EVALUATION OF YAM VARIETAL RESPONSE TO VINE MULTIPLICATION TECHNIQUE UNDER THREE GROWTH MEDIA

BY

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B.Sc. Agriculture (Hons.)

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EVALUATION OF YAM VARIETAL RESPONSE TO VINE

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MEDIA

A thesis submitted to the School of Graduate Studies, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, in partial fulfillment of the requirement for the award of MPhil. AGRONOMY DEGREE.

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(B.Sc. Agriculture)

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DECLARATION

I hereby declare that this research work presented in this thesis is my own work and that, to the best of my knowledge, it contains no material previously published by another person for the award of a degree in any other University, except where acknowledgement has been made in the text.

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ABSTRACT

A field trial was conducted at the CSIR-Crops Research Institute (CRI) experimental fields; Fumesua to identify the appropriate soil medium which best conserves soil nutrients and water for rapid growth and multiplication of seed yams. The experiment was a pot experiment, a 4 x 3 factorial design, and treatments were arranged in a Complete Randomized Design with three replications. The treatments consisted of four yam varieties; *Mankrong Pona, Dente, Kukrupa and CRI Pona* and three different soil media which were: blacksoil, blacksoil (5 parts): carbonized rice husk (3 parts) mixture and blacksoil (5 parts): sawdust (3 parts). This study was designed to evaluate the rooting and tuberization (mini tubers) potentials of vine cuttings of four yam varieties. Vine cuttings from 120 days old plants were collected from the yam varieties for root formation. Two nodes leafy vine cuttings were prepared and planted. The parameters measured were: percentage sprouting, percentage vine establishment, vine length, percentage root formation, mini tuber weight and number of mini tubers. Percentage sprouting in blacksoil/carbonized rice husk was significantly higher ($P < 0.05$) than all other soil treatments effects and *Dente* varietal effect was significantly higher than all other varietal effects. Percentage vine establishment was significantly higher in the blacksoil/carbonized rice husk media and higher percentage vine establishment was recorded in *Dente* variety. The study also revealed that the highest rooting of vines was in blacksoil/carbonized rice husk which was significantly higher than all other treatment effects and the poorest rooting was in blacksoil/sawdust mixture. Among the yam varieties, rooting in *Dente* was significantly higher than all the other varieties. The greatest number of tubers was in blacksoil/carbonized rice husk, and this was significantly higher than the other media effects. The *Dente* variety produced also the greatest number of mini tubers as well as tuber weight than all the other varieties. The weight of mini tubers in blacksoil/carbonized rice husk treatment effects was significantly greater than the others. The results indicated that the *Dente* variety showed the greatest response to the vine multiplication technology and the blacksoil/carbonized rice husk mixture was the most supporting medium.

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CHAPTER ONE

1.0 INTRODUCTION

1.1.BACKGROUND

Yams are predominantly cultivated in the humid forest, forest savanna transition and the southern guinea savanna (SGS) zones of West Africa. Large percentages of current production are in the SGS (Scott *et al*., 2006). Yams are usually made into various food items, recipes and confectionary according to individuals' preference or needs. It is an ancient crop in central West Africa and provides a promising avenue for alleviating the current food crises.

Worldwide yam production in 2007 amounted to 52 million tons, of which Africa produced 96%. Most of the world's production comes from West Africa representing 94%, with Nigeria alone producing 71%, equaling more than 37 million tons. Yam production is declining in some traditional producing areas due to declining soil fertility, increasing pest pressures and the high cost of labor.

Agriculture in Africa is also beset by the limited use of good quality planting materials. Planting materials are the basic unit of crop production and as such they are the most crucial input in agricultural production. Good quality planting materials usage and matching applications of other simple agricultural technologies can lead to doubling of current crop yields in Africa and ensure food security.

Limited availability and cost of planting materials are major constraints to yam production in Africa. Planting materials account for about 50% of the cost of the production. Large amounts of material (about 10,000 seed yams) are needed to plant 1 hectare. If farmers do not buy new seed yams, they must set aside about 30% of their harvest for the next year planting (Kambaska *et al*., 2009). In addition, seed yams are bulky and perish quickly.

In most tropical countries, food yams are propagated vegetatively by planting small whole tubers or pieces cut from large tubers. This means that some marketable tubers must be reserved for planting. This method competes with yam availability for human consumption and at the same time makes the cultivation expensive for large scale production. The cost of planting material is about 50% of the total outlay for yam production, so there is a need to improve the rate of yam multiplication. As a result of difficulties in propagation, yam is under threat in many traditional areas of production.

The yam mini sett technique which involves the cutting of whole tubers to small pieces (50g) has brought some relief to yam growers in obtaining more seed yam. In spite of this, additional technology called the Vine Multiplication Technique has been proposed as an alternative to quickly multiply seed yams for cultivation. The Vine Multiplication Technique is a newly developed technique introduced by Council for Scientific and Industrial Research-Crops Research Institute of propagating yam seeds through Vine Cuttings. It was developed in partnership with and introduced to farmers since 2008. Yam being a vital crop in Ghana both at the domestic and export markets contributes about 17 % of agricultural gross domestic product (GDP) and plays a major function in household food security with more than 2 million tons harvested each year.

In Ghana, of all tuber crops, yam is the most preferred and the second most widely cultivated, after cassava. Yams are highly desired by consumers in the European and American markets, especially in communities with large numbers of West Africans and

Caribbeans. The largest number of yams is exported to England. Neighboring countries such as Nigeria, Togo and Benin that produce yam also represent a potential market for seed yam. Like Ghana, these countries do not produce seed yam on a commercial scale and could benefit from increased access to seed yam and increased production of yam for export and domestic consumption.

Despite the important role of yam in the economy of Ghana as source of food and job creation, as much as 30 % of the previous harvest that should have been sold for income or eaten is reserved for planting in the succeeding cropping season. This shows how farmers are constrained in terms of availability and cost of planting materials. The seed system of yam in Ghana include; the traditional system where the yams are milked after the first six months of planting and plants left intact in the soil to allow for the formation of setts to be used for planting in the next season. The harvested yams are often physiologically immature and have short shelf life.

This study was therefore conducted to identify the appropriate soil medium which best conserves soil nutrients and water for rapid growth and multiplication of seed yams.

The specific objectives were to:

I. identify the appropriate medium that gives higher percentage of surviving yam shoots and mini tubers.

II. identify yam variety that offers the highest shoots and yield from the vine multiplication technique

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Distribution of yam

Yam belongs to the genus *Dioscorea*, which produces edible tubers. It is a monocot, despite occasional evidence of a second cotyledon (Lawton and Lawton, 1969). Various species of food yams are cultivated in the tropics and sub-tropics (IITA, 1992). The six most economically important species grown as staple foods in Africa are *D. rotundata* Poir (white guinea yam), *D. cayenensis* Lam (yellow yam*)*, *D. alata* L (water yam), D. *dumentorum* (Kunth) Pax (bitter yam) *D. bulbifera* L (aerial yam) and *D. esculenta* (Chinese yam) (Onwueme, 1978). These six species constitute over 90% of the food yams produced in the tropics (Hahn *et al*. 1987). In West Africa, man began to gather yams for domestic use as early as 5000 BC, i.e. during the Paleolithic era (Davies, 1967). Agricultural archaeologists estimate that true yam-based agriculture started in West Africa approximately 3000 BC, as in South East Asia (Alexander and Coursey, 1969; Coursey, 1967; Davies, 1967).

The occurrence of large number of cultivars of *D. rotundata* arising from thousands of years of domestication and culture of this species in eastern Nigeria (Uzozie, 1971; Coursey, 1976), lends support to the belief that *D. rotundata* is native to Nigeria, with its most probable place of origin at the eastern banks of the River Niger where it is the most preferred food crop (Hahn *et al*., 1987; Orkwor, 1992). In Nigeria *D. alata* comes second to *D. rotundata* in production and consumption. In West Indies, Papua New Guinea and

New Caledonia, *D. alata* is the major food yam grown and consumed by the people. Similarly, African food yams *D. rotundata* and *D. cayenensis* are widely grown in the Caribbean (Hahn *et al*., 1987). West Africa is believed to be the home of yams due to the fact that more yams are produced and consumed in this sub-region especially Nigeria. Clearly yams are produced and eaten in three continents: Africa, Asia and South America especially North Eastern parts of Brazil and the Caribbean Islands and South Pacific. *D. esculenta* (Chinese yam) has its origin in Indo-china. Chinese farmers have the longest production culture, dating back eighteen centuries. It is an important food in South East Asia; Indonesia, the Philippines and in the South Pacific Islands down to New Guinea

The aerial yam *D. bulbifera* originated both in Africa and Asia and spread to the other parts of the world. Nigeria alone accounts for 69% of world yam hectare and 78% of world production (Onwueme, 1977). The spread of yam, particularly *D. alata* from South-East Asia to Africa (Hahn *et al*., 1987) is believed to have occurred by the intervention of early agriculturalists and more recently by Portuguese and Spanish seafarers (east-west movement). Although there is an extensive cultivation and use of *D. alata* in the West Indies, these cultivars appear to have arrived in the West Indies from Africa. The African species, *D. rotundata* and *D. cayenensis* were taken westward to America and have now become important food crops in South and Central America and the Caribbean (Hahn *et al.,* 1987). The Niger and Benue river belts in Nigeria have the largest genetic base of cultivated *D. rotundata*. The *D. rotundata* is, however, cultivated in the West Africa zone/belt which stretches from west of the Cameroon mountains to the Bandama river in central Cote d'Ivoire (Coursey 1967, 1976, Hahn *et al.*,1987). This yam zone comprising

Nigeria, the Republic of Benin, Togo, Ghana, Cameroon and Cote d'Ivoire produces about 95% of the total world yam production estimated at 30.2 million metric tonnes in 1997 (Table 1) (FAO, 1998). Currently, the Asiatic yams, especially *D. alata* and *D. esculenta* are distributed widely in Africa. *D. alata* is now a major staple food in Cote d'Ivoire where it constitutes 65% of the yams grown in the country (IITA 1995).

In Ghana, the yam-growing belt is very narrowly delimited within the derived savannah area. The most important areas where yams are grown commercially are Berekum-Wenchi districts, covering Banda, Techiman, Kintampo, Nkoranza and Atebubu districts in BrongAhafo region; Northern Ashanti (Mampong and Ejura districts); Gonja and Dagomba districts; Bimbila in the Northern region; Mankessim and Bawjiase in the Central region; Asesewa in the Eastern region and Karachi, Kpando, Dambai and Nkwanta in the Volta region (Owusu and Ofori, 1969).

2.1.1 Cultivars grown in Ghana

Species predominantly grown Ghana are the white yams *D. rotundata*, Bulbil bearing yams (*D. bulbifera*), yellow yam (*D. cayenensis)* and *D. alata* (Irving 1969).

The cultivars grown have significant differences that separate them into varieties. These cultivars have local names in northern Ghana, some of which are "*Laribakor", "Pona", "Dundubanza*", "Chenchito", "Sola" and "Tantapurika" (Kuma *et al,* 1979). In southern Ghana, these same varieties are called "*Bayere fufuo*" (Twi); "*Yele*" (Ga) ; "*Ete*" (Ewe); and "*Etwo*" (Fante).

2.1.2 Characteristics of varieties grown and ecological requirements

D. rotundata is suited to the environmental conditions of northern Ghana, characterized by light sandy soils in the transitional or derived savannah vegetation zones. The plant takes about eight months to mature. The stems and leaves are hairless. The skin of tuber is smooth and brown, while the flesh is usually white and firm. The cultivar, *D. alata*, which is more fibrous, coarser and poorer in quality than the white and yellow yams, produces large late maturing tubers. These tubers are not poundable into fufu because of its high water content.

The tubers appear soft, and drops of water appear on the surface when cut, hence the name "water yam" (Irving, 1969). This species which is locally known as "*Afasew*" (Twi) matures in about eight to ten months (Doku, 1966).

The yellow yam, *D. cayenensis,* in many respects, is similar to the white yam except that it produces yellow flesh tubers which are poorer in quality than the white yams and do not store well. The yellow colour of its flesh gives it its common name, "yellow yam" although variants, which are almost white in colour, do occur. This yellow colour is due to the presence of carotenoids (Onwueme, 1982). The tuber skin is firmer and less extensively grooved than that of *D. rotundata*. The corm at the head of the tuber is also massive. Physiologically, *D. cayenensis* differs from *D. rotundata* in having a shorter period of dormancy and a longer growing season. Thus it can only be grown in areas where the rainy season is slightly longer than the minimum required for *D. rotundata*. It takes about twelve months to grow and mature. This species of yam will grow for as long as three years if they are continually milked. Yellow yam is locally known by different names such as "Afunu"

(Twi); "Esiem" (Fante); "Nkani" (Akuapem). (Akoto and Safo Kantanka, 1987).

2. 2 Importance of Yams

The importance of yams is in the excellent eating quality of the tubers. Food prepared from yam is always preferred at social gatherings. Yams are excellent sources of carbohydrate energy. They provide 200 dietary calories per day to over 60 million people. They are also relatively nutritious, providing some vitamins (including vitamin C), minerals and dietary protein (Bradbury and Holloway, 1988). Virtually, all of the world's yam production is used as food in contrast to other root crops e.g. cassava and sweet potato, which are also used for livestock feed. A consequence of the popularity of yam as food is that farmers always have considerable confidence that cash income can be obtained from yams, in addition to direct use by the family.

Additionally, yams play a significant role in African socio-cultural traditions. This role is not unique to West Africa. In various parts of Oceania, similar ceremonies and customs involving yams are an integral part of yam production. Notable in West Africa is that, the commercial importance of the crop has not eroded its traditional status. This co-existence of traditional food security and food business with respect to yam production illustrates that the strength of the long-standing tradition does not impede the realisation of changes that relate to the crop's commercial value. An example is the widespread marketing of yam tubers which are easy to handle, transport, and sell because price per tuber suites a wider range of potential buyers. Alongside this; the production of very large tubers for ceremonial purposes continues (Quin, 1998).

2. 3. 0 Uses of yam

The uses of yams can be categorised into alimentary and non-alimentary and industrial uses.

2. 3. 1 *Alimentary uses*

The food value is based on the carbohydrate, protein, amino acids, vitamin and mineral content of the tuber (Degras, 1993). Based on this, different food preparations are made in combination with other foods.

In Guyana, cultivars whose tubers contain anthocyanin are used to prepare beer (Grenand, 1980). In the Philippines, the most popular preparation is ice cream made with purple *D. alata* in addition to "guinatan" jellies and yam based candies. In their wild state, the *Dioscorea* are part of the diet of omnivorous and vegetarian burrowers of the humid tropics. Yam peels are more commonly used today to feed livestock on family-run farms. Yam can also be processed into flour, crisp, chips or cubes and flakes in addition to common

"ampesi" and "fufu", a traditional preparation of elastic, jellified, very dense paste that is obtained using pestle and mortar (Onyia *et al.*, 1987).

2. 3. 2 *Non-alimentary uses*

The direct role of the yam as food is paradoxically completed by the use of its toxic products for hunting (Coursey, 1967). Wild species like *D. dragena*, *D. rupicola* and *D. piscatorum* are used for arrow poisoning and bait. The alkaloids, saponins that they contain have convulsive, paralysing or haemolytic effects. Certain yams are also used in human toxicology, such as an ordeal poison in criminal poisoning. Chevalier (1963), mentioned *D. latifolia var contralatrones* as a type of repellent in plots of edible homomorphic cultivars. The toxicological properties of some yams used as insecticides for example, are comparable to those of rotenone. For example, *D. piscatorum* is used to protect rice in Malaysia and *D. deltoidea* is used for producing anti-lice shampoos in India (Coursey, 1967). Yam contains hormone diosgenin and has therefore become the predominant source for birth control pills (Crabbe, 1979).

2.4.0. Seed yam production techniques

Seed yam refers to the planting material derived from the tuber. It could be a small whole tuber with weight ranging from 15g to 95g (mini tuber); a tuber ranging from 150 to 250g (normal seed yam) or a tuber weighing 500g to 1000g (large seed yam for the production of ceremonial large tubers (5 -10kg and above) or even cut setts of whole tubers. A major constraint in yam production has been the requirement of large quantities of planting materials on a per hectare basis. As many as 10,000 normal seed yams are required to plant one hectare, in order to produce an economic quantity of ware yams. The scarcity and high cost of purchasing seed yams aggravates this problem, hence the need to improve seed yam production techniques.

2. 4. 1 Traditional methods of seed yam production

Traditionally, the farmer sets aside as much as 30% of the harvest, usually small sized tubers (200g to 1000g) as seed yams for the next cropping season. It has been estimated that planting materials constitutes over 33% of the cost out-lay in yam production. This limits the size of yam farms under the traditional cropping methods. Another method involves cutting up an average sized seed yam into setts of about 80g to 100g (Orkwor, *et al*., 1998).

2. 4. 2. Improved methods of seed yam production

2. 4. 2. 1 *Partial Sectioning Technique*

Nwosu (1975) introduced this partial sectioning technique at National Root Crops Research

Institute (NRCRI), Umudike, Nigeria as follows. An average sized seed yam of 300g to 400g is selected and decapitated to remove the apical dominance. The tuber is sectioned into partially cut setts using incisions that are 1cm deep to mark out sett areas of 3cm x 3cm on the tuber. The sectioning is first done longitudinally and then horizontally. The sectioned tuber is buried whole in a fertile soil, compost mixture or moist sawdust. The incision parts will sprout with vigorous roots arising from the base of the sprouting points. The sprouted sections are cut out from the sprouted body and planted in the field. The unsprouted sections are reburied until they sprout. Though tedious, this technique doubles the multiplication rate to 1:10 over the traditional rate of 1: 5. However, it is labor intensive since it requires considerable manpower for the repeated examining and digging out of tubers to excise sprouted sections for transplanting in the field. The seedlings thus sprouted are delicate and require careful handling, a method best suited for research stations.

2. 4. 2. 2 *Minisett and microsett techniques*

At the National Root Crop Research Institute, (NRCRI) Umudike successfully developed the yam minisett technology for rapid, high volume seed yam production (Okoli *et al.*, 1982). It involves the use of 25g sett sizes and it is an appropriation of the Anambra State traditional farmer's sett production method. Accompanying this technology was the development of a yam minisett dust, made up of fungicide, nematicide and insecticides for treating cut setts before planting to protect them from soil borne diseases. This technology has not only increased the multiplication ratio in seed yam production to 1:30, but has reduced the cost of seed yam production. The minisett technology has been found to be economically viable (Ezeh, 1991) and is being widely adopted across the yam belt of West Africa. This technique has also spread to the West Indies. The microsett technique, which is a modification of the minisett technique and introduced by Alvarez and Halm (1992) at IITA, involves the use of 2 - 10g setts, comprising two setts classes (2 - 5g and 5 - 10g). As reported by many workers, the minisetts and microsetts are pre-sprouted (a recommendation from IITA) prior to field transplanting.

Otoo (1984) reported minisett technique as a method for seed yam production which exploits the fact that yam tubers produce sprouts from almost any point on the yam surface. Other efforts at producing seed yams in large quantities and cheaply include the use of vine cuttings (Njoku, 1963), milking (Okigbo and Ibe, 1973), segmentation (Okoli, 1978), use of true seeds (Sadik and Okereke, 1975), the Anambra state method (Bachman and Winch, 1979) and leaf cutting method (Nwosu, 1975).

2. 4. 2. 3 *Vine cuttings*

Njoku (1963) reported a method of producing yams using vegetative vine cuttings. This method exploits the use of vine cuttings planted in a suitable media. He stated that the method is however suitable for cleaning yams of tuber borne disease pathogens such as nematodes. Nwosu (1975) reported that previous experimentation in Nigeria had established conclusively that stem cuttings of edible *Dioscorea spp*. could be rooted, but the experiments were not carried beyond that stage until recently.

Mantell *et al* (1979) in their attempt to find rapid propagation systems for yam, described the rooting vine cuttings of *D. alata* and *D. rotundata* under mist or in water. However, they stated that not all rooted cuttings produce new shoot growth, which is required for satisfactory level of tuber production.

2. 4. 2. 4 *Leaf cutting method*

Nwosu (1975) reported another development in stem propagation of yam, which was the leaf cutting method. He stated clearly that the procedure is as in vine propagation method except that here the vine is cut up into pieces 2.5 - 3.0 cm long, each bearing a pair of mature leaves and buds. He further stated that this exploratory experiment was done merely to establish possibilities.

2.4. 2.5 *Use of vine cuttings*

Njoku (1963) had shown that small tubers of white yam could be obtained by planting vines of yam in a suitable media. This method was used in NRCRI to produce small tubers weighing 5-15g in the green house without the use of growth hormones. Larger tubers of up to 3kg were obtained when these small tubers were planted. This method was constrained by the number of branch vines of the yam plant that could be chipped for rooting early enough in the season without adversely affecting the growth of the mother plant. It is also tedious and produces small tubers.

Although this method is yet to be perfected, it seems promising. Akoroda and Okonmah (1982) showed that parent plants could be set aside from which vine cuttings could be repeatedly obtained.

2.4.2.6 *Sprouted tuber segment method*

Okoli *et al* (1982) developed the segmentation method in NRCRI to obtain several planting materials from one tuber of yam. Up to 64 segments were obtained from one tuber and up to 28 sprouts appeared at one time on one segment tuber. When sprout-bearing segments were carved out and transplanted and the tuber replaced in the sprouting medium, sprouts emerged from the remaining segments on the tuber. Each of the transplanted segments had thick vigorous vine while on the main tuber, the reverse become true when it is detached from the mother apparently due to reduced quantity of food resources. Seed tubers weighing up to 500g were produced out of this method. This method was once thought to solve the scarcity of planting materials of yams but the careful excision of segments and the need to return tubers to the sprouting medium to allow more sprouts to develop restricted the practical use of the segmentation method for producing seed tubers.

This was recently confirmed by a team of investigators sponsored by National Agricultural Research Project (NARP) in 1998, Anuebunwa *et al*, (1998) findings showed that farmers preferred cropping larger setts than the recommended 25g. NARP became concerned about this feedback and asked NRCRI to modify the yam minisett technique so as to enhance farmer adoption. Root and Tuber Improvement Programme (RTIP) dealing with resource poor farmers in year 2000 also showed concern and asked for the same improvement on the technique. Work started in 2000 to modify the yam minisett technology and the focus this time was finding the type of mother yam to enhance the minisett technology.

2. 5. 0 The sprouting process

Sprouting is a very active and energy demanding physiological process. The sprouted tuber loses a lot of dry matter and moisture, and continues to deteriorate as the vine grows. Therefore, long shelf life of healthy yam tubers could be achieved if sprouting process is delayed by prolonging dormancy (Orkwor and Ekanayake, 1998).

A yam tuber if cut into setts is capable of sprouting from many points of the peel of the tuber starting from the head region followed by the tail. Sprouting from fleshy tissue is usually delayed, due to the time required for new bud formation. Sprouting in most cultivated clones of *D. rotundata* and *D. cayensis* starts through the growth of single bud at the apex due to apical dominance. The middle section comes third in order of sprouting ability (Miege, 1957; Coursey, 1967). The process of sprouting in budless tuber pieces of yam begins with active cell division by meristematic cell just beneath the tuber surface.

This mass of cells soon becomes organized and a shoot apex becomes differentiated within it, which pushes through the tuber skin to form a vine. The point of sprout is normally whitish and delicate after which a purplish or whitish or cream colour, depending on the cultivar, appears on the young vine. This also grows a curved scale-leaf that eventually develops into a protective structure. The scale-leaf stimulates the sequence of events involved in the formation of subsequent leaves. This whole process occurs within 1 – 2 weeks (Onwueme, 1973).

2. 5. 1 Factors affecting the sprouting of yam tubers

2. 5. 1. 1 Physiological age

Onwueme (1975) stated that the readiness with which a yam tuber sprouts and for that matter a minisett sprouts depends on the physiological age of the tuber. In other words, it depends on how long the tuber has stayed in the soil or harvested. Tubers harvested at the same time and planted at different times will have the earlier plantings requiring a very long time to sprout, while progressively later plantings will require relatively shorter time to sprout.

2. 5. 1. 2 *Quality of tuber*

Any bruises or cut on the tuber at harvest may render it liable to infestation by microorganisms such as fungi and bacteria which can cause wet or dry rot. Nematodes (*Scutellonema spp*. and *Melodogyne spp*.) which infest tubers in the field before harvest and can subsequently affect sprouting (Otoo, 1984).

2. 5. 1. 3. Temperature

Temperature is known to affect sprouting in yam. The optimum temperature for tuber sprouting is between 25°C and 30°C. Any appreciable change more than 5°C below or above this range delays sprouting (Onwueme, 1975). This explains the significance of mulching the mounds or ridges after sowing or planting during hot season.

2. 5. 1. 4. *Dormancy*

This is physiological resting period of yam during which sprouting is suppressed (Coursey, 1967). Tuber dormancy is important in cultivation. When the yam tuber is dormant it becomes resistant to pathogen attack, and if undamaged, will survive through the dry season. Dormancy also ensures continued food supply. But once dormancy has ended, tubers become more susceptible to pathogen attack (Passam and Noon, 1977), and nutrients in the tuber are mobilized for vine growth, reducing quality of the tuber as a food source. The ability to break yam dormancy early and to provide uniform sprouting times will enable farmers to grow two crops of early maturing varieties a year in environments with long growing seasons. Dormancy is not unusual in plants but in yam it is unusual in its duration from 28 days to 180 days depending on the species, and the average duration being 75-100 days. *D. cayenensis*, a species of the West African forest zone where the dry season is very short, has almost continuous vegetative growth. *D. elephantiphes*, at the other extreme, spends most of the year dormant, as it is a native of the semi-desert regions. *D. alata* and *D. rotundata*, the principal cropped species are between these extremes with considerable differences between species.

Yam after harvest has high respiration rates throughout the tuber especially at the tail since it is the most recently formed tissue. The respiration rate falls rapidly and immediately before dormancy break. The head region has the highest rate during dormancy. Dry matter is lost due to respiratory activity and respiratory rates decreases with temperature (Passam *et al*., 1978; Passam and Noon, 1977). However, temperatures below 13°C result in chilling injury (Coursey, 1967).

Moisture loss also occurs during dormancy, perhaps around 10%. These authors also showed that in 150 days, storage at 24-28°C and at 70-90% relative humidity, crude protein and starch levels fell, as did the vitamin C content.

2. 5. 1. 5. *Soil Moisture*

Lack of soil moisture does not affect the rate of bud formation or sprout on the tuber but the subsequent elongation of the bud is slowed by moisture stress. Tubers have long been known to sprout while in storage or on the shelf. Onwueme (1976) reported also that setts planted in dry sawdust, dry soil and on dry paper sprouted as readily as moistened setts. However, setts that sprouted under dry conditions tended to produce several more sprouting loci than those sprouted in moist media. Onwueme's work also indicated that the buds produced by setts under dry conditions remained relatively un-elongated, unless moisture was supplied. Apparently the yam tuber, with its high moisture content requires no further hydration for sprouting to occur. Moisture needed for the process is supplied endogenously as reported by Onwueme (1976).

2. 5 .1. 6. Soil drainage

Onwueme (1982) reported that yams cannot tolerate water logging to any appreciable extent and it is therefore imperative that the soil be well drained. Poorly drained soils and the resultant water logging cause the roots to be poorly aerated and may result in tuber rot.

2. 5. 1. 7. Oxygen

Onwueme (1982) reported that sprouting of yam setts require ample supply of oxygen. The germination (sprouting) was a process related to living cells and required an expenditure of energy by these cells by the process of oxidation. It involves an exchange of gases – output of carbon dioxide and also the uptake of oxygen for respiration. Lack of oxygen results in anaerobic respiration and metabolic processes will be depressed (Osei-Akoto and Sarfo- Kantanka (1987).

