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Uganda Coffee
Development Authority

CLONAL ROBUSTA COFFEE NURSERY MANUAL

For Extension Workers and Nursery Operators in Uganda

Citation: Clonal Robusta Coffee Nursery Manual For Extension Workers and Nursery Operators in Uganda

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PREFACE

The Ugandan Coffee sub-sector is currently operating below its full potential. It is therefore critical to enhancing the production and productivity of farmers in a sustainable way that addresses the social, ecological and economic dimensions. This requires a steady and sustainable supply of high yielding and disease-free planting materials, which when planted and properly managed can potentially increase yield per tree. This translates into improved livelihoods through generation of high household incomes.

Some of the gaps identified in the Coffee sub-sector have been lack of up-to-date technical resource materials to guide the nursery operators in production of improved planting materials. The existing Clonal Coffee Nursery manual produced in 1995 lacks information on recent practical, agronomic and production practices at the nursery level.

The Clonal Robusta Coffee Nursery Manual is developed to train nursery operators raising clonal Coffee plantlets of Robusta Coffee. The manual provides precise guidelines on how to cost-effectively produce healthy and quality Coffee planting materials. It also provides guidelines on planting and managing young Coffee trees up to the age of 6-9 months.

The manual has been developed for Coffee extension staff and nursery operators in Robusta Coffee growing districts. However, the knowledge and guidelines it provides are universal and can be used by Coffee researchers, students and subject matter specialists involved in teaching Coffee in schools, agricultural colleges and universities.

We appreciate the efforts and resources of all those who contributed to the development of this manual. In particular, USAID Feed the Future Uganda Enabling Environment for Agriculture Activity (EEA) and Café Africa for technical and financial support and members of the working group for technical input. I encourage key stakeholders in the sub-sector to utilize it as a key tool for transforming their enterprises.

Dr. Emmanuel Iyamulemye Niyibigira
MANAGING DIRECTOR

Chapter 1

INTRODUCTION

1.1 Background

Coffee is the most important cash crop of Uganda, both in terms of foreign exchange earnings and employment creation. Coffee plays a leading role in the livelihoods of Ugandans and contributes on average 17-20% of the country's foreign exchange earnings. Coffee is grown by 1.7 million households; the industry employs over 5 million people along the Coffee value chain.

There are two types of Coffee grown commercially in Uganda; Arabica Coffee, grown in highland areas and Robusta Coffee in lowland areas. Robusta Coffee accounts for 80% of the Coffee grown in Uganda. Currently, 104 districts grow Coffee; 66 grow only Robusta Coffee, 25 districts grow both Robusta and Arabica and 13 districts grow only Arabica.

1.2 Government policy and strategy on the Coffee sub-sector

Because of Coffee's economic importance, the government launched the Coffee Roadmap to increase Coffee exports from 3.5 million to 20 million 60 kg bags by 2025. To meet this target, in 2014 the government started a replanting programme of distributing Coffee seedlings to replace the old and unproductive Coffee trees and expand the area under Coffee cultivation. At the same time, many farmers are investing in Coffee to improve production and productivity of their farms and consequently, their income and welfare. This requires the availability of highly productive and disease-resistant planting material for the farmers.

This manual is intended to guide the propagation of Robusta Coffee by clonal or vegetative method.

1.3 Characteristics of Robusta Coffee and its Importance

Robusta Coffee (*Coffea canephora*) is grown in the low altitude areas of Uganda, ranging from about 900 metres to 1,200 metres above sea level. It has a shallow root system and grows as a robust tree or shrub to about 10 m tall. It flowers irregularly, taking about 10–11 months for cherries to ripen depending on rainfall distribution, producing oval-shaped beans. Robusta Coffee has a greater crop yield per tree than that of Arabica, contains more caffeine (2.7% compared to Arabica's 1.5% and contains less sugar (3–7% compared to Arabica's 6–9%). It is less susceptible to pests and disease, thus, needs less fungicides and pesticides than Arabica.

Commercial production of Robusta Coffee began in the early 1920's and an extensive production program was undertaken in the 1950s. By 1960, Coffee production had risen to about 2 million bags and reached its first peak of 3.7 million in the 1972/73 Coffee year and 4.2 million bags in 1996/97. Due to civil strife, marketing monopoly and old age of the Coffee trees, production had declined to as low as 2.1 million bags by 1991. However, Coffee production has been improving since the liberalization of the sector in 1991 except for the Coffee Wilt Disease (CWD) that has destroyed about 56% of Robusta trees since 1993, causing a big constraint to Robusta Coffee production. Nevertheless, through research and extension, Coffee Wilt Disease-resistant and high yielding varieties are currently available and being distributed to farmers thereby boosting production.

1.4 History of Robusta Coffee propagation in Uganda

Robusta Coffee grown in Uganda was derived from trees collected by agricultural workers in the early 1900s and consisted of two broad types: the "Erecta" type and the "Nganda" type. By mid-1930s, it was realized that more productive cultivars could be developed through deliberate selection within the existing tree population. Towards the end of the 1960s, some 25 individual trees (lines) had been selected on the basis of early maturity, high yield, large beans, good liquor and resistance to fungal diseases. These were further reduced to 8 clonal varieties that were later in 1995, reduced to 6. The six lines were distributed to nursery operators for propagation and released to farmers for planting.

Unfortunately, in 1993 the Coffee Wilt Disease (CWD) was identified to be attacking Robusta Coffee trees and the 6 clonal varieties were also found to succumb to the CWD. This destabilized the replacement of old traditional Coffee trees with clonal varieties and by 2002, about 56 percent of Robusta Coffee trees had been destroyed. However, through rigorous breeding for resistance to CWD, the National Coffee Research Institute (NaCORI) has developed 10 Coffee Wilt Disease-resistant (CWD-r) lines that were released by NARO's Variety Release Committee. Currently, 10 CWD-r lines are available for multiplication through both tissue culture and nodal cuttings (vegetative propagation), although the quantity available for planting by farmers is still low.

The major challenges in the multiplication of sufficient quantities of CWD-r planting materials include:-

- Insufficient knowledge and lack of practical skills by nursery operators in the propagation of clonal Coffee cuttings. This has led to high seedling mortality rates, which eventually demotivates the Coffee nursery operators.
- Limited entrepreneurial skills and techniques in managing Coffee nursery businesses, particularly in the areas of record keeping, cash-flow management, budgeting and planning.
- Inadequate development and dissemination of extension materials on Coffee nursery production techniques.
- Few skilled trainers on basic Coffee nursery production and management practices.
- Unfavourable weather due to climate change which has led to relatively high temperatures and humidity, which in turn affect the production of clones/cuttings.

1.5 Clonal Robusta Coffee propagation

Robusta Coffee is preferably propagated by vegetative means rather than through seed. This is because Robusta Coffee exhibits self-sterility. Robusta Coffee plants grown from seed will have a high degree of heterogeneity, which alters the desirable characteristics of the resultant Coffee plants. This variation may be manifested in the physical appearance of leaves, size of the fruits and beans, tree vigor, productivity, tolerance to drought, fruit formation, length of internodes, ripening time and uniformity. The method of vegetative propagation eliminates this progressive loss of the desired traits in the descendant Coffee trees.

Clonal Coffee propagation involves harvesting nodal cuttings from young shoots of recommended Coffee varieties and rooting the nodal cuttings under specialized conditions. This is the best method of propagating Coffee varieties derived from individual hybrid trees (controlled or open pollination), selected for exceptional agronomic and market traits that can be lost if the varieties are propagated by botanical seed. The major agronomic traits for selecting hybrid Coffee trees are high yields, tolerant to drought and disease resistance, e.g. Coffee wilt resistance; while the market traits are large beans (big screen size) and good taste (cup liquor).

Therefore, Robusta Coffee is vegetatively propagated using the **nodal stem cuttings** because of the following factors:

- Robusta Coffee is self-sterile and cross-fertilizing. This implies that Coffee flowers of the same tree

cannot self-fertilize because they are sterile among themselves. In contrast, Coffee trees of different clones can cross-fertilize. It is recommended, therefore, that at least 5 different clones be planted in a production garden to get good fertilization

- Vegetative propagation of Coffee can also be carried out by grafting. However, this method is not common in Coffee because the root stock on which to graft is always scarce. Therefore, propagation by nodal cuttings is the most commonly used technique, which involves producing roots and leaves on stem tissues that eventually develop into young plantlets.

1.6 Importance of Clonal Coffee Nurseries

Clonal Coffee nurseries provide a steady and suitable supply of improved, disease-free planting materials to support planting and replanting of Coffee farms. Maintaining the genetics of the mother plant in future generations assures long term sustainability of the Coffee enterprise. This can only be achieved through a rigorous breeding programme and effective clonal propagation practices.

Since 2009, the National Coffee Research Institute (NaCORI) has released 10 lines of Robusta Coffee which are high yielding and resistant to Coffee Wilt Disease. The Robusta clonal lines being propagated are KR1-KR10. These lines, which are commonly referred to as KR-lines, with their description, year of release and major attributes are presented in Table 1 below.

Table 1. Recommended CWD-r Lines

CWD-r Line	Year of Release	Major Attributes
KR1 (NARO-Kituza Robusta 1)	2009	Yield 2,200kg/ha/cc/year; resistant to leaf rust, tolerant to RBD resistant to CWD, has big beans, good cup quality
KR2 (NARO-Kituza Robusta 2)	2009	Yield 2,600kg/ha/cc/year; resistant to leaf rust, tolerant to RBD, resistant to CWD, has big beans, good cup quality
KR3 (NARO-Kituza Robusta 3)	2009	Yield 4,900kg/ha/cc/year; resistant to leaf rust, tolerant to RBD, resistant to CWD, has big beans, good cup quality
KR4 (NARO-Kituza Robusta 4)	2009	Yield 2,300kg/ha/cc/year; resistant to leaf rust, tolerant to RBD, resistant to CWD, has big beans, good cup quality
KR5 (NARO-Kituza Robusta 5)	2009	Yield 2,900kg/ha/cc/year; resistant to leaf rust, tolerant to RBD, resistant to CWD, has big beans, good cup quality
KR6 (NARO-Kituza Robusta 6)	2009	Yield 2,600kg/ha/cc/year; resistant to leaf rust, tolerant to RBD, resistant to CWD, has big beans, good cup quality
KR7 (NARO-Kituza Robusta 7)	2009	Yield 3,000kg/ha/cc/year; resistant to leaf rust, tolerant to RBD, resistant to CWD, has big beans, good cup quality
KR8 (NARO-Kituza Robusta 8)	2017	Yield 3,100kg/ha/cc/year; resistant to leaf rust, tolerant to RBD, resistant to CWD, has big beans, good cup quality
KR9 (NARO-Kituza Robusta 9)	2017	Yield 3,900kg/ha/cc/year; resistant to leaf rust, tolerant to RBD, resistant to CWD, has big beans, good cup quality

CWD-r Line	Year of Release	Major Attributes
KR10 (NARO-Kituza Robusta 10)	2017	Yield 4,800kg/ha/cc/year; resistant to leaf rust, tolerant to RBD, resistant to CWD, has big beans, good cup quality

1.7 Objectives of the Clonal Coffee Nursery Manual

This manual is intended to guide Coffee nursery operators, extension workers and all institutions engaged in the business of propagating clonal Coffee planting materials. It explains the recommended practices for the successful raising of clonal Coffee plantlets and acts as a reference guide for best practices in clonal Coffee propagation and provides harmonized messages to all actors in the Coffee nursery business. It also provides an update on mitigation and adaptation practices of the effects of climate change on clonal Coffee nursery management.

Chapter 2

ESTABLISHMENT OF A CLONAL COFFEE NURSERY

2.0 Introduction

A clonal Coffee nursery is a business entity for commercially generating Coffee planting materials from vegetative parts of an established Coffee plant and raising the resultant plantlets in a nursery. The nursery site should be located on gentle sloping and well-drained land, with a permanent water source and easily accessible by all-weather motorable road network.

A number of facilities and amenities must be available at the site for establishing a clonal Coffee nursery. These are illustrated in Figure 1 below:-

1. Water source
2. Toilet/pit latrine
3. Office and store
4. Rubbish pit
5. Working shade
6. Rooting shade
7. Hardening shade
8. Demonstration plot

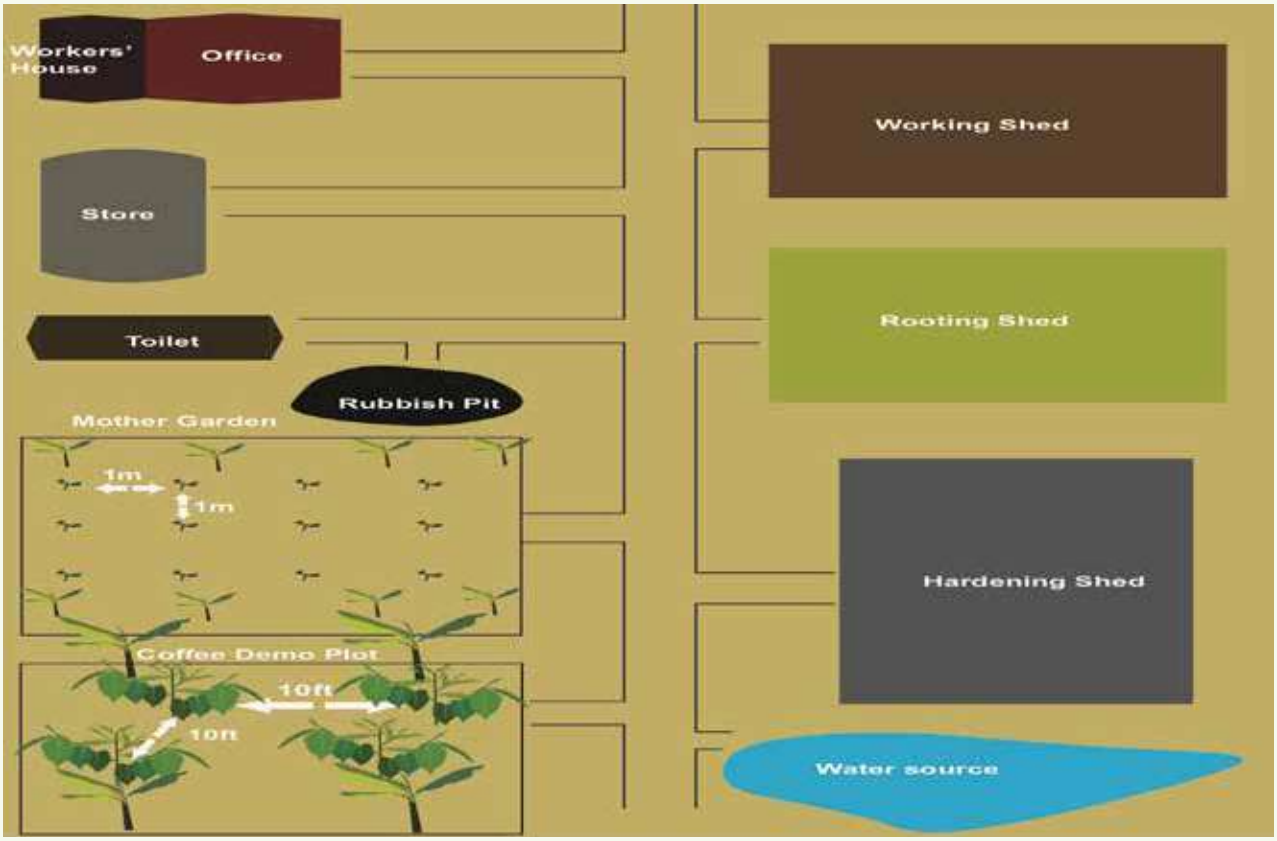

Figure 1: Layout of a clonal Coffee nursery

2.1 Water source

Water on a Coffee nursery is essential for good growth of the plantlets in the nursery and for human consumption. It is should be the first component to be established at any Coffee nursery site. An appropriate and reliable water source such as rain-harvested water as shown in Figure 2, wells, springs, boreholes and dams should be put in place to sustain the Coffee plantlets propagation process and ensure healthy growth of plants. The use of chemically treated water should be avoided in the propagation process.

Figure 2: Rain harvested water source

2.2 Toilet/pit latrine

Construction of toilet facilities, preferably VIP type, for workers as shown in Figure 3 is important in a clonal Coffee nursery setting for maintaining the quality of hygiene necessary in a commercial business environment.

Figure 3: A pit latrine facility at a clonal Coffee nursery

2.3 Office and store

A separate building with an office and store for the inputs and tools as shown in Figure 5 is recommended. Pallets, as shown in Figure 4, should be available in the store to safely hold agrochemicals and equipment instead of placing them directly on the store floor.

Figure 4: Pallets for holding nursery chemicals and equipment in a clonal nursery store

2.4 Rubbish pit

A rubbish pit as shown in Figure 5 is necessary for garbage collection, disposal and treatment for recycling of unwanted materials and waste at the clonal Coffee nursery. To ensure sustainable farming, appropriate disposal of non-biodegradable material such as plastics, glass bottles, metal, etc. should be practiced. The bio-degradable rubbish should be in a separate pit as it is useful for use as compost manure for the mother garden.

Figure 5: A simple rubbish pit at a clonal nursery facility

2.5 Working shed

A working shed as shown in Figure 6, is a sheltered area for holding potting materials, preparation and mixing of the potting media to be filled in pots prior to planting of the harvested cuttings.

Figure 6: A working shed at a clonal nursery facility

2.6 Rooting shed

A rooting shed shown in Figure 7 is a holding area for clonal cuttings that have been placed in polypots and/or propagation bins.

i. The shade top net should be 70% to 80% glass fiber net (for Agricultural Use). (Note; during extreme hot/dry weather conditions, increasing shade to 90% may be required, and in the wet, normal weather conditions, may use 70% shade nets.
ii. Size of the shed depends on the planned production capacity.
iii. Normally, the height of the shed should not be less than 9 feet high (an implication of poles not less than 11 feet).
iv. Side light entry of about 50% – 60% is preferable (use of bamboos/reeds/small weaved eucalyptus or black glass fiber net 50% to 60% shade can achieve this.
v. Ensure good, clean hygiene in the shed.

Figure 7: A properly built rooting shade for clonal cuttings

2.7 Hardening shed

A hardening shade, as shown in Figure 8 is a special facility used to gradually acclimatize the plantlets to the conditions of the external environment, prior to getting plantlets out for planting. This comprises of an agricultural fiber net on top that permits 40% to 50% shade but allowing for minimum light entry of about 50% – 60% light at the sides. This can be achieved by using bamboo's/reeds/small weaved eucalyptus/ or fiber glass which is capable of delivering at least 50% to 60% light into the shed. The size of the shed depends on the planned production capacity. The height of the shed should not be less than 9 feet high (an implication of poles not less than 11 feet).

Figure 8: A hardening shade for clonal cuttings

2.8 Demonstration plot

A clonal Coffee demonstration plot, as shown in Figure 9, is essential and used by the nursery owner primarily to demonstrate and showcase the performance and management practices of recommended clonal Robusta Coffee varieties under promotion. In addition, various agronomic practices for various Coffee Wilt Disease-resistant varieties are tested and showcased on this demo garden.

Figure 9: A clonal Coffee demonstration plot

2.9 Mother garden

The mother garden is the source of Coffee multiplication materials for the nursery. Its establishment and management is described in detain in Chapter 3.

Chapter 3

ESTABLISHMENT AND MANAGEMENT OF A CLONAL COFFEE MOTHER GARDEN

3.0 Introduction

A clonal Coffee mother garden as shown in Figure 10 is a special plot of land on which the parent plants of the recommended clonal varieties are grown, which will act as a continuous source of shoots that will be cloned to generate rooted plans.

A mother plant is a Coffee plant from which a nursery operator harvests the clones, which are then made to grow into new plants that are genetically identical to the mother plant. To create a clone, the nursery operator cuts a mature sucker from the mother plant and places the cut clone piece in a substrate, where it develops roots of its own. Eventually, if the cuttings and their new roots are kept in an environment where they receive the right amount of light and nutrients to continue developing roots and shoots, then the clones grow into fully developed Coffee plants.

Figure 10: Clonal Coffee mother garden

By routine harvesting of mother plants and growing clones in the propagation sheds, the commercial nursery operator gets to know exactly what to expect in terms of size, quality and harvest yields.

3. 1 Establishment of a clonal Coffee mother garden

The following are the recommended key steps for the successful establishment of the mother garden.

i. Selection of site for the mother garden
ii. Field preparation
iii. Layout of the mother garden
iv. Digging holes
v. Backfilling holes
vi. Sourcing and planting of mother plants
vii. Planting the mother garden

3.1.1 Site for the mother garden

The mother garden should be located:

- on fertile soil of gentle sloping land to enable proper drainage;
- near a reliable source of clean water (stream, a well, a borehole or piped supply, but not chemically treated water);
- on land with security of tenure (fully owned or on long term lease);
- on land with good road access;
- not too far/too isolated from dwellings to ensure security;
- on fenced land to avoid damage by animals and unauthorized entry by people;
- as close as possible to the rooting shade in order to reduce time loss, labour costs and damage to materials during transportation.

3.1.2 Field preparation

The area where a mother garden is to be established must be well prepared and existing trees should be ring-barked at least one year before planting in order to prevent infestation by the root rot disease (*Armillaria mellea)*. The roots of old tree stumps are a source of infection to the young Coffee by the above fungus. It is recommended to take the following steps:

- Clear the land and remove all tree stumps with their roots
- Plough and level the land during the dry season
- Plant windbreakers
- Mark out rows following the contours
- Plant shade trees
- Set up a water delivery system from the water source to the plants.

The above implies that:

a. Arable land must be cleared of all un-wanted vegetation in preparation for planting the mother garden.
b. Land must be free from obnoxious weeds such as couch grass (*Lumbugu*), the worst enemy of Coffee. It must be completely eradicated either by digging and handpicking or use of systemic herbicides prior to planting.
c. Leave some mature trees for shade cover, at a spacing of 20 m x 20 m. This gives a good shade cover while avoiding competition for water and nutrients. The trees should be managed (pruned) to give the right shed coverage while avoiding it being an alternate habitat for disease/pests and retarding sucker growth. Keep the trees at a maximum height of 4-5m to facilitate easy management. Examples of recommended shade trees include *Albisia coriaria* (Mugavu) and *Ficus natalensis* (Mutuba).
d. Avoid trees that are alternate hosts to the Black Coffee Twig Borer (BCTB). These include trees such as *Maesopsis eminni (*Musizi*)*, *Albizia chinensis* and Avocado.
e. Carry out deep ploughing. It is a good way of rejuvenating the soil.
f. Plant bananas for extra shade if required.
g. Cover crops should be planted at early stages of mother garden establishment to avoid soil erosion.
h. For sloped terrain, apply soil and water conservation measures such as contour trenches, contour terraces, vegetative barriers, soil bands, grass strips and cut-off drains to avoid soil, water and nutrient loss.
i. Permanently planted windbreaks are only recommended in sites exposed to strong winds, and even then, only where they are needed to supplement inadequate natural forest if required,
    - Windbreakers are usually located along boundaries of the Coffee area.
    - Windbreakers include *Ficus natalensis* (Mutuba); *Albizia coriaria* (Mugavu).
    - On sloping land, the spacing between windbreakers may be closer.

3.1.3 Layout of the mother garden

An ideal mother garden should be divided into blocks with each block having a different variety of clonal mother plants spaced at 1m x 1m with banana grown in between as intercrops at a spacing of 3m x 3m as shown in Figure 11.

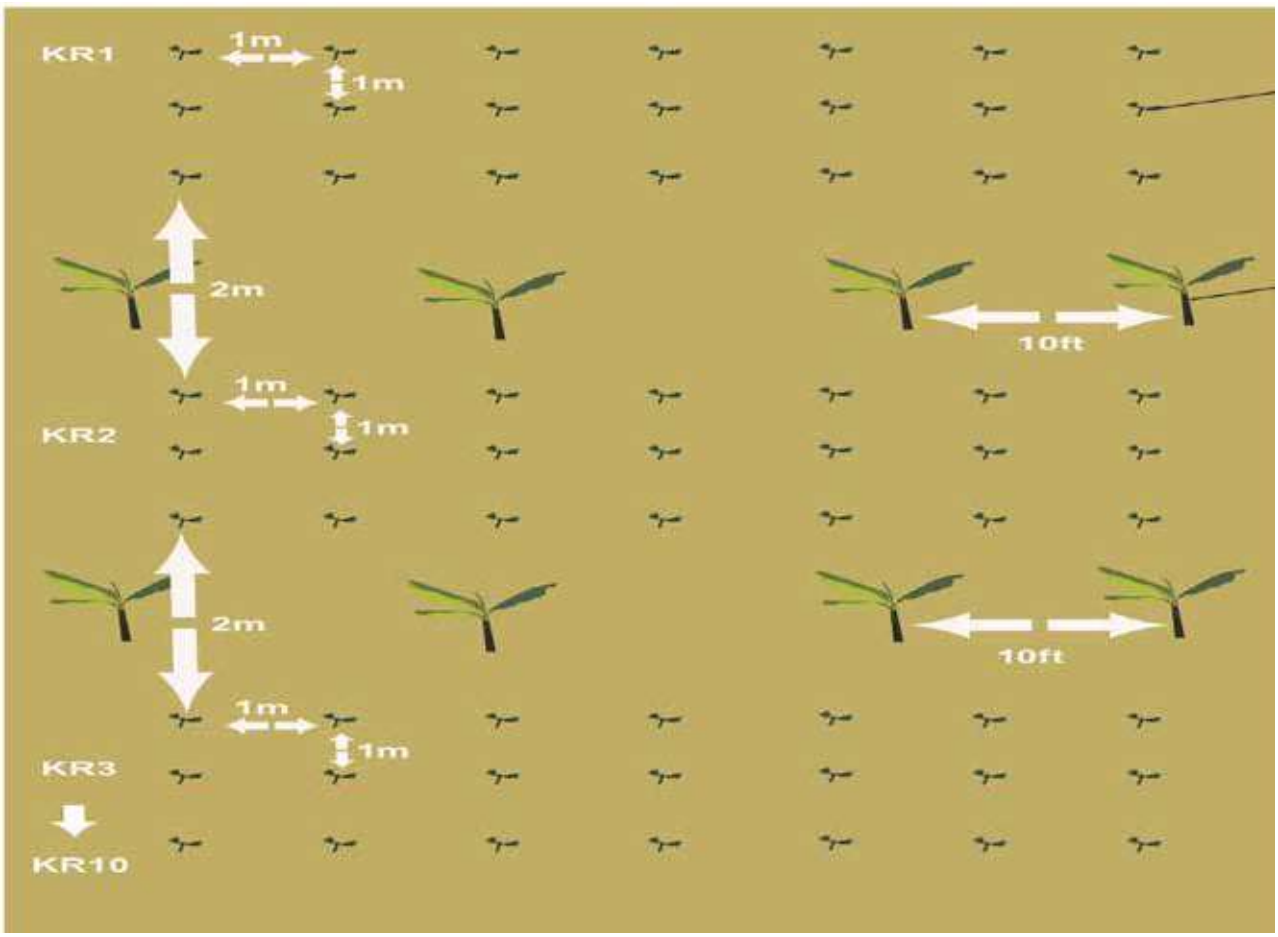

Figure 11: Layout of a KR mother garden

3.1.4 Preparing holes

It is recommended that holes are dug at least 3 months before the planting season to enable the nursery operator to get ready for planting at the onset of the following rains. The first step is to mark the land with spots marked at 1m x 1m using pegs/sticks. Align the market spots in square patterns. Dig holes of 2ft wide x 2ft long or 2ft in diameter and 2ft deep at the marked spots. When digging holes, keep the fertile topsoil separate from the subsoil as shown in Figure 12. In case of a sloping surface, the topsoil is placed on the upper side of the slope to allow it get into the hole first by runoff water when rains come before backfilling. The subsoil is placed on the sides of the hole to prevent it from getting back to the holes before the topsoil.

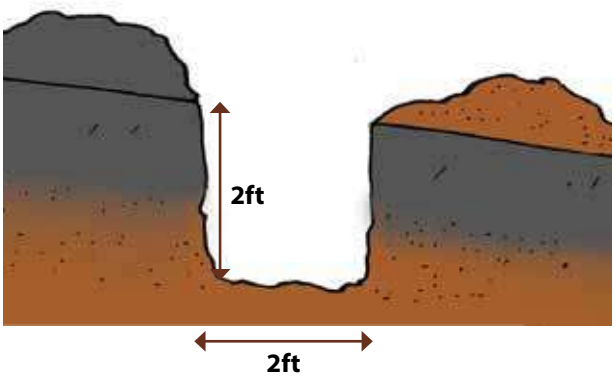

Figure 12: A prepared hole for planting a clonal Coffee mother plant

3.1.5 Backfilling of holes

Refill the holes with topsoil at least one month before planting. Mix the topsoil with a basinful of well-decomposed manure before re-filling each hole.

The decomposed manure mixed with soil should be placed in the hole first, to enable the roots quickly go down wards. After re-filling the hole, a peg is placed at the center of the hole in order to identify the center of the hole at planting time as illustrated in Figure 13 below.

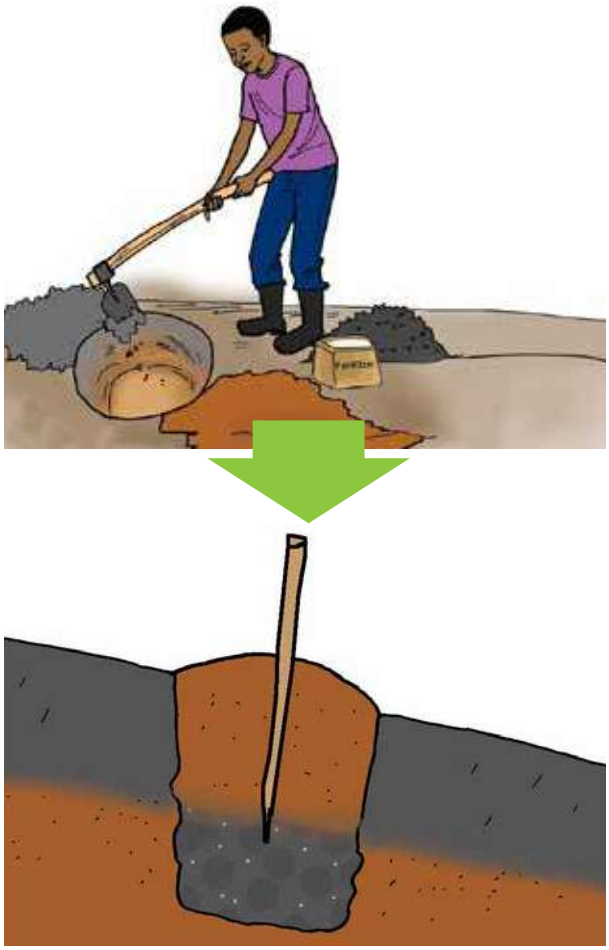

Figure 13: Backfilling of a clonal mother plant hole

3.1.6 Sourcing and planting clonal mother plants

It is recommended to use authorized, well-labeled plantlets after seeking guidance from UCDA, NaCORI or the District Agriculture Office in your area.

In selecting the best Coffee clones for planting in the mother garden, follow the following selection process:

- Get mature clonal Coffee seedlings with 3 – 4 pairs of leaves.
- Check all plantlets for signs of pests like root mealy-bugs, aphids and other sucking insects and diseases, especially brown eye leafspot. This prevents introducing pests and diseases into your garden.
- Avoid plantlets with twisted and/or roots protruding outside the polypot.
- Avoid plantlets that are already over 1.5 feet tall. These are overgrown and may not establish well.

Figure 14: Properly selected Coffee clone for a mother plant

3.1.7 Planting the mother garden

In planting the mother garden, follow the steps below:

- Soak the plantlets to loosen the soil in the polypot before planting.
- When planting in the dry season pour water in the entire backfilled hole prior to planting and continue to water the plantlets for the entire period before it rains.
- When you are depending on natural rains, it is advisable you plant after 4 consecutive good rain days, at the onset of the rainy season.
- Plant early morning or late afternoon and/or on cloudy days to minimize sun damage to the newly planted Coffee.
- As shown in Figure 15, place the plantlet in the East-West (Sunrise-Sunset) direction.
- Open up the centre of the back-filled hole sufficiently to accommodate the size of the potted plantlet.

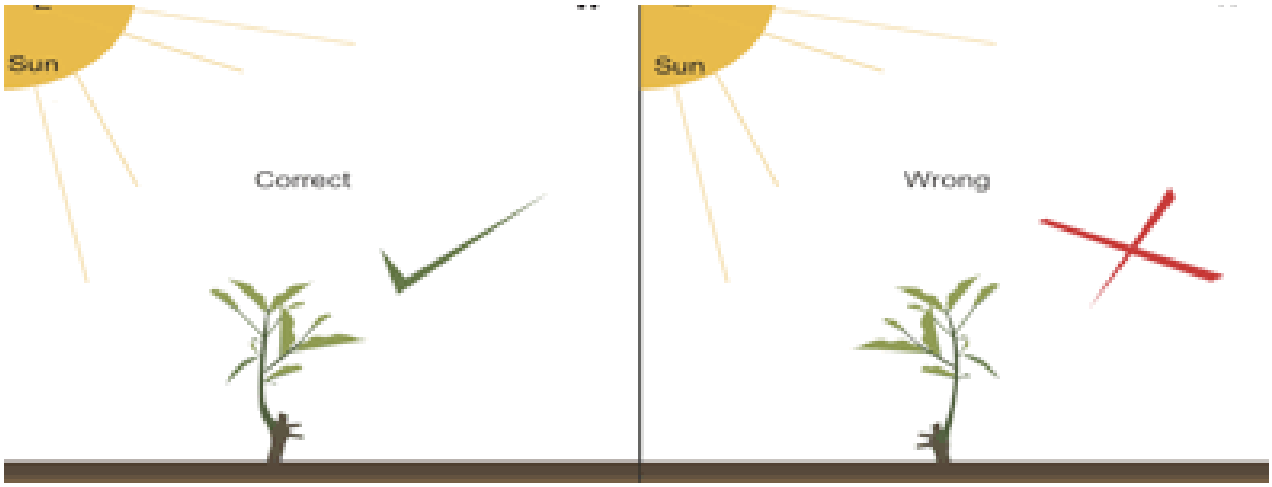

Figure 15: Positioning of the plantlet during planting in the mother garden

- Trim the bottom part of the roots and those protruding beyond the polythene pots before planting.
- Remove the polythene pots before planting by gently inverting the fully soaked plantlets in your hands and pulling off the polybag.
- Place the plantlet in the hole with the collar at about 2.5 cm (1 inch) above soil level.
- Apply 50 gms of Diammonium Phosphate (DAP) within the root zone of the plantlets to stimulate root development. Avoid putting fertilizer in direct contact with the plant in order to avoid fertilizer scotching the plant.
- Fill in the soil and press it firmly around the newly planted plantlet using your hands.
- Protect each plant from sunshine by providing a temporary shade (banana leaves, tree branch or palm tree fronds).
- The temporary shade should be removed when the new plant is firmly established and showing new suckers' growth.
- Mulch the entire row immediately after planting in order to conserve moisture, prevent weed growth and reduce soil erosion. If mulch is not sufficient, place a ring of mulch around the plantlet (but this must not be in contact with the plant). This can be done by providing cover at the base of the planted mother plant (mulch with split banana pseudo stems).
- Regularly inspect the planted field to identify occurrence of pests and diseases, dead plants and replace them as soon as possible to have a full-stand mother garden growing at same rate.
- During dry period continuously water the young plantlets using a bottle irrigation technique as shown in Figure 16 or other water delivery means until the plants get well established. The bottle is continuously filled with water, which is slowly released to the soil.
- The mother garden can be intercropped with beans in year 1, using a method of one line of beans intercrop per row of mother plants.
- In cases where labelled mother plants blocks are separated by a 2m spacing, it is recommended to intercrop bananas for shade at a spacing of 3 m from one banana stool to another, as shown in Figure 17.

Figure 16: How to adapt to extended drought/ dry weather (water bottle irrigation)

Figure 17: A well-managed mother garden with bananas and leguminous beans as intercrops

3.2 Management of a Clonal Coffee mother garden

The recommended management of a mother garden involves compliance to the best agronomic practices. These include:

1. Weed management
2. Soil and water conservation practices
3. Cultural practices
4. Training of mother plants
5. Nutrition and fertilizer management practices
6. Management of shade trees
7. Pre-harvest and post-harvest practices of suckers

3.2.1 Weed management

Weeds compete with plants for water and nutrients and eventually lead to reduced vegetative growth of the mother bush and thus low sucker yields in a mother garden. Weeds should, therefore, be properly managed and adequately suppressed to achieve maximum mother bush productivity. There are three basic methods of weed management namely:

i. **Cultural:** hand weeding, slashing, mulching or close spacing of crops or using cover crops to suppress weeds.

ii. **Mechanical:** hand hoeing, slashing or using a simple engine driven equipment is used to suppress weeds. Use of a forked hoe for weeding in mature mother gardens is recommended to avoid injuring the Coffee rooting system.

iii. **Chemical:** use of herbicides. However, the use of herbicides in the mother garden is not recommended and should as much as possible be avoided. This is because the mother bushes are often close together and application of herbicides would easily spill over the leaves and branches and retard growth of the mother bush.

3.2.2 Soil and water conservation practices

Soil and water conservation practices are important for conserving soil moisture for use in the dry period and for minimizing loss of soil fertility through erosion. The following soil and water conservation methods are recommended:

i. mechanical water harvesting practices
ii. terracing along contours
iii. construction of water retention bands

3.2.3 Mechanical water harvesting practices

The capacity of the pit reservoir is determined based on the production capacity of the mother garden and nursery per season. For example, a nursery that produces 25,000 plantlets per season requires 30,000 litres of water to sustain activities throughout that season. A water-harvesting dam as shown in Figure 18 is the most cost-effective method of harvesting and holding adequate water for watering a mother garden.

Figure 18: Water harvesting dam for providing water to a mother garden

If pits are used, rainwater is safely harvested with the aid of a water harvesting pit as shown in Figure 19.

The pit has a 'one-way' silt trap where water can enter. An outlet at the side prevents water from overflowing. A pit with the capacity of 30,000 litres is dug at a width of 13 feet at the top which narrows to 8 feet at bottom and 6 feet deep. Pits should be constructed during the dry season to prevent the risk of loose wet soil falling on people during excavation. Pits can be constructed using bricks, coated with cement or lined with polythene sheet.

Figure 19: Water harvesting pit for providing water needs of a mother garden

3.2.4 Terracing along contours

Terracing along contours as shown in Figure 20 is effective in cases of steep slopes to reduce soil erosion by minimizing rainwater runoff. A popular method known as *"Fanya Juu (*throw the soil up)" involves placement of soil on the upslope side of the contour trench. *"Fanya Chini (*throw the soil down*)"* involves the placement of soil on the lower side of the contour trench.

The terraces are laid in an alternate order starting with a *"Fanya Juu"* structure followed by a *"Fanya chini"*. The spacing of *"Fanya Juu"* terrace depends on the slope of the land. On a gentle sloping land, spacing of 10m between trenches can be used and on a steep slope spacing should be reduced to 8m or below.

Figure 20: Terracing along contours to minimize rainwater runoff

3.2.5 Construction of water retention bands

Water retention bands as shown in Figure 21 involves digging pits/troughs at some points within the mother garden to reduce run off and conserve rainwater. It is recommended to plant grass like *Paspalum spp* to stabilize bands.

Figure 21: Water retention bands along contours for reducing rainwater runoff

3.2.6 Cultural practices

Cultural management practices are crop production and management techniques utilized by the farmers to maximize their crop productivity. In the context of Coffee mother gardens these practices include:

- planting of cover crops
- planting of grass
- planting of trees
- mulching and manuring

i. **Planting of cover crops:** Planting of cover crops such as *Mucuna spp, Phaseolus spp, Lablab* and groundnuts can help to prevent soil erosion and retain soil moisture. Use *of Indigofera spicata* spp in the 3rd year is recommended when intercropping of the annual crops has stopped. Figure 22 shows *Lablab spp* being used as cover crop for preventing soil erosion in a mother garden.

Figure 22: Lablab spp. being used as cover crop in mother garden to help prevent soil erosion

ii. **Planting of grass:** Grasses such as Vetiver grass, leguminous plants such as *Tithonia diversifolia (wild sunflower) or Napier grass* should be planted at the edges of the mother gardens and ridges of terraces/contour bunds as shown in Figure 23 to reduce soil erosion. Besides controlling soil erosion, *Tithonia spp* has been known to enrich the soil with Nitrogen. Vetiver grass has favorable attributes for animal feed as it can be fed to domestic animals as fodder.

Figure 23: Napier grass being used in a mother garden to reduce soil erosion in a clonal Coffee mother garden

iii. **Planting of Trees:** Trees, as shown in Figure 24, are very effective in reducing soil erosion and recycling of soil nutrients through fallen and rotten leaves and other plant matter. In a clonal Coffee mother garden.

Figure 24: Trees being used in mother garden to reduce soil erosion in a clonal Coffee mother garden

iv. **Mulching and manuring:** Mulching is a soil and conservation measure but also a weed control measure. A split banana pseudo stems as shown in Figure 25 can be used to mitigate excessive evaporation at the foot of the mother bushes.

Manuring provides organic matter that improves the soil structure that enhances its water retention capacity thus reducing soil erosion.

Figure 25: Split banana pseudo stem mulch being used to reduce soil erosion in a clonal Coffee mother garden

3.2.7 Training of mother plants

Training is the bending of the young Coffee plants in an *East to West* direction and pegging them down at about 45 degrees to enable the orthotropic stem to produce suckers, from which harvesting of cuttings is done. Bending leads

to the breaking of dormancy resulting in multiple buds emerging at the base hence growth of numerous suckers. Bending is done when the Coffee seedlings are about 5-6 months after planting or when the Coffee plant reaches a "*knee-high*" height of 60 cm (2 feet) high as shown in Figures 27 to 30.

After 6 months, and the young plants are firm in the fields, all primaries (leaving at least one apical pair) should be removed. Do not remove the apical growing point at this stage. A useful technique of bending is to tie one plant to the base of the next (preferably in an east-west direction), while for the last plant, a peg would be used. Alternatively, use sisal or banana fibre to tie the bent mother plant to a peg. The bending stimulates dormant buds in the leaf axils to develop into suckers. When the main stem reaches a length of about 0.8 metre (after one year's growth), the main growing point (apex) should be capped to remove apical dominance.

Figure: 26: A 5-6 month young Coffee plantlet ready for planting in a mother garden

Figure 27: Training procedure of a young seedling using a peg

Figure 28: Training procedure in Coffee using a rope

Figure 29: A 3-month mother plant bush bearing young suckers after training.

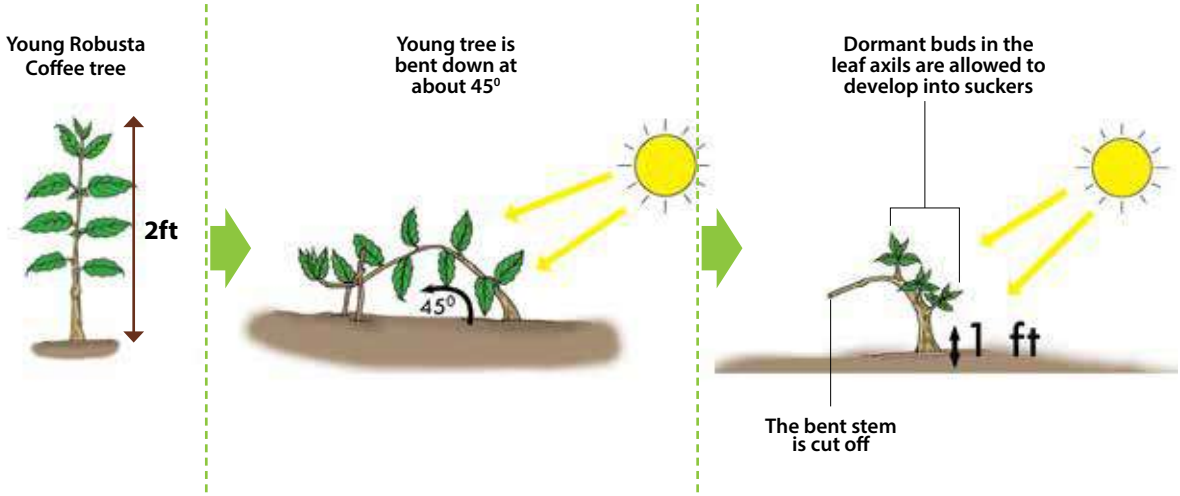

Figure 30: A trained Coffee mother plant after capping to remove apical dominance.

3.2.8 Nutrition and fertilizer management of a mother garden

Continuous harvesting of suckers leads to nutrient depletion. It is therefore, recommended that manure or fertilizers be applied to replenish the nutrients as per the results of the soil or leaf analysis.

The following are inorganic fertilizers applied in Coffee mother gardens.

Table 2 : Inorganic fertilizer/manure application program for Coffee mother garden

Year	Growth stage	Inorganic fertilizer gm/tree	Organic fertilizer (Animal/ crop residues) kg/tree
Year 1	At planting stage	50 gm/tree of DAP	One basin per plant.
	From 6 -12 months old	100gm/tree of N.P.K 17:17:17 or ASN or CAN	
Year 2	From 13-18 months old (during first rains)	100gm/tree of N.P.K (25:5:5) or ASN or CAN. Apply in two equal splits	One basin per Coffee bush per year
	From 19-24 months old (during second rains)	100 gm/tree of NPK 17:17:17 or ASN or CAN. Apply in two equal splits.	
Year 3	From 25- 30 months old	100 gm/tree of NPK (20.10.10)	One basin per bush per year.
	From 31- 36 months old	100 gm/tree of NPK (use 20:10:10)	
> Year 4	From 40 months old and above.	100 gm/tree of NPK (20:5:5) every 6 months	One basin per bush per year.

While applying fertilizers, the following recommended practices should be observed and adhered to:

a. At planting and in the 1st year, the plant requires phosphorus and therefore a phosphate fertilizer
b. Split the recommended application amounts into 3 or 4 equal portions and apply them at equal intervals during the season. This reduces the losses due to mineral leaching and run off
c. The recommended application amounts are varied basing on the soil and leaf analysis results
d. For liming, apply by broadcasting once a year using 250 gms of dolomite per tree from the age of 2 years old
e. Organic fertilizers complement and stablize soil pH (acidity/alkalinity) balance
f. The choice of either CAN or ASN should depend on the status of the soil pH
g. CAN or ASN should be applied occasionally to maintain a suitable pH range.
h. Compound fertilizers with trace elements are the best choice
i. Soil/leaf analysis should be carried out at least once in 2 years

3.2.9 Management of shade trees in the mother garden

- Periodic pruning of shade trees helps to maintain a balance of shade and light. Therefore, avoid excessive shade.
- Infestation of mother bushes by notorious pests such as Black Coffee Twig Borer (BCTB) is favored by excessive shade.
- In addition, too much shade retards suckers' growth and thus reducing yield of cuttings.

3.2.10 Pre-harvest, harvest and post-harvest practices of suckers in a mother garden

i. Pre-harvest practices

Before harvesting suckers from a mother garden, it is important to observe some pre-harvest practices as follows.

a. Two weeks before harvesting, the lower primaries on the suckers should be removed, leaving only one uppermost pair of primaries as shown in Figure 31. This practice ensures terminal growth of the suckers (like elongation of internodes and hardening of suckers).
b. Assemble the tools to use in the harvesting of the suckers.
c. Train workers on the harvesting of suckers, preparation of cuttings, and handling of the cuttings at preparation and potting stages.
d. If the weather is dry, adequate water should be provided to the mother plants the night before harvesting.

Figure 31: A Coffee mother bush with primaries removed.

ii. Harvesting and Post-harvesting practices

The harvesting of suckers should be done when the internodes have reached a size of pencil thickness in diameter and internode length range of between 7cm to 9cm. Recommended practices for harvesting suckers include:

a. Harvest suckers early in the morning (appropriately before 11.00am)
b. Cut off primaries that remain on the mother bush immediately after harvesting in order to reduce on loss of moisture and nutrients. Figure 32 shows a Coffee mother bush with primaries removed after harvesting suckers. If left intact, the primaries limit initiation, growth and development of more new suckers. To stimulate re-growth of suckers,

apply fertilizers 2 – 4 weeks after harvesting. Fertilizer application using 100gms per tree of N.P.K (25:5:5) preferably using two splits, each of 50gms.

c. To stop fungal infections, apply a copper fungicide spray at a rate of 50gms of powder in 20 litres of water.

Figure 32: A Coffee mother bush after harvesting suckers

3.3 Certification of clonal Coffee mother gardens and nurseries

To establish a clonal Coffee mother garden for purposes of generating planting materials for farmers or other nursery operators, one needs to have a certificate for the mother garden. The certificate is obtained after assessment and recommendation of technical inspectors from the Uganda Coffee Development Authority (UCDA) and National Coffee Research Institute (NaCORI). Each clonal Coffee nursery must be verified prior to its certification. One of the key requirements for certification is for the mother garden having well labelled and identifiable clonal Coffee lines as released by NaCORI. The target is to have at least one clonal Coffee nursery per sub-county in the Robusta Coffee growing districts.

Chapter 4

PROPAGATION OF CLONAL COFFEE PLANTLETS

4.0 Introduction

A cutting is the portion of a mother plant that is collected, treated, and planted to develop into a new intact plant complete with stems, leaves, and roots. Cuttings can be collected from mother plants grown in mother gardens and certified by UCDA and NaCORI.

Production of clonal plantlets involves the following:

1. Assembling of the right tools and equipment;
2. Construction of propagation bins (where applicable);
3. Construction of a propagation chamber;
4. Preparation of rooting media;
5. Harvesting of nodal cuttings;
6. Inducing rooting and shooting and
7. Hardening off the plantlets.

Propagation is a critical phase in the operations of a clonal Coffee nursery. A propagation unit creates an appropriate environment for rooting, shooting and subsequent growth of the plantlets. It is important to maintain hygiene at all points, as this will reduce disease and pest infestation that commonly translates into mortality of cuttings.

4.1 Tools and equipment for clonal Coffee propagation

The following are the minimum for operations of the clonal Coffee nursery.

1. Quarter rings for construction of cages
2. Clear sheet/white polythene sheets (gauge1000)
3. Polypots of variable size 5 inch by 8 inch
4. Metallic or plastic labels marked with the identity of the clone type/varieties e.g. KR1, KR2, KR3,……..KR10
5. Lake sand (free from clay or black soil)
6. Forest black soil)
7. Secateurs (at least 4 pairs)
8. Jerry cans
9. At least 2 metallic drums for soil steam sterilization
10. Plastic water drums
11. Agro-chemicals (fungicides and pesticides)
12. Rooting hormone
13. Watering cans
14. Wheelbarrows
15. Spades
16. Hoes

4.2 Construction of a propagation cage

A propagation cage is a structure for raising directly potted nodal cuttings. The cages are constructed in such a way that they can accommodate 8 filled pots (of size 5 inches by 8 inches) across and should be about 3 feet in width. This is wide enough to enable the polythene sheet to wrap around the cage well and prevent moisture from escaping from it.

The height of the cage should be at least 45cm. The cage is constructed using metallic rings, metallic hollow sections, timber and flexible sticks. Metallic iron quarter rings have been found to be durable by most nursery operators. The diagrammatic view of the cage setup is shown in Figure 33, with its side and end view in Figures 34 and 35 respectively.

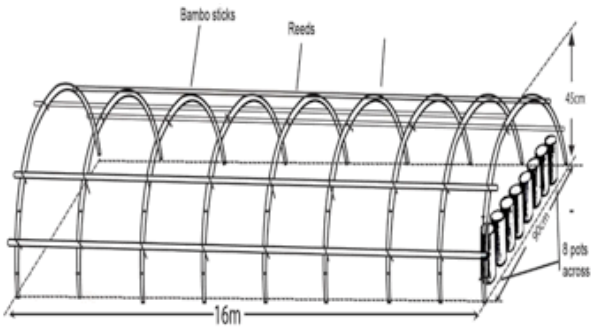

Figure 33: Diagrammatic view of a propagation cage set up

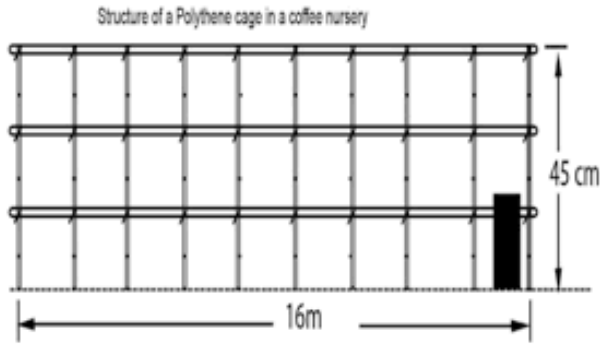

Figure 34: Side view of cage setup

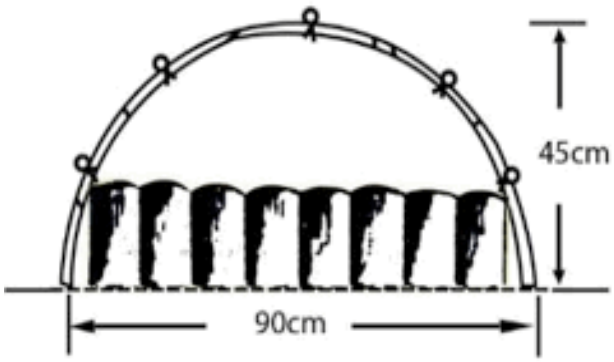

Figure 35: End view of cage set up

4.3 Clonal Coffee nursery shades

It is essential to have appropriate shades for rooting and raising rooted cuttings. Construct rooting shed with agricultural shade nets of 70-80% (meaning only allowing in 20-30% sunlight).

For hardening sheds, constrict the shade with agricultural shade nets of 40-50% (meaning the net allows in 50-60% sunlight. This is necessary as the rooted cuttings are almost ready to go out into the field.

Before placing the clonal Coffee cuttings into the sheds, the following process are completed first:

4.3.1 Preparation of rooting media

Rooting media enhances rooting, shooting of the cuttings and eventually the survival of rooted plantlets. The materials used for rooting media include black forest soil, white lake sand and saw dust.

i. **Black forest soil:** It is necessary to provide balanced nutrients to the cuttings after they have rooted. The soil should be transported to the site during the dry season, at least three months before use. It is then sieved to remove undesired materials such as stones, plant roots and any other debris. It is then heaped in the sun and covered with a black polythene sheet for solarisation to kill pathogenic microorganisms.

ii. **White lake sand:** The sand should have small to medium granules to provide suitable porosity to enable optimum aeration and drainage in the media. It should be free from any traces of clay and left in the sun for at least a month to dry.

iii. **Saw dust:** This is not commonly used these days. However, saw dust is an alternate substitute to lake sand as rooting media. Where sawdust is used, it is best to first leave it heaped in a pit or flat surface and wet it regularly to quicken its fermentation. During fermentation, temperatures may rise to a range of 60°C to 80°C (If fermentation occurs in the propagation cages, cuttings will die because of heat). Periodic watering of a heap of sawdust maintains the necessary humidity in it. Fermentation activity is checked by introducing a hand into the heap. When the temperature drops (after 6 -12 months), it means the fermentation is over. The sawdust is

then rinsed out, by packing in gunny bags and plugging the bags several times in plenty of clean water. This should be done to eliminate the tannins, which are toxic to the cuttings. However, the use of sawdust has some disadvantages:

- Some saw dust releases chemicals, which can be toxic to cuttings, when used without following the elaborate treatment.
- Fresh sawdust can also ferment in the pots and this can cause burning and eventually death.
- Fresh saw dust may attract termites that can destroy the cuttings.
- Sawdust is extracted may contain some tannins and other compounds that can lead to failure of rooting of the potted cuttings.
- It is difficult to determine whether the sawdust has completely decomposed.

4.3.2 Treatment and handling of rooting media

Treatment of rooting media involves cleaning the substrate of foreign materials that can possibly cause diseases or interfere with rooting, sprouting and growth of plantlets. It includes solarisation, sieving of soil and sand, sterilization, washing and fumigation. The treatment of rooting media is guided by the following practices:

- A medium with light, loose, porous, well-aerated and adequate moisture retention to encourage the formation of a "callus", which is the first biological process prior to formation of roots.
- A soilless media such as cocopeat is the best mix for starting the plant cuttings. Soilless mixes are considered sterile because they do not contain the bacteria and fungi that are usually found in soil.
- Rooting can be slowed if the rooting substrate is too heavy and retains too much water.
- Mandatory fumigation of rooting, potting and propagation facilities prior use. Fumigation is achieved by using fungicides such as Metalaxyl 80g/Kg + Mancozeb-50 gms in 20litres of water or Carbendazim 500gms per litre + 56gms per litre ethylene glycol-use1ml per litre of water or Mancozeb 64% + matalaxyl 8% and copper oxychloride. Just before placement of cuttings in the rooting media dip the cuttings in a solution made from 50gms of copper oxychloride in 20 litres of water.
- Insect pests and diseases in the rooting media can also be controlled using chemicals such as Chloropyrifos ethyl (Dursban), cypermethrin at a rate of 2mls per litre of water.
- Soil steam sterilization as shown in Figure 36 involves the heating of moist soil to induce steam that kills pests of plant cultures in the rooting media such as weeds, bacteria, fungi and viruses. Biologically, the method is considered effective disinfection. Heat-resistant pathogens cannot survive under the resultant temperatures. Depending on the sources, it is recommended to steam sterilize rooting media, especially where the nursery operator is not sure of its purity or has not subjected it to a rooting test.
- Many organisms, which are pathogenic to plants, reside in the soil and can contaminate even "soilless" mixes used to propagate plants in nurseries. Using pathogen-free potting media is an essential success starting point in propagation systems.

Figure 36: Steam sterilization of rooting media by use of a metallic drum

4.3.3 Mixing the rooting media

There are two options used in rooting media preparation:

a. A mixture of forest soil and sand (option one) as shown in Figure 37
b. A mixture of saw dust and sand (option 2) as shown in Figure 38.

The medium composed of black forest soil (option 1) and lake sand mixed in a ratio of 3:1 has been adopted by most nursery operators.

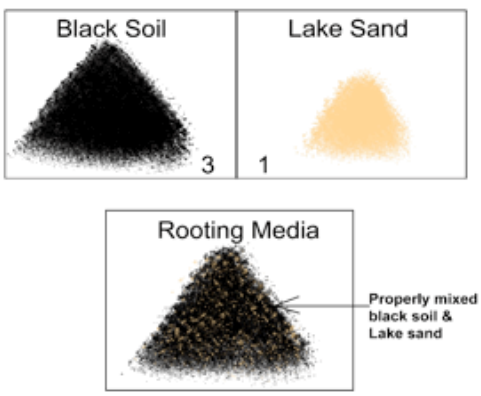

Figure 37: Mixing of rooting media under option one

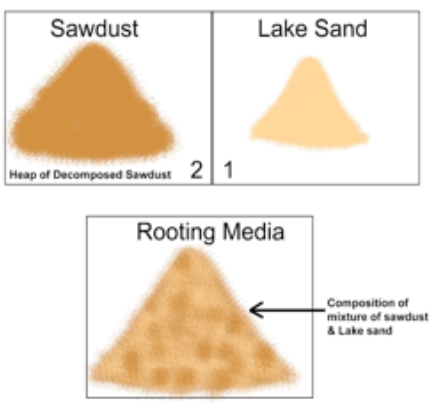

Figure 38: Mixing of rooting media in option 2

4.3.4 Filling rooting media in polypots

Polypots are filled with the already prepared rooting media as shown in Figure 39 and aligned in cages/ tunnels. In case the nursery operator is using the mixture of saw dust and lake sand media substrate filled in the polypot instead of the sterilized media.

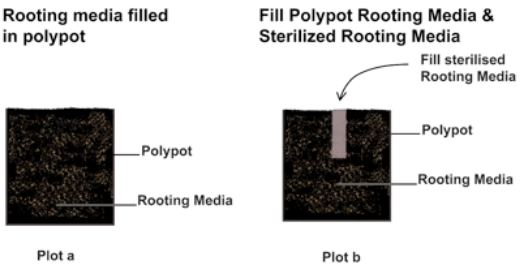

Figure 39: Filling rooting media in polypots

4.5 Harvesting suckers and preparation of cuttings

Harvesting of suckers is done when the mother bushes have produced mature suckers of pencil thickness as shown in Figure 40. It involves using a pair of sharp secateurs to cut mature suckers from the mother plant, collecting and heaping them under a shade in the potting preparation shed. Harvested cuttings will root well from a semi-hard wood tissue, which has not hardened because the interior cells are very active and easy to reproduce. The degree of hardness of the wood has an effect on the duration of rooting. Very soft wood rots, and hard wood may not root at all. Cuttings should therefore be sorted according to the type of wood. Routine supervision and timely harvesting are key to maximization of the productivity of the mother bush. An appropriate rooting hormone should also be used for different kinds of sucker stem hardness.

Figure 40: Checking suckers prior to harvesting

4.5.1 Selection and preparation of cuttings

In order to produce good clonal plantlets, cuttings should be harvested from mother plants that are healthy and well hydrated. The following procedure should be adhered to:

- Select from a Coffee mother bush that has plenty of suckers, so that if one is removed, it will not harm the mother plant.
- Use very sharp secateurs or cutting scissors in order to prevent damage to the parent plant and/or severing the cutting's rooting edges. The secateurs should be clean in order to minimize introducing pathogens to either the mother plant or the harvested sucker.
- Harvest nodal cuttings in the early morning because at this time the plant and ambience is moist and conducive. The cells in the tissue will need moisture to begin knitting together and create a root system. Excessive wetness or desiccated tissue will not provide good root cells and the injuries may result in rotting.
- Prepare nodal cuttings from a rectangular semi-hard wood section of the sucker. It is possible to obtain 2 or 3 cuttings from one sucker where the mother garden has been properly managed.
- Nodal cuttings should be 7 to 9 cm long and of a pencil size as shown in a freshly prepare cutting in Figure 41.
- Nodal cuttings are prepared by trimming off 2/3 of the pair of leaves to enable the continuation of photosythesis which leads to accumulation of carbohydrates at the base of cuttings. The unnecessary leaves are removed because the new plant has to devote all its energy to developing roots rather than feeding the leaves.
- Nodal cuttings are trimmed at a slunting angle of 45◦ at both the upper and lower part to facilitate drainage and rooting. Slanting of the lower part of the cutting prevents injury during placement in the rooting media. This facilitates callus formation.
- Keep the nodal cuttings cool and moist until you have potted them and avoid their direct exposure to sunlight.
- All harvested nodal cuttings should be potted that same day.
- The hard sections of the harvested suckers should be discarded.

Figure 41: A freshly prepared cutting

4.5.2 Application of rooting hormone

Using a rooting hormone to propagate plant nodal cuttings increases the chance that the new nodal cutting will root and thrive. When rooting hormone is used correctly, it causes the cutting to develop roots quickly and be more robust than cuttings that don't receive rooting hormone. A number of commercially prepared rooting homones for inducing rooting of the clonal Coffee cuttings are available in the market. The application of the rooting hormone follows the following procedure.

- Remove a fresh, healthy stem cutting from a parent plant using a clean secateur or shears. Use only cuttings from vigorous suckers and make sure the growing tip is between 3 inches and 8 inches long. The cut should be made near a node, which is a slightly swollen knob on the stem. Remove any leaves or flowers from the node area.
- Moisten the bottom few inches of the cutting so the rooting hormone will adhere to it.
- Pour a little rooting powder out of the container and dip the bottom surface of the cutting in the rooting powder as shown in

Figure 42. Do not dip the cutting directly into the rooting hormone container. Don't apply the powder any higher than the planting depth. Shake the excess powder off by lightly tapping the cutting against the edge of the container.

- Plant the cutting in a soilless potting medium. Make a hole in the potting medium with a pencil or similar tool. Make sure the planting hole is wide enough that the rooting hormone is not rubbed off as you sink the cutting into the soil.
- Press down the soil around the cutting to remove any air pockets and water lightly. Most clonal Coffee plants root better if they are kept out of direct sunlight.

Figure 42: A freshly prepared clonal Coffee cutting tip dipped in a rooting hormone

Caution: If the rooting hormone is carelessly left on the cutting, the excess powder causes death of the primordial root initiation cells and consequently causing root failure and eventual death of the cutting. Therefore ensure that:

- The cuttings are placed in the rooting media, ensuring firm contact with the media.
- The cuttings are carefully pushed into the media to the point where the leaf petioles (where the leaves join the stalk). The cuttings just rest on top of the media.
- At placement of cuttings, it is recommended to apply a preventive fungicide such as copper oxy-chloride. Spray a prepared solution of 50gms of fungicide in 20 litres of water.
- Immediately after placement of all the cuttings, thorough watering should be done, and the propagation cage/chamber/bin is tightly covered with a translucent polythene sheet of gauge 1000.
- Water again only when the condensation on the inside of the polythene sheet begins to disappear. Over watering should be avoided as this will lead to rotting and death of the cuttings.
- Keep the potted cuttings under warm and humid conditions to enable faster rooting and shooting.

4.5.3 Placement of cuttings in a propagation chamber

After preparing the cuttings, they are properly placed in the rooting media to enable formation of callus, initiation of roots, shoots and subsequent growth as shown in Figure 43. There are two methods of placement, namely; direct and indirect placement. The most used placement method is the direct method that involves placing the cutting in a polypot filled with rooting media. The indirect method involves placing the cuttings in the rooting media of a propagation bin. For the purposes of this manual, the direct method will be explained.

Figure 43: Placement of cuttings in a propagation chamber filled with polypots

4.5.4 Management of nodal cuttings in the rooting process

Successful rooting of cuttings requires careful

management of the micro-environment (air, temperature, humidity and light) within the cage. The following conditions are necessary for rooting of the nodal cuttings.

- Misting or fogging (condensation) should be managed through moderation of light intensity and media moisture, in order to ensure leaf surfaces don't dry before roots are established.
- The frequency of watering should be decreased as soon as the root system develops in order to avoid rotting of the developing tender roots.
- Light and temperature primarily drive the rate of root development. Therefore, rooting of cuttings can be improved by closely managing light during propagation. Inadequate light delays rooting while too much light can excessively increase leaf temperature and plant stress.
- The intensity of light should be adjusted according to the stage of root development. It should be low (but not dark) during the early rooting phase and then increased as roots develop.
- Excessive light should be diffused by inserting a second net of say 10 % just below the 70% shed net.
- Distribution of light in the rooting shed is determined by walking around the propagation area on a sunny day and observing how light penetration is scattered.
- In order to improve uniformity of rooting, avoid excessive shading of the cuttings.
- Cuttings start rooting between 20 to 30 days after placement of cutting in the rooting media. The process reaches optimal level after 45 to 100 days.
- Once the roots develop, fertilizers could be applied to enhance growth.
- Start by applying nutriplant (containing nutrients like NPK and micronutrients such as Boron, Copper, Molybdenum, Manganese, Cobalt and Zinc) or growth booster, once every fortnight at rates of 1 ml per liter of water and later on, you may alternate with application of 250 gms of N.P.K 17:17:17 in 200 litres of water.
- Maintain good sanitary conditions in order to prevent the potential spread of fungal diseases, viruses and pathogens. Sanitation is extremely important when handling cuttings and in the rooting environment and the success of a rooting facility depends on its cleanliness. The following should be done to ensure good sanitary conditions:

a. Cover all bare soil within the shed in order to avoid buildup of algae. Buildup of algae on the media surface indicates excessive water and dampness within the shed therefore, avoid stagnant water in the shed.
b. Routinely sanitize hands, tools and benches/ floors.
c. When polythene sheets get dirty, they should be washed using clean water without any detergent. The washed sheets should not be put back immediately but rather use another set of new clean sheets.
d. Sort out dead leaves and cuttings to ensure good sanitation and prevent the spread of diseases.

4.5.5 Management of rooted cuttings

After rooting, the nodal cuttings under the cages will require a regulated environment in terms of moisture, relative humidity and regulated amount of shade/light. Therefore, it is necessary to observe the following best practices in a propagation cage:

a. Maintain an airtight cover of the polythene sheet over the propagation cage.
b. Frequency of watering cuttings is dependent on the weather and size of polypots. During the dry season (weather characterized by hot and sunny days), watering is done following the regimes below:
   - For small polypots of sizes 4 inch by 7 inch water at least once every week (use at least 40 litres of water for every 2,000 potted cuttings).
   - For smaller polypots of 3.5 inch by 7 inch. Watering is done once every 10 to 11 days (use at least 30 litres of water for every 2,000 potted cuttings).

- For very small polypots of 3 inch by 6 inch. Watering is done once in every two weeks (use 20 liters of water for every 2,000 potted cuttings).
- Note however that the recommended polypots for clonal Coffee is of minimum size 5 inch by 8 inch.

c. Two months after placement of cuttings, the operator is advised to fortnightly expose the cuttings/open cages for 1 to 2 hours either (once in 14 days) morning hours from 6.00 - 8.00a.m. This is a cultural control measure that prevents growth of fungal mycelium that causes Coffee leaf spot, which results in the death of the young plantlets.

d. In case of an attack of leaf spot disease, use an integrated control measure, whereby in addition to the cultural measure in (iii) above, a chemical spray of Carbenduzium (formulation - 500 gms per litre) mixed with ethylene glycol (formulation-56gms per litre) at a rate of 1.5mls per litre of water. This chemical is alternated with Metalaxyl mixed with Mancozeb at rates of 50 gms in 20 litres of water.

Note: Higher survival rate of cuttings potted has been recorded at nurseries using small polypots. Even if the survival rate is high, after 3 to 4 months it is recommended to transfer the rooted cuttings to large pots of size 5 inches by 8 inches for further growth, prior to distribution to farmers for planting.

Chapter 5

HARDENING OF CLONAL COFFEE PLANTLETS

5.0 Introduction

A key requirement for successful transplanting of clonal Coffee plantlets is the hardening off to acclimatize to the changing environment outside the cage. The hardening off involves the gradual and step by step exposure to sunlight starting with a few additional hours of sunlight at a time and reducing the frequency of watering, but not allowing plantlets to wilt.

5.1 Hardening off procedures for directly potted cuttings.

Sorting of plantlets in the polypots begins at 3.5 to 4.5 months when the cuttings have developed roots with at least 2 pairs of leaves, as shown in Figure 44.

Some nodal cuttings are covered with polythene sheets again, with occasional re-sorting after 3 to 4 weeks. This continues up to 7 months from time of placement of nodal cuttings in the cage. Nodal cuttings that are covered fall under three categories:

- those that may not have developed roots
- those that have roots but no shoots or leaves, and
- those that have roots and only one pair of leaves

The mature plantlets that have been sorted out are transferred to a hardening cage, still within the 70-80% shade net cover. Under this shade, hardening commences with varying of exposure of plantlets to direct light at different intervals. This process of hardening consists of light watering and gradual reduction of overhead shade, as follows:

Day	Time to open cage		Time to cover cage with polyethene sheet	
Day 1	6.00 pm	Evening	7.00 am	Morning
Day 2	6.00 pm	Evening	8.00 am	Morning
Day 3	6.00 pm	Evening	9.00 am	Morning
Day 4	6.00 pm	Evening	10.00 am	Morning
Day 5	6.00 pm	Evening	11.00 am	Morning
Day 6	6.00 pm	Evening	12.00 Noon	Midday
Day 7	6.00 pm	Evening	Do not cover	Fully open
7 – 14 Days	Fully open	Fully open	Fully open	Fully open
After 14 Days	Transfer above rooted nodal cuttings to the hardening shade of 40-50% Shade net (50-60% sunlight allowed in)			

5.2 Management of plantlets/clones in the hardening shade

The plantlets are kept in the hardening shade until they are 7- 8 months old and ready for field planting. The plantlets in the hardening shade are watered at least 2 or 3 times a week. The shade is completely removed during the last week prior to planting. Plantlets in the hardening shade require fertilizers to grow well. Fertization systems that use water-soluble fertilizers have been developed to supply the correct amount of fertilizer according to the plants' nutrient deficiencies.

Figure 46: Coffee plantlets in the hardening shade

For Coffee plantlets at hardening, use 700 gms of N.P.K. (17:17:17) mixed in a bucket full of water, stir it and leave to stand for 30 to 60 minutes. Pour the prepared solution in a drum of 200 litres of water and stir thoroughly well. Scoop in a watering can and apply it directly on the plantlets. This is done once a week for plantlets at hardening.

At this stage the clones are under a 40-50% shade net and most of the times the shade net is removed, and the plantlets are fully acclimatized to open space weather.

5.3. Ready to plant Robusta Coffee clones

Ready to plant plantlets as shown in Figure 47 are once again sorted out if the cages and re-arranged remove dead and stunted plantlets.

Figure 47: Coffee plantlets after hardening and ready for planting

5.3 Transportation or shipment of Coffee plantlets

During times of loading, delivery and dispatch of clonal Coffee clones, some actions may occur that lead to stress and sometimes cause the death of the plantlets. Such stress acquired in the infancy of the clone affects the vigor of the plant and actually has an effect on its sub-sequential growth. In this regard, a specially designed wooden box shown in Figure 48 has been designed for loading and dispatch of young seedlings to minimize injury and stress.

Figure 48: Specially designed box for loading dispatch of mature Coffee plantlets

Chapter 6

MANAGEMENT OF CLONAL COFFEE NURSERY PESTS

6.0 Introduction

The major Robusta Coffee pests in a clonal Coffee nursery include the Coffee Mealybug and Coffee Leaf Miner, Coffee Leaf Skeletonizer, Black Coffee Twig Borer (BCTB), Tailed Caterpillar, Termites, Green Coffee scale and Aphids.

6. 1 Coffee Mealybug

6.1.1 Characteristics and description

Mealybugs *(Planococcus spp.)* are small sucking insects (about 3mm long) that appear on the Coffee leaves in form of white masses often accompanied by a sooty mould. Root mealybugs types form white masses on Coffee roots and base (collar) of the stems. Mealybugs are generally more of a problem in the dry season when water is lacking.

6.1.2 Damage and symptoms

In nurseries, they usually form a mass of many insects identifiable by a white mealy waxy cover. White waxy colonies are usually found on the underside of tender leaves as shown in Figure 49. They may also be found on young roots near the base of the main root. They feed by sucking sap from young shoots, leaves, flower buds, berries and roots resulting into yellowing and defoliation of the plants.

While sucking, they produce honeydew (excreta), which attracts attendant ants that protect them from natural enemies. The excreta attracts a black fungal mould as shown in Figure 50. The mould covers the leaves thereby interfering with the photosynthesis process of the young leaves.

Figure 49: Large white waxy mealybug

Figure 50: Black sooty mould on young leaves after a mealybug attack

6.1.3 Management and control

Chemical control is fairly effective, particularly with insecticides such as Imidachloprid (80mls/20 litre water), Chloropyrifos ethyl (4mls/litre of water) are effective in killing existing infestations in the leaves.

In the mother garden, root mealybugs can be controlled by drenching with Dursban (use 1 ml

of dursban in 2 litres of water. Scratch under the Coffee bush around the stem in the collar region and scoop I litre of the prepared solution in the measuring jar and apply 1 litre of the solution per Mother bush. Alternatively, use diluted insecticide like chloropyrifos ethyl, imidacloprid, diazinon can be applied by drenching to control root mealybugs. Care should be taken when mixing pesticides because they are toxic. Apply according to label recommendations and strictly follow safe use procedures.

6.2 Coffee Leaf Miner

6.2.1 Characteristics and description

Coffee Leaf miner *Leucoptera caffeina* (Washbourn) larvae bore into the leaf and feed on the leaf tissues between the lower and upper surfaces. If the mines are open, the caterpillars can be seen. Feeding causes brown irregular blotches on the leaf leading to premature shedding of leaves. The pest attacks Coffee both in nurseries and in the field.

6.2.2 Damage and symptoms

Coffee leaves infested with Coffee leaf miner are recognized by the presence of large, irregular, brown spots on the upper surface of the leaf as shown in Figure 51. Rubbing the spot, or bending the leaf across the spot, results in the separation of the upper epidermis and the exposure, in fresh mines, of small white caterpillars. Mined leaves are usually shed prematurely.

Figure 51: Coffee Leaf Miner damage symptoms on leaves

6.2.3 Management and control

Control is usually achieved by spraying when the caterpillars are still small and are in large numbers, using Fenitrothion 50% E.C. 70ml in 20litres of water or Pyrinex 1ml per litre of water. Spray when population of 30 moths per tree is sited. Strictly follow safe use procedures. In case of repeated outbreaks, suspend the use of mulch in the garden.

6.3 Coffee Leaf Skeletonizer

6.3.1 Characteristics and description

Coffee Leaf Skeletonizer *(Leucoplema dohertyi warr)* may attack the Coffee nursery. Attacks in Robusta Coffee are minor in the field but serious outbreaks may occur in Coffee farms close to natural forests and Coffee nurseries.

6.3.2 Damage and symptoms

Larvae feed on leaf upper surface leaving veins and upper epidermis to create a 'window' as shown in Figure 52. The caterpillars feed on the under surfaces of leaves, usually close to the midrib. They eat up all the leaf tissues leaving only the main veins and upper epidermis, resulting in irregular patches on the leaves.

Figure 52: Coffee Leaf Skeletonizer damage symptoms on leaves

6.3.3 Management and control

Cultural control includes opening up the canopy and reduction of shade in the nursery.

Chemical control includes spraying with pesticides

when the caterpillars are still small and are in large numbers, using Fenitrothion 50% E.C. with 70 ml in 20 litres of water, Imidachloprid at a rate of 80 ml per 20 litre water. Strictly follow safe chemical use procedures.

6.4 Tailed Caterpillar

6.4.1 Characteristics and description

Tailed Caterpillar *Epicampoptera andersoni* occurs occasionally in large numbers and can cause defoliation of Coffee in the nursery. The larvae have a large head and a characteristic tail-like appendage on the rear, hence the name. Larvae feed on leaf lamina, sometimes causing serious defoliation.

6.4.2 Damage and symptoms

The caterpillars feed on the under the surface of the leaf, about halfway between the midrib and the edge, leaving the upper surface intact. The older caterpillars, however, feed at the leaf margin, sometimes devouring everything except the midrib as shown in Figure 53. In severe attacks, the Coffee leaves are completely eaten leaving only a network of veins and the midrib.

Figure 53: Tailed Caterpillar damage symptoms on leaves

6.4.3 Management and Control

Cultural control is possible with a small number of plants where the pupae can be collected by hand and destroyed. Chemical control through spraying with insecticide can be done when the caterpillars are still small and are in large numbers, using Fenitrothion 50% E.C. with 70 ml in 20litres of water or Pyrinex, 1ml per litre of water. Strictly follow safe use procedures.

6.5 Termites

6.5.1 Characteristics and description

Termites (Macro-termites spp.) also known as white ants in Uganda are social insects that are often found in damp, rotting wood. Termites can be a big problem at nursery sites in termite prone areas. The worker termites are responsible for building nests owing to their strong biting mouthparts with which they chew seeds, wood or leaves and are considered a wood-damaging pest more so in a Coffee nursery.

6.5.2 Damage and symptoms

In Coffee nurseries, termites appear to be attracted primarily by the sawdust used in the rooting medium. Eventually, they attack the developing roots of cuttings in pots and the cuttings themselves, thus increasing the mortality rates in nurseries.

The first signs of termite attack on seedlings or older plants is wilting. Eventually, some plants die or fall over. Confirmation of the presence of termite is made by pulling out the affected plants and examining the roots and lower stem for live termites and tunneling. Plant roots and stems may be completely hollowed out and soil-filled.

6.5.3 Management and control

Cultural control of termites is possible in a Coffee nursery. Always plant Coffee in clean, well-prepared medium with no dead wood or plant debris and always avoid the use of fresh saw dust for rooting medium. Termites are sensitive to soil-water content and minimal irrigation can be attractive to termites, while regular irrigation can discourage them. Chemical control in termites involves the use of Dursban dust 2.5% EC, sprinkled around the cutting in the pot.

6.6 Black Coffee Twig Borer (BCTB)

6.6.1 Characteristics and description

Not common at nurseries but prominent in planted Coffee thereafter. The Black Coffee Twig Borer, *Xylosandrus compactus* is a very small, highly prolific dark and oval in shape beetle also known as the Ambrosia beetle. The beetle bores into the Coffee branches (twigs) mainly the primary branches but also the soft stems (below 2cm diameter) of Coffee.

Once inside, it does not feed on the host plant tissue but uses it as a medium for growing Ambrosia fungus, infesting the branch and causing it to wilt and die. The life cycle of BCTB is completed in about one month. The males spend their entire lives inside the brood gallery. The beetle under natural conditions feeds on Ambrosia fungus from which it derives its name. The pest is distributed worldwide and attacks mainly Robusta Coffee but has a very wide host range of more than 200 plant spp.

In Uganda, the pest is present in all Robusta Coffee growing areas. Due to its wide host range, the absence of a suitable host is not a limiting factor. