

DOMESTICATION POTENTIAL OF SELECTED INDIGENOUS FRUIT
TREES IN MUKONO DISTRICT

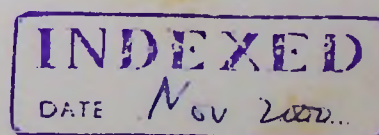


BY

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DECLARATION

I declare to the best of my knowledge that the work presented in this thesis is my own and that it has not been submitted for a degree in any other University.

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This thesis has been submitted with our approval as University Supervisors.

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DATE

DEDICATION

To my Parents for their continuous guidance and encouragement. To my Big Brother Augustine, B. Kyamuhangire for his endless support and encouragement since the inception of my Academic struggle.

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TABLE OF CONTENTS

CONTENTS	PAGE
Declaration	i
Dedication	ii
Acknowledgement	iii
Table of contents	iv
Abstract	viii

CHAPTER ONE : INTRODUCTION

1.1	Background	1
1.2	Problem statement	4
1.3	Justification	5
1.4	Objectives	5

CHAPTER TWO : LITERATURE REVIEW

2.1	Indigenous fruit trees	7
2.1.1	Ecological distribution and uses of indigenous fruit trees in Uganda	10
2.2	Domestication of indigenous fruit trees	18
2.3	Propagation of indigenous fruit trees	19
2.4	Propagation by seed	20
2.4.1	Seed collection and extraction	20
2.4.2	Seed dormancy and pretreatments	22
2.4.3	Seed sowing	25

2.5	Vegetative propagation	25
2.5.1	Cuttage(cutting)propagation	27
2.5.2	Layerage	29

CHAPTER THREE : IDENTIFICATION OF IMPORTANT INDIGENOUS FRUIT TREE SPECIES IN MUKONO DISTRICT

3.1	Introduction	31
3.2	Materials and methods	31
3.3	Results	34
3.4	Discussion	42

CHAPTER FOUR : SEED PROPAGATION OF *Garcinia buchananii*

4.1	Introduction	45
4.2	Materials and methods	45
4.3	Results	50
4.4	Discussion	55

CHAPTER FIVE : VEGETATIVE PROPAGATION OF *Garcinia buchananii*

5.1	Introduction	59
5.2	Materials and Methods	59
5.2.1	Cuttage propagation	59
5.2.2	Air layerage	61
5.3	Results	62

5.4	Discussion	65
CHAPTER SIX : CONCLUSIONS AND RECOMMENDATIONS . .		66
REFERENCES		68
APPENDICES		75

LIST OF FIGURES

Figure 1:	Ripe fruits and seeds of <i>Garcinia</i> <i>buchananii</i>	48
Figure 2:	Seedlings of <i>Garcinia buchananii</i> after germination	49
Figure 3:	Cumulative germination of seed propagation trial 3	54
Figure 4:	Cuttings <i>Garcinia buchananii</i> set in a polypropagator	63

LIST OF TABLES

Table 1:	General information of indigenous fruit tree species identified in areas surrounding Mabira Forest Reserve	36
Table 2:	Indigenous fruit trees and their uses in areas surrounding Mabira Forest Reserve	37
Table 3:	Methods of harvesting the indigenous fruits in areas around Mabira Forest Reserve	39
Table 4:	Quantities of indigenous fruits and their destination .	41
Table 5:	Sources of fruits sold in markets	42
Table 6:	Effect of various pregermination treatments on seeds of <i>G. buchananii</i> to rooting hormone (Trial 1)	52
Table 7:	The effect of various pregermination treatments on seeds of <i>G. buchananii</i> (Trial 2)	53
Table 8:	Percentage responses of different types of cuttings of <i>G. buchananii</i> to rooting powder	64

ABSTRACT

Indigenous fruit trees are predominantly growing in the wild in Uganda. Domestication of indigenous fruit trees involves identification, capturing of germplasm from the wild and the incorporation into existing farming systems. The main objective of this study was to identify indigenous fruit trees with the greatest potential for domestication and to evaluate the most appropriate propagation methods for the most highly ranked indigenous fruit tree species found in areas surrounding Mabira Forest Reserve, Mukono District, Uganda.

The survey results indicate that there are five indigenous fruit trees in Mukono namely *Garcinia buchananii*, *Canarium schweinfurthii*, *Tamarindus indica*, *Vangueria apiculata* and *Pseudospondius microcarpa*. None of these fruit species has ever been cultivated. *Garcinia buchananii* was ranked the most important.

Green house trials on evaluation of the most appropriate propagation methods showed that the germplasm of *Garcinia buchananii* can be captured through seed. Brazing seeds gave the best germination percentage (93%) followed by soaking in cold water (78%) compared to untreated seeds (51%).

Results from cuttage and layerage propagation showed that *G. buchananii* is a difficult-to-root fruit tree species with a slow response to rooting hormone. While callus was formed on only 6.6% of softwood cuttings treated with 0.4-0.8% IBA after a period of 9 weeks, there was no response to air layering.

CHAPTER 1

INTRODUCTION

1.1 Background

Rural populations in many developing countries in the tropics depend on indigenous fruit trees in many different ways depending on their needs. Indigenous fruit trees like *Balanites aegyptiaca*, *Vitex doniana*, *Ziziphus mauritiana*, *Tamarindus indica*, *Parkia filicoidea*, *Treculia africana* and *Canarium schweinfurthii* make a critical contribution to the diets and welfare of thousands of households in rural areas of Africa (Okafor, 1988). Fruit trees increase nutritional quality of rural diets, supplement other sources of food especially agricultural crops and are used as emergency food supplies during dry seasons, famine and war.

Indigenous tree fruits have been found to be rich in sugars, vitamins, vegetable oils and proteins which are essential for the proper maintenance of human health (Wehmeyer, 1966, Hans and Kumar, 1978). Species such as *Annona senegalensis* and *Trichilia emetica* fruits are important protein supplements, while others like *Strychnos spinosa*, *Azanza garckeana* and *Parinari curatelifolia* have a high crude fat content (average 31%), crude fibre (45%) and carbohydrate contents (21%) (Saka and Msonthi, 1994). The most important fruit trees include *Tamarindus indica* which is used to make juice in many countries of Africa (Kainja, 1991) and *Sclerocarya birrea* and *Uapaca kirkiana* which

are processed to make wine and jam (Gumbo *et al.*, 1990). These indigenous fruit trees represent a valuable resource that needs to be cared for by the people relying on them.

Unfortunately many of the indigenous fruit trees are gradually being lost through deforestation and over-harvesting of trees for charcoal and timber and other activities like construction of roads, mining, and expansion of ranches and farms. Forests in Uganda have been decreasing over the past years and FAO/UNEP (1981), estimated that the forest cover was 11 million hectare in 1890. Since then there has been systematic loss of forest land to other uses, leaving an estimated 3.5 million hectares only (Forest Department 1997). The impact of depleting indigenous fruit trees can be minimised or averted by cultivation through domestication of these trees.

Though indigenous fruits are important for human life, they have been accorded low priority in agricultural development. In most cases, it is only the exotic fruit trees which have been grown. This is basically due to greater attention given to their research, development and marketing. In Uganda, the wide variation in topography, climate and land fertility has resulted in the development of divergent farming systems and cropping patterns adapted to various agro-climatic zones. Uganda's typical homegarden consists of crops mainly grown to produce a wide range of products for subsistence. The main exotic fruit trees grown

include Avocado, Mango and Citrus (Zake, 1994). The revival of traditional mixed cropping systems may necessitate improving of crop yields, introducing new crops, and the greater utilisation of unexploited indigenous species (Goode, 1994).

Domestication of tropical tree species that produce high value products such as fruits is a research approach that will improve human nutrition. Fruit trees such as *Persia americana* (Avocado) and *Mangifera indica* (Mango) which are quite popular in Uganda, originated from Mexico and India, respectively, and both were domesticated from the wild in their native countries(Smith *et al.* 1992). Therefore efforts to promote indigenous fruit trees in Uganda through domestication could lead to increased incomes and improved diets for the rural people.

Since the 1990's, research has focused on the long neglected indigenous tree species which are often referred to as " Cinderella" tree species. Hundreds of cinderella species, which are used traditionally by people throughout the tropics, have been omitted from planted forests. The resources of these cinderella species can be tapped through the process of domestication. This process has been applied so successfully to agricultural and horticultural crops. The process of domestication involves identifying and improving tree species according to farmer and market demands while at the same time availing planting material to farmers. The process of domestication begins with farmers

who are the ultimate users and beneficiaries of improved tree species, and therefore, they are the only ones who can identify which trees they value most and why these are their priority species. Buwalda *et al.* (1997), found that farmers who live close to forests where indigenous fruit trees are found, generally more aware of the challenges and uncertainties of indigenous fruit production than those who live farther away. They further noted that throughout the process of domestication, farmers should be kept informed through both formal and informal channels and should be able to voice their opinions on the direction of research.

1.2 Problem statement

Little attention has been given to the horticultural production of fruits from the wild which in the past were simply 'gathered' when required. Many of the indigenous fruit trees are gradually being lost through over-cutting for timber, charcoal and firewood, clearing for all types of agricultural systems and infrastructural developments such as industries, roads, housing estates and sports facilities. There is, therefore, a need for farmers to plant their own indigenous fruit trees by either integrating them into the existing cropping systems or planting them as orchards if they are to continue benefiting from these trees. Indigenous fruit trees have also suffered unwarranted neglect in research. Information about indigenous fruit trees is scarce in all aspects and they are hardly mentioned in official statistics and surveys.

Therefore nobody knows their quantities and qualities and the monetary values of the products of these trees. In addition, the variety and value of indigenous fruit tree products are seldom appreciated at national level because they are always consumed at individual or household levels with only a fraction of the products entering the local and national markets. This, therefore, leads to no efforts being directed towards their domestication or cultivation.

1.3 Justification of the study

It is important to promote Uganda's indigenous fruit trees or else they will disappear completely. To save these fruit trees from being depleted they have to be cultivated and domesticated. The domestication process involves three stages which are: the identification of indigenous fruit trees with the potential for cultivation, the capturing of germplasm through seed or vegetative propagation and the incorporation of the potential species into existing farming system.

1.4 Objective

The main objective of this study was to determine the domestication potential of indigenous fruit tree species in areas around Mabira Forest, in Mukono district, Central Uganda. The specific objectives :

1. To identify the indigenous fruit trees species with high potential for domestication in the area.
2. To identify other uses of these fruit trees.

3. To Identify the current harvesting methods of the fruits that are being used by the local people in the study area.
4. To determine the suitable period for seed collection of the identified species.
5. To determine the appropriate propagation methods for the most highly ranked fruit tree species.

CHAPTER 2

LITERATURE REVIEW.

2.1 Indigenous fruit trees

Indigenous fruit trees are species which are native or which belong naturally to a region (Schmidt, 1997). Indigenous fruit trees are of different types and it is due to their variability that they are able to produce fruits throughout the year (Mateke *et al.*, 1995). Among rural communities, indigenous foods play an important role in meeting household food security needs and are usually the only source of protein, vitamins and minerals. Natural vegetation is a major resource that has continuously sustained the requirements of many communities in the provision of food, timber, firewood, fodder, fibre, medicaments and other products (Banana, 1994).

The flora found in natural forests, bushlands, along roads, hedges and field boundaries, often contribute to the local food security, dietary and nutritional status of the local people in many areas. Forest products are either consumed or sold to generate cash (Lindstrom and Kingamkono, 1991).

Local people have always gathered fruits from indigenous tree species and their use as food supplements, fodder for livestock and medicine dates back to precolonial times (Fanshawe, 1962). The recent rapid

increase in urban and rural populations and the use of improved methods of farming, have encouraged indiscriminate cutting of trees, including indigenous fruit trees. Farmers have tended to plant exotic species on such cleared land rather than indigenous species for local and export market (Mateke *et al.*, 1995).

The variety and nature of food products that can be obtained from the indigenous fruit trees are not fully appreciated despite the fact that many rural people derive most of their dietary requirements from these trees. There are considerable prospects for the introduction of forest food and fruit species in agricultural areas and their possible domestication and improvement. This will not only be for improved nutrition of rural populations but also in their economic potential to provide cash. Sharma (1998) points out that in Thar desert, farmers harvest fodder, pods, fruits, waxes, gums, resins, edible and non-edible oil and other products from naturally growing trees. He noted that when annual crops fail during drought, the yield of non-wood forest products does not decrease drastically, thus ensuring food security while providing additional cash income for marginal farmers.

The International Centre for Research in Agroforestry (ICRAF) is now working with these "Cinderella" trees. Their potential has yet to be realised and they have largely been overlooked. The resources of these cinderella species can be tapped through the process of

domestication that has been so successfully applied to agricultural crops. This will herald the start of a revolution in the plant world, a wood plant revolution that can help ease the destruction of earth's forests and woodlands, rehabilitate degraded land, reduce deforestation and permit human beings around the world to feed themselves (Leakey, 1994). One of the first groups of Cinderella species that can be domesticated is indigenous fruit trees. They are known by the rural farmer, appreciated and depended upon for fruits, food and medicinal products.

Farmers do not plant these trees, or include them in agroforestry systems because they view them "wild" or gifts of nature. The challenge researchers face is to identify indigenous fruit trees in tropical ecosystems with the help of the people who know them best, that is, the farmers. After that then the process of domestication can start. It is a process that must begin with the methods of establishing the trees and evaluating their subsequent performance in terms of growth and productivity.

ICRAF and its national partners began tree domestication and improvement projects in southern Africa and the humid lowlands of West Africa in 1994, and in Peru and the Semi-arid lowlands of West Africa in 1995. In selecting which species to domesticate, ICRAF

uses guidelines developed by the International Service for National Agricultural Research(ISNAR) which Combine farmer's preferences with the opinions of scientists(Franzel *et al.*, 1996).

2.1.1 Ecological distribution and Uses of Indigenous fruit trees in Uganda

Indigenous trees prevail under different ecological zones in Uganda and have various uses as described by Katende *et al.*(1995):

Tamarindus indica occurs mainly at low altitude in wooded grassland and along rivers. The fruit pulp and juice are consumed by humans, leaves and seeds are used for fodder, stem and branches for fuelwood and charcoal, while fruits, flowers and bark are used for medicine.

Parkia filicoidea is found in riparian forest, at an altitude of 500-1200 m. The pods are eaten, and it is also used for firewood, charcoal, mulch, ornamental and tannin dye.

Balanites aegyptiaca occurs in low lands with total rainfall of < 500 mm, the juice from fruits is consumed, and other uses include animal feed, timber, fuelwood, medicine and pest control.

Vitex doniana occurs at 0-2000 m altitude and in alluvial soils. The fruits are eaten, the stem and branches are used for timber and fuel respectively. Other uses include medicine, fodder, bee forage, shade and dye.

Treculia africana occurs at low altitudes, has edible fruits, leaves for fodder and stem for firewood and pulp.

Canarium schweinfurthii occurs in medium altitude, it is common in Kalinzu forest reserve and in forests around Lake Victoria. Often an isolated tree in cleared land. It's fruits and leaves are edible. Other uses include firewood, charcoal, timber, shade, ornamental and incense.

Beilschmiedia ugandensis is a tropical rain forest tree abundant in forests around the shores of Lake Victoria and lower montane forests. It is confined to swampy areas and damp places and is rare in drier forest. It's fruits are edible. Other uses include firewood, charcoal, timber and props for mines.

Carissa edulis is commonly found on termite mounds in wooded grassland, especially in low lying areas associated with *Grewia similis* and also in thickets in woodlands, forest edges and secondary scrub. It prefers dryish conditions as in the southern part of the Northern region and the northern part of the Central region. Tolerates most soils, including black cotton soils. It's fruits are edible while other uses include firewood, seasoning, medicine, ornamental and live fencing.

Chrysophyllum albidum is a dominant canopy tree of lowland mixed rain forest, sometimes riverine. It is widely distributed in Uganda for example in Budongo, Mabira and other forests. Its fruits are edible and its other uses include firewood, charcoal, timber and tool handles.

Chrysophyllum gorugosanum occurs in lower montane forests for example in Kibale, Kasyoha-Kitomi, Kalinzu and Bwindi forests. Its fruits are edible. Other uses include firewood, charcoal, timber and poles.

Cordia monoica in Uganda is common in dry thickets near rivers and in low lying short grass savannah in the North and North-east of the country. Its fruits are edible and its other uses include firewood and charcoal.

Dovyalis abyssinica is abundant in Kibale forest and Kasyoha-Kitomi forests, at the forest edges and in nearby thickets and scrubland. Its fruits are edible. *Flacourtia indica* in Uganda it grows in lower montane woodlands associated with *Vitex doniana*, *Vitex madiensis* and *Syzgium awariense*.

Garcinia buchananii is found in high rainfall savannah woodland, thickets, gallery forests and forest edges. It is widely distributed, ranging from very moist sites on the shores of Lake Victoria, particularly

on the Western shore, to very dry sites in North Eastern Region. It's fruits are edible and wine can be made from them. It's other uses include timber and firewood.

Lannea schweinfurthii is found in most parts in Uganda at altitudes of 700-1,600m. It's fruits are edible.

Mimusops kummel grows in wooded grassland and woodland and is common in thickets surrounding rocky outcrops. It's other uses include firewood, charcoal, tool handles and local utensils.

Mimusops bagshawei is a widespread tree in Uganda in lowland and upland rain forest. It's fruits are edible and it is also used for firewood, charcoal, carvings, pigfeed and shade.

Myrianthus holstii grows in lowland and mountain forests, preferring moist valleys and river banks. Two forms occur: the lowland form has larger fruits and the mountain form has smaller fruits. It's fruits are edible while it is also used for firewood, charcoal, mulch, soil water conservation.

Pachystela brevipes is widespread and abundant in forests on the shores of Lake Victoria. Apart from it's fruits being edible, it is also used for firewood, charcoal, timber, poles, shade and mulch.

Parinari curatellifolia in Uganda grows in wooded grassland and woodlands occurring as single trees on hills and is sometimes found scattered in grasslands on the Western shore of Lake Victoria, 1,000-1,300 m above sea level. Its fruits are edible and its other uses include firewood, charcoal, medicine, soil and water conservation.

Strychnos spinosa is a semi- evergreen tree found all over tropical Africa. It grows in a wide variety of dry woodland and thickets, frequently on sandy soils of river banks. Common in Northern and North Eastern regions of Uganda. Its fruits are edible and its other uses include firewood, charcoal, timber, fodder, medicine and musical instruments.

