at the beginning of storage.

Table 2: Percentage cuts and breakages in small unmarketable sweet potato tubers at the start of storage

	Sauti				Okumkom			
	Storage period (weeks)				Storage period (weeks)			
	0	5	10	15	0	5	10	15
% Cuts	4.5	2.2	0	0	6.7	11.1	13.3	4.5
% Breakages	13.3	2.2	4.5	0	2.2	6.7	4.4	2.2

3.5.1.1. Description of Storage facility:

A naturally ventilated, rodent-proof storage structure, 7.4m x 1.3m x 1.3m on 0.7m high supports, which was constructed with hardwood, and 5mm mesh expanded metal was used for storing the sweet potato tubers. The base served as a single 7.4m x 1.3m shelf for sweet potato tuber storage. The sides were hinged at the top and padlocks were fixed for security. The structure was roofed with thatch extending sufficiently over the sides to exclude direct sunshine from the shelf area. Plates 1 and 2 show pictures of the barn and how tubers were randomly placed on the shelf. Shelf temperature and relative humidity were measured with a thermo-hydrograph. Table 3 represents temperature and relative humidity values recorded compared to the atmospheric values.

Table 3. Mean monthly temperature (°C) and relative humidity (%) of barn and atmosphere

	Temperature (°C)		Relative humidity (%)	
	Barn	**Atmosphere**	**Barn**	**Atmosphere**
October 2001	28.9	27.4	75.5	81.5
November 2001	28.9	28.1	79.8	80.0
December 2001	28.3	28.3	78.0	81.0
January 2002	29.5	27.7	68.5	74.5
February 2002	29.0	28.9	79.6	74.5
March 2002	29.8	28.8	75.3	77.5

3.5.1.2 Data collection:

Initial data collected were:

- Initial average tuber weight = $\frac{\text{Total weight of tubers}}{\text{No. of tubers / treatment}}$
- Percentage breaks = $\frac{\text{No. of broken tubers}}{\text{No. of tubers / treatment}} \times 100$
- Percentage cuts = $\frac{\text{No. of tubers with cuts}}{\text{Total no. of tubers / treatment}} \times 100$

Data collected during storage at fortnightly intervals:

Average tuber weight = $\frac{\text{Total weight of tubers}}{\text{No. of tubers / treatment}}$

- Average weight loss = $\frac{\text{Average tuber weight}}{\text{Average tuber weight.}}$
- % Tuber weight loss = 100 - average weight loss x hundred.

Plate 1: Improved storage barn with thatch.

Plate 2 showing tubers randomly placed on shelves with thermo-hydrograph.

- $\% \text{ Shriveling} = \frac{\text{No. of shriveled tubers}}{\text{Total number of tubers / treatment}} \times 100$

- $\% \text{Rotting} = \frac{\text{No. of rotted tubers}}{\text{Total number of tubers / treatment}} \times 100.$

- $\% \text{ Sprouting} = \frac{\text{No. of tubers sprouted}}{\text{Total number of tubers / treatment}} \times 100$

- $\% \text{ Insect damage} = \frac{\text{No. of insect damaged tubers}}{\text{Total number of tubers / treatment}} \times 100$

3.5.1.3 Planting of whole tubers in nursery beds after storage

After the set period of storage for each treatment, the total number of whole tubers remaining was noted and then planted in 1m x 0.6m nursery ridges 30cm high, at the University of Ghana Farms, Legon. The beds were mulched with dry bahama grass (*Cynodon dactylon*). Soil temperature and moisture were monitored three times a week. Except for rainy days, beds were irrigated three times a week to maintain soil moisture at field capacity. Soil moisture content was measured with a tensiometer and kept between 70-90%. Soil temperature was recorded with a thermometer and ranged between 29 – 32°C.

3.5.1.4 Harvesting and data analysis

During the growing period, whenever 50% of the vines measured 30cm above the first two nodes, they were cut, and the total number of vines per plot recorded and replanted on different beds. Time to 50 % sprout, 50 % growth of vines to 30cm beyond the first two nodes, leaf and stem dry weight at vine harvest were recorded.

The following parameters were also recorded:

- Number of 30 cm vines at each harvest
- Total number of vine harvests per treatment,
- Average leaf and stem dry weight for five sample plants at each vine harvest
- Total number of vines at final harvest.
- Percent apical, middle and basal vines at final harvest.
- Cumulative number of vines generated per treatment at the end of the season

The average leaf and stem dry weight for 5 plants per treatment were taken after being oven dried at 70°C for 72 hours.

Data was analyzed using Statview statistical package. Data were subjected to Analysis of variance (ANOVA) and means separated at $P < 0.05$ by LSD.

3.5.2. Experiment 2: Effect of spacing on vine yield of two sweet potato cultivars.

The design for the experiment was a 2 x 3 factorial in Randomized Complete Block Design. Two factors, i.e., cultivar and planting distances, were studied. Two cultivars – Okumkom and Sauti, and three planting distances 25 cm x 10 cm, 25 x 15 cm, and 25 cm x 20 cm Treatments were replicated four times. The tubers were planted on 28th November 2001 and harvested on 22nd April 2002.

Tubers of the two cultivars were planted on ridges (1m x 0.6m 30cm) mulched with bahama grass (*Cynodon dactylon*) at three different planting distances 25cm x 10cm, 25cm x 15cm, and 25cm x 20cm, giving plant populations of 400,000 plants/ha, 266,666 plants/ha and 200,000 plants/ha respectively. After sprouting, the vines were maintained until after the first rains at the beginning of the planting season when the vines were then harvested. Time to 50% sprouting and the number of 30cm length vines were recorded. The stem and leaf dry weights of five sample plants were recorded. Data were analyzed using Statview statistical package and the means separated at $P < 0.05$ by LSD.

3.5.3. Experiment 3: Effect of dry season field conservation and early initiation of planting material production in two sweet potato cultivars.

This experiment studied the most suitable time to initiate multiplication of vines in the nursery for field planting and the most suitable period for maintaining vines in the field.

The experimental design was a 2 x 6 factorial in a Randomized Complete Block Design. Two factors were studied, i.e., cultivar and time for initiating vine multiplication. The cultivars were Okumkom and Sauti, and the time for initiating vine multiplication were 14, 10, 8, 6, 4 and 0weeks before field planting. The treatments were replicated three times.

Vines of the Sauti and Okumkom cultivars obtained from the Agricultural Research Station at Asuansi were planted on the 1st October 2001 at the University of Ghana Farm, Legon. Two 30 cm vines per stand were planted at a spacing of 40 x 40cm giving a population of 125,000 plants per ha. 36 beds (i.e. 2 cultivars x 6 treatments for time of initiation of vine multiplication and replicated 3 times) measuring 3m x 0.60m x 30cm high were used. The beds were mulched with bahama grass (*Cynodon dactylon*).

Watering and weeding were done when necessary. Plants were sprayed with Cymethoate at 25ml/l two times during the experimental period to control grasshoppers. The time of field planting was hypothetically set for the second week of March 2002 when all vines in the plots were cut and counted. Final harvest was done on 13th March 2002.

3.5.5.1. Vine multiplication

Fourteen weeks before the hypothetic date of 13th March 2002, that is, on the 6th December 2001, vines of the plots representing this treatment were harvested, cut into 30cm pieces, counted and replanted (T1).

- On 2nd January 2002, the plots representing vine initiation at ten weeks before field planting were harvested cut into 30cm pieces, counted and replanted (T2).
- On 16th January 2002, those plots representing vine initiation at eight weeks before field planting were harvested cut into 30cm pieces, counted and replanted (T3).
- The plots representing vine initiation at six weeks before field planting were harvested cut into 30cm pieces, counted and replanted on 30th January 2002 (T4).
- Plots representing vine initiation at four weeks before field planting were harvested cut into 30cm pieces, counted and replanted on 13th February 2002 (T5).

- Plots representing no initial multiplication before field planting i.e. 0 weeks were harvested cut into 30cm pieces and counted on 13th March 2002 (T6).

In between these harvests, anytime a plot had 50% of the vines longer than 30cm and two nodes, they were cut. The number of 30cm vines produced per plot were counted and replanted. In all, T1 was harvested seven times. T2, T3, T4, and T5 were harvested three times and T6 once

3.5.3.1 Data collection

The following data were collected;

- Number of 30cm vines harvested initially,
- Average leaf and stem dry weight for five sample plants at each vine harvest
- Number of 30cm vines of subsequent harvests times
- Total number of vines at final harvest.
- The % apical, middle and basal vines at final harvest.
- The cumulative number of vines generated per treatment by the end of the season for each experiment.

3.5.3.2 Data analysis

Data was analyzed using the StatView statistical package. Analysis of variance (ANOVA) was based on 2 x 6 factorial randomized complete block design.

CHAPTER FOUR

4.0 RESULTS

4.1. EXPERIMENT 1: Effect of dry season storage of small unmarketable sweet potato tubers on planting material production of two sweet potato cultivars.

4.2.1 Tuber storage.

4.2.1.1. Effect of storage period on the percentage weight loss of sweet potato cultivars.

Table 4 shows the percentage weight loss of the sweet potato tubers stored for 0, 5, 10 and 15weeks. Percentage tuber weight loss increased significantly (P=0.05) with duration of storage. With Sauti, the differences observed were significant for tubers stored for 0 week and those stored for 10 and 15 weeks. There were no significant differences between tubers stored for 0 and 5 weeks, 5 and 10 weeks and 10 and 15 weeks. On the other hand, in Okumkom, significant differences were observed between 0 week and 5, 10 and 15 weeks of storage, but differences between 5,10 and 15 weeks were not significant. Even though numerical differences were also observed among the varieties tested, these were not statistically significant ($P<0.05$).

Table 4. Percentage weight loss in sweet potato tubers stored in improved barn

	Variety		
Weeks in storage	**Sauti**	**Okumkom**	**$LSD_{(5\%)}$**
0	0	0	23.5
5	22.0	26.5	
10	24.9	28.1	
15	27.7	40.4	
$LSD_{(5\%)}$	N.S.		

4.1.1.2 Effect of storage period on percentage shriveling in sweet potato cultivars

Shriveling was identified by dryness and wrinkling of the skin of tubers. Table 5 shows percentage shriveling in both cultivars. % Shriveling increased as duration of storage increased, percentage shriveling also increased. Significant differences (P = 0.05) were observed between 0 week and 5, 10 and 15 weeks of storage and between 5 and 15weeks, but differences between 5 and 10weeks of storage were not significant at P=0.05. Differences observed between the cultivars were not significant.

Table 5. Percentage shriveling of sweet potato cultivars in improved barn

Weeks in storage	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	0	0	19.6
5	55.5	65.6	
10	66.8	66.7	
15	84.0	88.9	
$LSD_{(5\%)}$	N.S.		

4.1.1.3 Effect of storage period on percentage rot in sweet potato cultivars

Apart from the tubers planted without prior storage (0 weeks) rotting was observed in all tubers stored before planting. Table 6 shows percentage tuber rot at the end of storage for all the treatments. Significant differences (P = 0.05) were observed among storage

Plate 3: Sauti sweet potato tubers with signs of rotting five weeks after storage.

Plate 4: Okumkom sweet potato tubers with signs of rotting five weeks after storage

Plate 5: Sauti sweet potato tubers with signs of rotting fifteen weeks after storage.

Plate 6: Okumkom sweet potato tubers with signs of rotting fifteen weeks after storage.

(a) (b)

Plate 7: Sprouting in tubers of Sauti (a) and Okumkom (b) five weeks after storage.

Plate 8: Sprouting in Sauti sweet potato tubers fifteen weeks after storage.

Plate 9: Sprouting in Okumkom sweet potato tubers fifteen weeks after storage.

periods with percentage rot increasing as storage period increased from 0 to 15 weeks. Differences between 0 week of storage and for 5, 10 and 15 weeks were significant for Sauti. The differences between tubers stored for 5, 10 and 5 weeks were not significant. On the other hand, in Okumkom, significant differences were observed between 0 weeks and 5, 10 and 15 weeks of storage, and 15 and 5 and 10 weeks of storage. Differences between 5 and 10 weeks were not significant. The pathogen causing the rot was identified as *Botryodiplodia theobromae*. Differences observed among cultivars were not significant (P=0.05) Plates 3 and 4 show tubers with signs of rotting five weeks after storage. Plates 5 and 6 show some of the rotten tubers at 15 weeks after storage.

Table 6. Percentage rot of sweet potato tubers in improved barn

Weeks in storage	**Variety**		
	Sauti	**Okumkom**	**$LSD_{(5\%)}$**
0	0	0	16.6
5	26.7	22.2	
10	34.9	37.2	
15	34.8	58.3	
$LSD_{(5\%)}$	N.S.		

4.1.1.4 **Effect of storage period on percentage sprouting in sweet potato cultivars**

Generally, percentage sprouting increased with increased period of storage. Results of the analysis indicated that differences were significant at P = 0.05. Although sprouting had occurred in both cultivars by the 5th week of storage, LSD values showed that differences between tubers stored and those not stored (which had no sprouts) were not significant (Table 7). Plates 7a and b shows sprouting in tubers 5 weeks after storage, and Plates 8 and 9 show sprouting in tubers 15 weeks after storage.

Table 7. Percentage sprouting in sweet potato tubers in improved barn

Weeks in storage	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	0	0	23.7
5	13.5	20.0	
10	34.9	60.0	
15	62.8	60.6	
$LSD_{(5\%)}$	N.S.		

4.1.1.5.Effect of storage period on percentage insect damage in sweet potato cultivars

The percent insect damage on the sweet potato tubers increased with increased period of storage with Sauti being more susceptible to insect damage than Okumkom (Table 8, Figure 1). Significant differences (P = 0.05) were observed between the different storage periods, and between the cultivars at 15 weeks of storage. The main insect pest was identified as *Cylas puncticollis* (Sum). Other insects observed in the barn were identified as *Araecerus fasciculatus (Deyeer) (Coleoptera: Anthribidae)* and *Lasioderma serricorne (Fabricius) (Coleoptera: Anobiidae).*

Table 8. Percentage insect damage in sweet potato tubers; Sauti and Okumkom stored in improved barn

Weeks in storage	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	0	0	5.5
5	2.2	2.2	
10	7.9	6.7	
15	42.8	12.2	
$LSD_{(5\%)}$	7.7		

4.1.1.6. Effect of storage period on percentage tuber loss in sweet potato cultivars

Prior to field planting, the percentage of tubers lost during storage for each cultivar was assessed. There was a significant increase with increased period of storage (P=0.05). By the end of the 5th week Sauti had lost significantly more tubers than Okumkom. Tuber losses in the 10th week were not different between the cultivars, but this changed again in the 15th week with Okumkom loosing more tubers than Sauti (Table 9). Significant differences (P = 0.05) were also observed between the interaction effect of cultivar and period of storage – Figures 2 and 3.

Table 9. Percentage tuber loss of sweet potato cultivars stored in improved barn

Weeks in storage	Cultivar		
	Sauti	**Okumkom**	**$LSD_{(5\%)}$**
0	0	0	7.3
5	60.0	26.7	
10	66.0	69.3	
15	72.0	89.3	
$LSD_{(5\%)}$	N.S.		

4.1.2 Nursery

4.1.2.1. First vine harvest from tubers planted after a period of storage

4.1.2.1.1. Effect of storage period on number of tubers of sweet potato cultivars planted

Table 10 shows the number of tubers planted in the nursery for each treatment after the set storage period. With respect to storage period, significant differences (P<0.05) were observed in the number of tubers planted whereas differences observed between cultivars were not significant at P=0.05. Figure 2 shows the interaction effect of storage period and cultivars stored. The interaction effect observed was significant (P=0.05) only at five weeks of tuber storage.

Table 10. Number of tubers of two sweet potato cultivars planted in nursery.

Weeks in storage	Cultivar		
	Sauti	**Okumkom**	**$LSD_{(5\%)}$**
0	50.0	50.0	4.3
5	20.0	36.7	
10	17.0	15.3	
15	14.0	5.3	
$LSD_{(5\%)}$	N.S.		

