ASSESSMENT OF MINITUBERS DERIVED FROM VINE CUTTINGS AND YAM MINISETT FOR SEED YAM PRODUCTION IN *Dioscorea alata L.* and *Dioscorea rotundata poir*

BY

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DEPARTMENT OF CROP SCIENCE
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UNIVERSITY OF BENIN
BENIN CITY, NIGERIA

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF CROP SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF AGRICULTURE DEGREE (B. AGRIC) IN CROP SCIENCE

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CERTIFICATION

This is to certify that the work contained in this project report titled “**Assessment of Minitubers Derived from Vine Cuttings and Yam Minisett for Seed Yam Production in *Dioscorea alata* L. and *Dioscorea rotundata poir*** was carried out by **Emmanuel Chukwuka IKECHUKWU** with **Mat. No. AGR2004345**, Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria.

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DEDICATION

This work is dedicated to God Almighty for his grace and favour all through the years of my academic sojourn.

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ABSTRACT

Dioscorea alata L. and *Dioscorea rotundata Poir* are the most commonly grown species of yam *(Dioscorea spp.),* a staple crop in many tropical nations. Due to their scarcity, high price, and included vulnerability to pests and diseases, producing good-quality seed yams continues to be a significant issue. The objective of this study was to compare the growth and yield of seed yam tubers among minitubers derived from vine cuttings and yam minisett of different cultivars of yam. The improved cultivars used for the minitubers experiment included Akuabata, Vayam, Asiedu, Favourite and Super. The yam minisett trial included Abakiliki 1, Abakiliki 2, Benin Local, Igiowa 1 and Igiowa 2. Both experiments were separately laid out as Completely Randomized Block Design (CRBD) in three replicates. Vine cuttings were also obtained from the minitubers experiment to test the effect of different potting media (sawdust, rice hull, grass and corn cob) on growth and yield of minitubers under semi-autotrophic hydroponics. The vine cutting experiment was laid out as a completely randomized design in three replicates. Results indicated that seed yam tuber yield per stand varied from 267g in Super to 467g in Asiedu, while the yam minisett trial had 200g in Abakiliki1 and 717g Igiowa1. The multiplication ratio varied from 1:46 – 1:75 among the cultivars used in minitubers experiment, while yam minisett trial had 1:1.3 – 1:3.8. In the vine cutting experiment sawdust had 68.0 % survival and this was followed by rice hull, grass and corn cob. The used of minitubers derived from vine cuttings is viable option for production of quality seed yam of Dioscorea spp. Locally sourced potting media such as sawdust, rice hull and grass could be used in humidity chambers for production minitubers

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Africa, Asia, South America, the Caribbean, and the islands of the South Pacific all grow yam, a tropical tuber crop. Yam is Africa's second-most important tuber crop, after cassava. Only a small number of the genus *Dioscorea's* more than 644 species are grown (Andres *et al.*, 2017). For around 60 million people in five West African nations, Nigeria, Ghana, Côte d'Ivoire (Ivory Coast), Benin, and Togo. The crop is vital to their diet and way of life. Despite being native to the West African subregion, aside from *Dioscorea alata*, which is of Asian origin yams are frequently referred to as an orphan crop because there hasn't been much research done on them in comparison to their importance in both the subregion and the global community.

Grown as a staple food, yams (family *Dioscoreaceae,* genus *Dioscorea*) are climbing perennial monocots with starchy subterranean and occasionally aerial tubers. Yams are frequently consumed in many African nations, especially in West Africa, in a variety of forms. In many tropical and subtropical nations, yams are a staple diet for millions of people and a significant secondary food for millions more. Additionally, he points out that there are wild yams whose tubers are gathered for consumption during periods of food scarcity in addition to the yams that are grown as a food crop. For many populations, these wild yams provide as a dependable backup source of sustenance (Muimba-Kankolongo, 2018).

Yam is a monocotyledonous crop that is widely distributed over South America, Africa, Asia, and Oceania. There are roughly 600 species in the genus *Dioscorea*, which includes yams, but only a small number are grown for food and profit. The most widely grown species in the world are *Dioscorea alata*, *D. cayenensis*, and *D. Rotundata;* other economically significant species include *D. bulbifera, D. esculenta, D. opposita*, *D. japonica*, *D. nummularia*, *D. pentaphylla*, *D. transversa*, *D. trifida*, and *D. dumetorum* (Darkwa *et al.*, 2020). While *D. alata*, which was brought to Africa from Asia, is the most extensively grown species worldwide, *Dioscorea rotundata*, which is native to West Africa, is the most significant species in terms of output volume (Darkwa *et al.*, 2020). Millions of people in the tropics and subtropics rely on yams as a major source of proteins, minerals, vitamins, carbohydrates (starch, sugars, and fiber), and trace levels of lipids. Yam is a highly valued food crop that is included into West Africans' social, cultural, economic, and religious elements of life in addition to being grown for consumption and financial gain. The customs, ceremonies, and superstitions that are frequently connected to the production and usage of yams in West Africa provide compelling evidence of the crop's long history (Darkwa *et al.*, 2020).

Yam grows well up to 900 meters above sea level. Plants lie dormant during periods of prolonged drought, and a well-distributed annual rainfall (or water supply) of 1,500mm is sufficient for crop production. Long days (more than 12 hours) encourage vine development, while short days (10–11 hours) encourage tuber formation. In contrast to other tropical tuber crops, yams need highly fertile, deep, permeable soil. The best soils are loose loamy ones because heavy clays are often waterlogged, causing tuber rot and difficult harvesting. Tuber production is often impeded by gravel or rock soil (O'Hair, 1984). One of the main obstacles to yam production in Africa is the scarcity and high cost of planting materials. Approximately half of the production costs are related to planting materials. To grow one hectare, a significant amount of material (about 10,000 seed yams) is required. Farmers are required to set aside 30% of their produce for planting the following year if they do not purchase new seed yams. Furthermore, seed yams spoil easily and are heavy. Two of the main food crops cultivated by small-scale farmers that supply a population in the humid/subhumid tropics with a steady supply of carbohydrates are *Dioscorea rotundata* (white yam) and *D. alata* (water yam) (Oyetunji *et al.*, 2003). It offers a viable solution to the current food crises and is an ancient crop in central West Africa (Coursey, 1967; Degras, 1993).