Syzgium cordatum is a tree found besides fresh water and in swamps in Uganda. It occurs in lowland forests as well as medium to higher altitudes, always near water, along water courses, in riverine thickets and forests. Apart from its fruits being edible, it is also used for firewood, charcoal, timber, beams, rafters, bee forage, medicine and dye.

Syzgium owariense grows in wooded grassland and semi-arid woodland preferring stony ground and hills.

Eugenia capensis is a small tree found at forest edges, particularly in

Central and Western Regions, Mengo, Sesse, Masaka and Ankole. It has edible fruits and it is also used for live fencing.

Pseudospondius microcarpa is widespread and often abundant growing on Lake shores, at rain forests edge and in swampy areas in tropical forests and near streams. Apart from its fruits being edible, it is also used for firewood, charcoal, soil and water conservation.

Vangeuria apiculata is a widely spread tree, distributed in secondary scrub, in open forest and in cultivated areas. Its fruits are edible and its other uses include firewood, charcoal, poles and utensils.

Acacia nilotica is an Egyptian thorn, scented-pod *Acacia*. Common in arid and semi-arid areas in Africa. A very variable species that can grow on a wide variety of soils, from coastal sandy soils to black cotton soils. In Uganda, it occurs in the dry savannah of Gulu, Kitgum, Moroto and Kotido and Mbale Districts, usually on gravel soils, 600-1,800 m above sea level. Its uses include poles, tools, carvings, food, medicine, stimulant, fodder, bee forage, nitrogen fixation, soil conservation, windbreaks, gum, tannin, dye, live fencing and toothbrushes.

Acokanthera schimperi is found in dry woodland, thickets and grasslands at 1,000- 2,300 m above sea level, often at the margin of dry forest. It prefers rich well-drained forest soil but also grows in black

cotton and poor soils in dry areas. It used for firewood, charcoal, tools, food, medicine, ornamental, arrow poison.

Annona senegalensis is a wild fruit found all over Africa in semi- arid to sub-humid regions. In Uganda it occurs in dryish wooded grasslands and woodlands, often associated with *Combretum* and *Albizia* species. It's uses include fruit, medicine, fodder and dye.

Balanites orbicularis is found in arid areas where it may be very common. It is evergreen, drought resistant and grows on a variety of soils, often found in very dry river beds. In Uganda it grows in very dry savannah for example in North Eastern Region.

Borassus aethiopiim is widespread throughout the dry areas of Tropical Africa but only where the water table is high. It is usually found in sandy well- drained soil, sometimes Coastal or at lower altitudes, often in dense stands. In Uganda it is common in flood plains along rivers Semuliki and Kafu, also Palabek County of Kitgum district. It's uses include firewood, charcoal, poles, timber.

Bridelia micrantha is a tree of high potential areas in East and Southern Africa. In Uganda it occurs in riverine forests, forests edges or in wet places in thickets in Eastern, Central, North Western and parts of Northern Regions, 600-2,200 m. It does well in a wide variety of

climates. Its uses include firewood, charcoal, timber, poles, tool handles, fruits, medicine, fodder, mulch and shade.

Carissa edulis is an evergreen shrub common in much of Africa. In Uganda it is commonly found on termite mounds in wooded grassland, especially in low-lying areas associated with *Grewia similis* and also in thickets in woodlands, forest edges and secondary scrub. It prefers dryish conditions as in the Southern part of Northern Region and the Northern part of Central Region at 1,000-2,000 m above sea level. Tolerates most soils, including black cotton soils. Its uses include firewood, food, seasoning, medicine, ornamental and live fencing.

Diospyros mespiliformis is an evergreen tree of medium to low altitudes found in West, East, and Southern Africa in woodland, savannah and on rocky hillsides. In Uganda it is found in Northern, Western and Northern Eastern Regions, often on termite mounds. Its uses include firewood, charcoal, timber, carvings, food, medicine bee forage, shade and ornamental.

Ficus sycomorus is one of the commonest African fig trees. In Uganda it grows in woodland and wooded grasslands, evergreen bushlands, forest edges and forest clearings. It is a large semi-deciduous spreading tree to 25 m, sometimes with stem buttresses. Its uses include firewood, charcoal, carvings, food, medicine, mulch, soil conservation and improvement, shade and bee hives.

2.2 Domestication of indigenous fruit trees

Domestication is a 2-stage process in plants, that is the bringing into cultivation of wild plants and exposing them to some form of management, and subjecting these to differential selection (Janick *et al.*, 1982). Domestication is an interactive procedure involving the identification, production, management and adoption of desirable germplasm. Strategies for individual species vary according to their functional use, biology and target environments. Domestication can occur at any point along the continuum from the wild to the genetically transformed (Leakey and Simons, personal communication 1997). The domestication of wild species of trees is proving to be an effective way to give farmers continued access to the trees hence their products and services.

Jeanette (1995) noted that priority setting and characterization based on users perceptions is an essential starting point for tree domestication research. This means a researcher does not have to impose top-down research procedures but has to consult the user communities in deciding which indigenous fruit trees have the greatest potential for domestication.

She further noted that in the past researchers' own interests and views on the importance of different trees, have tended to be the most important criteria when priority species were selected for tree improvement activities. Therefore the beneficiaries have not always had a say in the process of choosing trees, and this in turn, has not bode well for the impact of tree improvement activities.

Franzel *et al.* (1995) emphasized that the identification of important indigenous fruit trees through surveys is the first step in helping to determine which indigenous fruit species with greatest potential to be domesticated or cultivated and which other species may be substituted to produce the same end product. The second step is the capturing of germplasm by seed or vegetative propagation, followed by its conservation and selection. The third step is the incorporation of selected materials into existing farming systems.

Maghembe (1995), reported success in domestication trials of species like *Syzgium cordatum* and *Parkia filicoidea* which exhibited a survival rate of 85-100%. *Uapaca kirkiana*, *Azanza garkeana*, *Annona senegalensis* and *Parinari curatellifolia* species also grew well and exceeded 2.5 m in height. The most significant results of the trial, therefore, exposed the myth that indigenous tree species are slow growers. Other tropical fruit trees which were domesticated from the wilderness and improved upon include mango, avocado, guava and many others (Smith *et al.*, 1992).

2.3 Propagation of indigenous fruit trees

Simplified techniques of propagation from seed and vegetative parts are important in the domestication process. Prins and Maghembe (1994), emphasized that propagation provides flexibility in choosing sites for the domestication of indigenous fruit trees, a task that is becoming more

urgent with the increasing distances from homesteads to forested areas. They further noted that initial studies in Malawi showed that indigenous fruit trees can be successfully cultivated. However, Kwapata (1995) noted that one of the major problems with successful domestication of many of the horticulturally acceptable indigenous fruits is the difficulty of getting enough quantities of propagules. Characteristics such as very hard seed coat, physiological dormancy and low viability, contribute to poor germination of many wild fruit species.

2.4 Propagation by seed

2.4.1 Seed collection and extraction

People usually collect seed is generally collected from the fruits of wild indigenous forests or woodlands. Very few countries have reached the stage where collection of seed is from plantations or seed orchards. Seed collection from standing trees is the most common large scale method for collecting forest seeds. It is a sure method but care should be taken and the right equipment should be used. There are various ways of seed collection (Turnbull 1975)

(a) On ground collection which involves collecting seeds of fruits which have fallen from standing trees or collecting seeds from felled or fallen trees. It is a low-cost, easy and widespread method. However its disadvantages are that seeds collected from the ground are very prone to insect, fungi and animal damages, and it is not possible to identify

the mother tree if the population of that species is dense.

(b) Collection from standing trees can be by climbing the tree or by using long, light poles for striking and shaking branches to get the fruits down; using knives with long handles for cutting fruits; using collection sticks, pole pruners and others. Seed collection from standing trees by climbing involves the use of climbing equipments such as climbing irons, tree bicycle, portable ladders, rope ladders, scaling ladders, nets and other various methods.

Doran (1986) suggested that while collecting seeds, the following tips should be considered: (1) Straight, tall and trees of good form, should be considered while collecting seed for timber species. (2) Very young and over mature trees generally produce seed of poor quality, therefore seeds should be collected from trees in their prime age. (3) Seeds should be collected from mature and healthy fruits. The early and last to ripen fruits are not good seed producers. (4) The timing of seed collection should be right, as some pods shed off the seeds early and insect damage is very common in mature fruits.

Seeds should be extracted from the fruits or pods. This process is necessary in order to maximize production of clean seed of high viability. The extraction process is done usually manually and involves, either maceration and depulping, drying, separation, tumbling and

threshing, dewinging and cleaning. However many indigenous fruit trees for example *Uapaca kirkiana* have recalcitrant seeds. This poses problems of collection, transport and storage even in short periods of time (Sally and Jean, 1995).

2.4.2 Seed dormancy and pretreatments

Once seeds have matured, they require to germinate at a time and place favourable for growth and survival of the seedlings (Ditevsen, 1980). However seeds of certain species cannot be induced to germinate freely under natural conditions without being subjected to one or a number of pre-germination treatments. This is usually due to seed dormancy. Various forms of seed dormancy are generally considered to confer on the species some adaptive advantages which allow it to survive seasonal or fortuitous conditions of the environment. The seeds of these species are prevented from germinating when conditions for survival of the young seedling are not favourable. Similarly, many species from arid environments, where conditions favouring regeneration occur rarely, have seeds protected by a hard coat, impervious to both water and gases. These seeds can lie dormant on the forest floor or in the surface layers of the soil quite undamaged for years, even decades (Doran *et al.*, 1983).

The seed coat is usually disturbed so as to allow germination to occur as a result of conditions that favour safe regeneration. Examples of

seed dormancy include: immaturity of the embryo, complete inhibition of water absorption and a state of dormancy in the embryo itself. Dormancy due to complete inhibition of water absorption predominates in the leguminosae but also common in a number of other families. Examples include *Acacia spp.*, *Prosopis spp.*, and *Albizia spp.* Most seeds require different treatments prior to sowing in order to break dormancy. Maghembe (1995), reported that simple seed germination pretreatments resulted in high germination percentages of *Uapaca kirkiana*, *Parkia filicoidea* and *Syzgium cordatum*.

Seeds will only germinate when the conditions are favourable. Seeds from different species may require different methods of pre-treatment. When implementing a pre treatment method, care should be taken so that the embryo and the endosperm is not damaged.

There are various methods of seed pre-treatments. Scarification is a treatment which destroys or reduces seed coat impermeability. This is a simple but time consuming method. The technique involves the piercing, clipping, nicking, filing the seed coat of individual seed with a needle, knife, scalpel or handfile. Sandpaper is normally used to reduce seedcoat thickness by abrasion in hard coated species.

Hot-water treatment involves immersing seeds in 4-10 times their volume of boiling water (100° C), then allowed to soak and cool for 12 to 24 hours. The initial soaking temperature has a bigger effect than the soaking duration.

Cold water treatment involves the soaking of seeds in cold water in about five times the volume of the seeds for about 12-24 hours. Floating seeds are discarded as they are empty while healthy seeds imbibe water and swell and fall to the bottom of the container. Washing and prolonged soaking in water is the only way of removing germination inhibitors around the mesocarp of certain seeds (Maghembe 1995).

Burning serves the same purpose as the hot water treatment. It is normally used for seeds with tough seed coat such as *Acacia mearnsii*. The procedure involves covering the seed with a thin layer of soil. Debris is then piled on top of the buried seed and burnt. When the fire burns, out, the seeds are retrieved and soaked in cold water and sown.

Acid treatment involves the pouring of concentrated sulphuric acid over the seeds in a glass container, just enough to cover and wet them. The seeds are stirred with a glass rod for about 10-minutes, then the acid decanted. The seeds are washed by running cold water for 5-10 minutes to remove all traces of acid. The seeds are then soaked in cold water for 12-24 hours and immediately sown.

2.4.3 Seed sowing

Seeds can be sown directly in filled pots (polythene bags) or onto seed beds (germination trays), with a media composed of various proportions of sand and soil. The size of the seed will determine the sowing method. Large sized seeds can be sown directly in pots while small sized seeds should be sown first in seed beds and then the germinated seedlings are pricked out into pots. Seedlings are usually watered in the mornings and evenings. Over-watering should be avoided as it generally increases fungal infection. Exposure of nursery plants to sunlight has to be adjusted according to time and species requirements. Seedlings need to be protected from direct sunlight (Doran *et al.*, 1983).

Shading is necessary in order to avoid sun-scorch and excessive water loss especially during the dry season. Too much shading should be avoided as it causes etiolation of seedlings and may promote fungal diseases. Little shading on the other hand will promote rapid desiccation of the young plants.

2.5 Vegetative propagation

Domesticating desirable plants using vegetative propagation is not new, but dates back to millennia. Theophrastus, writing about plants in about 300BC, was already talking about the propagation of trees by means of cutting or layering (Janick, 1979). Vegetative propagation techniques are increasingly being applied to the domestication of tropical tree

species (Leakey *et al.*, 1990). A range of approaches can be used such as budding, grafting, stem cuttings, marcotting, suckering and *in vitro* techniques. Vegetative propagation has a number of advantages which include: true to type in such a way that the fruits resemble those of the mother tree and there is no difference in their genetic make-up and by rooting cuttings, plenty of nursery plants can be obtained at any time, without having to rely on seeds. Vegetative multiplication is also particularly valuable when: (i) Pests or diseases destroy most of the seed crop. (ii) Fruits or seeds are hard to collect, so the crop is small. Vegetative propagation allows trees to get improved quickly since most species have not undergone selection by mankind and their breeding is slow. Vegetative propagation allows more rapid genetic improvement, because

- (i) Trees with desirable characters can be selected directly to produce improved planting stock.
- (ii) This direct selection captures more of the desired characters.
- (iii) With each selected clone existing as many plants, it is easier to check which characters are strongly inherited (Longman, 1993).

However, the main disadvantage of vegetative propagation is the likelihood of disease transmission from the parent to the new individuals (Pgachanja and Ilg, 1990).

Insufficient knowledge of the anatomy, morphology and physiology of the wild plants leads to a poor understanding of their morphogenesis and failure to produce large quantities of propagules when conventional methods of vegetative propagation are used.

2.5.1 Cuttage(cutting) propagation

A detached plant organ such as a stem, leaf or root or a combination of organs such as a shoot which consists of stem, bud and leaf is capable of regenerating new missing organs under appropriate environmental conditions. By phenological classification, cuttings may be herbaceous, semi-hardwood and hardwood cuttings. As described by Longman (1993), herbaceous cuttings are leafy cuttings taken from un lignified and active growing tips. They are made from the terminal portion of a stem of current season's growth. Semi-hardwood cuttings are leafy and non-leafy cuttings taken from partially mature or slightly woody shoots. The cutting is neither woody nor too soft. The cuttings are usually 10 to 15 centimeters long with the basal cut just below a node. Leafy cuttings are rooted under high humidity such as in the mist propagation beds or in closed covered frames. Hardwood cuttings are made up of sections of a stem that is usually taken from the previous season's growth. Such stems are usually about a year old. Cuttings are usually 13 to 38 centimeters long or more, depending on the species and diameter of the cuttings varies from 1 to 2 cm. Roots develop from around the lower node while the shoot arises from the upper buds. The cuts are usually made just below a node or about 2.5 cm. above the node.

The subsequent rooting potential of a cutting is influenced by the position within a stem from which the cuttings originates (Leakey and Coutts, 1989). Most tropical trees can be vegetatively propagated using cuttings in a low-technology "mist poly-propagator" grown in a nursery and planted out just like seedlings (Longman, 1993). However, certain cuttings require very high humidity, moderately low light intensity, a suitable rooting medium and protection from wind, heavy raindrops, pests and diseases. Macellino (1980), noted that rooting of cuttings depends on the age of the plant, the condition of the cutting, the time of collection, the rooting medium and special treatments given.

Rooting hormones in plants stimulate the formation of new root tips in stem cuttings. Two artificial auxins known as Indolebutyric acid (IBA) and Napthalinacetic acid (NAA), are mostly used, either singly or in a mixture. Rooting hormones or plant regulators usually cause a greater percentage of cuttings to root, hasten the formation of roots, induce more roots per cutting and increase the uniformity of rooting (Godfrey *et al* 1996)

Hormones are applied on the cuttings using three main methods: a quick dip, powder or soaking. Quick dip involves the dissolving of a hormone in alcohol and dipping "basal end" of prepared cuttings in the solution a few millimeters for 1-5 seconds and drying off the alcohol quickly after which the cuttings are set. For the powder method, the

basal end of the prepared cutting is dipped a few millimeters into a talc powder preparation, the excess powder is then gently tapped off and the cutting set. For the soak method, the hormone is dissolved in water and the prepared cuttings are left to stand in this solution with the basal 2 to 3 cm in a solution for some minutes before setting them (Longman 1993).

2.5.2 Layerage

As described by Godfrey *et al.* (1996), layering is the regeneration of new roots on a portion of the shoot of an intact plant, followed by the detachment of the newly rooted shoot to give a new intact plant. Layering may occur naturally when a shoot comes in contact with moist soil. However, layering can also be induced deliberately by forcing a branch into contact with moist soil. The IBA solution can also be used to induce root formation to a wounded part of the layered shoot. One of the major advantages of layering is that it enables the propagation of the difficult- to- root species because water and carbohydrates from the layered plant's own intact root system are continuously translocated to the zone of root formation. Therefore water and nutrient stress are avoided. In addition it requires relatively low levels of skills, equipment and facilities.

The disadvantages of layering are labour intensiveness, relatively low multiplication rate from a single stock plant when compared to other

vegetative propagation techniques. This is because the stock plants must be well spread out and relatively few rooted layers can be obtained from each.

There are different types of layering such tip, simple, air (marcottage), mound and etiolation layering (Godfrey *et al.*, 1996)

Tip layering is where a shoot tip is buried approximately 2-4 cm deep to encourage rooting and new shoot growth. Simple layering is similar to tip layering except that the shoot is left exposed above ground while the buried portion just behind the tip is induced to root by wounding or girdling. Air layering induces new roots to regenerate on the aerial portion of the trunk or branches of an established tree while they are still attached to the parent plant. Later on the rooted branch is detached to form a new plant. It involves wounding the branch and moist sphagnum is wrapped around the branch it and it is then covered with polythene film to keep the moisture around the injured to facilitate rooting. Mound layering is a standard method used in the propagation of clonal apple rootstocks and effective with many other species. Etiolation or trench layering is similar to mound layering. This technique is used in the modern propagation of apple rootstocks.