Fig.1. Interacton effect of storage period and sweet potato tubers on the rate of insect damage in tubers

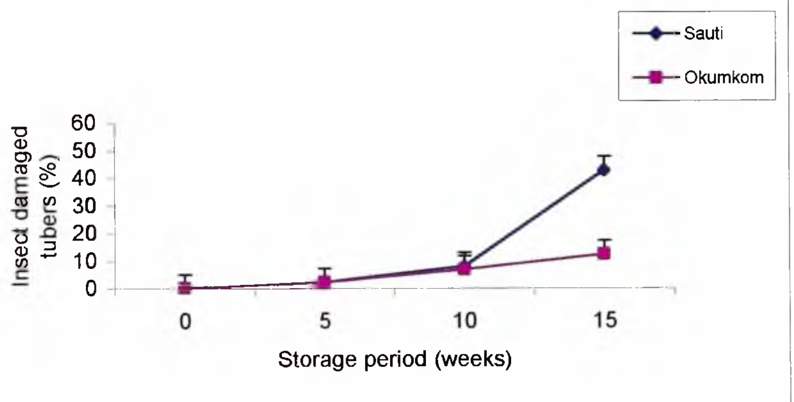
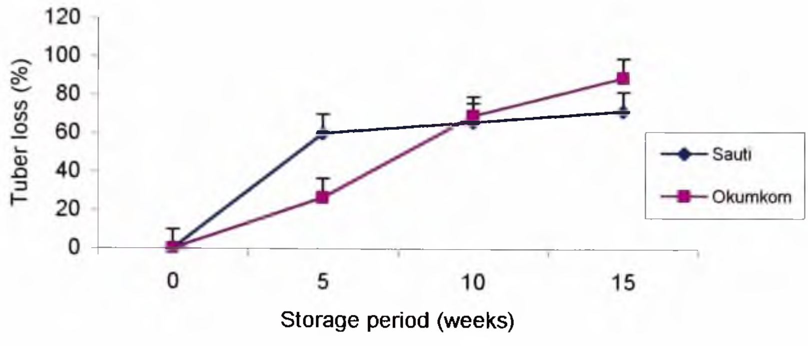


Fig.2: Interaction effect of storage period and sweet potato tubers on the rate of tuber loss



4.1.2.1.2. Effect of storage period on the number of days to fifty percent sprouting in sweet potato cultivars

The rate of sprouting of the two sweet potato cultivars, Sauti and Okumkom, in the nursery increased as the storage period increased such that tubers not stored at all (0 weeks) took about 21 days to reach fifty percent sprouting while those stored for fifteen weeks reached fifty percent sprouting in 10 and 13 days for Sauti and Okumkom, respectively. Differences observed among the storage periods were significant at P=0.05 (Table 11). However, differences observed between the varieties were not significant.

Table 11. Number of days to fifty percent sprouting in tubers of sweet potato cultivars stored in improved barn and planted in nursery

Weeks in storage	Cultivar		
	Sauti	**Okumkom**	**$LSD_{(5\%)}$**
0	21.0	21.7	3.1
5	18.3	17.3	
10	9.7	13.3	
15	10.0	13.0	
$LSD_{(5\%)}$	N.S.		

4.1.2.1.3. Effect of storage period on number of days to first vine harvest of sweet potato cultivars planted in nursery

In the nursery, the period of storage showed significant differences (P=0.05) in the time to first vine harvest for all storage periods except for 10 and 15 weeks of storage in Sauti (Table 12). In all but 5 weeks of storage, vines of Sauti were ready for harvesting earlier than those of Okumkom though the differences between the varieties were not statistically significant.

Fig.3: Interaction effect of storage period and sweet potato cultivars on available tubers for planting

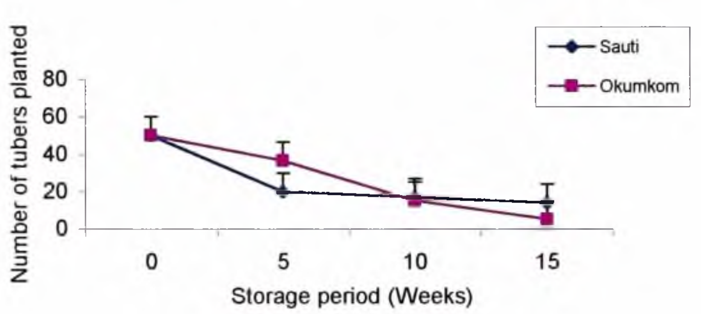


Table 12. Number of days to first vine harvest in tubers of sweet potato cultivars stored in improved barn and planted in nursery

Weeks in storage	Cultivar		
	Sauti	**Okumkom**	**LSD$_{(5\%)}$**
0	78.3	85.7	12.3
5	104.7	102.3	
10	63.0	70.0	
15	59.7	72.0	
LSD$_{(5\%)}$	N.S.		

4.1.2.1.4. Effect of storage period on the number of plants at first vine harvest in sweet potato cultivars planted in nursery

At the time of first vine harvest of each plot, significant differences (P=0.05, and P=0.05 respectively) were observed between the cultivars and the storage period in the number of plants per plot; although no such differences were observed for the interaction. Regarding the storage period, differences observed were between 0 and 5, 10 and 15 weeks of storage for both cultivars. Differences between 5, 10, and 15 weeks were not statistically significant in Sauti but were so between 15 weeks and 5 and 10 weeks (Table 13).

Table 13. Number of plants at first vine harvest in tubers of sweet potato cultivars stored in improved barn and planted in nursery

Weeks in storage	Variety		
	Sauti	**Okumkom**	**$LSD_{(5\%)}$**
0	99.3	64.3	18.5
5	48.7	58.7	
10	47.3	39.7	
15	37.0	8.0	
$LSD_{(5\%)}$	13.1		

4.1.2.1.5. Effect of storage period on the number of plants with vines longer than 30cm at harvest in sweet potato cultivars.

Significant differences (P=0.05) were observed between the number of plants per plot with vines longer than 30cm for both the cultivars and the different storage periods (Table 14) at the time of first vine harvest. However, differences in the cultivar and storage period interaction were not statistically significant.

Table 14. Number of plants with vines longer than 30cm at harvest in sweet potato tubers: Sauti and Okumkom stored in improved barn and planted in nursery

Weeks in storage	Variety		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	54.7	32. 0	9.1
5	33.0	29.3	
10	25.0	23.7	
15	23.0	5.3	
$LSD_{(5\%)}$	6.4		

4.1.2.1.6. Effect of storage period on the initial number of 30cm vines harvested in sweet potato cultivars planted in nursery beds.

The initial number of 30cm vines produced in the first harvest is presented in Figure 4. Significant differences (P=0.05) were observed between the cultivars as well as between the storage periods. Generally, vine production was higher in Sauti than in Okumkom except for 0weeks of storage in which Okumkom produced more vines than Sauti,. The difference observed here was however not statistically significant. Tubers of Sauti stored for five weeks gave the highest vine yield at this stage while tubers of Okumkom stored for 15 weeks gave the lowest number of 30 cm vines.

4.1.2.1.7 Effect of storage period on the initial mean leaf, mean stem and mean total dry weight of vines harvested in sweet potato cultivars planted in nursery beds.

The initial mean leaf, mean stem and mean total (stem dry weight + leaf dry weight) dry weights of the cultivars tested are presented in Table 15. The difference in the mean leaf dry weight between both cultivars was not significant at P=0.05. However, significant differences (P=0.05) were observed among the storage periods. In Sauti, the mean leaf dry weight was lower at 0 weeks of storage when compared to the mean leaf dry weight of those stored for 5,10 and 15 weeks. The mean leaf dry weight was also lower at 15 weeks of storage than 5 and 10 weeks of storage. In Okumkom, significant differences were observed only between 10 weeks of storage and 0, 5, and 15 weeks. In both mean stem dry weight and mean total dry weight, no significant differences were recorded for the period of storage. However, Sauti produced more mean stem dry weight and mean total dry weight than Okumkom.

Table 15. Effect of storage period of tubers on the initial mean leaf, stem and total dry weight (g) of sweet potato vines at harvest

A	Leaf dry weight		
Weeks in storage	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	2.0	3.3	2.7
5	7.0	3.9	
10	6.3	6.8	
15	4.3	3.2	
$LSD_{(5\%)}$	1.9		
B	Stem dry weight		
Weeks in storage	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	3.7	3.4	5.1
5	13.5	4.8	
10	12.0	5.5	
15	8.4	4.3	
$LSD_{(5\%)}$	3.6		
C	Total dry weight		
Weeks in storage	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	5.7	6.7	7.5
5	20.5	8.8	
10	18.3	12.3	
15	12.7	7.5	
$LSD_{(5\%)}$	5.3		

Fig.4: Effect of storage period on the total number of 30cm vines in sweet potato cultivars at first harvest

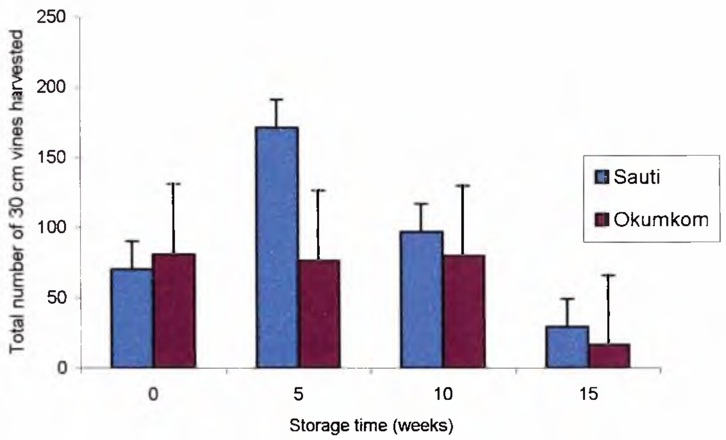
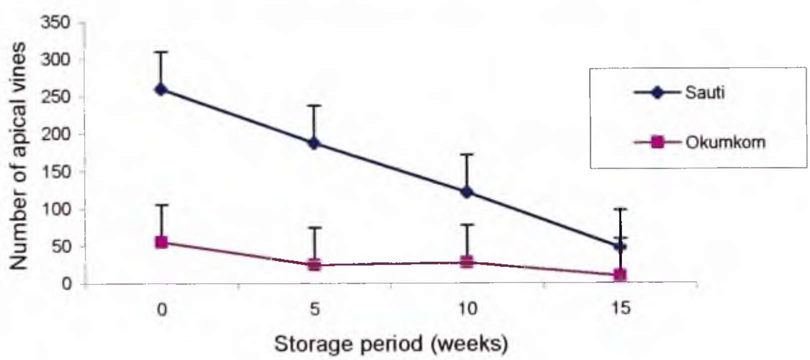


Fig.5: Interaction effect of storage period on the number of apical vines produced in sweet potato cultivars



4.1.2.2 Final vine harvest from tubers planted after a period of storage

4.1.2.2.1 Effect of storage period on number of vine harvests in sweet potato cultivars planted in the nursery.

By the beginning of the rainy season when the experiment ended, the tubers of both cultivars not stored prior to planting, i.e., 0 weeks of storage, had been harvested five times, and plots for 5 and 10 weeks of storage had been harvested three times. With plots where tubers had been stored for 15 weeks before planting, Sauti was harvested 1.7 times and Okumkom was harvested once (Table 16). Differences observed in the number of times vines were harvested for the storage periods studied were significant (P=0.05).

Table 16. Total number of vine harvests in tubers of sweet potato stored in improved barn and planted in nursery.

Weeks in storage	Variety		
	Sauti	**Okumkom**	**$LSD_{(5\%)}$**
0	5.0	5.0	0.5
5	3.0	3.0	
10	3.0	3.0	
15	1.7	1.0	
$LSD_{(5\%)}$	N.S.		

4.1.2.2.2 Effect of storage period on vine production of sweet potato cultivars planted in nursery beds.

Table 17 shows the number of apical, middle and basal vines produced by the different treatments. Results indicated significant differences (P=0.05) for both the cultivars and storage periods. There was a marked decrease in the number of apical vines produced with increased storage period. Figure 5 shows the interaction between the cultivars and storage period. In all cases but 15 weeks of storage, Sauti produced higher numbers of apical vines than Okumkom.

Table 17. Total number of vines harvested per plot in tubers of sweet potato stored in improved barn and planted in nursery.

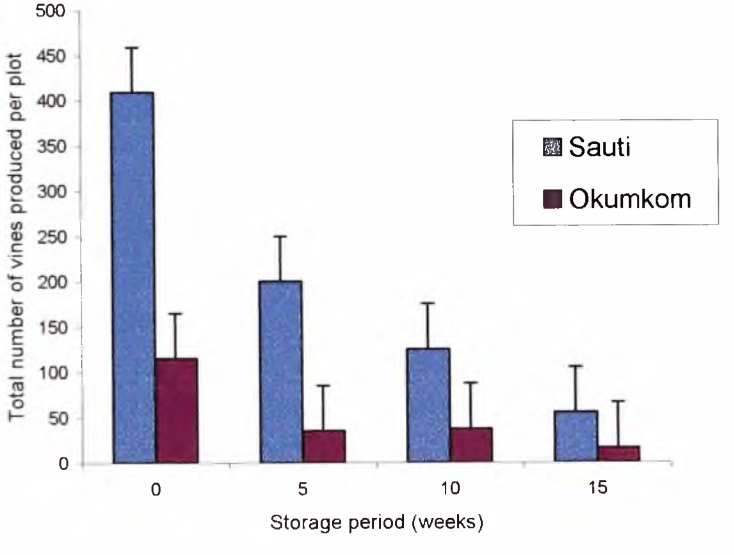
A	Total number of apical vines harvested per plot		
Weeks in storage	**Cultivar**		
	Sauti	**Okumkom**	**$LSD_{(5\%)}$**
0	259.9	55.1	64.6
5	187.3	23.7	
10	121.2	27.2	
15	46.9	8.7	
$LSD_{(5\%)}$	45.6		
B	**Total number of middle vines harvested per plot**		
Weeks in storage	**Cultivar**		
	Sauti	**Okumkom**	**$LSD_{(5\%)}$**
0	129.2	54.0	61.8
5	13.0	8.7	
10	3.7	7.0	
15	8.0	6.0	
$LSD_{(5\%)}$	43.7		
C	**Total number of basal vines harvested per plot**		
Weeks in storage	**Cultivar**		
	Sauti	**Okumkom**	**$LSD_{(5\%)}$**
0	20.2	5.9	N.S.
5	0.0	3.0	
10	0.3	2.3	
15	0.7	1.7	
$LSD_{(5\%)}$	N.S.		

Generally, the total number of middle vines harvested per cultivar and storage period decreased with increased storage Significant differences (P=0.05) were observed in both cultivars and in the storage periods. The differences observed between the storage periods were only in relation with Sauti as the LSD values indicated no such differences in the case of Okumkom. The total number of basal vines harvested for both cultivars for the different storage periods. No significant differences (P=0.05) were observed in both factors studied.

4.1.2.2.5 Effect of storage period on the total number of 30cm vines harvested per plot in sweet potato cultivars planted in nursery beds.

Figure 6 show the final vine yield of sweet potato tubers stored in the improved barn and used to produce vines for field planting. Sauti produced significantly (P=0.05) more 30cm vines than Okumkom for all the different storage periods studied except at 15 weeks. Tubers of both cultivars not stored before vine production yielded the highest 30cm vines followed by those stored for 5, 10 and 15 weeks respectively. Significant differences (P=0.05) were observed between 0 and the storage periods in Sauti. However, no such differences were observed in Okumkom.

Fig.6: Effect of storage period on the total number of 30cm long vines produced in sweet potato cultivars



4.1.2.2.6 Effect of storage period on the percentage vine production in sweet potato cultivars planted in nursery beds.

Table 18 shows the percentage vine yield of sweet potato tubers stored in the improved barn and used to produce vines for field planting. Both cultivars produced more apical

Table 18: Effect of tuber storage period on percent vine production in sweet potato cultivars – Final Harvest

A	Percent apical vine production		
Weeks in storage	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	69.8	50.4	11.9
5	94.2	66.5	
10	97.2	74.0	
15	83.7	52.8	
$LSD_{(5\%)}$	8.4		
B	**Percent middle vine production**		
Weeks in storage	**Cultivar**		
	Sauti	**Okumkom**	$LSD_{(5\%)}$
0	26.1	44.4	9.9
5	5.8	24.7	
10	2.6	19.5	
15	14.8	37.4	
$LSD_{(5\%)}$	7.0		
C	**Percent basal vine production**		
Weeks in storage	**Cultivar**		
	Sauti	**Okumkom**	$LSD_{(5\%)}$
0	4.1	5.2	N.S.
5	0.0	8.8	
10	0.2	6.6	
15	1.4	9.7	
$LSD_{(5\%)}$	2.5		

vines than middle vines followed by basal vines. Sauti produced a significantly (P=0.05) higher percentage of apical vines than Okumkom for all the different storage periods. Okumkom however, produced a higher percentage of middle vines. The percentage basal vines produced did not show any significant differences (P=0.05) between the different storage periods studied in both cultivars. The tubers stored for ten weeks before planting produced the highest percentage apical vines and the lowest percentage of middle vines. In both cultivars, significant differences (P=0.05) were observed between the storage periods.

4.1.2.2.7 Effect of storage period on dry matter production of vines of sweet potato cultivars planted in nursery.

Table 19. Effect of tuber storage period on mean dry weight (g) in sweet potato cultivars– Final Harvest

A	mean leaf dry weight (g)		
Weeks in storage	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	5.1	1.2	N.S.
5	2.0	1.2	
10	1.8	0.9	
15	3.8	3.2	
$LSD_{(5\%)}$	1.3		
B	Mean stem dry weight (g)		
Weeks in storage	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	11.5	3.5	4.5
5	2.6	0.9	
10	2.4	0.7	
15	7.8	4.3	
$LSD_{(5\%)}$	3.2		
A	Mean total dry weight (g)		
Weeks in storage	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	16.6	4.7	6.2
5	4.6	2.0	
10	4.1	1.6	
15	11.6	7.5	
$LSD_{(5\%)}$	4.4		

Table 19 shows the mean leaf, mean stem and mean total dry weight of vines of sweet potato tubers stored in the improved barn and used to produce vines for field planting. Among the cultivars, Sauti produced significantly (P=0.05) higher mean leaf, stem and total dry weight than Okumkom. Storage periods had no significant effect on mean leaf dry weight. However, significant differences (P=0.05) were observed with respect to mean stem and mean total dry weight.

4.2. EXPERIMENT 2: Effect of spacing of small unmarketable sweet potato tubers on planting material production of two sweet potato cultivars.

4.2.1. Effect of spacing of small unmarketable tubers on the rate of sprouting of two sweet potato cultivars.

Figures 7, 8 and 9 show sprouting in sweet potato tubers planted at 25 cm x 10 cm, 25cm x 15 cm, and 25 cm x 20 cm. Significant differences (P=0.05) were observed between the two cultivars at the initial stages with Okumkom producing higher number of sprouts than Sauti. As the experiment progressed, i.e., by 20 days, this difference was no longer significant. However, Okumkom still produced a higher number of sprouts than Sauti except for the spacing of 2 cm x 20 cm where Sauti produced more sprouts than Okumkom. From 20 days after planting, significant differences (P=0.05) were observed between the planting distances.

Fig.7 Rate of Sprouting in Sweet Potato tubers planted at 25cm x 10cm

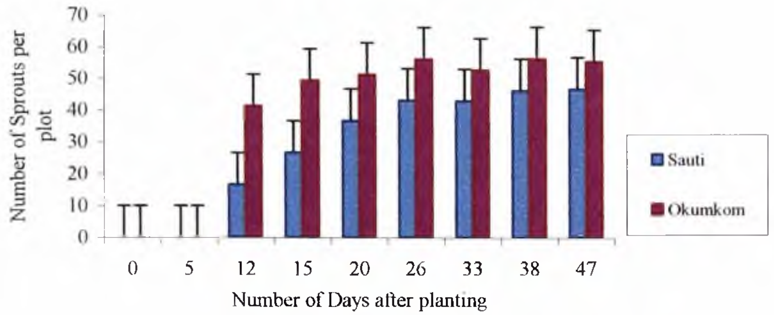


Fig 8. Rate of Sprouting of Sweet Potato Tubers planted at 25cm x 15cm

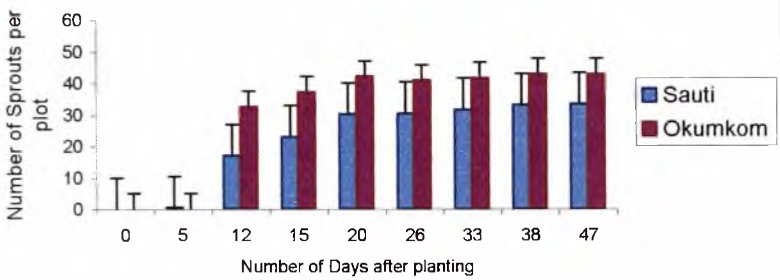
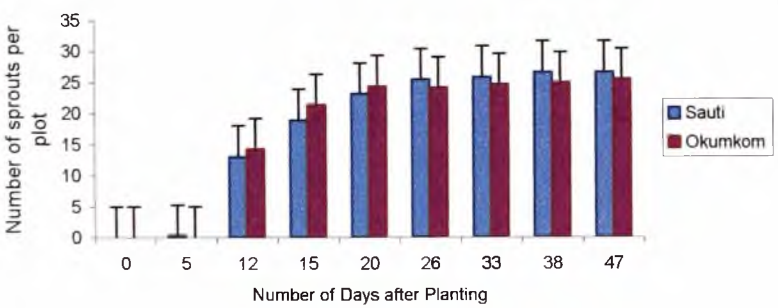


Fig 9.Rate of Sprouting of Sweet Potato tubers planted at 25cm x 20cm



4.2.2. Effect of spacing of small unmarketable sweet potato tubers on the rate of increase in the number of vines longer than 30cm in two sweet potato cultivars.

Tables 20 - 23 show the number of sprouts longer than 30 cm produced after 47, 62, 70 and 77 days after planting. Significant differences (P=0.05) were observed between Okumkom and Sauti 47 and 62 days after planting with Okumkom producing more vines longer than 30cm. No significant differences were observed among the different spacings.

Table 20. Effect of spacing of sweet potato tubers on the rate of increase in the number of vines longer than 30cm produced 47 days after planting

	Cultivar		
Spacing	**Sauti**	**Okumkom**	**$LSD_{(5\%)}$**
25 cm x 10 cm	13.3	20.0	N.S.
25 cm x 15 cm	12.3	16.0	
25 cm x 20 cm	8.8	12.5	
$LSD_{(5\%)}$	3.8		

Table 21. Effect of spacing of sweet potato tubers on the rate of increase in the number of vines longer than 30cm produced 62 days after planting

	Cultivar		
Spacing	**Sauti**	**Okumkom**	**$LSD_{(5\%)}$**
25 cm x 10 cm	16.3	21.0	N.S.
25 cm x 15 cm	14.5	18.8	
25 cm x 20 cm	10.5	14.3	
$LSD_{(5\%)}$	4.2		

Table 22. Effect of spacing of sweet potato tubers on the rate of increase in the number of vines longer than 30cm produced 70 days after planting

	Cultivar		
Spacing	**Sauti**	**Okumkom**	**$LSD_{(5\%)}$**
25 cm x 10 cm	21.3	24.0	N.S
25 cm x 15 cm	17.5	26.5	
25 cm x 20 cm	16.0	16.8	
$LSD_{(5\%)}$	N.S.		

Table 23. Effect of spacing of sweet potato tubers on the rate of increase in the number of vines longer than 30cm produced 77 days after planting

	Cultivar		
Spacing	Sauti	Okumkom	$LSD_{(5\%)}$
25 cm x 10 cm	26.5	27.8	N.S.
25 cm x 15 cm	22.8	32.0	
25 cm x 20 cm	20.3	19.3	
$LSD_{(5\%)}$	N.S.		

4.2.3. Effect of spacing of small unmarketable sweet potato tubers on vine production in two sweet potato cultivars.

Tables 24 to 27 show the effect of spacing on the number of plants harvested as well as the number of apical, middle, basal vines produced by tubers of two sweet potato cultivars, Sauti and Okumkom. Significant differences (P=0.05) were recorded between the two cultivars for all the parameters. Among the spacings tested, differences were significant (P=0.05) only in the number of middle vines produced although 25 cm x 20 cm gave the highest number of vines. Figure 10 shows the effect of spacing on the total number of 30 cm vines harvested.

Table 24. Effect of spacing of tubers on vine production in sweet potato cultivars on the total number of plants harvested per plot

	Cultivar		
Spacing	Sauti	Okumkom	$LSD_{(5\%)}$
25 cm x 10 cm	25.8	28.8	N.S.
25 cm x 15 cm	24.5	20.3	
25 cm x 20 cm	20.0	16.5	
$LSD_{(5\%)}$	N.S.		

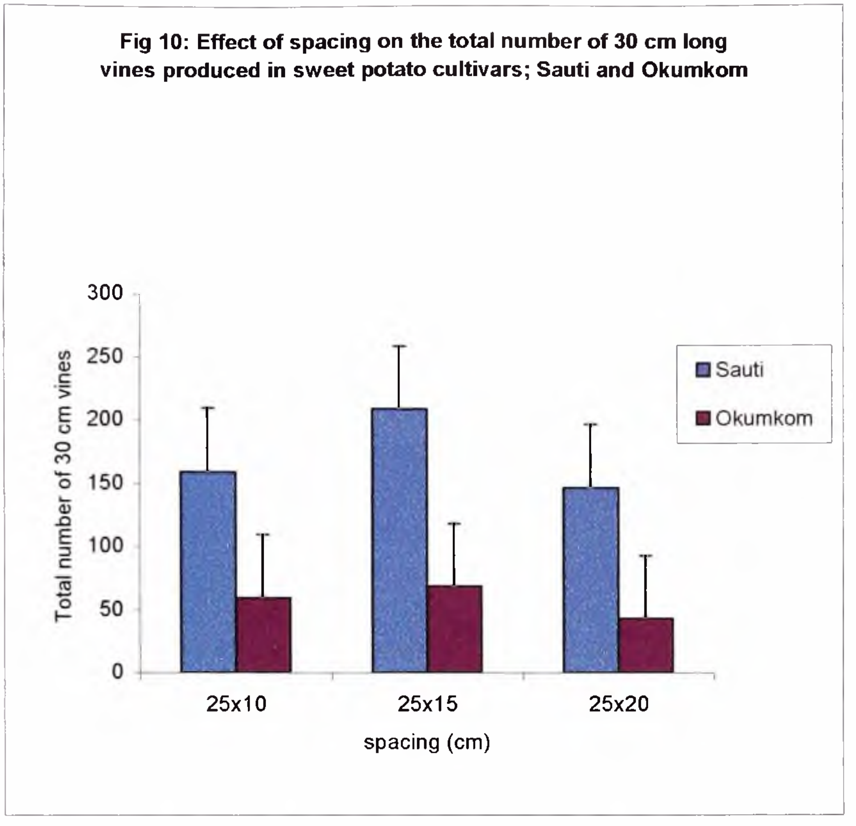


Table 25. Effect of spacing of tubers on vine production in sweet potato cultivars on the number of apical vines harvested per plot

	Cultivar		
Spacing	**Sauti**	**Okumkom**	**$LSD_{(5\%)}$**
25 cm x 10 cm	82.8	12.3	N.S.
25 cm x 15 cm	97.5	11.3	
25 cm x 20 cm	77.5	15.5	
$LSD_{(5\%)}$	15.9		

Table 26. Effect of spacing of tubers on vine production in sweet potato cultivars on the number of middle vines harvested per plot

	Cultivar		
Spacing	**Sauti**	**Okumkom**	**$LSD_{(5\%)}$**
25 cm x 10 cm	26.5	27.8	25.4
25 cm x 15 cm	22.8	32.0	
25 cm x 20 cm	20.3	19.3	
$LSD_{(5\%)}$	N.S.		

Table 27. Effect of spacing of tubers on vine production in sweet potato cultivars on the number of basal vines harvested per plot

Spacing	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
25 cm x 10 cm	18.5	8.5	N.S.
25 cm x 15 cm	17.8	11.8	
25 cm x 20 cm	16.8	7.0	
$LSD_{(5\%)}$	5.2		

Table 28. Effect of spacing on the percent (%) vine production in sweet potato cultivars

A	Percent (%) apical vine production		
Spacing	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
25cm x 10cm	52.3	21.3	9.0
25cm x 15cm	47.4	18.4	
25cm x 20cm	53.6	29.9	
$LSD_{(5\%)}$	7.4		
B	**Percent (%) middle vine production**		
Spacing	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
25cm x 10cm	36.0	64.2	8.4
25cm x 15cm	44.5	64.4	
25cm x 20cm	35.6	51.5	
$LSD_{(5\%)}$	6.9		
C	**Percent (%) basal vine production**		
Spacing	Cultivar		
	Sauti	Okumkom	$LSD_{(5\%)}$
25cm x 10cm	11.6	14.5	3.6
25cm x 15cm	8.4	17.2	
25cm x 20cm	11.2	18.7	
$LSD_{(5\%)}$	3.0		

4.2.5. Effect of spacing of small unmarketable sweet potato tubers on dry matter production in two sweet potato cultivars.

Table 29 shows the mean leaf, mean stem and mean total dry weight of vines of sweet potato tubers planted at 25cm x 10cm, 25cm x 15cm and 25 x 20cm. Among the cultivars, Sauti produced significantly (P=0.05) higher mean leaf, stem and total dry weight than Okumkom. However, the mean leaf, mean stem and mean total dry weight for the different spacings were not significant.

Table29. Effect of spacing of tubers on mean dry weight of sweet potato cultivars at harvest

A	mean leaf dry weight		
	Cultivar		
Spacing	Sauti	Okumkom	$LSD_{(5\%)}$
25cm x 10cm	7.3	2.7	N.S.
25cm x 15cm	7.0	3.1	
25cm x 20cm	7.3	4.2	
$LSD_{(5\%)}$	1.6		
B	mean stem dry weight		
	Cultivar		
Spacing	Sauti	Okumkom	$LSD_{(5\%)}$
25cm x 10cm	15.9	4.6	N.S.
25cm x 15cm	18.8	7.8	
25cm x 20cm	15.2	8.8	
$LSD_{(5\%)}$	3.8		
C	mean total dry weight		
	Cultivar		
Spacing	Sauti	Okumkom	$LSD_{(5\%)}$
25cm x 10cm	23.1	7.3	N.S.
25cm x 15cm	25.8	10.9	
25cm x 20cm	22.5	12.9	
$LSD_{(5\%)}$	5.1		

4.3. EXPERIMENT 3: Effect of early initiation of vine multiplication on planting material production of two sweet potato cultivars nurtured in nursery.

4.3.1 Initial Harvest

Tables 30 - 34 show initial results of planting material production from vines of the two cultivars, Sauti and Okumkom, planted in the field.

4.3.1.1 Effect of early initiation of vine multiplication on the number of plants harvested in two sweet potato cultivars nurtured in nursery.

The effect of early initiation of vine multiplication in the two cultivars is shown in Table 30. No significant differences (P=0.05) were found among the different times of initiation of vine multiplication. However, significant differences (P=0.05) were found between the cultivars with Sauti having a higher number of plants per plot than Okumkom.

Table 30. Effect of time of initiation of vine multiplication on the initial number of plants harvested in sweet potato cultivars nurtured in nursery

Time of initiation of vine multiplication (weeks before field planting)	Variety		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	17.0	11.0	N.S.
4	19.0	12.7	
6	19.3	15.7	
8	17.0	14.3	
10	18.3	15.0	
14	18.0	13.0	
$LSD_{(5\%)}$	1.4		

4.3.1.2. Effect of early initiation of vine multiplication on the initial number of 30cm vines harvested in sweet potato cultivars nurtured in nursery

Table 31 shows the effect of early initiation of vine multiplication on the initial number of 30cm vines produced in the two cultivars. Sauti produced a significantly higher

(P=0.05) number of 30cm vines plants per plot than Okumkom. The differences observed among the different times of initiation of vine multiplication were found to be significant at P=0.05. An interaction effect, Figure 11, was also observed among cultivars and the different times of initiation of vine multiplication. Sauti produced a relatively higher number of 30cm vines with a decrease in the time of initiation of vine multiplication whereas Okumkom produced almost the same number of 30cm vines irrespective of the time of initiation of vine multiplication.

Table 31. Effect of time of initiation of vine multiplication on the initial number of 30cm vines harvested in sweet potato cultivars nurtured in nursery

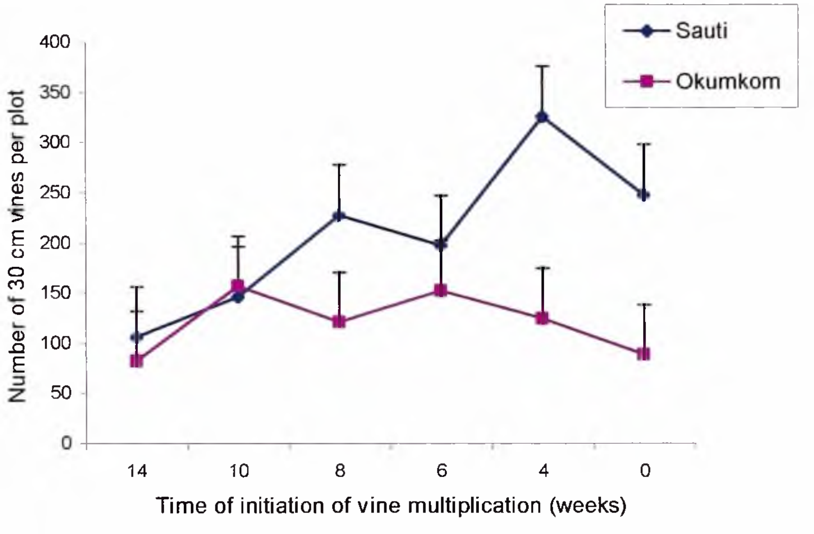
Time of initiation of vine multiplication (weeks before field planting)	Variety		
	Sauti	Okumkom	$LSD_{(5\%)}$
0	249.0	88.7	70.3
4	327.0	125.0	
6	198.0	153.0	
8	228.3	121.3	
10	146.3	157.0	
14	106.0	81.7	
$LSD_{(5\%)}$	40.6		

4.3.1.3. Effect of early initiation of vine multiplication on the initial mean dry matter production in sweet potato cultivars nurtured in nursery

Tables 32, 33 and 34 show the effect of early initiation of multiplication of planting material on the initial mean leaf, mean stem and mean total dry weight of vines of sweet potato cultivars nurtured in the nursery and used to produce planting material at different times of initiation of planting material production.

Among the cultivars, Sauti produced a significantly (P=0.05) higher mean leaf dry weight than Okumkom (Table 32). The variations between the different times of initiation of multiplication of planting material were also highly significant (P=0.05). Sauti at 8 weeks before field planting produced the highest mean leaf dry weight followed by 6 weeks and 4 weeks. 14 weeks and 0 weeks produced about the same mean leaf dry weight and 10 weeks produced the least mean leaf dry weight. On the other hand, Okumkom at 14 weeks before field planting produced the highest mean leaf dry weight followed by 8 weeks and then 6 weeks. 4 and 10 weeks produced about the same mean leaf dry weight and 0 weeks produced the least mean leaf dry weight.

Fig.11: Effect of time of harvest on the total number of 30 cm vines produced in sweet potato cultivars



With regards to the mean stem dry weight (Table 33), Sauti produced a significantly (P=0.05) higher mean stem dry weight than Okumkom. The variations between the different times of initiation of multiplication of planting material were also highly significant (P=0.05). Sauti at 4 weeks before field planting produced the highest mean stem dry weight followed by 8 weeks and 6 weeks. 14 weeks and 0 weeks produced about the same mean stem dry weight and 10 weeks produced the least mean stem dry weight. On the other hand, except for the variation between 0 and 8 weeks recorded, differences between all the treatments in Okumkom were not significant.

Table 32. Effect of time of initiation of vine multiplication on initial mean leaf dry matter production in sweet potato cultivars

Time of initiation of vine multiplication (weeks before field planting)	Mean leaf dry weight (g)		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	7.8	3.0	3.7
4	11.6	6.1	
6	13.6	8.9	
8	20.2	8.9	
10	4.4	6.1	
14	9.8	9.0	
$LSD_{(0.05)}$	2.1		

Table 33. Effect of time of initiation of vine multiplication on initial mean stem dry matter production in sweet potato cultivars, Sauti and Okumkom

Time of initiation of vine multiplication (weeks before field planting)	Mean stem dry weight (g)		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	21.7	6.2	9.3
4	38.2	11.3	
6	27.0	12.8	
8	35.5	17.0	
10	12.1	10.0	
14	20.2	8.6	
$LSD_{(0.05)}$	5.3		

Table 33 represents the mean total dry weight at the first harvest. Among the cultivars, Sauti produced a significantly (P=0.05) higher mean total dry weight than Okumkom. The variations between the different times of initiation of multiplication of planting material were also highly significant (P=0.05). Sauti at 8weeks before field planting produced the highest mean total dry weight followed by 4 weeks and 6 weeks. 14 weeks and 0 weeks produced about the same mean total weight and 10 weeks produced the least mean total dry weight. Similarly, Okumkom at 8 weeks before field planting produced the highest mean leaf, mean stem and mean total dry weight followed by 4 weeks and then 6 weeks. 14 weeks and 10 weeks produced about the same mean total weight and 0weeks produced the least mean total dry weight.

Table 34. Effect of time of initiation of vine multiplication on initial mean total dry matter production in sweet potato cultivars

Time of initiation of vine multiplication (weeks before field planting)	Mean total dry weight (g)		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	29.4	9.2	12.5
4	49.8	17.4	
6	40.6	21.7	
8	56.3	25.9	
10	16.5	16.1	
14	30.0	17.6	
$LSD_{(0.05)}$	7.2		

4.3.2. Final harvest

4.3.2.1. Effect of early initiation of vine multiplication on the number of apical vines harvested in sweet potato cultivars nurtured in nursery

Early initiation of multiplication of vines resulted in significantly higher (P=0.05) apical vine yields in Sauti than Okumkom (Table 35). Similarly, significantly higher yield variations (P=0.05) were observed among the various times of initiating vine multiplication. In Sauti, the differences were observed between 0weeks and 4, 6, 8, 10 and 14 weeks; 4 and 8, 10 and 14 weeks; 6 and 14 weeks and 14 and 8 an 10 weeks. In Okumkom, the differences observed occurred between 0 and 6, 10 and 14 weeks; 4 and 14 weeks; 6 weeks and 14weeks; 8 weeks and 14 weeks and 10 weeks and 14 weeks.

Table 35. Effect of time of initiation of vine multiplication on number of apical vines produced in sweet potato cultivars nurtured in the nursery.

Time of initiation of vine multiplication (weeks before field planting)	Number of apical vines		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	101.0	20.0	120.3
4	251.6	81.1	
6	369.9	179.3	
8	400.8	84.2	
10	448.1	170.8	
14	742.1	371.0	
$LSD_{(0.05)}$	69.4		

4.3.2.2. Effect of early initiation of vine multiplication on the number of middle vines harvested in sweet potato cultivars nurtured in nursery

Table 36 shows the effect of early initiation of multiplication of vines on the number of middle vines produced. Sauti yielded significantly more (P=0.05) middle vines than Okumkom. Significant variations (P=0.05) were observed among the various times of initiating vine multiplication. In Sauti, 0 weeks yielded more middle vines than 4 weeks and less middle vines than 10 and 14 weeks. The number of middle vines harvested when multiplication was initiated at 4 weeks to field planting was less than the number harvested when vine multiplication was initiated at 8, 10 and 14 weeks. Similarly, initiation of vine multiplication at 6 weeks yielded a lesser number of middle vines than when initiation of vine multiplication began at 10 and 14 weeks before field planting. Similar differences were observed among 8 and 10 and 14weeks initiation of vine multiplication. Similar differences were observed with Okumkom.

Table 36. Effect of time of initiation of vine multiplication on number of middle vines produced in sweet potato cultivars

Time of initiation of vine multiplication (weeks before field planting)	Number of middle vines		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	111.7	54.7	85.2
4	10.3	14.3	
6	86.6	170.1	
8	155.1	73.7	
10	211.0	204.4	
14	204.5	248.2	
$LSD_{(0.05)}$	49.2		

4.3.2.3. Effect of early initiation of vine multiplication on the number of basal vines harvested in sweet potato cultivars nurtured in nursery

Early initiation of multiplication of vines resulted in significantly higher (P=0.05) basal vine yields in Sauti than Okumkom (Table 37). Similarly, significant variations (P=0.05) were observed among the various times of initiating vine multiplication. In Sauti, 0 weeks gave the highest basal vine yield followed by 10, 8, 14, 4 and 6 weeks. However, only the differences observed between 4weeks and 0 and 10 weeks; and 6 weeks and 0 and 10 weeks were significant. In Okumkom, the highest number of basal vines were harvested when multiplication was initiated at 10 weeks to field planting followed by 0, 6, 14, 8 and 4 weeks. Only the differences observed between 10 weeks and 4, 8 and 14 weeks, and 0 and 4 weeks to field planting were significant.

Table 37. Effect of time of initiation of vine multiplication on number of basal vines produced in sweet potato cultivars

Time of initiation of vine multiplication (weeks before field planting)	Number of basal vines		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	37.0	24.7	19.4
4	8.0	3.7	
6	6.1	21.0	
8	24.2	13.1	
10	32.7	39.8	
14	19.3	19.9	
$LSD_{(0.05)}$	11.2		

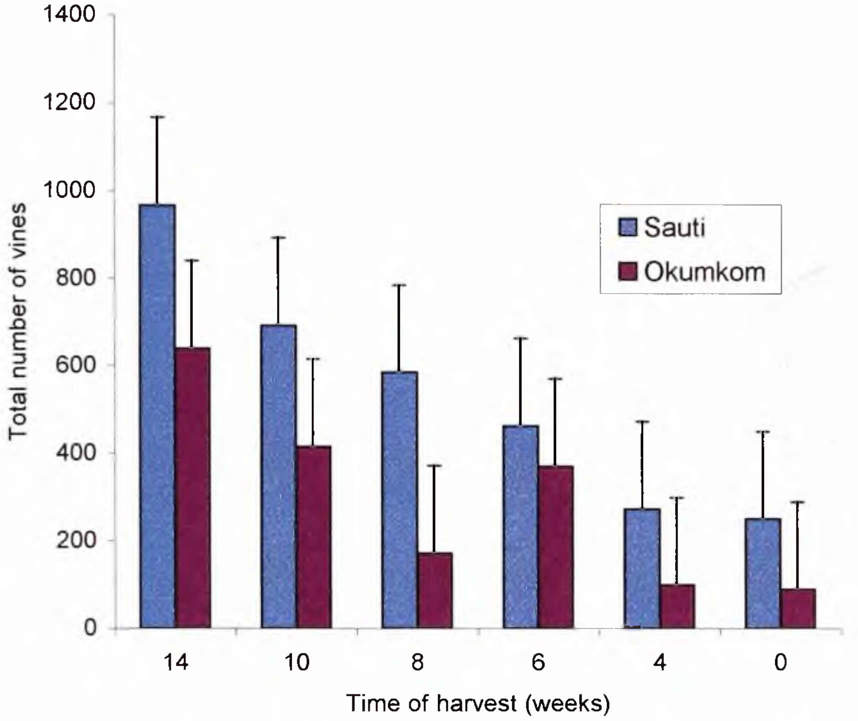
4.3.2.4. Effect of early initiation of vine multiplication on the final number of 30cm vines harvested in sweet potato cultivars, Sauti and Okumkom nurtured in nursery

The effect of early initiation of vine multiplication on the final number of 30cm vines harvested is presented in Figure 12. There were significant differences (P=0.05) among cultivars and time of initiation of vine multiplication. Initiating vine multiplication as early as 14 weeks before field planting resulted in the highest vine yield in both cultivars. Differences observed between 0 and 4 weeks were not significant for both cultivars. As initiation of vine multiplication was delayed the resultant vine yield decreased, except for Okumkom at 6 weeks that gave a higher vine yield than Okumkom at 8 weeks.

4.3.2.5. Effect of early initiation of vine multiplication on the percentage of the vine parts produced in sweet potato cultivars nurtured in nursery

Tables 38, 39 and 40 show the effect of early initiation of vine multiplication in Sauti and Okumkom nurtured in the nursery on the percentage vine parts produced. For percentage apical vines produced, Sauti yielded significantly higher (P=0.05) percentage of apical vines when compared to Okumkom, whereas Okumkom yielded more middle and basal vines than Sauti.

Fig.12: Effect of time of initiation of vine multiplication on the total number of 30cm long vines produced in sweet potato cultivars at final harvest



4.3.2.5.1. Effect of early initiation of vine multiplication on the percentage of the apical vines produced in sweet potato cultivars nurtured in nursery

With respect to the percentage apical vine production (Table 38), significant differences (P=0.05) were observed between all the times of vine multiplication tested except for 6 and 8 weeks in Sauti and 6, 8 and 10 weeks in Okumkom. The highest percentage of apical vines recorded in Sauti was obtained when multiplication of vines was initiated at 4 weeks. This was followed by 6, 14, 8, 10 and 0 weeks in a decreasing order. In Okumkom, the highest percentage of apical vines was obtained at 4 weeks followed by 14, 6, 8, 10 and 0 weeks in a decreasing order.

Table 38. Effect of time of initiation of vine multiplication on percentage apical vine production in sweet potato cultivars

Time of initiation of vine multiplication (weeks before field planting)	Percent apical vines		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	42.2	21.1	9.7
4	93.7	78.8	
6	80.2	47.2	
8	71.2	46.6	
10	64.7	43.4	
14	76.6	58.4	
$LSD_{(0.05)}$	5.6		

4.3.2.5.2. Effect of early initiation of vine multiplication on the percentage of the middle vines produced in sweet potato cultivars nurtured in nursery

Compared to Sauti, Okumkom produced a higher percentage of middle vines. Table 39 shows significant differences (P=0.05) in the percentage of middle vine produced by the cultivars. The variations among the different times of vine multiplication were also found to be significant (P=0.05). The highest percentage of middle vines was recorded in

Okumkom, when vine multiplication was initiated at 0 weeks followed by 6, 10, 8, 14, and 4 weeks in a decreasing order. Initiation of vine multiplication at 0 weeks in Sauti also yielded the highest percentage when compared with the other times studied for the same cultivar.

Table 39. Effect of time of initiation of vine multiplication on percentage middle vine production in sweet potato cultivars

Time of initiation of vine multiplication (weeks before field planting)	Percent middle vines		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	43.4	57.0	8.2
4	3.5	15.3	
6	18.4	47.0	
8	25.4	45.1	
10	30.2	47.0	
14	21.3	38.3	
$LSD_{(0.05)}$	4.7		

4.3.2.5.3. Effect of early initiation of vine multiplication on the percentage of the basal vines produced in sweet potato cultivars nurtured in nursery

With respect to the percentage basal vine production (Table 40), significant differences (P=0.05) were observed between the cultivars and the times of vine multiplication. Okumkom had a higher percentage basal vine production than Sauti. For both cultivars initiating vine production at 0 weeks gave the highest percentage of basal vines. Initiating vine multiplication 8 weeks before field planting in Sauti and 4 weeks before field planting in Okumkom gave the lowest percentage basal yield.

Table 40. Effect of time of initiation of vine multiplication on percentage basal vine production in sweet potato cultivars

Time of initiation of vine multiplication (weeks before field planting)	Percent basal vines		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	14.4	22.0	4.2
4	2.9	6.0	
6	1.4	5.9	
8	3.4	8.3	
10	5.0	9.6	
14	2.1	3.3	
$LSD_{(0.05)}$	2.4		

4.3.3. Effect of early initiation of vine multiplication on the final mean dry matter production in sweet potato cultivars nurtured in nursery

Tables 41, 42 and 43 show the effect of early initiation of multiplication of planting material on the final mean leaf weight, mean stem weight and mean total dry weight of vines of sweet potato cultivars raised in the nursery and used to produce planting material at different times of initiation of planting material production.

4.3.3.1. Effect of early initiation of vine multiplication on the final mean leaf dry weight of vines of sweet potato cultivars nurtured in nursery

Sauti produced a significantly (P=0.05) higher mean leaf dry weight than Okumkom as shown in Table 41. The variations between the different times of initiation of multiplication of planting material were also highly significant (P=0.05) as were the interaction effects of the cultivars and the time of initiation of vine multiplication. Sauti at 0 weeks before field planting produced the highest mean leaf dry weight followed by 10 weeks, 6 and 8 weeks. 14 and 4 weeks produced about the least mean leaf Similarly, Okumkom at 0 weeks before field planting produced the highest mean leaf dry weight followed by 6 weeks and then 10 weeks. 8 weeks and 10 weeks produced about the same mean leaf dry weight and 4 weeks produced the least mean leaf dry weight. The interaction effect between the cultivars and time of initiation of vine multiplication was significant only at 0 weeks when Sauti yielded a significantly higher mean leaf dry weight than Okumkom.

Table 41. Effect of time of initiation of vine multiplication on final mean leaf dry matter production in sweet potato cultivars

Time of initiation of vine multiplication (weeks before field planting)	Mean leaf dry weight (g)		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	7.8	3.0	1.3
4	1.2	0.8	
6	3.1	3.0	
8	2.4	1.0	
10	3.4	1.4	
14	1.2	1.0	
$LSD_{(0.05)}$	0.7		

4.3.3.2. Effect of early initiation of vine multiplication on the final mean stem dry weight of vines of sweet potato cultivars nurtured in nursery

Regarding final mean stem dry weight as shown in Table 42, Sauti produced a significantly (P=0.05) higher mean stem dry weight than Okumkom. The variations between the different times of initiation of multiplication of planting material were also highly significant (P=0.05) as were the interaction effects of the cultivars and the time of initiation of vine multiplication. Sauti at 0 weeks before field planting produced the highest mean stem dry weight followed by 10 weeks, 8, 6 and 14 weeks and 4 weeks. As in the case of Sauti, Okumkom at 0 weeks yielded the highest mean stem dry weight and this varied significantly from the other times studied. Delaying initiation of vine multiplication resulted in Sauti producing a higher stem dry weight when compared to Okumkom.

Table 42.Eeffect of time of initiation of vine multiplication on final mean stem dry matter production in sweet potato cultivars

Ti me of initiation of vine multiplication (weeks before field planting)	Mean stem dry weight (g)		
	Sauti	Okumkom	$LSD_{(0.05)}$
0	21.6	6.2	2.9
4	2.1	0.9	
6	4.3	2.8	
8	4.9	1.3	
10	7.0	2.2	
14	2.7	0.9	
$LSD_{(0.05)}$	1.7		

4.3.3.3. Effect of early initiation of vine multiplication on the final mean total dry weight of vines of sweet potato cultivars nurtured in nursery

Table 43 represents the mean total dry weight at final harvest. Among the cultivars, Sauti produced a significantly (P=0.05) higher mean total dry weight than Okumkom. The variations between the different times of initiation of multiplication of planting material were also highly significant (P=0.05). An interaction effect was also observed at 0 weeks of initiation of vine multiplication as shown in the figure. Sauti at 0 weeks before field planting produced the highest mean total dry weight followed by 10, 6 and 8 weeks. 14 and 4 weeks produced the least mean total weight. Similarly, Okumkom at 0 weeks before field planting produced the highest mean total dry weight and 4 weeks produced the least. The interaction effect showed that delaying initiation of vine multiplication resulted in Sauti producing a higher mean total dry weight when compared to Okumkom).

Table 43. Effect of time of initiation of vine multiplication on final mean total dry matter production in sweet potato cultivars

Time of initiation of vine multiplication (weeks before field planting)	Sauti	Okumkom	$LSD_{(0.05)}$
0	29.4	9.2	4.0
4	3.3	1.7	
6	7.4	5.8	
8	7.3	2.4	
10	10.4	2.5	
14	3.9	1.9	
$LSD_{(0.05)}$	2.3		

CHAPTER FIVE

5.0 DISCUSSION

5.1 Storage of small unmarketable sweet potato tubers.

The barn used in the study consisted of a wooden frame and 5mm mesh expanded metal. It was constructed as such so as to offer the maximum ventilation possible. It was roofed with thatch extending sufficiently over the sides to exclude direct sunshine from shelf area, Plates 1 and 2. Temperature and relative humidity values recorded during the period of study were 28.9 - 29.8°C and 68.5 – 79.8%RH (taken at 1:00pm). The tubers did not store well in this barn although these conditions fit the description of rural storage structures, made by Bani and Josiah, (1995). Sixty percent of Sauti and 26% of Okumkom were lost by the end of the fifth week of storage. This increased to 66% and 69% for Sauti and Okumkom respectively by the tenth week; and by the end of the experiment fifteen weeks after storage, 72% of Sauti and 89.3% of Okumkom were lost (Table 9, Figure 2).

The optimum conditions for sweet potato storage have been reported by Data *et al.* (1989) and Onwueme and Sinha (1991), as 15°C and 85-90% RH. Under these conditions certain cultivars like the Jewel have been stored for up to nine months (Wilson *et al.*, 1992). However, they all agreed that the attainment of such conditions was not economically feasible for most parts of the tropics. For storage of produce under tropical conditions, Kamalam, *et al.*, (1998), recommended the use of barn, pit, clamp storage, and storage in wooden boxes, baskets, sawdust, and sand. Other studies also indicated that sweet potatoes can be stored for between one and four months under these conditions (MOA, 1988; Data *et al.*, 1989; Kamalam, *et al.*, 1998; Satish *et al.*, 1999; Sowley, 1999). The high percentage losses recorded in the present study can be attributed to the high temperature and low relative humidity that led to high respiratory activity. Another reason may be due to the fact that the tubers were too small, and so were adversely affected by factors such as weight loss, shriveling, rotting, and insect damage.

The high percentage tuber losses obtained during storage in the dry season from October to January, and the resultant low 30cm vine yields obtained from tubers planted at the end of the experiment (in April at the beginning of the rainy season) is an indication that storing tubers in the barn for a period before planting them in the field to produce vines for field planting may not be advisable since a high proportion of the tubers could be lost during storage.

5.1.1. Weight loss and shriveling in stored sweet potato tubers.

The weight of the tubers studied ranged from 20g to 200g, with majority of them weighing between 80g to 120g. The percentage weight loss and shriveling increased significantly with increase in period of storage. By the end of fifteen weeks, weight loss in Sauti was 27.7% and 40.4% in Okumkom. Similarly 84% of Sauti and 88.9% of Okumkom tubers were shriveled (Tables 5 & 6). During the study, it was observed that more of the smaller sized tubers shriveled than the larger sized ones. As small objects have wider surface areas, and the rate of transpiration increases with increased surface area, the small sizes of the tubers could have resulted in an increase in the rate of transpiration and contributed to the high percent shriveling. Further studies would be necessary to determine the most reasonable sizes of tubers that could be stored for later generation of planting material without compromising on marketability. Nair (2000), recommended the use of tubers of 125 to 150g weight for vine production.

Storage of fresh tubers in moist sawdust, sand, and under ambient conditions have been studied, and results have shown weight losses of 11.4%, 9.88% and 40.71% respectively after 6 weeks of storage (Data *et al.*, 1989). Sowley (1999) reported fresh weight losses of up to 22.69% in sweet potatoes stored for 8 weeks in storage barn. Satish *et al.* (1999) observed shrinkage in tubers after 7 to 12 weeks of storage. Although Data *et al.*, (1989) had reported that weight loss and shriveling could adversely affect table quality no such effect had been reported in the case of tubers being stored for planting material production at a later date. Some of the tubers under this study were however not suitable for planting because they were completely shriveled.

5.1.2. Rotting in stored sweet potato tubers.

In this study, the percentage tuber rot increased with storage period. In Sauti rotting increased from 26.7% in the 5th week to 34.8 by the 15^{th} week (Table 7 & Plates 3, 4, 5 & 6), whereas in Okumkom, it increased from 22.2% in the 5^{th} week to 58.3% in the 15^{th} week. This indicates that rotting is a serious problem in sweet potato storage. Kamalam *et al.* (1998) reported that in storage, sweet potatoes are subjected to several types of post harvest losses including pathological decay, and losses due to diseases particularly soft rots could be very substantial. Sowley (1999) also observed a general increase in the severity of rot in tubers stored and concluded that the maximum storage period for sweet potatoes is one month. This study shows that to avoid a total loss of material, it may be advisable not to store tubers beyond 5 weeks, especially for Okumkom. On the other hand other forms of pre storage treatments like hormone treatment, fungicide application and irradiation could be studied and if possible recommended for the extension of storage life. It is possible to control tuber rots in storage by the application of irradiation. [Avakyan *et al.*, (1974); Adesiyan; (1977); Maghrabi and El-Sayed (1988); Gasiorowska and Zarzecka (2000) and USEPA (2002)].

Botryodiplodia theobromae was identified as the pathogen that caused the rot in the tubers stored in the present study, a confirmation of observations by Edmond (1971b) and Sowley (1999).

5.1.3. Dormancy and sprouting in stored sweet potato tubers.

The results of Experiment 1 showed that, sprouting had occurred in both cultivars by the 5^{th} week of storage and increased with further increases in period of storage. In Sauti 13.5% of the tubers had sprouted by the 5^{th} week and increased to 62.8% by the 15^{th} week. In Okumkom 20% of tubers had sprouted by the 5^{th} week. This increased to 60.6% in the 15^{th} week (Table 8; Plates 7a, 7b, 8 and 9). Once steps are taken to control shriveling, rotting and insect damage, storing tubers could provide a convenient means of conserving planting material so long as sprouted tubers are kept under such conditions that prevent deterioration. At the end of his study, Sowley (1999) proposed that sweet potato tubers stored could be used to generate planting material when necessary. Tubers not stored at all before field planting yielded the most vines. The possibility of irradiating tubers, and/or the use of sprout inhibiting chemicals like isopropyl-N-chlorophynylcarbamate to delay sprouting and thus extend storage life could be explored so that nursery activities could be initiated by the fifteenth to twentieth week after storage. If this is done nursery activities could be further delayed and labour could be employed elsewhere (Avakyan *et al.*, 1974; Adesiyan, 1997; Diop, 1998; USEPA, 2002).

Sweet potato is said to have no state of dormancy, that is, it can sprout in spite of an unfavourable environment (Sowley, 1999). Satish *et al.* (1999) observed sprouting between 3 to 8 weeks of storage. Sowley (1999) reported that the rate of sprouting increased with increase in the period of storage and observed that up to 40% of the tubers stored sprouted within the first week and up to 98.1% of tubers had sprouted by the eighth week of storage. Although his results were higher than those obtained in this study the trend in sprouting was similar as sprouting in tubers of Sauti increased from 13.5% in the fifth week to 62.8% in the fifteenth week. Sprouting in tubers of Okumkom increased from 20% in the fifth week to 60.6% in the fifteenth week.

5.1.4. Insect damage in stored sweet potato tubers.

With respect to insect damage, significant differences were observed between the varieties with Suati being more susceptible to insect damage than Okumkom in storage. The main pest was identified to be the sweet potato weevil (***Cylas puncticollis***). The percent infestation in Sauti (42.8%) and Okumkom (12.2%) 15 weeks after storage were quite high, and is similar to that reported by Otoo (1998). *Cylas* infestation normally occurs in the field prior to storage (Théberge 1985; Missah and Kissiedu, 1994; Capinera, 1998). It is therefore possible that the tubers studied had been infected in the field prior to storage because the barn had been rehabilitated and disinfected before tubers were introduced and so could not have been the source of infestation. The differences could also have resulted from the sorting of the tubers prior to storage. Sowley (1999) demonstrated that the sweet potato weevil, *Cylas* sp. was the most important pest associated with sweet potato storage in Ghana. Indeed attack by sweet potato weevil is a major constraint associated with sweet potato production (Théberge 1985; Missah and Kissiedu*et al* 1994; Capinera, 1998; and Sowley, 1999). Practising farm hygiene, removal of alternate hosts, early harvesting and stringently sorting before storage could prevent infestation in storage (Onwueme and Sinha, 1991; Missah & Kissiedu, 1994; Diop, 1998). Irradiating tubers prior to storage could also destroy eggs and larvae already laid inside tubers and prevent tuber damage during storage (Avakyan *et al.*, 1974; Adesiyan, 1997; USEPA, 2002).

5.1.5. Behaviour of tubers of sweet potato cultivars in storage.

Generally, no significant variations were observed among the cultivars tested in relation to percentage weight loss, shrinkage, percentage sprouting and percentage rotting in storage. This implies that the cultivars were similarly affected by the storage conditions. These results are in disagreement with those of Data *et al* (1989), and Wilson *et al.* (1992) who reported that different sweet potato varieties behaved differently even under optimum conditions with some storing for longer periods than others.

5.2. Conservation of sweet potato tubers and vines in the nursery.

Results obtained from the experiments all show that planting material of Sauti and Okumkom can be obtained at the time of field planting if small unmarketable tubers or vines are raised in the nursery during the dry season. The higher number of 30cm vines and dry matter contents obtained for Sauti when compared to Okumkom confirm the fact that some sweet potato cultivars are more tolerant to drought than others (Hahn, 1977).

For almost all the experiments in this study, Sauti produced a significantly higher number of 30cm vines and a higher percentage of apical vines than Okumkom, suggesting that Sauti branched more and was more tolerant to drought. Between January and March, when the temperatures increased slightly (Appendix 1b&c), some vine multiplication was done on both varieties. It was observed that vines of Sauti had better establishment and were more vigorous than those of Okumkom. The cumulative effects of these reflected in the final vine yields obtained. These findings agree with Otoo *et al.*, (1998) who indicated that apart from the higher mean tuber yields obtained by Okumkom in almost all the agroecologies in the country, Sauti had a better plant establishment, fresh vine production and a higher biomass production than Okumkom.

On the whole, vine yields obtained for both cultivars were low when compared to the number of vines required per hectare. For Experiment 1, the highest yields of 409 vines obtained from an initial number of 50 unmarketable tubers planted at 10cm intervals on an area of $0.5m^2$ implies that 4,900 of these tubers would have to be planted on an initial area of $49m^2$ to be able to produce an equivalent of 40,000 vines necessary to establish one hectare of sweet potato. This number of unmarketable tubers could still represent quite a volume and using these to generate planting material may not look attractive to a prospective farmer. A probable alternative could be to further explore the use of tissue culture techniques on a commercial basis to conserve planting material during the dry season, and multiplying them to provide adequate number of vines at the onset of the rains. This technique is already being employed successfully in other countries including China (Fuglie *et. al.*, (1999)

For Experiment 3, planting vines at 40cm x 40cm on a plot of 3m x 0.6m and initiating multiplication of planting material 14 weeks before field planting yielded the highest number of 966 vines. By extrapolation, initially planting vines at 40cm x 40cm on a plot of $33.2m^2$, and initiating vine multiplication 14 weeks before field planting would yield about 40,000 vines, enough to plant one hectare. When compared to delaying harvesting to 10, 8, 6 or 4 weeks before field planting, this yield may be significant. However, the total number of 7 harvests made for the treatment in which vine multiplication was initiated at 14 weeks before field planting as against 3 harvests for the others raises the question of labour and other input costs. Although this study did not consider the cost of production, it may seem more suitable to increase the initial area planted, raise the vines for the early part of the dry season and initiate vine multiplication 10 to 8 weeks before field planting in order to reduce the number of harvests and save on labour.