2.6.1 *Carbonized rice husk (CRH)*

Now, rice husk can be carbonized to become an extra source of income. Biomass experts at PhilRice perfected the process and were able to develop low-cost equipment for rice hull carbonization. They now train interested individuals and farmer-groups in making quality carbonized rice hull (CRH) not just for local use, but also for export. The first recorded export of CRH to Japan was made by Organic Farmers Unit Association, Inc. (OFUAI) of Balbalungao, Lupao, Nueva Ecija. This venture gave them a gross income of PhP45, 000 in a month. This was made possible through the technical expertise of PhilRice, the assistance of NGO-partner, the Philippine Rural Reconstruction Movement (PRRM), and a private company, AIM Trading Corporation, as the main exporter of quality CRH.

Positive yield as well as biomass responses resulting from biochar applications were reported repeatedly and attributed to various mechanisms, including the benefit from direct nutrient additions, improved nutrient availability, increased nutrient retention through higher exchange capacity, improved soil physical characteristics, and positive effects on soil microorganisms (Lehmann and Rondon, 2006; Glaser *et al.*, 2002). However, most of these studies were conducted for non-rice crops and most of them used biochar produced from wood. Positive effects of applied biochar from wood on a rice crop (single rice crop planted after clearing secondary forest, mostly aerobic soil conditions) were reported by Steiner *et al.* (2007), but limited beneficial effects were found in a permanent upland rice field by Asai *et al.* (2009).

Even fewer studies are available on the use of CRH. CRH have been used traditionally in Japan, but mostly as a cover material for rice nurseries and as a soil amendment in home gardens (Haefele *et al.*, 2009). In recent years, a number of reports described the production and use of CRH but hardly any research studies on this topic were published and only gray literature reports are available (e.g., FFTC, 2001, 2007; PhilRice, 2002). Haefele *et al.*, (2011) reported that at IRRI, which was the site with the most fertile soil and full irrigation, CRH application rather decreased rice yields, especially in the first few seasons after application. In Siniloan, no significant effect on yield was observed but the treatments with RH and CRH application yielded slightly higher than the control treatments. These observed effects appeared as a logical consequence of the above-described effects of the application on soil characteristics. They also reported that at IRRI, the available nutrients applied with CRH (mainly K) were not limiting, the CEC was very high already, and water stress did not occur. But, the high C/N ratio of CRH presumably limited N availability (soil and fertilizer N), thereby slightly reducing grain yields (this mechanism was also proposed by Lehmann *et al.*, (2003).

2.6.2. Saw Dust

The advantages of sawdust as a mulch must be weighed against the cost of application and renewal, and the necessity for adding additional nitrogen fertilizer during decomposition. Since wood contains only a small amount of nitrogen, microorganisms decomposing sawdust compete for this element with the crop grown. Potatoes and tomatoes grown with L inches of sawdust cultivated into the soil may require as much as l0o pounds of actual nitrogen to the acre the first year. Lesser amounts are needed when the sawdust is used as mulch or in later year safter application, or with other crops such as strawberries. The nitrogen assimilated by microorganisms is not lost, however, but becomes available to crops after the sawdust is decomposed. In green house studies sunflowers have shown no evidence of nitrogen deficiency in. The presence of sawdust, even without added nitrogen fertilizer. Corn, on the other hand, has shown nitrogen starvation symptoms as on field plots regardless of fertilizer supplements with the sawdust. Further studies are necessary to evaluate such differences in response, and to correlate them with soil type and growing conditions.

2.7 Summary of literature review

To circumvent challenges encountered in seed systems of yam production, the success and eventual adoption of the Vine Multiplication Technique would effectively address the need for fast and wide multiplication and distribution of high-quality improved varieties to meet the increasing demand for yam since the technology offers a rapid, clean and cost-effective mass method of multiplying yam. The technique would substantially reduce the volume of the root crop used as seed, in effect; increase the amount of yam available for sale or consumption. Apart from its economic and food security benefits, the new technique will also substantially decrease or even eliminate the transmission of diseases (nematodes) which is the main cause of low yield in yams (IITA, 2009).

CHAPTER THREE

3.0 Materials and Methods

The experiment was conducted at the Council for Scientific and Industrial Research, Crops Research Institute (CSIR-CRI), Fumesua-Kumasi (06^{o}41'N, 01^{o}28'W), in a semideciduous forest zone. The station experiences an annual mean rainfall, which falls within two rainy seasons (double maxima). The major rains come in April to July followed by a short dry spell in August in most years. The minor rainy season is between September and

October. Temperatures are mostly high but uniform with a monthly mean of about 25.4ºC. A total of four (4) yam varieties, *Mankrong Pona*, *Dente*, *Kukrupa* and *CRI Pona* were studied to evaluate the tuberization potentials from vine cuttings.

3.1 Land Preparation for Minisett Planting

Yam is generally planted on ridges and in mounds. Bush clearing was followed by ploughing to loosen up the soil, and harrowing to break up clods and improve the physical condition of the soil. After harrowing, the ridges were made using a tractor-drawn ridger. The ridges were spaced 1-1.2 m apart.

3.2 Treatment and Planting of Minisetts.

Clean, healthy and disease-free mature tubers of *Mankrong Pona, Dente, Kukrupa and CRI Pona* were selected from the newly produced tubers. The selected tubers were cut into minisetts sizes ranging from 25-30 grams. An average sized tuber gave between 20-40 minisetts.

The minisetts were treated in a suspension of Funguran before planting. Thirty (30) freshly cut minisetts from each of the four varieties were planted in the field.

The planting of the setts on the ridge was carried out by opening up the soil at the crest of the ridge with a hoe and inserting the sett about 10 cm deep, and covering it with soil. Agronomic practices, such as weeding, re-soiling of exposed setts were done as and when necessary. Staking was done two weeks after sprouting. Twelve plants of each variety were randomly selected at 120 days after planting (DAP) and healthy vine cuttings were collected around 9 am.

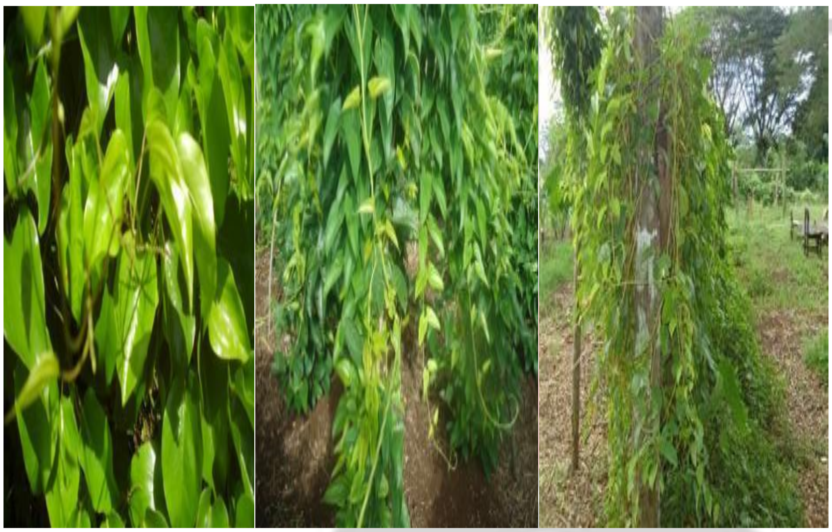

Plate 1. Yam vines of parents plants

3.3 Preparation of Vine Cuttings

3.4 Collection of vines

Vine collection was done 3-4 months after planting the yam into the field, when the main stems had produced lateral branches. Lateral branches (side shoots) were used so as not to disturb the growth of the main plant. Side shoots with more than 3 nodes were selected.

Extra care was taken to avoid damaging the main stem.

Parents of the four yam healthy plants that were growing vigorously with no symptoms of disease or nutrient deficiency were selected. Using scissors, the selected side branches from the main stem were cut. For each cutting, the main part of the stem which is not too hard (mature) nor too soft (young) was located. This part of the stem was cut in a 45^{o} angle. In order to maintain moisture, vines of each variety were placed in buckets containing water immediately after collection and then taken to the field for further processing.

3.7 Planting of vine cuttings

Vines were cut into pieces (10–12 cm long), each bearing a pair of mature leaves and two nodes. The end of each yam vine was inserted into poly bags already filled with the appropriate growth media and the medium was gently firmed around the cutting. The entire leafless portion of the vines was slantly buried under only 2-3 cm of soil, leaving just the leafy tip above the soil and firmed around.

An irrigation system was constructed from a small water pond behind the field and water was sucked, powered by a generator into the misting hose and water was distributed to the various planted vine cuttings.

3.8 Growth media and black poly bags

Three different growth media: blacksoil, blacksoil (5 parts): carbonized rice husk (3 parts) mixture and blacksoil (5 parts): Sawdust (3 parts) mixtures were prepared. Three different sets of black polythene bags, containing thirty poly bags in each set were filled with the three growth medium and replicated three (3) times for each yam variety. Carbonized rice husk was pyrolysized at 300-350 °C with a residence time of 1 hour. It was then cooled.

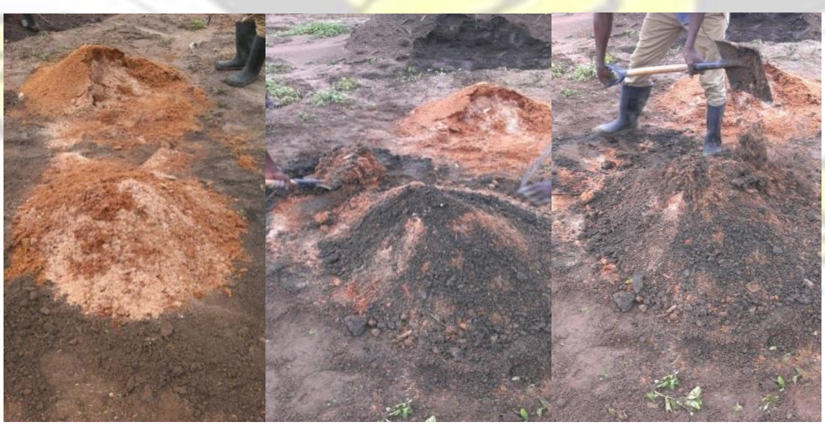

Plate 2. Blacksoil + sawdust mixture

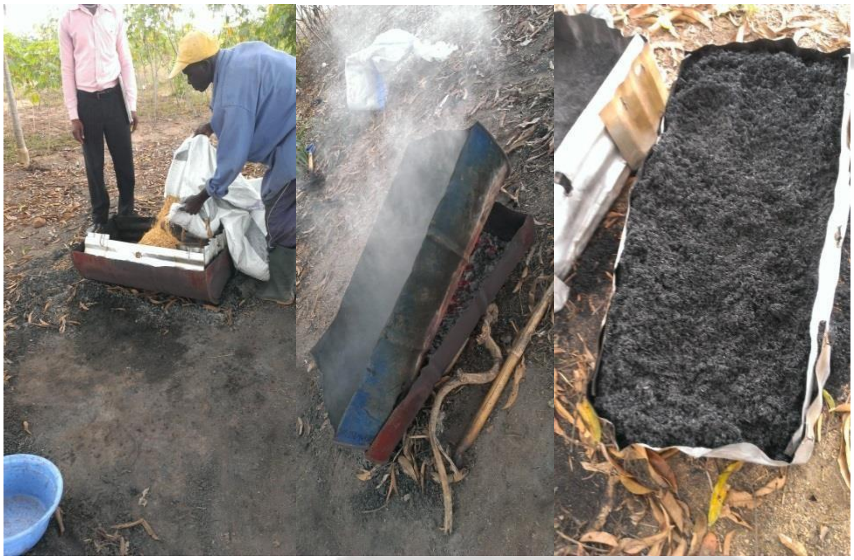

Plate 3. Carbonized rice husk

3.7 Experimental Design

The experiment was a 4 x 3 factorial, and treatments were arranged in a Complete Randomized Design with three replications. Cheesecloth was used to construct a shade above the poly bags in order to reduce the incidence of sunlight and maintain a higher relative humidity within the chamber.

3.8.0 Cultural Practices

3.8.1 Irrigation

Vine cuttings was gently and thoroughly irrigated shortly after placing them in the medium, and misted regularly so the soil remained uniformly moist, but not wet until new growth emerges from the cuttings. Irrigation was gradually decreased to allow the soil to dry somewhat between watering.

3.8.2 Weeding

Hand picking of weeds from growth media surfaces was carried out as needed.

3.8.3 Trailing

Trailing is done with ropes fastened to growing vines and vertically held. This helps sprouted vines to intercept sunlight energy.

Plate 4. Trailing

3.8.4 Pest Management

There was no significant visual presence of pests in the pots. However, hand picking of few identified scale insects was carried out as needed.

3.9.0 Data Analysis

All data obtained from the experiment were analyzed with analysis of variance (ANOVA) technique using Genstat statistical package (discovery edition 12). Differences between treatment means were determined using Least Significant Difference (LSD) at 5% level of probability.

3.10.0 Data Collection

3.10.1 Percentage sprouting

This was taken three weeks after planting of vines. It was determined by dividing the total number of sprouted vines by number of planted vines and multiplied by 100.

$$\text{Sprouting percentage\%} = \frac{\text{number of sprouted vines}}{\text{number of planted vines}} \times 100$$

3.10.2 Percentage vine survival/establishment

Percentage establishment data was collected at six weeks after planting. It was done by dividing the total number of survived sprouted vines by the total number of planted vines and multiplied by 100.

$$\text{percentage vine establishment} = \frac{\text{number of survived sprouted vines}}{\text{number of planted vines}} \times 100$$

3.10.4 Vine length of sprouted vines

This was taken at six weeks after planting. Five vines of sprouted cuttings were selected randomly from the three replications of each variety and length taken with a measuring rule. The means were calculated

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3.10.4 Percentage root formation

This was taken at six weeks after planting. Five vine cuttings of established vines were picked as samples from the three replications of each yam variety and then monitored for root initiation. The average means were calculated and divided by number of vine cuttings planted and multiplied by 100.

$$\text{percentage root formation} = \frac{\text{mean number of rooted vines}}{\text{number of planted vines}} \times 100$$

3.10.5 Mini tuber weight

This was taken at three months after planting at harvest. The mini tubers were harvested and average weight of each treatment was recorded.

3.10.6 Mini tubers number

This was measured by counting mini tubers harvested and the averages calculated for each yam variety.

CHAPTER FOUR 4.0 RESULTS

4.1 Percentage sprouting

Percentage sprouting of yam vines at 21 Days after Planting (DAP) under the various treatments are presented in Table 4.1. The mean percentage sprouting under the three growth media ranged from 43.12 % to 64.65 % while that of the yam varieties ranged from 44.03 % to 60.67 %.

Table 4.1 Treatment effects on percentage sprouting of yam vines at 21 DAP.

Growth media	Percentage (%) sprouting

Black soil	47.61
Black soil/Carbinized rice husk	64.65
Black soil/Saw dust	43.12
LSD (5%)	2.31
Variety	
Dente	60.67
Mankrong Pona	52.82
Kukrupa	49.64
CRI Pona	44.03
LSD (5%)	2.66
Grand mean	51.79
CV (%)	5.3

The percentage sprouting of the yam vines differed significantly ($P<0.05$) among the growth media used (Table 4.1). The highest shooting of the vine was observed in blacksoil/carbonized rice husk and this was significantly higher than all other treatments effects. The black soil treatment effect was also significantly higher than that of the blacksoil/saw dust medium. Varietal effect was also significantly ($P<0.05$) different, with the Dente producing more sprouts than all other varieties tested. The *Mankrong Pona* variety produced more sprouts than *Kukrupa* and *CRI Pona* varieities. *CRI Pona* was lower in sprout percentage than Kukrupa variety.

4.2 Percentage vine survival/establishment

Results of percentage vine survival of sprouted yam vines of four yam varieties at six weeks after planting (6 WAP) under the various treatments are presented in Table 4.2. The mean percentage vine establishment under the three growth media ranged from 33.88 % to 56.89 % while that of the yam varieties ranged from 35.13 % in *CRI pona* to 51.31 % in Dente.

Table 4.2. Treatment effects on percentage vine establishment of sprouted yam vines at 6 WAP.

Growth media	Percentage vine establishment
Black soil	38.71
Black soil/Carbinized rice husk	56.89
Black soil/Saw dust	33.88
LSD (5%)	3.11
Variety	
Dente	51.31
Mankrong Pona	44.62
Kukrupa	41.57
CRI Pona	35.13
LSD (5%)	3.59
Grand mean	43.16
CV (%)	8.6

The growth media significantly (P<0.05) affected percentage vine establishment of sprouted yam vines. Higher value was observed in the blacksoil/carbonized rice husk media. The blacksoil only treatment effect was significantly higher than the blacksoil/sawdust mixture. There was a significant (P<0.05) variation in percentage vine survival among the yam varieties. The percentage vine establishment was significantly (P<0.05) higher in *Dente* than in all other varieties. There was no significant difference between *Mankrong Pona* and *Kukrupa* varieties, but either varietal effect was significantly higher than that of the CRI Pona variety.

4.3 Vine Length

Vine length results are presented in Table 4.3.

Table 4.3. Treatment effects on vine length of established yam vines at 6 WAP.

Growth media	**Mean vine length (cm)**
Black soil	13.74
Black soil/Carbinized rice husk	13.56
Black soil/Saw dust	10.34
LSD (5%)	0.70
Variety	
Dente	16.31
Mankrong Pona	13.48
Kukrupa	11.26
CRI Pona	9.14
LSD (5%)	0.80
Grand mean	12.55
CV (%)	6.6

There was a significant media effect, with the black soil and blacksoil/carbonized rice husk mixture showing no significant difference (P>0.05), but either effect was significantly higher than that of the blacksoil/sawdust medium. The vine length did differ significantly (P<0.05) among the yam varieties. Treatment effect of *Mankrong Pona* was also greater than those of *Kukrupa* and *CRI Pona* varieties. *Kukrupa* variety produced longer vine length than that of the *CRI Pona* variety.

4.4 Percentage root production

The results of percentage root production of established yam vines of four yam varieties at six weeks after planting under the various treatments are presented in Table 4.4.

Table 4.4. Treatment effects on percentage root production of established yam vines at 6 WAP.

Growth media	Percentage root formation
Black soil	36.16
Black soil/Carbinized rice husk	53.48
Black soil/Saw dust	31.05
LSD (5%)	3.78
Variety	
Dente	48.74
Mankrong Pona	40.72
Kukrupa	38.07
CRI Pona	33.38
LSD (5%)	4.36
Grand mean	40.23
CV (%)	11.1

The rooting percentage of the yam vines differed significantly (P<0.05) among the growth media and yam varieties (Table 4.4). The highest rooting of vines was observed in blacksoil/carbonized rice husk which was significantly higher (P < 0.05) than that of other growth media. The black soil only treatment effect was significantly higher than that of blacksoil/sawdust mixture. Among the yam varieties, rooting in *Dente* was significantly higher than all the other varieties. Root formation in *Mankrong Pona* and *Kukrupa* were similar but significantly more than that of the *CRI Pona* variety.

4.5 Number of mini tubers

The results of number of mini tubers produced from rooted yam vines of four yam varieties at three months after planting (3 MAP) are presented in Table 4.5.

Table 4.5. Treatment effects on Mini tubers number produced from established yam vines at 3 MAP.

Growth media	Mini tubers number
Black soil	10.17
Black soil/Carbinized rice husk	15.83
Black soil/Saw dust	8.92
LSD (5%)	1.51
Variety	
Dente	14.22
Mankrong Pona	12.11
Kukrupa	10.89
CRI Pona	9.33
LSD (5%)	1.74
Grand mean	11.64
CV (%)	15.4

The mini tubers number of the yam vines differed significantly ($P<0.05$) among the growth media used. The greatest number of tubers was observed in blacksoil/carbonized rice husk, and this was significantly higher than that of the other media. The black soil and blacksoil/saw dust mixture produced statistically similar number of mini tubers. Among the yam varieties, the *Dente* variety produced significantly the highest number of mini tubers than all the other varieties evaluated. The treatment effect of the *Mankrong Pona* was significantly higher than that of the *CRI Pona*.

4.6 Weight of mini tuber

Mini tuber weight results from rooted yam vines of four yam varieties at three months after planting under the various treatments are presented in Table 4.6

Table 4.6. Treatment effects on Mini tuber weight produced from established rooted yam vines at 3 MAP.

Growth media	Mini tuber weight (g)
Black soil	6.08
Black soil/Carbinized rice husk	11.52
Black soil/Saw dust	4.97
LSD (5%)	1.46
Variety	
Dente	9.53
Mankrong Pona	8.22
Kukrupa	6.56
CRI Pona	5.79
LSD (5%)	1.69
Grand mean	7.53
CV (%)	23

The growth media effect was significant ($P<0.05$) with respect to weight of mini tubers. The treatment effect of blacksoil/carbonized rice husk medium was significantly greater than the others, both of which had similar treatment effects. Among the yam varieties, tuber weight from the Dente variety was the greatest, and this was significantly higher than that of the *Kukrupa* and *CRI Pona* varieties only. The *Mankrong Pona* varietal effect was also significantly higher than that of the CRI Pona variety. Varietal differences between the *Kukrupa* and *CRI Pona* were not, however, significant at 5 % level of probability.