CHAPTER 3

IDENTIFICATION OF IMPORTANT INDIGENOUS FRUIT TREE SPECIES IN MUKONO DISTRICT, UGANDA

3.1 Introduction

Identification is the first step in the process of domesticating indigenous fruit tree species. Jeanette(1995), noted that priority setting and characterisation based on users perceptions is an essential starting point for tree domestication research. This means that the user community should be consulted in deciding which indigenous fruit tree species have the greatest potential for domestication. Franzel *et al* (1995) emphasized that the identification of fruit trees species through surveys helps determine the species with the greatest potential for domestication or cultivation and which other species may be substituted to produce the same end product.

The objective of this study was to identify the indigenous fruit tree species with potential for domestication in areas surrounding Mabira Forest Reserve, Mukono district, Uganda.

3.2 Materials and methods

The study was carried out in Mukono District located in the Central Region of Uganda, roughly 16 Km from Kampala,(Appendix 1). It borders with the districts of Jinja in the east, Kampala and Luwero in

the west, Lake Kyoga in the north and Lake Victoria in the south (Mugisha, 1994). Mukono district has a land area of 4,819.34 sq km and comprises six counties, thirty-four subcounties and one hundred and ninety-seven parishes. The six counties are Mukono, Nakifuma, Buikwe, Ntenjeru, Bbaale and Buvuma. Mukono district receives an average annual rainfall of 1130mm with peak rain levels in March and October. The rainfall distribution pattern is bimodal with two peak periods in March to May and September to November. The mean maximum temperature varies from 23-28 °C while the mean minimum temperature varies from about 18-23°C. The relative humidity for the area is lower in the northern part of the district than the southern part. The vegetation comprises of tropical high forests, forest plantations, woodlands, bush, grasslands and wetlands. The forested areas covers 13% of the district, comprising of the southern parts and the biggest block being Mabira Forest. The woodlands, bushlands and grasslands cover the northern part of the district, while the wetlands cover the north-western part of the district.

The district has ferrosols and hydromorphic soils. In general, the ferrisols soils are more fertile and productive, while the hydromorphic soils (found mainly along rivers and Lake Victoria) are highly and easily leached.

The study was conducted using the survey method. Interviews and participatory rural appraisals were carried out in three subcounties (Najjembe, Nakifuma and Kangulumira) surrounding Mabira Forest Reserve. It was expected that more consumers of (indigenous fruits) would be in this area than further away, (Appendix 2). A questionnaire (Appendix 3) was developed and pretested by interviewing ten respondents from each subcounty where the actual interviews were going to be carried out. A list of people in these areas in each subcounty was obtained from the local council, and by random sampling forty (40) respondents were chosen from each subcounty for the interviews.

The total of 120 respondents interviewed were households heads and data was collected on the following:

- (i) indigenous fruit tree species in the study area
- (ii) their uses
- (iii) their regeneration and distribution within the forest
- (iv) their harvesting methods
- (v) their fruiting patterns
- (iv) their propagation methods

After the field interviews, ten (10) respondents from each subcounty where interviews had been conducted were assembled in a group and asked to rank the identified fruit tree species using bean seeds. Five

bean seeds indicated that the species was extremely important, four most important, three very important, two important and one somehow important.

Forty (40) market vendors were also interviewed from both Lugazi and Mukono markets. Twenty (20) vendors from each market were selected based on the fact that they were found selling some of the identified indigenous fruits or any other tree products for example medicine. Data was collected on the source of the fruits which were being sold, the conditions in which they were being sold.

The data was analysed using Excel and Genstat computer programmes. The statistics employed in the analysis were mostly frequencies and percentages. Cross tabulation was used to get the frequencies and percentage of people consuming a certain species and also using a particular product from a particular tree species.

3.3 Results

The participatory rural appraisal survey showed that there are five main indigenous fruit trees in Mukono District (Table 1). These are : *Garcinia buchananii* (Musaali), *Canarium schweinfurthii* (Muwafu), *Tamarindus indica* (Mukoge), *Vangueria apiculata* (Mutugundo) and *Pseudospondias microcarpa* (Muziru). The status of regeneration of all identified species was found to be decreasing and all of them had never

been cultivated before for providing fruits. The distribution of these trees within the forest was distinct: *C. schweinfurthii* was found scattered in all parts of the forest, *P. microcarpa* was found to be scattered in swampy areas while *V. apiculata*, *T. indica* and *G. buchananii* were found growing at the forest edges.

It was observed that the identified indigenous fruit trees have various uses in Mukono district (Table 2). *Garcinia buchananii* provides fruits, medicine for curing cough, poles for building and firewood for cooking. *Tamarindus indica* provides fruits, fuelwood for cooking and poles only, while *V. apiculata* and *P. microcarpa* provide fruits and fuelwood. *Canarium schweinfurthii* provides fruits, gum and timber.

Table 1: General information of indigenous fruit trees identified in areas surrounding Mabira Forest Reserve.

Species	Status of regeneration	Distribution	Propagation
<i>Garcinia buchananii</i>	Decreased	Forest edge	None
<i>Canarium schweinfurthii</i>	Decreased	Scattered in forest	None
<i>Tamarindus indica</i>	Decreased	Forest edge	None
<i>Vangueria apiculata</i>	Decreased	Forest edge	None
<i>Pseudospondius microcarpa</i>	Decreased	Swampy forest areas	None

Table 2: Indigenous fruit trees and their uses in areas surrounding Mabira Forest Reserve, Mukono district, Uganda.

Species	Uses	Frequency (f)	Percentage (%)
<i>Garcinia buchananii</i>	Fruit	54	45
	Medicine	50	41.5
	Fuelwood	4	3.4
<i>Canarium schweinfurthii</i>	Fruit	57	47.5
	Poles	23	19.1
	Timber	2	1.7
<i>Tamarindus indica</i>	Fruit	30	25.0
	Poles	10	8.5
	Fuelwood	27	22.5
<i>Vangueria apiculata</i>	Fruit	24	20.0
	Fuelwood	15	12.5
	Poles	6	3.4
<i>Pseundospondius microcarpa</i>	Fruit	24	20.0
	Fuelwood	15	12.5
	Poles	4	3.4

N=120

Garcinia buchananii was ranked as the most important fruit species followed by *C. schweinfurthii*, *T. indica*, *V. apiculata* and *P. microcarpa*.

Garcinia buchananii and *V. apiculata* fruit from April to July, *T. indica* fruits from April to August, while *P. microcarpa* fruits from April to August and *Canarium schweinfurthii* fruits from June to December (Table 3).

Methods of harvesting fruit trees in Mukono district include tree climbing, picking from the ground and tree felling. *Garcinia buchananii* fruits are mainly harvested by climbing the tree (32) and picking the fruits from the ground (22). Medicine for curing cough is obtained by debarking the trees (52). *Canarium schweinfurthii* fruits are harvested by picking from the ground (50), branch cutting (5) and to a small extent by climbing (2). *Pseudospondius microcarpa* fruits are mainly harvested by picking from the ground (18) and by tree felling (5). *Tamarindus indica* fruits are obtained by tree climbing (21), tree felling (6) and by picking from the ground (3). *Vangueria apiculata* is mainly harvested by climbing (23).

There are three categories of fruit collectors in Mukono District: those who simply collect for home use, those who collect and sell to market vendors and those who sell at the roadside or take the fruits to the market. The first group does not earn income but the second and third group do.

Table 3: Seasonality and methods of harvesting indigenous fruits and medicine in areas around Mabira Forest in Mukono district, Uganda

Species	Fruiting	Harvesting	Frequency
<i>Garcinia b Buchananii</i>	April to July	Climbing Ground Debarking	32 22 52
<i>Canarium schweinfurthii</i>	June to December	Climbing Branch cutting Ground	2 5 50
<i>Tamarindus indica</i>	April to August	Climbing Felling Ground	21 6 3
<i>Vangueria apiculata</i>	April to July	Climbing Ground	23 1
<i>Pseudospondius microcarpa</i>	April to August	Ground Felling	18 5

Most of the fruits from the identified indigenous species are mainly for home consumption. For instance 97.8%, 34.6%, 100%, 45.6% and 74.5% of the quantities collected from *G. b Buchananii*, *C. schweinfurthii*, *P. microcarpa*, *T. indica* and *V. apiculata* respectively end up being consumed at home rather than being sold (Table 4).

Market vendors obtained their fruits from three main sources (Table 5): by collecting the fruits from the wild themselves (primary source), buying from someone who collected them from the wild (secondary source) and in a few cases, buying from a fellow market vendor with large quantities of fruits (tertiary source).

Fruit	Primary source	Secondary source	Tertiary source	
			Vendor	Market
<i>Passiflora</i>	33	37	Home use	24.8
			Vendor	43.5
			Market	22.7
<i>Passiflora</i>	0.5	10	Home use	45.6
			Vendor	52.5
			Market	2.5
<i>Passiflora</i>	4.2	24	Home use	74.5
			Vendor	21.5
<i>Passiflora</i>	0.5	24	Home use	14.5

Table 4: Quantities of indigenous fruits harvested and their destination

Species	Average quantities (kg)	Frequency (f)	Destination (%)	
<i>Garcinia buchananii</i>	2.5	54	Home use	97.8
			Market	2.2
<i>Canarium schweinfurthii</i>	3.5	57	Home use	34.6
			Vendor	43.1
			Market	22.1
<i>Tamarindus indica</i>	0.5	30	Home use	45.6
			Vendor	52.9
			Market	2.5
<i>Vangueria apiculata</i>	0.2	24	Home use	74.5
			Vendor	25.5
<i>Pseudospondius indica</i>	0.5	24	Home use	100

N= 120

2.6. Discussion

As has already been stated, the study was conducted in a rural area of the country. However, the statistical data show a significant difference between the rural and urban areas. This difference is due to the fact that the rural area is more developed than the urban area. The rural area is more developed than the urban area because it has more resources and a higher level of education. The rural area is more developed than the urban area because it has more resources and a higher level of education.

Table 5: Sources of indigenous fruits sold in markets in Mukono

Species	Source	Frequency (f)
<i>Garcinia buchananii</i>	Primary	2
<i>Canarium schweinfurthii</i>	Primary	7
	Secondary	18
	Tertiary	5
<i>Tamarindus indica</i>	Secondary	2
	Tertiary	18
<i>Vangueria apiculata</i>	Secondary	5

N= 40

3.4 Discussion

All the identified fruit trees provide edible fruits to the local communities in the area. However, their additional uses play a big role in the lives of the rural communities. These provisions include medicine, income generation, food security, construction materials and fuelwood.

These findings are similar to those of Maghembe and Seyani,(1991) who during their ethanobotanical studies in Mlawi found out that indigenous wild fruit trees were greatly being valued by farmers for food,cash,medicine,fodder, fuelwood, shade and building materials.

Garcinia buchananii was identified as the most important indigenous fruit tree species to the local communities in areas surrounding Mabira Forest Reserve. This was due to the fact that the local communities obtain cough mixture from its bark.

All the five identified indigenous fruit trees face the danger of depletion if nothing is done to save the situation. As the survey results show regeneration of all the species (young seedlings, saplings, mature trees) is decreasing such that with time there will be no mother trees (seeding trees) in the future to replace overmature trees. Unfortunately no efforts have been made by the local communities to plant these indigenous fruit trees to ensure their continuity. Therefore, there is a need to capture the germplasm of these indigenous fruit tree species from the wild before they are completely depleted.

All these tree species except *P. microcarpa* grow on the forest edge in Mukono implying that these species could survive on farms if properly domesticated and cultivated.

The local communities in the areas surrounding Mabira Forest are able to consume indigenous fruits through three quarters of the year since the duration of fruiting of the identified fruit tree species lie between April and December. Therefore in case of famine they can be used as emergency food supplies. According to Sharma (1998) in Thar desert, when annual crops fail during drought, the yield on non-wood forest products does not decrease drastically thus ensuring food security while providing additional income for marginal farmers.

Methods of harvesting the indigenous fruits include picking from the ground, climbing and tree felling. However the tree felling harvesting method is a threat to the survival of these fruit tree species. Furthermore the continuous debarking of *G. buchananii* by the local people to obtain cough mixture renders it an endangered fruit tree species.

CHAPTER 4

SEED PROPAGATION OF *Garcinia buchananii*

4.1 Introduction

The second step in domestication of indigenous fruit tree species is the capturing of germplasm through seed or vegetative propagation. Mateke et al. (1995) noted that simplified seed propagation techniques are important in the domestication process. However, Kwapata (1995), noted that one of the major problems with successful domestication of many of the horticulturally acceptable indigenous fruits, is the difficulty in obtaining sufficient quantities of propagules, and characteristics such as very hard seed coats, physiological dormancy and low viability which contribute to poor germination of many wild fruit species. Maghembe (1995) showed that simple germination pretreatments can result in high germination percentages.

The objective of this work was to determine the most suitable methods for seed propagation of *Garcinia buchananii* identified as the indigenous fruit tree species with the greatest potential for domestication in areas surrounding Mabira Forest, Mukono district, Uganda.

4.2 Materials and methods

Seed propagation trials for *Garcinia buchananii* were carried out at Makerere University Agriculture Research Institute Kabanyolo

(MUARIK), located about 14 km North East of Kampala. The station is in Mpigi district, at an elevation ranging from 1250 m to 1320 m above sea level. The soils are formed on residuum and colluvium from quartzite, gneiss and other basement complex rocks. The climate is tropical, with main daily maximum temperature varying from 28.5° C. in January to 26.0° C. in July. The minimum temperatures vary from 17.4° C. in to and 15.5 °C in July and August. The relative humidity is between 90 to 100 percent. The annual rainfall is about 1300 mm for about 150 rainy days, with a broad peak in March-May and a narrow peak in October-November (Yost and Eswarana, 1990).

Trial 1

Ripe fruits of *Garcinia buchananii* were collected from trees with good vigour during the survey. They were cleaned, and put in clearly labelled polythene bags. The seeds were removed from the fruit pulp (Fig.1), sun dried for one week and then subjected to the following pregermination treatments :

- (i) Nicking of seed coat,
- (ii) Soaking in cold water at 25 ° C for 12 hours
- (iii) Soaking in hot water at 60 ° C for 12 hours,
- (iv) No treatment (control)

The trial was laid out as a complete randomised block design (CRBD), with each treatment replicated three times and each replicate consisted of 40 seeds. The seeds were sown in an outdoor seed bed prepared

with a medium containing a mixture of sand and top soil at a ratio of 3:1. A papyrus mat shade was constructed using poles to provide shade to the seedlings. Watering was done uniformly twice a day on all the treatments over the trial period.

Trial 2

Trial 2 was similar to trial 1 with the following changes:

(1) The pre-germination treatments which included:

(i) seed brazing

(ii) soaking of seeds in cold water at 25 ° C for 24 hours.

(2) The growing medium was washed and sterilised coarse sand

(3) Each treatment was replicated three times and each replicate consisted of 50 seeds.

(4) The trial was carried out indoors in a green house.

For both trials, data was collected on the following aspects:

(i) time to germination

(ii) emergency rate of seedlings,

(iii) survival of seedlings 30 days after germination,

(iv) height of seedlings 30 days after germination

The data was analysed using MSTAC computer programme.



Figure 1: Ripe fruits and seeds of Garcinia buchananii.



Figure 2: Seedlings of Garcinia buchananii after germination

4.3 Results

Nicking and brazing of seeds before sowing resulted in high germination percentages compared to other pregermination seed treatments. High growth rates were also observed in seedlings which germinated from seeds which were brazed before sowing (Fig. 2).

Nicked and brazed seed germinated significantly ($P < 0.05$) earlier as compared to seeds under other treatments. Nicked seeds started to germinate 40 days after sowing, while soaked and control seeds started to germinate 44 and 50 days after sowing respectively (Table 6).

Brazed seeds started to germinate 32 days after sowing compared to seeds soaked in water for 24 hours (35 days) and untreated seeds (38 days) (Table 7). Pregermination seed treatments also had a significant effect on seed germination percentages. Seeds which were brazed and nicked had significantly ($P < 0.05$) higher seed germination percentages of 93% and 40% respectively as compared to soaking in cold water and untreated seeds (Table 6 and 7). The cumulative percentage seed germination for *G. buchananii* after undergoing the various pregermination treatments is shown in Fig. 3.

Pregermination seed treatments had also a significant effect on growth rates in terms of height of seedlings of *G. buchananii*. Nicking the seed coat resulted in significant ($P < 0.05$) taller (2.1 cm) compared to soaking in cold water (1.6 cm) which was also significantly ($P < 0.05$) taller than the control (1.2 cm). Brazing resulted in significantly ($P <$

0.05) taller seedlings (2.3 cm) compared to the water soaked seeds (1.8 cm) which were also significantly ($P<0.05$) taller than the control (1.4) seeds.

Soaking in cold water for 24 hours resulted in earlier onset of germination (35 days) and higher germination percentage (78%) (Table 7) as compared to soaking in cold water for 12 hours which germinated after 44 days and had a germination percentage of 17.5.

There was no germination with soaking in hot water (Table 6).

Table 6: The effect of various pregermination treatments on seeds of *G. buchananii* (trial 1)

Treatment	Onset of germination (days)	Germination %	Height (cm)
Nicking	40	40	2.1
Soaking in cold water for 12 hours	44	17.5	1.6
Soaking in hot water for 12 hours	0	0	0
Control	50	7.5	1.2
LSD (5%)	2.0	1.29	0.2
CV	2.9	3.9	6.9

Table 7: The effect of various pregermination treatments on seeds of *G. buchananii* (trial 2)

Treatment	Onset of germination (days)		Germination %	Height (cm)
Brazing	32		93	2.3
Soaking in cold water for 24 hours	35	78		1.8
Control	38		51	1.4
LSD (5%)	2.2		4.7	0.3
CV	2.7		2.8	7.3

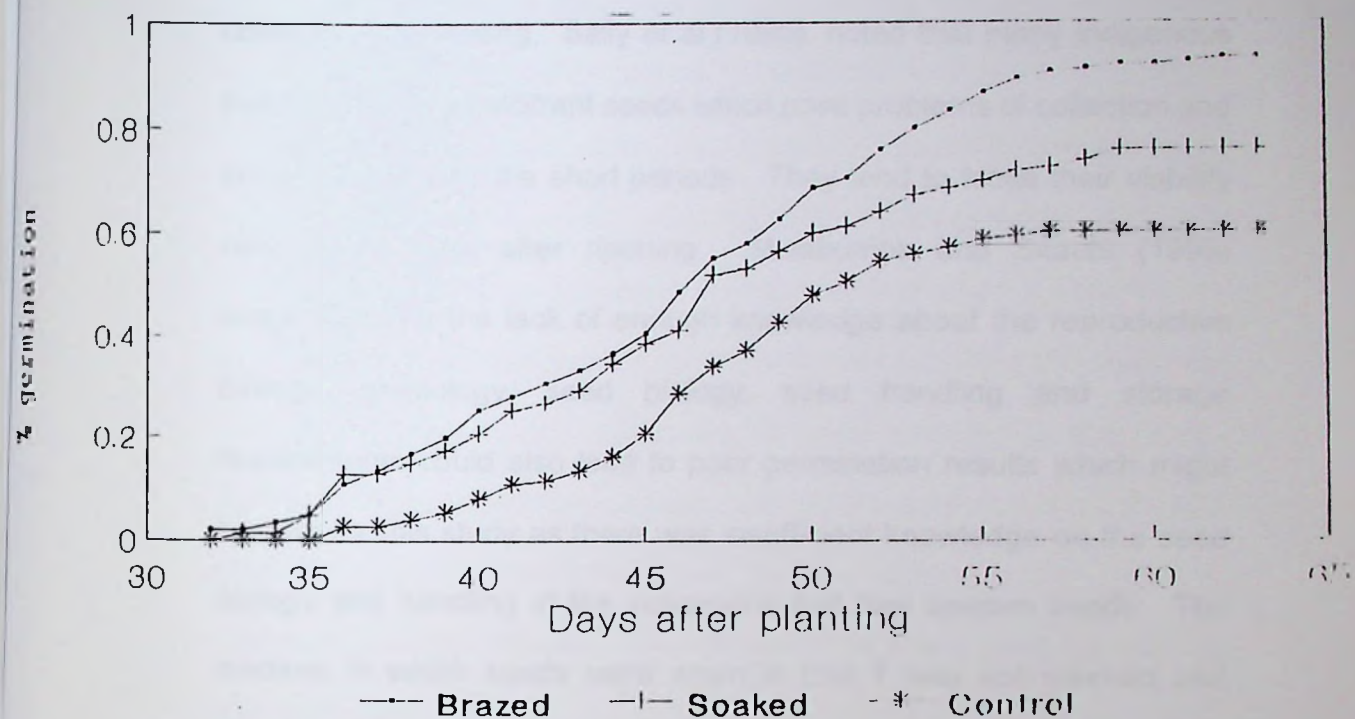


Fig. 3: Cumulative seed germination of *G. buchananii* after undergoing various pregermination treatments

4.4 Discussions

The overall cause of poor seed germination in trial 1 was possibly due to the fact that the seeds of *Garcinia buchananii* are recalcitrant type of seeds which might have lost their viability over the period of seed collection and sowing. Sally *et al* (1995), noted that many indigenous fruit trees have recalcitrant seeds which pose problems of collection and storage even over the short periods. They tend to lose their viability very easily soon after ripening. Mwabumba and Sitaubi (1995) suggested that the lack of enough knowledge about the reproductive biology, phenology, seed biology, seed handling and storage requirements could also lead to poor germination results which might be true for this study as there was insufficient knowledge on the seed biology and handling of the indigenous fruit tree species seeds. The medium in which seeds were sown in trial 1 was not washed and sterilised, the soil microorganisms could have damaged the seeds rendering them unviable. Due to the fact that the seeds in trial 1 were sown in an outdoor seed bed, predation on seeds by rodents cannot be ruled out and could have contributed to the overall poor germination results as some ungerminated seeds were missing. Some ungerminated seeds had also turned from brown to black at the end of trial 1. Gordon *et al.*, (1991) noted that seeds that have not produced any part of a seedling at the end of a trial are classified as dead seeds.

These dead seeds are usually discoloured and may be mouldy. They further noted that seeds which have not germinated may be classified as empty, insect infested and embryo-less.

The seeds of *G. buchananii* seem to have seed coat dormancy. The removal of part of the seed coat through nicking in trial 1 enabled the seeds to imbibe water to initiate germination faster than the seeds subjected to other treatments. The soaking of seeds in cold water (25 ° C) helped to weaken the seed coats to facilitate water uptake to initiate the germination process. The seeds under control were the last ones to germinate due to slow uptake of water caused by the seed coat resistance. The results are similar to those obtained by Maghembe (1995) on the pregermination seed treatments on *Azanza garckeana*, where nicking had the highest seed germination percentage of 100%, followed by seeds soaked in cold water with 40% and finally control had the lowest with 17%.

Villiers (1972) noted that seed coat dormancy is mainly due to the thick-walled, palisade like cells of the seed coat and the cuticle layer. Kozlowski (1971) noted that seeds of most tree and shrub species show some degree of dormancy as germination is not completed even in the most favourable environments.

Brazed seeds had an earlier seed germination onset, high germination percentage and high growth rates. These results further confirms that

the seeds of *G. buchananii* have seed coats which have high resistance (seed coat dormancy) to water and therefore need to be weakened by brazing (disturbance of the seed coats) to allow ease water uptake by seeds and initiate the germination process to take place.

It seems the degree of seed coat disturbance has an effect on the onset of seed germination *G. buchananii*. This could be attributed by the fact that the higher the degree of seed coat disturbance the faster the water uptake hence the earlier onset of germination. Brazing gave higher germination percentage (93%) compared to nicking (40%) in this study.

None of the seeds soaked in hot water (60 ° C) germinated implying that soaking of seeds in hot water could have killed the seed embryos.

Furthermore, the period of soaking of seeds in water has also an effect on the onset of seed germination and germination percentage of *G. buchananii*. The longer the soaking period, the more weaker the seed coat becomes making it more easy for water uptake and hence earlier onset of germination. Seeds which were soaked in cold water for 24 hours had earlier (35 days) and higher percentage of germination (78%) compared onset of germination than those which were soaked for 12 hours which germinated after 44 days with only 17.5% germination.

Although there was delayed onset of germination in the control, the fact that these seeds were able to germinate without soaking in water shows that seeds of *G. burchananii* have no germination inhibitors around their mesocarp. Maghembe (1995), noted that seeds with germination inhibitors around their mesocarp require prolonged soaking in water in order to remove germination inhibitors before they can germinate.

The results from the pregermination seed treatments clearly show that in order to get earlier onset of germination, higher germination percentages and better growth rates, the seeds of *G. burchananii* should be brazed before being sown.

CHAPTER 5

VEGETATIVE PROPAGATION OF *Garcinia buchananii*

5.1 Introduction

Vegetative propagation is another method used in the capturing of the germplasm of indigenous fruit trees from the wild. Leakey *et al.*, (1990) noted that vegetative propagation techniques are increasingly being applied to the domestication of tropical tree species. He further noted that a range of approaches that can be utilised include stem cuttings, layerage, grafting, budding and tissue culture.

The main objective of this study was to evaluate cuttage and layerage vegetative propagation methods for *Garcinia buchananii*, which was identified as the indigenous fruit tree species with the greatest potential for domestication in areas surrounding Mabira Forest, Mukono district, Uganda.

5.2 Materials and methods

5.2.1 Cuttage propagation

Trial 1

Stem cuttings of *G. buchananii* for propagation were collected from Gayaza subcounty in Mpigi district. The collected cuttings were put in polythene bags and kept in cool moist conditions and delivered to Makerere Agricultural Research Institute, Kabanyolo on the same day

for propagation. The basal ends of the cuttings were dipped into the rooting hormone powder (Seradix talc) and set in the rooting medium. Seradix talc is a rooting powder which contains IBA. Seradix 1 contains 0.1% IBA, Seradix 2 contains 0.4% IBA and Seradix 3 contains 0.8% IBA. The rooting medium was a mixture of murram and decomposed saw dust at a ratio of 1:2 was prepared and put in polythene tubes. The polythene tubes were put under a constructed frame and a white polythene sheet was used to cover completely the frame and the cuttings (Fig.4). Watering was done uniformly twice, in the morning and evening on all the treatments throughout the trial period.

The trial was carried out in the green house and it consisted of seven treatments as follows:

- (i) Herbaceous cuttings treated with Seradix 1,
- (ii) Herbaceous cuttings treated with Seradix 2,
- (iii) Herbaceous cuttings treated with Seradix 3,
- (iv) Semi-hardwood cuttings treated with Seradix 2,
- (v) Semi-hardwood cuttings treated with Seradix 3
- (vi) Hard-wood cuttings treated with Seradix 3,
- (vii) Control for all treatments.

Each treatment consisted of 15 cuttings.