Further studies could be done to determine the possibility of reducing the initial number of unmarketable tubers stored and increasing the number of sprouts per tuber, in order to further increase the planting material yields. The effect of fertilizer application and/or organic manuring and possibly the effect of shading of sweet potato vines in the dry season could also be evaluated as Ravi (2000) indicated that shading has some effect on vine production and tuber yields in sweet potato.

The results obtained from these studies are relevant because, they suggest an alternate way of conserving and multiplying planting material for the rainy season. This is because whereas some crop yield may be obtained under harsh growing conditions, conservation of planting material over a long dry season is necessary if material is to be available for planting at the onset of the rains (Onwueme and Sinha, 1991; Otoo, 1998; Kakraba, 2000). Sweet potato vines do not store for more than seven days hence, specific arrangements to provide material for the crop that is harvested at a time when a new crop is not being planted must be made, and techniques for producing large quantities of the planting material must be developed (Okoli, 1988).

It has been proposed that where the non-growing season is either too long or too severe for vines to survive, apart from maintaining a small, well-watered plot of sweet potatoes, tubers could be stored for some time(Onwueme and Sinha, 1991; and Yankey, 2001). A few weeks before the start of the growing season, they could be buried in moist soil, and sprouts from the tubers harvested at intervals and planted on the field. Rapid establishment and superior maintenance of top growth under extreme stress are vital characteristics to ensure availability of planting materials during the short rainy periods that occur in the dry lands of Africa (CIP, 1995).

Sprouting in the two cultivars under the different planting distances showed significant variations at the initial stages with Okumkom having more sprouts than Sauti, but the variations were no longer significant by the twentieth day after planting. Beyond this period, results showed no significant variations among the cultivars and planting distances tested, although both cultivars planted at 25cm x 10cm produced the highest number of sprouts and gave the highest 30cm vine yields as well as apical, middle and basal vines produced. Carey *et al.* (1997) reported that in a study undertaken to examine differences in sprouting ability among CIP–bred clones significant variations were observed in the sprouting ability of the different cultivars. In addition, clones found to produce the highest number of sprouts sprouted earliest.

Missah and Kissiedu, (1994) observed that the weight of vines decreased with time probably due to age and drying environmental conditions. Although the variations between the different times of initiation of vine multiplication which correspond to the age of vines in nursery beds was highly significant, it did not follow the same trend. The highest total dry weight for both cultivars was obtained at 8 weeks before field planting whereas 10 weeks and 0 weeks before field planting yielded the lowest dry matter. Having spent 5 months in the field, dry matter yields of vines obtained at 0 weeks would have been expected to be low, since a major portion of the vine dry mater would have been partitioned to the roots for tuber formation (Ravi, 2000).

5.3. Vine yield resulting from early initiation of vine multiplication.

Further to conservation of tubers and vines during the dry season, this study explored the possibility of initiating vine multiplication early in order to obtain a higher number of vines for field planting. Results obtained from Experiment 3 showed that early initiation of vine multiplication increased number of vines available for field planting. Initiation of vine multiplication at 14 weeks before field planting gave the highest vine yield. As the time of initiation of vine multiplication was delayed, the number of vines obtained decreased consistently until the time when no multiplication was done. This could be due to the fact that whereas the vines harvested 14 weeks before field planting had the opportunity to rejuvenate after being cut and replanted, partitioning of photosynthate from source to sink, and senescence of the older vines could have begun for those treatments in which vine multiplication was further delayed resulting in the lower planting material yields observed.

Rapid establishment and superior maintenance of top growth under extreme stress are vital characteristics to ensure availability of planting materials during the short rainy periods that occur in the dry lands of Africa (CIP, 1995). For almost all the experiments in this study, Sauti produced a significantly higher number of 30 cm vines than Okumkom, suggesting that Sauti was more tolerant to drought. These findings agree with Otoo *et al.*, (1998) who indicated that apart from the higher mean tuber yield obtained by Okumkom in almost all the agroecologies in Ghana, Sauti had a better plant establishment, fresh vine production and a higher biomass production than Okumkom.

5.3.1. Vine parts

For vines conserved in the field the highest apical, middle, basal and hence total vine yields for both cultivars were obtained when multiplication was initiated fourteen weeks before field planting. The percentage apical vines were highest for all the treatments studied. There was a consistent decrease in the respective numbers of 30 cm vines harvested in the subsequent treatments except for harvests made six weeks before field planting This implies that instead of simply maintaining vines in a nursery during the dry season, the number of planting material available for field planting could be increased further by early initiation of multiplication. Furthermore, a higher number of apical vines could be obtained with this practice and as reported by other workers (Du Plooy *et al.*, 1988; Nair *et al.*, 1989; Onwueme and Sinha, 1991; Hossain and Mondal, 1994; and Hoa, 1998), the higher number of apical vines when planted would result in higher yields than when stem vines were planted thus, tuber yields could be increased if multiplication of planting materials is initiated early.

CHAPTER SIX

6.0. CONCLUSIONS

Judging from the number of tubers remaining after each set period of storage, it appears that there is no advantage in storing small unmarketable sweet potato tubers after harvest during the early part of the dry season, i.e., from October to January, to be used later in the season from November to January for planting material production unless adequate measures are taken to prevent or control *Cylas* infestation, rotting and excessive shriveling. Although weight loss per se may not result in tuber damage, excessive shriveling, rotting and insect damage could result in tubers losing viability and becoming unacceptable for planting after five, ten and fifteen weeks of storage. With respect to planting material production from tubers, the vine yield obtained after multiplication in the field suggests that planting the tubers at 25cm x 15cm immediately after curing and watering them regularly to ensure that they do not dry out under the harsh conditions of the dry season could give the most vines for field planting.

Results obtained from Experiments 1, 2 and 3 all show that planting material of Sauti and Okumkom can be obtained at the time of field planting if small unmarketable tubers or vines are raised in the nursery during the dry season. However, to obtain a higher number of vines and especially a higher number of apical vines which when planted would result in higher yields, vine multiplication could be initiated as early as fourteen weeks before field planting.

4,900 (four thousand, nine hundred) of these tubers would be required to produce an equivalent of 40,000 vines necessary to establish one hectare of sweet potato on an initial area of 49 m^2. On the other hand, planting vines at 40 cm x 40 cm on a plot of 33.2 m^2, and initiating vine multiplication 14 weeks before field planting would yield about 40,000 vines, enough to plant one hectare.

The following recommendations are being made based on this study

1. To conserve sweet potato planting material during the dry season, small unmarketable tubers could be planted at 0.25m x 0.15m immediately after curing and watered regularly to ensure that they do not dry out under the harsh conditions of the dry season.
2. To increase the number of planting materials, especially the number of apical vines available for field planting, multiplication of vines should be initiated between fourteen and six weeks before planting.
3. For further improvement, studies should be done to determine the most suitable tuber weights to be stored for planting material production. The possibility of reducing the initial number of unmarketable tubers to be stored, the effect of irradiation, the application of sprout inhibiting chemicals like CIPC (isopropyl-N-chlorophenylcarbamate) and fungicides on the extension of storage life of the

tubers and the use of tissue culture to conserve and multiply planting materials could also be studied.

4. In the field, the effect of fertilizer application and/or organic manuring and possibly the effect of shading of sweet potato vines in the dry season could be investigated.

REFERENCES

Adesiyan, S. O. (1977). Studies on the Effect of Gamma Radiation (from Cobalt 60 source) on Storage Life of White Yam (*Dioscorea rotundata* var. efon) infected with *Scutellonema bradys*. Annals of Applied Biology. 86:2, 23-218

Ahn J. K., Collins W. W., and Phan D. M. (1980). Influence of Pre-harvest Temperature and Flooding on Sweet Potato Roots in Storage. HortScience 15(3): 261-263.

Ahn Y. S., Jeong B. C., Chung M. N., Oh Y. B., Song Y. S., Min K. S., and Kang Y. K.. (2000). Optimum culture conditions of sweetpotato stem cut for shoot production during winter. Korean Journal of Crop Science. 45:6, 382-386.

Akoroda M. O, Pfeiffer H. J., and Mbahe R. E. (1992). Sweet potato systems in Adamaoua, Cameroon pages 321-329 in: Promotion of Root Crop Based Industries. Tropical Root Crops: Proceedings of the 4th Triennial Symposium, ISTRC – AB. M. O. Akoroda and O. B. Arene (ed.). IITA Ibadan, Nigeria.

Alvarez M. N., 1992. Sweet potato Cropping Systems in Africa. Pages 133-142 in Sweet Potato Technology for the 21st Century. W. A. Hill, C. K. Bonsi and P. A. Loretan (Eds.). Tuskegee University, Tuskegee, AL.

Ambe J. T. (1997). Response of Sweet potato (Ipomea batatas (L) Lam.) to seedbed preparation in high rainfall forest zone of Cameroon. African Journal of Root and Tuber Crops. 3 (1): 22-23.

Association of Official Analytical Chemists (AOAC) (1975). Official methods of analysis 12th ed (W. Horonwitz, ed.). Washington: AOAC, 1015 PP

Avakyan, V. A.; Avakyan S. O.; and Grigoryan, E. M. (1974). Effect of X-ray Irradiation on Tuber Yield and Quality of Potatoes. Plant Production, Plant Physiology and Biochemistry 2: 107-110

Bani, R. J. and Josiah, M. N. (1995). The Use of a Simple Evaporative Cooler to Preserve Okro and Tomatoes. Legon Agricultural Research and Extension Journal 4:17-25.

Biswas V. R., and Singh I. J., (1990). Short Note on the Effect of Maturity of Cutting, Planting Method and Depth of Ploughing on the quality of Sweet Potato (Ipomea batatas Poir) cv. Pusa Suffaid. Vegetable Science. 17(1): 82-86.

Bonte D. R. la, Villordon A. Q., Schultheis J. R., Monks D. W., la and Bonte D. R. (2000). Black Polythene Tunnel Covers Affect Plant Production and Quality of Sweet Potato Transplants. HortScience. 35(2): 202-204.

Bouwkamp J. C. (1982). Research on Production of Sweet Potatoes from cut root pieces. Pp 191-201 in Sweet Potato. Proceedings of the First International Symposium. Eds. Ruben L Villareal and T. D. Griggs.

Brammer H. (1967). Soils of the Accra Plains. Memoir No. 3. Soil Research Institute, Kumasi.

Bray, R. H and Kurtz L. T (1945). Determination of total organic and available phosphorus in soils. Journal of Soil Science, 59: 39-45

Capinera, L. J. (1998). Sweet potato weevil. *Cylas formicerius* (Fabricius). 5pp. Publication No. EENY-27. University of Florida.

Carey, E. E., Gichuki, S. T., Hidalgo, O., and Zhang, D. P. (1997). Sweet potato Seed Units for the Dissemination of Planting Materials of Improved Varieties. Pp 233-237 International Potato Center Program Report 1995-96. Lima, Peru. 323p.

Chukwu, G. O. (1995) Crop irrigation water needs of sweet potato (Ipomea batatas). African Journal of Root and Tuber Crops (1995) Vol. 1(1): 35-38.

Cobley L. S. and Steele W. M. (1983). An Introduction to the Botany of Tropical Crops. Second edition Longman Group Limited. London and New York.

Crops Research Institute, (2000). Steps to Good Sweet Potato Production. 20 pages. Published for the Root and Tuber Improvement Programme (RTIP) Ministry of Food and Agriculture. Kumasi.

Daisy, E. K. (1998). Sweet Potatoes. Pp 2-16; in Root Crops (Natural Resources Institute). Revised by E. G. B. Gooding; Tropical Development and Research Institute 127 Clerkwell Road, London EC1R 5DB Overseas Development Administration.

Data S. E, Diamante C. J and Eronico S. P. (1989). Post harvest handling and storage of sweet potato roots. Pp 169-182 in Sweet potato research and development for small farmers. eds. Kenneth T Macay, Manuel K. Paloma and Rolinda T Samico. Pub. SEAMEO – SEARCA. Philippines. 391pp.

Diop A. (1998). Storage and Processing of Roots and Tubers in the Tropics (ed) Calverley D. J. B. Food and Agriculture Organization of the United Nations Agro-

Industries and Post Harvest Management Service Agricultural Support Systems Division. Viale delle Terme di Caracalla, 00100 Rome, Italy.

Doku E. V. (1988). West African Tropical Root Crop Farming Systems. Pp. 13-20 In Third West African Root Crops Workshop: Proceedings. (Ed.) Robert L Théberge. International Institute of Yropical Agriculture. Ibaban, Nigeria.

Dodds J. H. 1989. In Vitro Sweet Potato Germplasm Management. Pp 131-137 In Sweet Potato Research and Development for Small Farmers. eds. Kenneth T Macay, Manuel K. Paloma and Rolinda T Samico. Pub. SEAMEO – SEARCA. Philippines. 391pp.

Du Plooy C. P., Wagner J. J. and Bosch S. E. (1988). Cultivation of Sweet Potatoes. Sweet Potatoes A. J./1988. Printed and Published in the Republic of South Africa by the Department of Agriculture and Water Supply. Pp 1-8.

Edmond, J. B. (1971a). Field Production Practices and Operations. In Edmond, J. B. and Ammerman, G. R., (Ed.) Sweet potato: Production, Processing and Marketing. AVI Publishing Co. Inc., Westport, Connecticut. 334pp.

Edmond, J. B. (1971b). Sweet potato pests. In Edmond, J. B. and Ammerman, G. R., (Ed.) Sweet potato: Production, Processing and Marketing. AVI Publishing Co. Inc., Westport, Connecticut. 334pp.

Ekanayake I. J., Dodds J. H., Lizarranga R. E. (1990). Effect of Planting Density on Storage Root Production from In-Vitro Sweet Potato Plantlets. Rivista de Agricoltura Subtropicale e Tropicale 84:3, 397-402.

Food and Agriculture Organization of the United Nations (2001). Processed Statistics for 2001. (Unpublished). Rome.

Fuglie, K. O., Zhang, L., Salazar, L. and Walker, T. (1999). Economic Impact of Virus-Free Sweet Potato Planting Material in Shandong Province, China. Pp 249-254 in International Potato Center Program Report 1997-1998. Lima, Peru.

Gasiorowska B. and Zarzecka K. (2000). The Application of Fazor 80 SG in Limiting Storage Losses of Table Potatoes. Proceedings of the Conference "Table and Food Processing Potato – Agro-technical and Storage Factors Conditioning Quality", Radzikow, Poland. 2000 N0.213, 233-238.

Ghana Export Promotion Council. (2002) Comparison of Export Performance of Non-Traditional Products for the Period January – December 2000 and 2001. Accra, Ghana.

Gibson R. W., Mwanga R. O. M., Kasule S., Mpembe I., and Carey E. E. (1997). Apparent Absence of Viruses in Most Symptomless Field-Grown Sweet Potato in Uganda. Ann. Appl. Biol. 130: 481-490.

Hahn S. K. (1977). Sweet Potato. In Ecophysiology of Tropical Crops. Academic Press Inc. New York, San Francisco, London. 237-248.

Hall M. R. (1986). Pre-sprouting, root size and cutting related to plant production by bedded sweet potato roots. HortScience 21 (4) 985-986.

Hall M. R. (1990). Short duration pre-sprouting, ethephon, and cutting increase plant production by sweet potato roots. HortScience 25 (4) 403-404.

Hall M. R. (1993). Mid-storage heating increased plant production from bedded sweet potato roots. HortScience 28 (8) 780-781.

Hall M. R. (1994). Combined heating applications increased plant production from bedded sweet potato roots. HortScience 29 (9) 1022-1024.

Hoa Vu Dinh (1998). Sweet Potato Production and Research in Vietnam. Pp 109-127 in Proceedings of International Workshop on Sweet Potato. Production Systems Toward the 21st Century. (Eds.) D. R. LaBonte, M. Yamashita and H. Mochida. Published by Deputy of Upland Farming, KNAES Yokoichi, Japan.

Holwerda H. T. and Ekanayake I. J. (1991). Establishment of Sweet Potato Stem Cuttings as Influenced by Size, Depth of Planting, Water Stress, Hormones and Herbicide Residues for Two Genotypes. Scientia Horticulturae 48 (3-4) 193-203.

Horton E. D., (1989). Recent trends in World Sweet Potato Production and Use. Pp 17-32 in Sweet Potato Research and Development for Small Farmers. (eds.) Kenneth T Mackay, Manuel K. Paloma and Rolinda T Samico. Pub. SEAMEO – SEARCA. Philippines. 391pp.

Hossain M. M. and Mondal M. A. A. (1994). Effect of Vine Parts on the Growth and Yield of Three Sweet Potato varieties. Bangladesh Journal of Scientific and Industrial Research 29 (3) 181-184.

International Institute of Tropical Agriculture (IITA) (1981). Automated and Semi-automated methods for Soil and Plant Analysis. IITA Manual series No. 7. Pp 11.2.3-11.5.3. Nigeria, Ibadan.

International Potato Center (CIP) (1995a) Program Report 1993-94. Propagation of Healthy Clonal Sweet Potato Planting Materials in Diverse Agricultural Systems. International Potato Center Program Report 1993-94Pp 112-113. Lima, Peru.

International Potato Center Annual Report (CIP) (1995b). IPM Studies show promise at grass roots / Component Technologies Undergo Testing in Africa and the Caribbean. Pp 21-22 International Potato Center Annual Report Lima, Peru.

International Potato Center Annual Report (CIP) (1997). Virus Clean Up Boosts Chinese Sweet potato production pp. 10-11 International Potato Center Annual Report. Lima, Peru.

International Potato Center (CIP) (1998). Annual Report. Food Security in East Africa: A Battle on Many Fronts. International Potato Center, Lima, Peru.

Iwama K., Yoshinaga M., and Kukimura H. (1990). Dry Matter Production of Sweet Potato in True Seed Planting Culture. Japanese Journal of Crop Science. 59 (1) 146-152.

Jusuf, M., Widodo, Y. and Antarlina S. S. (1998). Problems and Subject of Sweet Potato and Utilization in Indonesia. Pp 87- 101 in Proceedings of International

Workshop on Sweet Potato. Production Systems Toward the 21st Century. (Eds.) D. R. La-Bonte, M. Yamashita and H. Mochida. Published by Deputy of Upland Farming, KNAES Yokoichi, Japan.

Kakraba Yaw. 2001 Sweet potato grower, Apewusika, near Cape-Coast, Central Region of Ghana, Personal communication.

Kamalam, P., Naurm, C. Balagopalan, Palaniswami, M. S., Easwari Amma, C. S., and Vasudevan, K. (1998). Sweet Potato Production and Utilization in India – Problems and Prospects. Pp 51-71 in in Proceedings of International Workshop on Sweet Potato. Production Systems Toward the 21st Century. (Eds.) D. R. LaBonte, M. Yamashita and H. Mochida. Published by Deputy of Upland Farming, KNAES Yokoichi, Japan.

Kissiedu A. F. K., Okoli O. O., Asare Bediako J. N. L., Lamptey A. M. and Danso A. K. (1994). Ghana Root and Tuber Crops Research at Kumasi. Pp 435-440. In Root Crops for Food Security in Africa: Proceedings of the fifth Triennial Symposium of the ISTRC – AB. M. O. Akoroda (ed). Ibadan, Nigeria.

Knoth J. (1993) Traditional Storage of Yams and Cassava and its improvement. Pub. GTZ- Postharvest Project, Pickhuben 4, D-20457 Hamburg

Kozai, T., Kubota, C., Heo, J., Chun, C., Ohyama, K., Niu, G., and Mikami, H. (1998). Towards Efficient Vegetative Propagation and Transplant Production of Sweetpotato (Ipomea batatas (L.) Lam.) under Artificial Light in Closed Ecosystems. Pp 201-214 in Proceedings of International Workshop on Sweet Potato. Production Systems Toward the 21st Century. (Eds.) D. R. LaBonte, M. Yamashita and H. Mochida. Published by Deputy of Upland Farming, KNAES Yokoichi, Japan.

Lema, K. M. (1992). Reducing Weevil Damage in Sweet Potato, Using Host-Plant Resistance and Early Planting and Harvesting. Pp 345-346 In Promotion of Root Crop Based Industries. Tropical Root Crops: Proceedings of the 4th Triennial Symposium, ISTRC – AB. M. O. Akoroda and O. B. Arene (ed.). IITA Ibadan, Nigeria.

Lewthwaite S. L. (1999). Field Establishment of Sweet Potato Transplants. Proceedings of the 29th Annual Conference, Agronomy Society of New Zealand, Albany, New Zealand, 1999. Agronomy New Zealand. 1999, 29: 51-57.

Lewthwaite S. L. and Triggs C. M. (1999). Plug Transplants for Sweet Potato Establishment. Proceedings of the 29th Annual Conference, Agronomy Society of New Zealand, Albany, New Zealand. Agronomy New Zealand. 29: 47-50.

Maghrabi, Y. M. and El-Sayed, S. A. (1988). Storage Stability in Gamma Irradiation Potatoes for Sprout Inhibiion in Relation to Phytoalexin Formation. Annals of Agricultural Science, University of Ain Shams, Egypt. 33(1):423-433.

Martin W. F. (1982). Technique for Rooting Sweet Potato Leaves. HortScience 17(3): 395-396.

Martin F. W. (1986). Technique for Re-Sprouting Sweet Potatoes for Propagation Purposes. Tropical Root and Tuber Crops Newsletter. 1986-1987, No. 16-17, 37-38.

Ministry of Agriculture (M.O.A.) (1988). Sweet potato. Pp9-15 in: Food production and Utilization Training Course Resource Materials, 27th December 1987-8th January 1988. F. Osei-Opare, J. D. Nsarkoh and A. N. Aryeetey eds. Ministry of Agriculture, Ghana.

Ministry of Agriculture (M. O. A.) (1991). Agriculture in Ghana – Facts and Figures. Issued by Policy Planning, Monitoring & Evaluation. Ministry of Agriculture. Accra.

Missah A. and Kissiedu A. F. K. (1994). Effect of Time of Harvesting on the Yield and Pest Incidence of Two Sweet Potato Varieties in the Forest Zone of Ghana. Pp 267-270. In Root Crops for Food Security in Africa: Proceedings of the fifth Triennial Symposium of the ISTRC – AB. M. O. Akoroda (ed). Ibadan, Nigeria.

Moss, P (1961). Limits of interference by iron, manganese, aluminium and phosphate in the EDTA determination of Calcium in the presence of magnesium using cal – red as indicator. Journal of Science, Food and Agriculture, 12: 30-34.

Nair, G. M. (2000). Cultural and Manurial Requirements of Sweet Potato. Pp 43-72 In: Production Technology of Tuber Crops. Central Tuber Crops Research Institute. Sreekariyam, Thiruvananthapuram 695 017 Kerala, India.

Nair, G. M., Ravindran, C. S., Moorthy S. N., and Ghosh S. P. (1987 – 89). Sweet potato indigenous technologies and recent advances of production, processing and utilization in India. Pp 301-312 In sweet Potato research and Development for small Farmers. Ed. by Mackey T K, Paloma K M. and Sanico T R. Pub. by SEAMEO – SEARCA, College, Laguna, the Philippines.

Nakatani M. and Komeichi M. (1988). Holding of Cut Sprouts in Sweet Potato (*Ipomea batatas* Lam.) 4. Effect of Holding on Rooting Under Low Soil Temperature or Moisture. Japanese Journal of Crop Science. 57 (3) 464-469.

Nakatani M., Oyanagi A., Watanabe Y., and Komiechi M. (1986). Effects of Soil Temperatures on the Rooting of Cut Sprouts of Sweet Potato (Ipomea batatas Lam.). I. Optimum Soil Temperature for Rooting and Effects of High Soil Temperature in the Physiological and Anatomical Characteristics of Roots. Japanese Journal of Crop Science. 58 (1): 35-41.

Nakatani M., Oyanagi A., Watanabe Y., and Komiechi M. (1989). Effects of Soil Temperatures on the Rooting of Cut Sprouts of Sweet Potato (Ipomea batatas Lam.). II. Varietal Differences in the Optimum Soil Temperature for Rooting and Rooting Ability Under Low Soil Temperature. Japanese Journal of Crop Science. 58 (1) 35-41.

Nelson R. and Mantell S. H. (1989). Growth Performance of Micro-Propagated Plantlets of Sweet Potato (Ipomea batatas (L.) Lam.) Established in a nutrient film technique system. Crop research, UK. 28 (2) 145-156.

Nelson D. W. and Sommers L. E. (1982). Total organic carbon and organic matter. In: Page *et al.*, (Eds.) Methods of soil analysis Part 2. Agronomy Monograph 9. ASA, Madison W1. p. 639-594

Nzima, M. D. S and Banga D. J. (1999). Developing cheap techniques for sustainable maintenance and multiplication of sweet potato planting materials by households. Journal of the Southern African Society for Horticultural Sciences. 9 (1) 25-28.

Okoli O. O. (1988). Rapid Multiplication of Root and Tuber Planting Materials. Pp. 32-41 in Third West African Root Crops Workshop: Proceedings. (Ed.) Robert L Theberge. International Institute of Yropical Agriculture. Ibaban, Nigeria.

Onwueme, I. C. and Sinha, T. D. (1991). Sweet potatoes (*Ipomea batatas* (L.) Lam). Pp 267- 275 in: Field Crop Production in Tropical Africa – Principles and Practice. Pub. CTA, Ede, The Netherlands.

Opena, R. T., Takagi, H., and Tsou, S. C. S. (1989). AVRDC Sweet Potato Improvement Program. Pages 107-118 in Sweet Potato Research and Development for Small Farmers. (eds.) Kenneth T Mackay, Manuel K. Paloma and Rolinda T Samico. Pub. SEAMEO – SEARCA. Philippines. 391pp.

Otoo, J. A. (1998) Second Inspection of Sweet Potato Varietal Release. Crop Research Institute. Kumasi.

Otoo, J. A., Missah A., Osei, C., Carson, A. G., Alhaassan A. Y., Taah, J. K., Frimpong-Manso, P. P., Asubonteng, K. O., and Ankoma, (1998). Performance of sweet potato in different agro-ecologies in Ghana. Trop. Agric. (Trinidad) 75 (1) 25-28.

Pardales J. R. Jr., Banoc D. M., Yamauchi A., Iijima M., and Esquibel C. B.(2000). The Effect of Fluctuations of Soil Moisture on Root Development During the Establishment Phase of Sweet Potato. Plant Production Science. 3(2): 134-139.

Plooy C. P. Du, Berg A. Van-Den, Hammes P. S., Holzhausen L. C., Du Plooy C. P., and Van-den-Berg A. (1992). Storage Root Formation at individual nodes of the Sweet Potato (Ipomea batatas (L.) Lam). South African Journal of plant and Soil 9 (3): 136-138.

Purseglove, J. W. 1987. Tropical Crops: Dicotyledons Vol. 1 and 2 combined. Longman Group Ltd., England. 719pp.

Rashid M. M. (1989). Indigenous Technologies and recent advances in sweet potato production, processing, utilization and marketing in Bangladesh. Pp 287-300 In Sweet potato research and development for small farmers. eds. Kenneth T Macay, Manuel K. Paloma and Rolinda T Samico. Pub. SEAMEO – SEARCA. Philippines. 391pp.

Ravi, V. (2000). Physiological Aspects of Tuber Crops. Pp 133-173 in Production Technology of Tuber Crops. Central Tuber Crops Research Institute. Sreekariyam, Thiruvananthapuram 695 017 Kerala, India.

Ravindran C. S. and Mohankumar C. R. (1989). Effect of Storage Life of Vines with and without Leaves on the Establishment and Tuber Yield of Sweet Potato. Journal of Root Crops. 15(2): 145-146

Rayment, G. E and Higginson, F. R (1992). Echangeable bases and CEC – 1M ammonium acetate at pH 7.0, pretreatment for soluble salts; manual leach. Pp 154-159. Australian Laboratory Handbook of Soil and Water, Chemical Methods. Inkata Press, Melbourne. Sydney.

Rice R. P., Rice L. W. and Tindall H. D. 1991. Fruit and Vegetable Production in Warm Countries. Macmillan Publishers Ltd. London and Basingstoke. 371pp.

Ruiz-Martinez L., Milian-Morales O., Portieles Rodriguez J. M., and Lameda-Morales M. (1992). Effect of Nitrogen Fertilizers on Quality and Production of Sweet Potato "Seed" and Their Effect on Tuber Yield. Agrotecnia de Cuba 24 (1): 75-80.

Satish Kumar; Gupta A. K., and Kumar S. (2000). Studies on Non-Refrigerated Storage of Potatoes. Journal of Research, Punjab Agricultural University. 36 (3-4), 242-251.

Saunders, W. M. H and Williams, E. G (1955). Laboratory Plant and Soil Analysis. Journal of Soil Science 6: 254.

Schultheis J. R.; Cantliffe D. J. and Bryan H. H. (1994). Early Plant Growth and Yield of Sweet Potato Grown from Seed, Vegetative Cuttings and Somatic Embryos. Journal of the American Society of Horticultural Science. 119 (5): 1104-1111.

Setijati S., Niniek W. S., Sakat D., and Roekmini S. (1981). Ipomoea batatas (L.). pp 68-69 in Root and Tuber Crops. IBPGR Secretariat. Rome. English version written by Made Sri Prana and Sarkat Danimihardja. (eds) Charles H. Lamoureux and Mien A. Rifai.

Sihachakr D., Haicour R., Cavalcante Alves J. M., Umboh I., Nzoghe D., Servaes A., and Ducreux G. (1997). Plant Regeneration in Sweet Potato (Ipomea batatas L., Convolvulaceae). Euphytica 96: 143-152.

Silva S. de-Oe, Souza A. da-s, and Paz-O. P. da. (1991). Effect of In-Vitro Vegetative Multiplication on the Yield of Sweet Potatoes (Ipomea batatas L. Lam.). Revista Brasieleira de Fisiologia Vegetal 3 (1): 47-52.

Sowa Niedzialkowska G. (2000). Influence of Storage Conditions of Seed Potatoes on Growth and Yield of Table Cultivars. In Proceedings of the Conference “Table and Food Processing Potato – Agro-technical and Storage Factors Conditioning Quality”. 2000, No. 213, 217-233.

Sowley, E. N. K. (1999). Etiology of Storage Rot of Sweet Potato (*Ipomoea batatas (L.) Lam*) and its Control by Curing. A thesis presented to the Department of Crop Science, University of Ghana Legon. 120pp.

Théberge L. R. (1985). Common African Pests and Diseases of Cassava, Yam, Sweet Potato and Cocoyam. 108 pages. International Institute of Tropical Agriculture Ibadan, Nigeria.

U. S. D. A. Soil Taxonomy System (Soil Survey Staff 1992). Keys to Soil Taxonomy: 5th ed. Soil Management Support Service, Tech. Monograph. No. 19. Pocahantas Press Inc. Blaasburg, Virginia, USA.

US Environmental Protection Agency (USEPA) (2002). The Use of Irradiation for Post- Harvest and Quarantine Commodity Control. URL:http://www.epa.gov/spdpublc/mbr/casestudies/volume2/irad2html

Villamayor F. G. Jr. (1988). Production and Evaluation of Cut Sprouts From Sweet Potato Roots. Philippine Journal of Crop Science 1988, 13: Supplement No.1, S4; In 4th Scientific Meeting of the Federation of Crop Science Societies of the Philippines, 1988.

Villamayor F. G. Jr. and Perez R. D. (1988). Effect of Time and Frequency of Topping on Storage Root and Cutting Production of a Bushy Sweet Potato Cultivar. Annals of Tropical Research. 1988, 10 (1): 26-36.

Walker H. O. (1957). Weather and Climate of Ghana. Ghana Meteorology Department Note 5 (1962) – Weather and Climate In Agriculture and Land Use in Ghana (ed) J. B. Wills Ch. 2 pp 7-50. London O. U. P.

Wang Lin Sheng, Li You Jun, Kong Xiang Sheng, (2000) Growth Analysis of Virus-Free Sweet Potato Xushu 18. Acta Agriculturae Shanghai. 16:2 54-56.

Wholey D. W., and Cook J. H., (1973). A rapid method for the propagation of cassava (*Manihot esculenta* Crantz). Pp 250-258 in Proceedings of the third Symposium of the International Society for Tropical Root Crops. Ed. Colin L. A. Leakey. IITA Ibadan, Nigeria.

Wilson L. G., Averre, C. W., and Covington, H. M. (1992). Sweet potato production, Handling, Curing, Storage and Marketing in North Carolina. Pp. 146-150 In Promotion of Root Crop Based Industries. Tropical Root Crops: Proceedings of the 4th Triennial Symposium, ISTRC – AB. M. O. Akoroda and O. B. Arene (ed.). IITA Ibadan, Nigeria.

Yamashita M. (2000). Nurturing of Plantlets Using Cut Pieces from the Storage Roots of Sweet Potatoes (Ipomea batatas (L.) Lam.) and their Productivity in the Field. Plant Production Science. 3(3): 259-267.

Yankey, J. A. K. 2001, Sweet potato grower, Jukwaa, Central Region of Ghana, Personal communication.

APPENDICES

APPENDIX 1: FIVE YEAR METEOROLOGICAL DATA FOR LEGON, ACCRA (1997-2002)

APPENDIX 1a. MEAN TOTAL RAINFALL FIGURES (MM) AND RAINDAYS (IN BRACKETS) FOR 1997-2002

YEAR	September	October	November	December	January	February	March	April
1996-97	27.9(7)	9.9(2)	7.2(2)	22.1(2)	1.8(1)	0(0)	138.9(11)	76.4(9)
1997-98	72.9(1)	83.3(10)	41(3)	74.6(4)	0(0)	42.9(1)	6.9(1)	24.5(2)
1998-99	23.5(6)	130(7)	6.9(3)	9.1(3)	39.4(3)	46.4(4)	17.2(2)	50.8(5)
1999-00	25.7(8)	69.3(8)	6.9(4)	12.7(4)	11.7(2)	0(0)	60.2(3)	21.4(4)
2000-01	5.5(3)	50.2(2)	28.2(2)	25.2(4)	0(0)	0.5(1)	57.1(8)	141(6)
2001-02	54.3(8)	43.3(4)	14.1(4)	9.7(3)	125.2(1)	29.8(3)	45(4)	136.8(7)

Source: Ghana Meteorological Services.

APPENDIX 1b. MEAN MONTHLY MAXIMUM TEMPERATURE (°C) FOR 1997-2002

YEAR	September	October	November	December	January	February	March	April
1996-97	28.9	31.4	32.8	32	32.7	34.3	32.3	31.5
1997-98	31.1	31.6	32.4	32.1	33.5	34.6	35	35.1
1998-99	30.7	31.4	32.9	33.3	32.6	33.7	33.9	33.4
1999-00	29.1	30.8	32.5	32.9	32.9	34.5	34.1	33.2
2000-01	30.4	32.3	32.7	32.8	33	34.3	38.2	32.7
2001-02	28.9	31.4	32.1	32.8	32.2	33.7	33.1	32.9

Source: Ghana Meteorological Services.

APPENDIX 1c. MEAN MONTHLY MINIMUM TEMPERATURE (°C) FOR 1997-2002

YEAR	September	October	November	December	January	February	March	April
1996-97	22.7	23.2	24	24	24.3	24.4	24.2	24.1
1997-98	23.5	23.8	24.1	23.9	22.1	25.4	26.3	25.4
1998-99	23.3	23.8	24.6	24.3	24.3	23.9	24.5	24.4
1999-00	22.8	23.3	23.9	24.3	24	23.8	25.4	24.8
2000-01	22.9	23.5	24.2	24.1	23.8	23.8	24.1	24.2
2001-02	22.3	23.4	24.1	24.7	23.1	24.1	24.5	24.4

Source: Ghana Meteorological Services.

APPENDIX .1d. MEAN MONTHLY RELATIVE HUMIDITY (%) AT 6:00 HOURS FOR 1997-2002

YEAR	September	October	November	December	January	February	March	April
1996-97	94	92	94	94	93	88	92	92
1997-98	92	94	94	92	88	92	91	90
1998-99	92	94	94	93	93	91	92	90
1999-00	95	93	94	93	91	87	91	90
2000-01	92	92	93	92	91	87	90	90
2001-02	93	93	93	95	90	88	91	91

Source: Ghana Meteorological Services.

APPENDIX 1e. MEAN MONTHLY RELATIVE HUMIDITY (%) AT 15:00 HOURS FOR 1997-2002

YEAR	September	October	November	December	January	February	March	April
1996-97	74	68	66	68	66	58	66	70
1997-98	69	68	68	70	54	62	64	63
1998-99	68	70	73	64	67	62	64	62
1999-00	73	71	67	60	62	48	59	61
2000-01	69	66	68	65	63	55	63	64
2001-02	74	70	67	67	59	61	64	67

Source: Ghana Meteorological Services.

APPENDIX 2: EXPERIMENT 1 (BARN STORAGE)

EFFECTS OF STORAGE PERIOD ON TUBERS

ANALYSIS OF VARIANCE TABLE

Sources of Variation	Df	MEAN SQUARES							
		Tuber Loss	Tuber Wt Loss	Tuber Cuts	Tuber Breakages	Tuber Sprouts	Tuber Rots	Tubers Shrivel	Insect Damage
Variety (A)	1	0.0003	156.1	312.48**	7.48	326.3	186.5	82.1	380.81**
Storage (B)	3	1.0384**	126.8**	26.42	44.44	4757.4**	2375.1**	7930.9**	945.76**
A x B	3	0.1201**	78.8	36.43	71.43	231	238.9	447.7	342.05**
Error	16	0.0064	359.9	29.59	80.14	366.3	179.7	250.5	43.55

** Significant at both 1% and 5% levels of probability

APPENDIX 3: EXPERIMENT 1 (FIELD)

EFFECTS OF PERIOD OF TUBER STORAGE ON VINE PRODUCTION – FIRST HARVEST

ANALYSIS OF VARIANCE TABLE

Sources of Variation	Df	MEAN SQUARES						
		# Of days to 50% sprouting	% Of tubers stored	# Of tubers planted	# Of days to first harvest	Total # of 30cm vines	# Of vines longer than 30cm + 2 nodes	Number of plants at harvest
Variety (A)	1	15.042	60.167	15.042	222.042	4873.500**	770.67**	1426.042*
Storage (B)	3	142.931**	7559.278**	1889.819**	1876.042**	10564.111**	899.39**	3649.486**
A x B	3	6.931	691.278**	172.819**	56.153	3142.278**	163.67	637.042
Error	16	6.583	48.500	12.125	101.458	540.417	56.99	227.625

* Significant at 5% level of probability

** Significant at both 1% and 5% levels of probability

APPENDIX 4: EXPERIMENT 1 (FIELD)

EFFECTS OF PERIOD OF TUBER STORAGE ON DRY MATTER PRODUCTION – FIRST HARVEST

ANALYSIS OF VARIANCE TABLE

Sources of Variation	Df	MEAN SQUARES		
		Leaf dry weight	Shoot dry weight	Total dry matter
Variety (A)	1	2.137	143.298*	180.431*
Storage (B)	3	18.062*	40.039	108.277
A x B	3	5.619	19.371	41.131
Error	16	4.821	17.653	37.304

* Significant at 5% level of probability

APPENDIX 5: EXPERIMENT 1 (FIELD)

EFFECTS OF PERIOD OF TUBER STORAGE ON VINE PRODUCTION – FINAL HARVEST

ANALYSIS OF VARIANCE TABLE

Sources of Variation	Df	MEAN SQUARES				
		# Of harvests	# Of 30cm apical vines	# Of 30cm middle vines	# Of 30cm basal vines	Total # of 30cm vines
Variety (A)	1	0.167	93987.650**	2296.148*	25.73	129286.760**
Storage (B)	3	13.500**	17825.851**	10581.750*	205.739	57476.734**
A x B	3	0.167	8179.461*	2080.480	100.430	18527.126
Error	16	0.167	2782.163	2545.780	64.805	11774.015

* Significant at 5% level of probability

** Significant at both 1% and 5% levels of probability

APPENDIX 6: EXPERIMENT 1 (FIELD)

EFFECTS OF PERIOD OF TUBER STORAGE ON VINE PRODUCTION – FINAL HARVEST

ANALYSIS OF VARIANCE TABLE

Sources of Variation	Df	MEAN SQUARES		
		% Apical vines	% Middle vines	% Basal vines
Variety (A)	1	3845.916**	2202.276**	227.619**
Storage (B)	3	799.131**	718.059**	4.970
A x B	3	38.066	8.894	18.693
Error	16	94.793	65.834	8.583

Significant at 5% level of probability

** Significant at both 1% and 5% levels of probability

APPENDIX 7: EXPERIMENT 1 (FIELD)

EFFECTS OF PERIOD OF TUBER STORAGE ON DRY MATTER PRODUCTION – FINAL HARVEST

ANALYSIS OF VARIANCE TABLE

Sources of Variation	Df	MEAN SQUARES		
		Leaf dry weight	Shoot dry weight	Total dry matter
Variety (A)	1	14.815*	82.981*	167.919**
Storage (B)	3	7.172	54.663*	99.422*
A x B	3	3.741	13.502	30.574
Error	16	2.305	13.304	26.030

* Significant at 5% level of probability

APPENDIX 8: EXPERIMENT 2 (FIELD)

EFFECT OF SPACING ON THE NUMBER OF SPROUTS PRODUCED

ANALYSIS OF VARIANCE TABLE

Sources of Variation	Df	MEAN SQUARES								
		# Of tubers planted	5 DAP	12 DAP	15 DAP	20 DAP	26 DAP	33 DAP	38 DAP	47 DAP
Variety (A)	1	1.500	0.375	1148.167*	1040.167*	513.375	322.667	228.167	216.000	192.667
Spacing (B)	2	451.500**	0.125	497.792	642.792	827.542*	1229.292*	1012.875*	1287.875*	1250.042*
A x B	2	1.500	0.125	280.292	206.792	99.125	113.042	82.542	90.125	72.042
Error	18	1.500	0.208	177.528	230.778	214.625	230.917	200.500	250.472	248.917

* Significant at 5% level of probability

** Significant at both 1% and 5% levels of probability

APPENDIX 9: EXPERIMENT 2 (FIELD)
EFFECT OF SPACING ON THE NUMBER OF SPROUTS LONGER THAN 30CM
ANALYSIS OF VARIANCE

Sources of Variation	Df	MEAN SQUARES			
		47DAP	62DAP	70DAP	77DAP
Variety (A)	1	135.375*	108.375	104.167	60.167
Spacing (B)	2	72.667*	81.500	94.792	150.125
A x B	2	6.000	0.500	37.042	58.042
Error	18	19.958	23.681	37.750	56.556

* Significant at 5% level of probability

APPENDIX 10: EXPERIMENT 2 (FIELD)
EFFECT OF SPACING ON THE NUMBER OF VINES PRODUCED
ANALYSIS OF VARIANCE

Sources of Variation	Df	MEAN SQUARES				
		Total plant harvest	Total vines produced	Apical 30cm vines	Middle 30cm vines	Basal 30cm vines
Variety (A)	1	15.042	79120.167**	31901.042**	6834.375**	442.042**
Spacing (B)	2	162.375	3969.042	147.042	2222.167*	16.625
A x B	2	31.792	998.292	302.792	435.500	10.042
Error	18	82.347	2015.278	342.069	582.736	37.014

* Significant at 5% level of probability
** Significant at both 1% and 5% levels of probability

APPENDIX 11: EXPERIMENT 2 (FIELD)

EFFECT OF SPACING ON THE % APICAL, MIDDLE, AND BASAL VINE PRPDUCTION

ANALYSIS OF VARIANCE TABLE

Sources of Variation	Df	MEAN SQUARES		
		% Apical vines	% Middle vines	%Basal vines
Variety (A)	1	4671.716**	2716.392**	245.818**
Spacing (B)	2	157.036	242.174*	10.920
A x B	2	27.798	78.203	19.328
Error	18	73.971	64.170	12.009

** Significant at both 1% and 5% levels of probability

APPENDIX 12: EXPERIMENT 2 (FIELD)

EFFECT OF SPACING ON THE DRY MATTER PRPDUCTION

ANALYSIS OF VARIANCE TABLE

Sources of Variation	Df	MEAN SQUARES		
		Mean leaf dry weight	Mean stem dry weight	Mean total dry weight
Variety (A)	1	90.04**	546.501**	1080.203**
Spacing (B)	2	1.320	18.899	22.211
A x B	2	0.962	15.046	22.949
Error	18	3.564	19.682	35.181

** Significant at both 1% and 5% levels of probability

APPENDIX 13: EXPERIMENT 3 - INITIAL HARVEST

EFFECT OF TIME OF INITIATION OF MULTIPLICATION OF PLANTING MATERIAL ON VINE PRODUCTION

ANALYSIS OF VARIANCE TABLE

Sources of Variation	Df	MEAN SQUARES					
		Number of plants harvested	Total harvest	Number of 30 cm vines	Mean leaf dry weight	Stem dry weight	Total dry weight
Variety A)	1	182.250**	182.25**	69696.00**	168.39**	1974.143**	3295.602**
Storage B)	5	8.361	8.361	11022.044*	79.69**	232.685**	529.642**
A x B	5	3.383	3.383	10268.00*	32.48**	99.803	209.724
Error	24	4.306	4.306	3483.139	9.606	60.619	110.462

* Significant at 5% level of probability

** Significant at both 1% and 5% levels of probability

APPENDIX 14: EXPERIMENT 3 - FINAL HARVEST

EFFECT OF TIME OF INITIATION OF MULTIPLICATION OF PLANTING MATERIAL ON VINE PRODUCTION

ANALYSIS OF VARIANCE

Sources of Variation	Df	MEAN SQUARES			
		Total vines produced	Apical 30 cm vines	Middle 30 cm vines	Basal 30 cm vines
Variety (A)	1	508351.095**	494954.559**	48.215*	6.318*
Harvest (B)	5	338148.061**	166869.063**	42319**	746.238
A x B	5	21635.744	17045.524	4575	169.139
Error	24	26065.438	10189.701	4757	265.886

* Significant at 5% level of probability

** Significant at both 1% and 5% levels of probability

APPENDIX 15: EXPERIMENT 3 - FINAL HARVEST

EFFECT OF TIME OF INITIATION OF MULTIPLICATION OF PLANTING MATERIAL ON VINE PRODUCTION

ANALYSIS OF VARIANCE

Sources of Variation	Df	MEAN SQUARES		
		Percent apical vines	Percent middle vines	Percent basal vines
Variety (A)	1	4431.50**	2879.293**	166.681**
Harvest (B)	5	1917.285**	1078.980**	196.069**
A x B	5	58.379	52.506	6.529
Error	24	65.665	47.020	12.269

* Significant at 5% level of probability

** Significant at both 1% and 5% levels of probability

APPENDIX 16: EXPERIMENT 3 FINAL HARVEST

EFFECT OF TIME OF INITIATION OF MULTIPLICATION OF PLANTING MATERIAL ON THE DRY MATTER PRPDUCTION

ANALYSIS OF VARIANCE

Sources of Variation	Df	MEAN SQUARES		
		Mean leaf dry weight	Mean stem dry weight	Mean total dry weight
Variety (A)	1	19.817**	199.713**	345.353**
Harvest (B)	5	16.112**	129.421**	232.502**
A x B	5	4.770**	44.349**	77.641**
Error	24	1.160	5.892	11.415

* Significant at 5% level of probability

** Significant at both 1% and 5% levels of probability