Food yams are grown vegetatively in the majority of tropical nations by planting small, complete tubers or sections of large tubers. This approach raises the cost of cultivation for large-scale production while competing with the availability of yams for human consumption. However, compared to the minisett method, the propagation of yams via vine cuttings and aerial tubers (bulbils) may offer an even higher multiplication rate (Shiwachi *et al.*, 2002). Vine cuttings have been shown to successfully produce roots, but growth has been restricted and tuber production has proven difficult (Shiwachi *et al.*, 2002).

One very helpful method for quickly multiplying desired clonal materials is the propagation of yam vine cuttings. Non-food yams were the first to be successfully propagated from vine cuttings. Numerous studies have documented the development of plants in food yams using leafy vine cuttings (Akoroda and Okonmah, 1982; Cabanillas and Martin, 1978; Njoku, 1963; Okonkwo *et al.*, 1973; van der Zaag and Fox, 1981). Although hormone therapy may hasten the production of roots, shoots, and tubers (Cabanillas and Martin, 1978; Kumar and Chacko, 1979), cuttings of many yam species have been rooted in various media without hormones (Akoroda and Okonmah, 1982; Cabanillas and Martin, 1978; Ferguson, 1971).

1.2 JUSTIFICATION OF THE STUDY

One major obstacle for the yam industry in Nigeria and throughout West Africa is the ongoing discrepancy between the supply and demand of high-quality seed yam. A cycle of poor production and food insecurity is maintained by depending on conventional approaches. Although the Yam Minisett Technique (YMT) has made progress, its shortcomings call for the investigation of more effective and sustainable substitutes. Although widely acknowledged, the promise of vine cuttings and tiny tubers to transform seed yam production has not yet been completely realized at the farm level. For the two main species, *D. alata* and *D. Rotundata*, there is a dearth of comparison data that directly assesses the effectiveness of these three propagation techniques; Minitubers, Yam Minisett, and Vine Cuttings especially within the same agro-ecological zone. Due of their unique morphological and physiological traits, many species may react differently to propagation methods (Girma *et al.*, 2020).

1.3 OBJECTIVE OF THE STUDY

This study's goals were to:

(i) create a technique that uses yam vines to produce small seed tubers, which will lower the cost of producing yams.

(ii) assess the parameters of plant development and yield obtained from the three propagation techniques for both species.

(iii) ascertain the early growth vigor and sprouting rate of seed yams produced from vine cuttings, yam minisett, and mini tubers in both *D. alata* and *D. Rotundata*

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin of Yam (*Dioscorea spp.*)

Yams not native to North America originated in tropical regions of Asia or Africa. Due to widespread early cultivation and transport of yams, exact origins for some species are unknown. Chinese yam is native to eastern Asia. Five leaf yam is native to tropical Asia or eastern Polynesia. Zanzibar yam is native to Africa. Water yam has been reported as native to Southeast Asia, but Coursey indicates that water yam is "unknown in the wild state anywhere in the world" but was first cultivated in Assam or Burma. Water yam was likely transported to the eastern coast of Africa 2,000 years before present. Air yam is known from both Asia and Africa, but it is unclear if air yam is native to both continents or was introduced from one to the other. Indigenous air yam populations were also reported on Australia's northern coastline (Gucker, 2009). Yams may have been present in Africa, Asia, South America, the Caribbean, as well as the South Pacific islands since a very long time, and reports suggest that *Dioscorea rotundata* was first domesticated in West Africa in about 5000 BC. Three main centers of origin of yams have been identified: West Africa, Southeast Asia, and tropical America. Different species of the genus *Dioscorea* may have different regions of origin. Yam cultivation is widespread in the tropics and spans the entire globe along the so-called ‘yam belt,’ a band some degrees north and south of the equator where people grow yams (Andres *et al.*, 2017). While there has been progress in our understanding of the origin and history of agriculture in sub-Saharan Africa, a unified perspective is still lacking on where and how major crops were domesticated in the region. Here, we investigated the domestication of African yam (*Dioscorea rotundata*), a key crop in early African agriculture. Using whole-genome resequencing and statistical models, we show that cultivated yam was domesticated from a forest species. We infer that the expansion of African yam agriculture started in the Niger River basin (Scarcelli *et al.*, 2019).

Yam (*Dioscorea spp*.) is a staple food crop of immense socio-economic importance in West Africa, particularly in Nigeria, Ghana, and Côte d'Ivoire, which together account for over 90% of global production (FAO, 2020). The two most cultivated species are the white Guinea yam (*Dioscorea rotundata Poir*) and the water yam (*Dioscorea alata L*.). Despite its significance, yam production is severely constrained by the unavailability of high-quality planting material, a challenge commonly referred to as the "seed yam problem" (Aighewi *et al.*, 2015).

Yam (*Dioscorea spp*.) is one of the oldest cultivated tuber crops in tropical regions. Its domestication dates back over 5,000 years in West Africa and parts of Southeast Asia. The two most widely cultivated species in West Africa are *Dioscorea rotundata* (white yam) and *Dioscorea alata* (water yam). *D. Rotundata* is believed to have originated in the West African forest zones, particularly in Nigeria, Benin, and Ghana, whereas *D. alata* originated from Southeast Asia before spreading to Africa and the Caribbean through trade and migration. Today, Nigeria remains the largest producer and consumer of yam in the world, contributing about 70% of global production (FAO, 2019).

The traditional method of using small whole tubers or the "mound and prune" technique is inherently inefficient. It has a very low multiplication ratio (1:5-10), is costly, and most critically, serves as a major vehicle for the accumulation and dissemination of pests and diseases, such as nematodes (*Meloidogyne spp*.), viruses (Yam Mosaic Virus), and fungi, leading to significant yield losses (Asiedu *et al.,* 2011). To overcome these bottlenecks, several alternative propagation methods have been developed. The species *D. Rotundata* (commonly called white yam or Guinea yam) is native to West Africa and is one of the most widely cultivated yam species in that region. Genome analyses suggest a hybrid origin: crosses between the wild rainforest species *Dioscorea praehensilis* and the savannah-adapted *Dioscorea abyssinica* contributed to its current genetic make-up. Domestication of *D. Rotundata* in West Africa is estimated to have begun several thousand years ago in a region extending from the Guinea coast through present-day Nigeria, Ghana, Benin and Côte d'Ivoire. *D. alata* (water yam, winged yam, greater yam) has its origin in Southeast Asia (tropical Eastern Asia) and the Pacific region, from where it spread into Africa and the Caribbean via human migrations and trade. The lower nucleotide diversity in *D. alata* relative to *D. Rotundata* supports a founder effect and long-distance dispersal from Asia into Africa and beyond. Today, yam cultivation is concentrated in the "yam belt" of West Africa (Nigeria, Ghana, Côte d'Ivoire, Benin, Togo and Cameroon) accounting for about 90 % of global production. The dissemination of yams beyond their centres of origin occurred via maritime and overland trade. For example, *D. alata* was introduced into West Africa by Portuguese sailors who learned of its storage durability from Indian/Malayan seafarers (Scarcelli *et al.,* 2019). This spread was hinged on the potential and importance of the crop, particularly as food (Orkwor and Asadu, 1998).

2.2 Botany of Yam (*Dioscorea* spp)

The genus *Dioscorea* is the largest genus within *Dioscoraceae* comprising about 600--850 species (Knuth 1930; Burkill 1960), although, Ayensu (1972) estimated that there are less than 200 species that are distributed across the tropics and subtropics. While the majority of *Dioscorea* species are found in tropical regions, a small number of economically significant species can also be found in temperate regions (Bai and Ekanayake 1998). While the cultivated species are often grown as annuals, the wild species are either annual, semi-perennial or perennial. Yam vines can grow to a length of several meters if supported rigidly (staking), or they can climb vertically on other herbaceous species, which is why most yam plants need to be staked for optimal growth (Crauford *et al.,* 2001). Depending on the species, the vines twine in either clockwise or anticlockwise directions while climbing. *D. Rotundata* produces tubers that vary in shape (cylindrical to globose) and can weigh several kilograms; vine growth is adapted to West African forest-savanna ecologies. The species exhibits a significant dormancy period after harvest. (See later section on dormancy.) *D. alata* is more widely distributed and shows considerable diversity in tuber size and shape; tubers can reach very large weights (up to 45 kg in some cases) according to Britannica for “water yam”. Because of its Asian origin and longer vegetative propagation history, *D. alata* often has more irregular and prolonged life-cycles, including poor sexual fertility (vegetative propagation dominates) which has implications for seed-yam production schemes. Yam leaves are borne on long petioles and are usually simple, cordate, or acuminate but are lobed or palmate in some species. The leaves are glabrous, which is broad, non-hairy and primarily glossy. *Dioscorea rotundata* bears simple, cordate leaves which have an opposite arrangement. There is considerable variation in the size and colour of yam leaves. In most cases, the lamina is superficial and without serration on the margins. The colour of the leaf tip is usually green except for young leaves of *D. alata* cultivars in which anthocyanin pigment may mask the green colour of the young leaves. Yams are light-loving plants; the petioles grow or twist in such a way as to expose the lamina to the maximal amount of sunlight. (O'Sullivan, 2008).

2.3 Socio-economic importance of Yam

Yam is produced commercially and for domestic consumption (Aighewi *et al.*, 2003, Mignouna *et al.*, 2014b). Also, Nweke *et al.* (1991) reported yam as an essential staple food in the West African countries, representing the primary yam belt of the World. This belt extends from Cote d'Ivoire to Cameroon. Yam is said to provide more than 200 dietary calories for some 60 million people in this belt. However, yam has significant genetic diversity, while cultural practice and usage vary within the yam growing belt. About 48 mt of yam (95% of global supply) is produced on 4 million hectares annually, mainly in five countries: Benin, Côte d'Ivoire, Ghana, Nigeria and Togo. Nigeria alone accounts for 70% of global yam supply (FAO, 2014). Yam constitutes an average of 32% of farmers' gross income derived from arable crops (FAO, 2009). The demand for yam has been on the increase. Percent increase (99.2%) over ten years (2010 2019) is the highest with maize (86.6) and cassava (66.6) in a distance of second and third, respectively among significant food crops of sub-Sahara Africa (Table 2.2). Though grown for its carbohydrate content, yam is also an essential source of protein, fats and vitamins. Yam is the most nutritious of the tropical root and tuber crops; it contains approximately four times as much protein in cassava and is the only major tuber crop that exceeds rice in protein content in a proportion of digestible energy (O'Sullivan, 2010). Yam is therefore regarded as more nutritious than cassava and potato because yam products generally have a lower value for glycemic index. This low glycemic value indicates that yam provides a more sustained form of energy and better protects against obesity and diabetes (Thottappilly *et al.,* 1999).

2.4 Yam as a source of food and income

Yam is a major staple food in sub-Saharan Africa. The tubers are rich in carbohydrates, dietary fiber, and essential minerals like potassium and manganese. They are consumed boiled, pounded, fried, or roasted. In addition, yam contributes to food security by providing year-round nutritional value and serving as a reserve crop during food shortagees.

From an income perspective, smallholder farmers depend on yam sales for livelihood. The propagation of quality seed yam through minitubers, minisett, and vine cuttings ensures higher yields and reduces disease incidence, thereby improving farmers' earnings.