CHAPTER FIVE

5.0 DISCUSSION

Increase in yam production in Africa has been achieved dominantly through expansion in cultivated area but little improvement in productivity (Nakasone *et al*., 2006). The traditional production systems of the regions are under growing pressure to adapt short fallow periods owing to limited availability of new lands to support shifting cultivation. Global annual yam production is probably reaching the plateau of growth as estimated by Manyong *et al*. (1996) and it decreased by 11.5% in 2007 (FAO, 2010). Majority of yam farmers in Africa are smallholder farmers with limited resources to struggle further with their traditional methods. To meet the ever enlarging demand for food yams of the fast growing population and to tackle the threats that further limit yam production, new technologies that target African smallholder farmers are of urgent need.

5.1 Percentage sprouting

In this study, the blacksoil/carbonized rice husk medium had the highest sprouting of vines (table 4.1) because it allowed for good aeration of the vines and easy drainage of any excess water thus providing a conducive environment for sprouting. The very high sprouting in this medium compared to others implied that it was ideal for sprouting of yam vines. Carbonized rice husks consist of a very light material with a micro-porous structure and a bulk density of about 0.150g compared with wood shavings. (Haefele *et al.*, 2009). The carbonization process also improves the water-holding capacity of the rice husks (Oshio *et al.*, 1981). Additionally, Schmidt *et al*. (2000) reported that the widespread practice of burning rice straw in the field indicates that black carbon from incompletely burnt (i.e. carbonized) rice residues could be an important source of organic matter in rice soils, as it has been previously shown for a range of other soil types. Williams *et al.* (1972) reported that research has shown that incorporation of carbonized rice husks can significantly improve soil properties by decreasing soil bulk density, enhancing soil pH, adding organic carbon, increasing available nutrients and removing heavy metals from the system, ultimately increasing crop yields.

The lowest sprouting of vines under sawdust/blacksoil mixture medium was attributed to high heat generation by decomposing sawdust which might have affected growth of vines as reported by Wilson (1989). The higher sprouting in the sole blacksoil compared to sawdust/blacksoil mixture could be attributed to lower heat generation in the medium. The differences in sprouting by the yam vines in the sprouting media justify the suggestion by Otoo *et al.* (2001) that substitutes to sawdust as a sprouting medium should be found.

Muamba J. Kabeya *et al.* (2013) reported that vines of six genotypes of *D. rotundata* gave a sprouting percentage ranging from 56.9 % to 96.3 %. The generally high percentage sprouting of vines of the yam varieties in this study ranging between 58.2 % in *CRI Pona* to 60.67 % in *Dente* implies that they could also perform well in the vine technology of production of seed yams. The significant variation in sprouting of the vines among the yam varieties was attributed to genotypic differences as suggested by Ikeorgu and Ogbanna (2009). The high percentage sprouting in *Dente* (60.67) implied its good attribute for adoption in yam vine cutting technology. This is a good prospect for the success of the vine technology which is ideal for the production of seed yam to boost yam production.
However, the carbonized rice husk was particularly suitable for all the yam varieties in this study.

5.2 Percentage vine establishment

The non-significant effect of the growth media on percentage vine survival was attributed to the uniform condition under which the sprouted vines were planted. However, the relatively higher percentage vine establishment for vines that sprouted in blacksoil/carbonized rice husk medium compared to the other media was attributed to the influence of the earlier better sprouting condition in that medium. The establishment performance was reflective of their media sprouting percentage performance. The significant difference among the yam varieties was attributed to genotypic differences. The higher percentage establishment in *Dente* and *Mankrong Pona* varieties compared to *Kukrupa* and *CRI Pona* varieties implied better genotypic characteristics for adoption in yam vine technique of seed yam production.

5.3 Percentage root formation

Acha *et al* (2004) reported that healthy vine cuttings were prepared from branches of two to three months old plants of seven genotypes of *D. rotundata* rooted 50% to 77.1% under intermittent mist in a rooting medium of equal quantities of carbonized rice husk. In this study, 33.38 % to 48.74 % rooting was observed on the yam varieties evaluated in table 4.4. This low performance could be due to the type of varieties of yam evaluated in this study or due to the age of the vine cuttings. This could also be attributed to reduction in the activity of the meristem due to age of cuttings. As old aged plant already changed growth phase from vegetative phase to reproductive phase, the growth of new shoots and leaves are hampered which eventually affects rooting of yam vines. Amin *et al*. (1997) reported that in *Shorea leprosul* a plantlet production through vine cutting, rooting decreased when the leaf area increased. From this studies, it was observed that the higher the percentage of established vines, the higher the percentage of root formation among the varieties and the higher the mini tubers number. It can then be suggested that, root formation among the established vines contributes to mini tuber initiation which affects mini tubers number. The highest rooting percentage recorded in the blacksoil/carbonized rice husk medium eventually produced the highest mini tubers number.

5.4 Number of mini tubers

Shiwachi *et al. (*2002) observed the formation of mini tubers when studying the effect of auxins on root development in *D. rotundata* vine, but whose size and quantity were not specified. Kabeya (2006) reported the production of mini tubers from vine cuttings, which ranged from 1.2 g to 4.2 g in weights. The generally high tuber weights from rooted vines of the yam varieties in this study ranging between 5.79 g in *CRI Pona* to 9.53 in *Dente* in table 4.6 implies that they are highly promising for success in the vine technology of production of seed yams. It was observed that the varieties with higher vine survival rates (*Dente and Mankrong Pona*) produced the highest tuber weights while those with low vine establishment (*Kukrupa and CRI Pona*) produced the lowest tuber weights. This suggests that those with low vine survival could not utilize sufficient sunlight to prepare assimilates for mini tuber growth, while those with higher vine survival rates captured more sunlight energy and diverted more photo-assimilates to the storage tissue (i.e. tubers).

The results show that carbonized rice husk (CRH) help improve the soil for quick vine growth and establishment since it offers the highest surviving vines and number of mini tubers. The results strongly suggest that CRH are relatively stable in performance for all four yam varieties. However, the study also strongly agrees with Otoo *et al*, (2001) observations that substitutes to sawdust as a sprouting medium should be found since it was inferior in both vine establishment and mini tuber growth. Carbonization of rice husk which is readily available in rural areas is recommended for adoption in the sprouting and rooting of yam vines to facilitate the yam vine cutting technique of seed yam production by rural farmers.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

The vine multiplication technology should be considered as an effective yam propagation method. Varieties of both *Dente* and *Mankrong pona* were successfully propagated in growth media. Results of these studies revealed that vines cutting taken from 3-4 months from parent plants rooted at six (6) WAP. A range of 33.38 % - 48.74 % rooting of vine cutting was registered for the yam varieties used. Varieties performed differently in growth media for mini-tuber production. Yam mini-tubers harvested varied from 5.79 g to 9.53 g. Various sizes of mini-tubers of yam can be generated using vine multiplication technique.

Sprouting of vines of the four yam varieties was successful in the three growth media of black soil, blacksoil/carbonized rice husk and blacksoil/sawdust with greater success in carbonized rice husk mixture. *Dente* and *Mankrong Pona* yam varieties exhibited greater potential for success in the yam vine multiplication technique of seed yam production and are recommended for adoption since they recorded higher vine growth, establishment and mini tuber yields.

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