Trial 2

Trial 2 was similar to trial 1 with the following changes:

- (1) The rooting medium was coarse sand prepared by washing and sterilization to free it from soil micro-organisms

5.2.2 Air layerage

The indigenous fruit tree of *G. buchananii* was located and identified in Gayaza subcounty in Mpigi district. A selection of 60 upright growing semi hardwood branches of about 3 cm thick were identified on the tree. Two girdles of about 2 cm apart were made on the selected branches by cutting through the bark to the wood all the way around the branch. Rooting hormone (Seradix 2- 0.4% IBA) talc was applied around the wounded areas of only 30 branches and the remaining 30 branches had no rooting hormone treatment, and therefore constituted the control. Using clear polythene wrappers, wet and decomposed saw dust was put around the wounded areas of all the 60 branches. The wrappers were tied tightly at both ends. After four weeks the wounded areas were checked for any root formation.

For both vegetative propagation methods, data was collected on the following: (i) Date of shoot sprouting

(ii) Date of callus formation

(iii) Time to root

(iv) Number of rooted cuttings

(v) Number of roots per cutting

(vi) Quality of the rooting system

Genstat computer program was used to analyse the data. Results were presented in form of tables.

5.3 Results

Cuttage

In trial 1 there was no callusing and cuttings never rooted. However some buds sprouted and remained alive for 15-20 days and then died and were shedded and the whole cutting rotted.

Trial 2 had almost similar results as trial 1 except that softwood cuttings started callusing 9 weeks after being set in the polypropagator. Hardwood cuttings had a higher percentage sprouting (33% and 66%).

Untreated cuttings had no sprouting. Only softwood cuttings treated with seradix 2 and 3 started callusing nine weeks after being set in the propagator (Table 8).

Air layerage

There were no roots formed on branches for the Air layerage trial period of 6 weeks.



Figure 4: Cuttings of Garcinia buchananii set in a Polypropagator.

	Sprouted %	Callused %	Sprouted %	Callused %
Softwood cuttings treated with seradix 1 ^a	6.6	0	13.2	0
Softwood cuttings treated with seradix 2 ^b	6.6	0	13.2	6.6
Softwood cuttings treated with seradix 3 ^c	13.2	0	19.8	6.6
Semihardwood cuttings treated with seradix 2	6.6	0	19.8	0
Semihardwood cuttings treated with seradix 3	13.2	0	33.0	0
Hardwood cuttings treated with seradix 3	33.0	0	66	0
Control	0	0	0	0

^aSeradix = 0.1% IBA

^bSeradix = 0.4% IBA

^cSeradix = 0.8% IBA

5.4 Discussion

Garcinia buchananii seems to be a difficult-to-root fruit tree species. It took nine (9) weeks for the softwood cuttings to start callusing which was much longer than the periods suggested by Mudge *et al.* (1992) of 2-6 weeks for softwood cuttings, 5-25 weeks for semi hardwood and 8-36 weeks for hardwood cuttings.

Poor results from both cuttage and layerage could have been due to insufficient knowledge of the anatomy, morphology and physiology of *Garcinia buchananii*. Kwapata (1995) noted that poor understanding of the morphogenesis of wild plants has lead to failure to produce large quantities of propagules when conventional methods of vegetative propagation methods are used. The response of *G. buchananii* to rooting hormone (IBA) was poor since there was no rooting by the end of the trials.

Godfrey *et al.* (1996) suggested that when dealing with difficult-to-root species, the dormant hardwood cuttings should be treated with 100 ppm IBA for 24 hours, then the cuttings should be placed upright in boxes of damp peat-moss over bottom heat at 21 ° C to 24 ° C in unheated, open shed. This method keeps the bases of the cuttings warm but exposes the top buds to the cold. They further noted that sometimes dormant hardwood cuttings of difficult-to-root species are prepared and bundled in groups, wrapped in clear plastic sheets and tied. The plastic sheet-wrapped cuttings are buried or stored in callusing beds for at least 30 days until they are ready for planting.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Indigenous fruit tree species identified in Mukono district include *Garcinia buchananii*, *Canarium schweinfurthii*, *Tamarindus indica*, *Vangueria apiculata* and *Pseudospondius microcarpa*. These five indigenous fruit tree species apart from providing fruits from the local communities, they are also a source of firewood, timber, poles and medicine.

Garcinia buchananii was prioritized as the most important fruit tree species because of its additional value for providing a cough mixture.

In addition to providing fruits, firewood, poles, and wine, its distribution at the forest edge, medicinal value and endangered status due to continuous debarking renders *Garcinia buchananii* the indigenous fruit tree species with the highest domestication potential in Mukono district.

Through seed propagation, seed brazing resulted in significantly earlier onset of germination (32 days), higher seed germination percentage (93%) and better growth rates (2.3 cm).

Garcinia buchananii is a difficult-to-root species with slow response to hormone treatment. Less than 7.0% softwood cuttings treated with 0.4-0.8% IBA callused after 9 weeks.

However rooting could be improved with application of higher concentrations of rooting hormone for longer periods of time (24 hours) in combination with applications of basal heating.

It is recommended that other methods (i.e. grafting and budding, tissue culture etc) to be carried out on *Garcinia buchananii*.

Seed and vegetative propagation trials should be carried out for the other four species.

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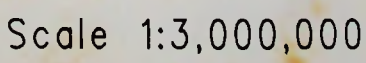
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IND:



ND:

- Surveyed Sites
- District Boundary
- County Boundary
- Mabira Forest Reserve Boundary
- Lake Shore



Scale 1:950,000

Appendix 3: Questionnaire

The aim of this questionnaire is to gather information about forest products in line with fruit trees and also other uses such as medicine, timber, pole and firewood. The information will be used to identify and rank the indigenous fruit trees in this area and finally evaluate the propagation methods of the indigenous fruit species will have been ranked highly among the identified indigenous fruit trees. Therefore we will be grateful if you give us the relevant information to enable us meet our goal.

PART ONE

Collection of data on indigenous fruit trees from farmer

1 Code of respondent.....

2. Do you harvest products from the forest, and if you do please specify them.

3. For fruits, what kind of fruit trees do you harvest?

Species (Botanical)

Luganda

4. What time of the year do each of the fruit species mentioned in (3) above flower?

5. What time of the year do you harvest and how many times a year do you harvest each species mentioned in (3) above?

6. How do you collect each of the fruit species mentioned in (3) above?

1. Felling the trees
2. Climbing the tree
3. From the ground

7. Which part (s) of the fruit do you consume

1. Flesh
2. Seeds
3. Whole

8. In what form do you consume the fruits

1. Direct
2. Juice extract
3. Dried first

9. How far inside the forest do you go for each kind of fruit?

10. Do you think that the availability of these fruits has changed during the last 5 to 10 years? Please tick one.

1. Today it is easier to gather the fruits
2. Today it is more difficult to gather the fruits
3. No change
4. Don't know

11. Of the fruit trees mentioned in (3) above do you notice in young trees an increase or decrease in number in the forest?

12. How much do you collect from the forest in terms of kilograms for each species mentioned in (3) above?

13. Do you sell some of the fruits you collect from the forest and in what form?

1. Fresh
2. Dried
3. Boiled

14. In what quantities do you sell each of the fruit species mentioned in (13) above?

15. Who is your customer?

16. Do you store some of the fruits gathered from the forest mentioned in (3) above? If yes in what form and conditions?

17. Do you cultivate some of the species mentioned in (3) above. If yes what methods do you use?

1. Seeds
2. Cuttings
3. Grafting

18. For fruit species where seeds are used for planting do they germinate easily?

19. If not what treatment do you apply to the seeds to make them germinate easily?

20. For fruit species where cuttings are used, What type of cuttings do you use?

21. Do you apply hormones to your cuttings before planting? If yes, name the hormones

22. For fruit species where grafting is used, how do you carry it out? Give other uses of fruit tree species mentioned in 3 above.

PART TWO

Collection of data on indigenous fruit trees from market vendors

Respondent code.....

1. I would like to know the name of the trees/shrub products you are selling.

BOTANICAL

LUGANDA

1.

2.

3.

4.

5.

2. For fruits, how do you get them?

3. In what month of the year do you get them?

4. How many times a year do you get them?

5. In what quantities do you get them in terms of kilograms?

6. How much do you buy and sell fruits obtained in 2 above

7. In what form do you buy and sell fruits in 2 above

1. Boiled

2. Liquid

3. Powder

8. What are the uses of these fruits

9. How much quantity in terms of kilogram are you able to sell for each fruit species?

PART THREE

Collection of data on indigenous fruit trees from Forest Department staff such as Forest officers, Rangers and Guards)

Respondent code.....

1. I would like to know what kind of forest products that are harvested from the forest.

2. If fruits, what kind of fruits is harvested?

1. Fruits from trees
2. Fruits from shrubs
3. Others

3. If from trees, what is the name of the tree

BOTANICAL LUGANDA

- 1.
- 2.
- 3.
- 4.
- 5.

4. For the species mentioned in (4) where about in the forest does each species prosper best

Species Locality (in the forest)

5. Indicate in terms of hectares the approximate area covered by each species mentioned in (4)

Species Harvesting period (month)

6. Indicate the flowering time for each species mentioned in (3) above.

7. When are the fruit harvested for the individual species mentioned in (3) above

8. Indicate the species (3) whose seeds can germinate

9. What are the conditions of establishment of species mentioned in (9) above.

Species

Conditions of establishment

10. Indicate the level of depletion of each species mentioned in (3) above

11. Give other uses of the tree species mentioned in (3).