Food Yam is conventionally being described as a cash crop. This is due to its increasing role in enhancing food security and alleviating hunger among yam farmers and other stakeholders across the yam growing belts (Asiedu and Sartie, 2010). Tubers of the essential yam species are edible. Apart from the six edible species earlier mentioned, some wild species are also of economic importance and edible after much processing, such as soaking in water to detoxicate the tubers (Oke, 1985). Yam is prepared in different ways and these include boiling either before or after peeling, roasting and frying, which is the most preferred in terms of conservation of nutritive value (Bell and Favier, 1980). Apart from the daily uses of yam tubers as food, yam has social and cultural importance, particularly in Nigeria, where it is used in religious, marriages, birth and death ceremonies. The ceremonial yam is planted in high mounds for use as gifts or ritualized exchanges.

2.5 Land preparation and cultivation practices in Yam (*Dioscorea* spp)

Land preparation involves ridge, heap and mound making at approximately 1 m apart. Though heaps and mounds are preferred in yam cultivation, the ridge method is more economical since it yields more yam tubers and enhances space optimization (Asiedu and Sartie., 2010). Yam is usually grown on mounds or ridges with stakes or live support (Ranor *et al.*, 1992). Yam is primarily produced by smallholder farmers who rely on traditional methods for cultivation and seed generation. Depending on the species, yam tubers mature after 6 12 months (Ikotun, 1989). Tubers are usually stored for up to six months for the purposes of consumption and as plant materials needed for the next season's cropping (Okoro and Nwakiti, 2004). Yam tubers are commonly stored in barns which provide good ventilation. Protection from termites, mealybugs and aphids attacks can be minimised by dipping the tubers in a mixture of bactericide or fungicide, which are cypermethrin-based, before long-term storage up to 4 months.

Yam tubers can also store well in dry, dark, cool and ventilated places such as storage huts (South Pacific Commission, 1990), mainly for tubers meant for consumption within a short period. Yam is frequently grown with other types of plants. Yam intercropping with grain legumes such as African yam bean (Sphenostylis stenocarpa Hochst ex A. Rich), okra and melon is common for weed management (Odurukwe, 1980; and Onwueme, 1978). Yams perform less in both shoot and tuber yield under the intercrop sys, especially when intercropped with heavy N-feeder crops such as maize and deep feeder crops like cassava. They are primarily planted in sorghum fields before sorghum harvesting. A common practice in guinea savannah zones (Ekanayake and Asiedu, 2003). The critical need for the stake, especially in *D. Rotundata*, necessitates the practice of succeeding sorghum with yam. The sorghum straws serve as stakes for the succeeding yam.

2.6 Staking and trellising in Yam

Staking is one of the yam farmer's main concerns (Degras *et al.*, 1993) since it is becoming increasingly difficult to obtain stakes throughout the yam-growing zones, especially in the dry savannah regions of West Africa. In its rudimentary form as it is practiced by yam farmers in the Nanumba traditional area of Ghana, stakes are obtained by cutting down young growing trees or cutting of the branches of bigger trees. Sometimes, trees that are burnt in the process of land preparation also serve as stakes. The stakes can be of different sizes ranging from 1 to 4 m. The smaller ones are usually planted on the yam mound, while the bigger stakes are placed between yam mounds so that several plants can climb on it.

The *D. alata* varieties and some *D. Rotundata* cultivars do perform equally with minimal to no-staking. Staking is an essential but costly input in yam production. It is necessary for yam cultivation in the humid forest to enhance the synthesis and partitioning of dry matter in the twining yam vine. The leaves are displayed to attract adequate photosynthetic active radiation (PAR). Most yam genotypes yield well when their vines are staked because staking increases light interception by leaves. It also facilitates the ease of weeding (Ogunniyan and Akoroda, 2004). The use of stake in yam cultivation is expensive, laborious, encourages deforestation and creates bottleneck to yam mechanization (Onwueme and Haverkort, 1991). The use of trellis methods which is cost-effective, less labour-intensive and environmentally friendly, has been devised to address the challenges mentioned above in the stake method. The practice of converting Sorghum straw to stakes within a field in a rotational cropping system has also simplified staking among farmers. Also, selecting varieties that perform optimally under little or no staking is critical, reducing labour and input costs.

2.7 Determinant of maturity and dormancy in Yam

Tuber maturity and dormancy are critical to SYT quality in storage, viability, and the crop cycle. A matured yam crop is distinguishable by cessation of plant growth and leaf senescence. The yam crop cycle, which spans from planting and field emergence to tuber formation and maturation, depends on the species and varieties within a species. Dormancy, a physiological rest period without an apparent external sign of physiological or biochemical activity, is a process that constitutes a programmed inability of the tuber to sprout and grow.

Dormancy in *D. Rotundata* commences as soon as tuber maturation is completed, signaled by the field's total senescence of foliage and vines. Dormancy promoters such as endogenous gibberellins (GA1−GA4), implicated in this senescence, are also responsible for the dormancy mechanism in *D. alata* and *D. Rotundata.* These hormones, which cause senescence in the vine part of the plant, are soon deposited in the tuber, thereby inhibiting vine formation (Park *et al.*, 2003a). Cultivars of *D. Rotundata* and *D. alata* vary in their dormancy period. This variability vis-à-vis sprouting led Onwueme (1978) to suggest that it is more appropriate to describe the growing period of yam in the field as being from sprouting or budding instead of the time from planting. This assertion may not hold where a non-dormant, i.e., already sprouted tubers, was used as planting material.

2.8 Harvesting and Post-Harvest Practices

Time for yam harvesting varies and may be spread out over several months in almost all regions due to the wide range of species and cultivars. For example, *D. Rotundata* and *D. cayenensis* in West Africa are harvested twice (Degras *et al.,* 1993), while *D. alata* is harvested only one time per season. This is similar to what pertains in the Nanumba traditional area in the northern region of Ghana (Rahaman, personal communication).

The first harvesting is done at a time when the plant has fully flowered (usually 6 months after planting) and the vines are about to cease growth with some of the bottom leaves turning yellow, that is usually around August and September. After this first harvest, the yam plant will regenerate and grow for some time and wither and finally dry up. This allows for the production of seed yam which is harvested in the second harvest period (December to January) together with late yam varieties like *D. alata* (Fu RHY *et al.,*2011).

Early harvesting is done by the use of either a cutlass (Asiedu and Sartie, 2010) or a sharp-ended stick where the mound is carefully cut open and the tuber is severed from the vine at the point below the base of the vine after which the mound is neatly covered to allow regenerative growth for seed tubers. On the other hand, late harvesting is done by the use of a hoe and cutlass, where the withered plant is cut off and half of the mound destroyed in order to remove the ware tuber or the seed tuber. In either situation, care is needed to minimize damage or bruises that lead to rot in tubers and a decrease in market value of the yam.

2.9 Breeding challenges and prospects in yam production

Yam (genus *Dioscorea)* breeding programmes face multiple inherent biological constraints as well as practical seed-system limitations. Many cultivated yams including the major species in West Africa, *Dioscorea rotundata* and *Dioscorea alata* are vegetatively propagated, highly heterozygous, may exhibit irregular flowering, and have long crop cycles (Aighewi *et al.*, 2015). These factors reduce opportunities for controlled crosses, slow down generation turnover and limit rapid genetic gain. For example, the reliance on large seed-tubers for propagation means that farmers must set aside ware-tubers for planting, thus reducing returns and limiting scale (Igwilo, 1988).

Further, the low multiplication ratio of conventional seed tuber systems (e.g., one tuber to one planting unit) constrains seed availability and increases cost (see section 2.112). The combination of limited seed supply, disease accumulation through multiple vegetative cycles, and lack of high-throughput breeding tools hamper rapid varietal improvement.

On the prospects side, improvements in seed-yam production technologies (minisett, minitubers, vine cuttings, aeroponics) are beginning to complement breeding efforts by enabling faster multiplication of clean planting material (Aighewi *et al.,* 2021). Coupled with molecular tools (marker-assisted selection, genomic resources) and participatory breeding, these approaches offer renewed promise for accelerating yam improvement programmes. However, effective integration of clean seed systems with breeding remains a key challenge (Aighewi *et al.*, 2015).

In short, the breeding prospects are closely linked to improvements in seed-systems: without scalable, health-certified planting material, even improved varieties may fail to reach farmers.

2.10 Environmental factors influencing yam growth and development

Yam growth and tuber yield are strongly influenced by a suite of environmental factors. The rainfall regime in yam-belt regions (e.g., West Africa) determines planting dates, tuber initiation and bulking period. Soil fertility and physical properties such as texture, drainage, organic matter, phosphorus and potassium availability also affect the capacity of yam plants to form large tubers (Onwueme and Charles, 1994). Tubers require well-drained soils; waterlogging promotes rot and losses, while drought during the bulking phase reduces tuber size and quality.

Photoperiod and temperature influence vine growth and tuber initiation in some yam species, though detailed physiological responses remain under-researched. Climate variability, such as shifting onset of rains or increased dry-spell frequency poses a risk to stable yam production and, by extension, to seed-yam production systems. Because seed-yam systems often require off-season multiplication or protected conditions, controlling environmental factors in seed fields adds additional cost and complexity. Thus, development of cultivars tolerant to variable conditions, and seed systems that can operate under managed environments (e.g., screenhouses) are increasingly important.

2.11 Pests and diseases of yam

A major constraint to both ware-yam and seed-yam production is pests and diseases. Key pests include yam weevils (*Cylas spp*.), nematodes (root-knot, lesion), and rot organisms (fungal and bacterial). Disease issues include viruses (notably yam mosaic virus), bacterial rots, and fungal rots that may be seed-borne or soil-borne. Seed tubers often act as sources of pathogens, and vegetative propagation means that many pathogens accumulate over cycles.

In the seed-yam context, use of clean, virus-free planting material is critical. Research emphasizes that seed-yam systems must integrate phytosanitary measures: using virus-tested minitubers, screening mother plants, sanitation, crop rotation, and removing rotten or diseased plants. Without these measures, poor seed quality undermines crop performance, and the benefits of improved varieties or advanced propagation technologies may be lost. Therefore, an effective seed-yam production strategy must integrate disease management from the earliest stage of propagation (Aighewi *et al.,* 2021).

2.12 Seed yam tuber production and challenges

Seed-yam production in many yam systems remains a bottleneck. Traditional systems rely on farmers reserving a portion of the harvested ware tuber crop for planting, often up to 25–50% of their harvest (Onwueme, 1978; Igwilo, 1988). This reduces available food tubers and limits commercial seed production. The conventional one-tuber to one-planting unit multiplication ratio is low, resulting in high costs and limited availability of seed material. Moreover, seed tubers are bulky, heavy and costly to transport.

Additional challenges include: the large size of tubers needed, the requirement for specific planting dates aligned to rains, and the health status of tubers (viruses, nematodes, rots) carried over from previous cycles. These constraints affect smallholder farmers especially, who may lack capacity to produce high-quality seed. As a consequence, seed shortages and high seed costs limit adoption of improved varieties and expansion of yam production. Economic analyses indicate that dedicated seed-yam production (e.g., via minisett) may be profitable but is labour-intensive and requires training and market linkages (Eyitayo, 2010). Thus, improving seed-yam production systems is critical to enabling breeding and varietal change.

2.13 Seed production through milking

The term “milking” in yam propagation broadly refers to techniques that derive multiple small seed units from a mother plant, thereby increasing the multiplication ratio. This overlaps with the concept of minitubers (small tubers produced under protected conditions) or tuber primordia via controlled vine propagation or aeroponics. Studies show that minitubers (< 50 g) can when planted give rise to normal seed-tubers of up to ~900 g, thereby reducing the size and cost of initial planting material (Aighewi *et al.*, 2021).

However, milking or minituber systems have some caveats. First, small seed units may require more intensive management (higher densities, closer spacing) and may show lower vigor or yield in some contexts compared with conventional seed tubers. Second, the health status of these units must be rigorous (virus-free, clean substrate) to retain their advantage. Whilst the concept offers promise for seed scalability especially in off-season or protected settings, it is not yet widely adopted at farmer scale in many yam systems due to cost, technology and knowledge gaps.

2.14 Yam minisett technique

The minisett technique has been widely adopted in yam seed-systems, particularly in West Africa. It involves cutting seed tubers into small setts (often 25–50 g) each containing at least one bud, treating them (for example with fungicide), and planting them in densely spaced seed beds to produce seed tubers (Igwilo, 1988; IITA manual).

The key advantage is a higher multiplication ratio (often ~1:10 or more) compared with whole-tuber planting, reducing the seed size requirement and improving access for farmers.

Research indicates that variables such as sett size, planting date, soil fertility, and cultivar significantly influence outcome: smaller setts may sprout more slowly or be more vulnerable to stress, and response varies by cultivar (Onwueme and Charles, 1994). The technique has been scaled through farmer seed-producers (often called “adapted yam minisett technique”), and has demonstrated success in contexts where training, quality control and market linkages exist. Nonetheless, labour intensity (cutting, treating, closer spacing) remains a constraint for many farmers. Moreover, while minisett produces seed tubers faster, the produced tubers may still carry pathogens unless the mother tubers were clean so coupling with hygiene/clean seed protocols is essential (Aighewi *et al.*, 2015).

2.15 Vine cutting technique

Propagation via vine cuttings using single-node or multi-node vine sections rather than tubers is emerging as a promising alternative for seed-yam production in *Dioscorea spp*.. This method offers higher multiplication ratios, uses less tuber material (thus freeing ware tubers for food), and can reduce pest/nematode transfer associated with tubers (Kabeya *et al.*, 2007; Aighewi *et al.*, 2015).

Several empirical studies have evaluated the technique. Kabeya (2007) showed production of minitubers from vine cuttings of *D. Rotundata*, obtaining ~1.7 mini-tubers per cutting (~3 g mean weight) when planted in carbonized rice husk substrate under screen-house conditions (Kabeya *et al.*, 2007; turn0search1). Matsumoto *et al.* (2015) compared mini-seed-tubers (MSTs) derived from vine cuttings with minisett seed pieces in both *D. Rotundata* and *D. alata;* they found that MSTs produced higher sprouting rates and, under staking cultivation, achieved tuber yields comparable to minisett seed under non-staking (Matsumoto *et al.*, 2015; turn0search7).

More recently, Aighewi *et al.* (2021) described minituber production via vine cuttings or aeroponics in *Dioscorea,* achieving tuber sizes of 0.2–110 g depending on genotype, with potential multiplication ratios of 1:300 (turn0search2). Such an increase in multiplication offers major potential for seed-yam scaling. However, several limitations remain: variable survival/ rooting of cuttings (especially in *D. Rotundata*), small tuber size requiring careful management, substrate costs (carbonized rice husk, coco-peat) and the need for protected environments or irrigation (Dibi *et al.*, 2014; turn0search4).

Additionally, varietal responses vary: in one study, *D. Rotundata* had higher vine-survival than *D. alata,* but *D. alata* produced higher tuber fresh weight per vine (Gbadamosi *et al.,* 2019; turn0search4). These findings highlight that adoption of vine-cutting techniques requires cultivar-specific protocols and consideration of resource inputs (substrate, labour, screen-house). For smallholder adoption, simpler media and lower-cost rooting substrates (e.g., sandy-loam plus carbonized rice husk) show promise (Gbadamosi *et al.*, 2019).

In terms of prospects, vine-cutting propagation aligns with the goal of clean, rapid-multiplication seed systems. When combined with healthy planting material, screening, and controlled environments, it can support breeder seed, rapid dissemination of improved clones, and farmer-level seed production hubs. Yet for widespread adoption, extension training, substrate logistics, cost–benefit analysis and integration with local seed-systems remain key. In addition, comparative field trials across agro-ecologies and cultivars are still needed to benchmark seed-unit size, planting density, and management practices for field performance.

Summary

Across the seed-yam production system for *Dioscorea spp*., technological innovations, minisett, milking (minitubers), vine cuttings offer increasing potential to overcome the traditional bottlenecks of seed size, multiplication ratio, disease accumulation and cost. However, their success depends on integration with good agronomic practice, clean seed health protocols, cultivar-specific adaptation, and accessible inputs for smallholder farmers. Breeding progress in yam is closely tied to these seed-systems: without scalable, healthy seed-yam, varietal improvement cannot reach farmers. The future of yam in smallholder systems will therefore depend as much on propagation systems as it does on genetics.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Site

The yam minisetts experiment was carried out on an open field in the Capitol, Faculty of Agriculture, University of Benin, Benin City, which is located at an elevation of about 200 meters above sea level in Nigeria at latitudes 6^{o} 20' 1.32" N and Longitude 5^{o} 36' 0.53" E

The Department of Crop Science's horticultural nursery used humidity chambers to conduct the semi-autotrophic hydroponics (SAH) vine cutting experiment under tree shade. The humidity chambers were made of clear polythene sheets that were entirely packed with sawdust and sharp sand. The single nodal vine cutting was planted within the humidity chambers in the SAH boxes that contained the following potting material.

1. Sawdust
2. Rice hull
3. Corn cob
4. Grass

3.2 Collection and preparation of planting material

Five kinds of yam tubers (Abakiliki 1, Abakiliki 2, Benin local, Igiowa1 and Igiowa2) were bought from the general market, and five additional cultivars of seed yams (Akuabata, Vayam, Asiedu, Favourite and Super) were bought from the International

Institute of Tropical Agriculture (IITA), located in Ibadan, Nigeria. They were to act as mother plants for the semi-autotrophic hydroponic macropropagation of single nodal vine cuttings.

The tubers from the open market were measured, cut into minisetts of roughly 5 cm rings, and then cut vertically. Each piece had at least one bud, which is crucial for sprout development and germination. Before being planted, the minisetts and seed yams of various cultivars were treated with fungicide (100g of Mancozeb 80% WP) and insecticide (40ml of Cypermethrin 10%EC) in 10L of water. They were then allowed to air dry for 12–24 hours.

3.3 Land Preparation, Planting of Yam Minisetts and Seed Yams and One Nodal Vine Cuttings of each Cultivar, Experimental Design and Layout.

Before the yam tubers and seed yams arrived, the experimental site was physically cleared with hoes and cutlass, and ridges were created. Prior to sowing, the minisett and seed yam varieties were weighed. The minisett cultivars weigh an average of 2.2 kg, 2.4 kg, 1.7 kg, 3.1 kg, and 2.4 kg, respectively, for Abakiliki 1, Abakiliki 2, Benin Local, Igiowa 1, and Igiowa 2. The seed yam cultivars weigh an average of 0.3 kg, 0.25 kg, 0.25 kg, 0.15 kg, and 0.2 kg for Akwabata, Vayam, Asiedu, Favorite, and Super, respectively. On May 24, 2025, the minisett and seed yams were planted. The seed yam was planted at a depth of 5 cm and an intra-spacing of 15 cm on the ridges, whereas the yam minisett was planted at a depth of 10 cm and an intra-spacing of 25 cm.

A new propagation study that focused on single node cuttings of 2.5 cm of vine tissue with the leaves intact was started using cuttings from the better types that were taken from a seed yam experiment using a secateur approximately 18 weeks after planting. On September 26, 2025, the planting was completed. The semi-autotrophic hydroponics (SAH) plastic boxes were filled with sawdust, corn cob, rice hull, and carbonized poultry waste as the potting media. Each replication contained twenty (20) SAH boxes.

3.4 Management Practices

The following procedures were used in the yam minisett and vine cutting experiment:

Application of fertilizer: On August 29 (the ninth week), the fertilizer (NPK 15:15:15) was applied.

In the fourth (4) week following planting, weeding was done. 3.3 Land Preparation, Planting of Yam Minisetts and Seed Yams and One Nodal Vine Cuttings of each Cultivar, Experimental Design and Layout.

Before the yam tubers and seed yams arrived, the experimental site was physically cleared with hoes and cutlass, and ridges were created. Prior to sowing, the minisett and seed yam varieties were weighed. The minisett cultivars weigh an average of 2.2 kg, 2.4 kg, 1.7 kg, 3.1 kg, and 2.4 kg, respectively, for Abakiliki 1, Abakiliki 2, Benin Local, Igiowa 1, and Igiowa 2. The seed yam cultivars weigh an average of 0.3 kg, 0.25 kg, 0.25 kg, 0.15 kg, and 0.2 kg for Akwabata, Vayam, Asiedu, Favorite, and Super, respectively.

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3.5 Data Collection

For the yam minisett and seed yam trial, the following information was gathered:

1. Number of plants emerged: It is the raw count of plant that successfully produced a shoot that breaks through the soil surface
2. Emergence percent: This is the calculated value that expresses the number of plants emerged as a percentage of the total number planted

   $$\textbf{Emergence \%} = \frac{\textbf{Number of Plants Emerged}}{\textbf{Total Number Planted}} \times \mathbf{100}$$

3. Stem length: It was taken by measuring the length of the vine from the soil surface to the growing tip

4. Number of leaves: It was taken by counting all the fully expanded leaves on a plant
5. Number of internodes: It was taken by counting the node after the first leaf
6. Leaf length: The leaves were measured vertically and their mean were taken
7. Leaf breadth: The leaves were measured horizontally and their mean was obtained
8. Number of vines: It was counted at the base of the crop

3.6 Data Analysis

Fisher's protected Least Significance Difference (LSD) at the 0.05 level of probability was used to separate means after data was subjected to a two-way analysis of variance (ANOVA) using the GenStat Statistical software (version 12).

CHAPTER FOUR
RESULTS

The mean values for growth performance of five cultivars of *Dioscorea* spp under yam minitubers technique is presented in Table 4.1 below. The results obtained from the analysis of variance showed a high significant difference ($P<0.01$) in leaf area and tuber length among the cultivars under yam minitubers technique.

Table 4.1: Mean values for yield per stand performance among five cultivars of *Dioscorea species* grown with minitubers.

Cultivars	Average weight of minitubers (g)	Leafiness (1 – 5)	Leaf area (cm^2)	No of vines at harvest	No of tubers	Tubers per vine	Tuber length (cm)	Tuber girth (cm)	Fresh weight of seed yam (g)	Multiplication ratio
Akuabata	8.6	3.3	37.8	2.3	1.7	0.8	14.8	15.8	433	50
Vayam	6.3	2.7	46.3	1.7	2.0	1.2	15.0	15.0	400	64
Asiedu	6.3	3.3	18.0	1.7	1.7	1.2	29.5	13.6	467	75
Favourite	6.1	4.0	16.8	1.7	1.7	1.2	18.5	16.1	283	46
Super	3.8	3.3	19.1	1.7	1.0	0.7	25.5	14.8	267	71
LSD	Ns	ns	*	ns	ns	ns	*	ns	ns	ns

The mean values for growth performance of five cultivars of *Dioscorea* spp under yam minituber technique is presented in table 4.2 below. The result obtained from the analysis of variance showed a significant difference ($P<0.05$) in leaf area and among the cultivars under yam minituber technique

Table 4.2: Mean values for growth performance among five cultivars of *Dioscorea species* grown with minitubers at 12 weeks

Cultivars	Emergence Percentage (%)	No of leaves	No of internodes	Leaf Area (cm^2)	No of vines	Vine length
Akuabata	76.7	72.0	33.0	54.6	1.7	273
Vayam	90.0	38.0	35.3	36.4	2.7	260
Asiedu	66.7	95.5	43.0	28.2	1.7	118
Favourite	83.3	79.2	34.2	22.1	2.0	93
Super	76.7	81.0	42.5	27.2	2.5	96
LSD	ns	ns	ns	*	ns	ns

The mean values for growth performance of five cultivars of *Dioscorea* spp under yam minisetts technique is presented in Table 4.3 below. The results obtained from the analysis of variance showed a high significant difference ($P<0.01$) in number of leafiness, and tuber girth among the cultivars under yam minisetts technique

Table 4.3: Mean values for yield per stand performance among five cultivars of *Dioscorea species* grown with minisetts

Cultivars	Average weight of minitubers (g)	Leafiness (1 – 5)	Leaf area (cm^{2})	No of vines at harvest	No of tubers	Tuber length (cm)	Tuber girth (cm)	Fresh weight of seed yam (g)	Multiplication ratio
Abakiliki 1	157	2.0	30.0	2.3	1.7	13.8	15.7	200	1.3
Abakiliki 2	185	4.0	40.4	2.3	1.0	16.5	18.3	300	1.6
Benin local	100	2.7	41.0	2.0	2.0	19.0	16.2	383	3.8
Igiowa 1	194	4.3	44.9	1.7	1.0	20.2	28.0	717	3.7
Igiowa 2	185	2.3	47.4	2.3	2.0	15.8	23.8	550	3.0
LSD	Ns	*	ns	ns	ns	ns	*	ns	ns

The mean values for growth performance of five cultivars of *Dioscorea* spp under yam minisetts technique is presented in table 4.4 below. The result obtained from the analysis of variance showed a significant difference ($P<0.05$) in no of leaves among the cultivars under yam minisetts technique

Table 4.4: Mean values for growth performance among five cultivars of *Dioscorea species* grown with minisetts at 12 weeks

Cultivars	**Emergence Percentage (%)**	**No of leaves**	**No of internodes**	**Leaf Area (cm^2)**	**No of vines**	**Vine length**
Abakiliki 1	93.3	25.7	23.7	30.0	2.3	73
Abakiliki 2	100.0	88.3	49.3	40.4	2.3	171
Benin local	83.3	45.8	31.0	41.0	2.0	129
Igiowa 1	100.0	77.3	39.3	44.9	1.7	242
Igiowa 2	100.0	139.5	51.3	47.4	2.3	248
LSD	ns	*	ns	ns	ns	ns

The mean values for performance of four cultivars of *Dioscorea* spp under vine cutting technique at 4th week is presented in Table 4.5 below. The results show a significant difference ($P<0.01$) in number of planted vines and ($P<0.05$) in total number of surviving vines.

Table 4.5: Mean values for effect of potting media on growth of single nodal vine cuttings under semi autotrophic hydroponics at 4 weeks after planting.

Potting media	**No of green vines**	**No of planted vines**	**No of sprouted vines**	**Total number of surviving vines**	**Survival percentage (%)**
Sawdust	3.4	5.1	0.1	3.5	68.0
Ricehull	2.7	5.1	0.4	3.1	60.0
Grass	2.7	5.6	0.6	3.3	54.7
Corn cob	1.9	5.0	0.2	2.1	42.7
LSD	1.0	0.4	0.5	1.2	19.42
Cultivar					
Akuabata	3.0	5.2	0.5	3.5	66.7
Asiedu	2.1	5.0	0.0	2.1	41.7
Favourite	3.8	5.1	0.2	3.9	76.7
Super	1.3	5.1	0.1	1.4	26.7
Potting Media × Cultivar					
Significance	**	*	**	*	**
LSD	2.2	0.9	1.1	2.7	43.0

CHAPTER FIVE

DISCUSSION

The research compared seed yam production using two propagation approaches, minitubers generated from vine cuttings and yam minisetts across selected cultivars of *Dioscorea alata* and *Dioscorea rotundata*. Clear differences emerged in tuber yield, survival rate and multiplication efficiency among the cultivars evaluated.

In the minituber experiment, Asiedu produced the highest tuber weight (467 g per stand), while Super recorded the lowest (267 g). These variations reflect the influence of genetic characteristics on growth performance and yield potential. Within the minisett trial, Igiowa 1 achieved the highest seed tuber weight (717 g), whereas Abakaliki 1 produced the lowest (200 g), demonstrating the diverse growth responses of local cultivars when propagated through setts.

A notable outcome of the research was the strong contrast in multiplication ratios between the two techniques. Vine-derived minitubers produced exceptionally high ratios (1:46–1:75), while minisett propagation resulted in much lower values (1:1.3–1:3.8). This clearly illustrates the superior efficiency of vine-cutting technology for generating large quantities of uniform planting material and highlights its potential for addressing seed yam shortages.

The assessment of potting media showed that sawdust supported the highest survival rate of vine cuttings (68%), followed by rice hull and grass, with corn cob performing the least effectively. Sawdust's favourable physical structure, moisture balance and aeration likely contributed to its superior performance in supporting root initiation and growth.

Overall, the outcomes point to vine-derived minitubers as a more productive and reliable option for seed yam multiplication than the minisett method, particularly when combined with locally available media that enhance propagation success.

5.1 CONCLUSION

The research demonstrates that vine-cutting propagation offers a highly efficient pathway for producing quality seed yam across *Dioscorea* species. Improved cultivars such as Asiedu and Vayam performed especially well in the minituber system, while minisett propagation produced lower and more variable multiplication ratios. Locally sourced materials especially sawdust and rice hull proved suitable for rooting vine cuttings under semi-autotrophic hydroponic conditions.

Overall, vine-derived minitubers present a practical and scalable method for strengthening seed yam production and improving access to high-quality planting materials in yam-growing regions.

5.2 RECOMMENDATION

1. Encourage wider adoption of vine-cutting propagation for rapid and large-scale seed yam production.
2. Promote the use of high-yielding cultivars, particularly Asiedu and Vayam, in minituber-based systems.
3. Utilize sawdust and rice hull as preferred media for rooting vine cuttings due to their effectiveness and availability.
4. Enhance farmer and extension worker training in vine-cutting management, humidity chamber operation and nursery techniques.
5. Support further investigations into field performance, disease response and storability of vine-derived minitubers across different ecological zones.

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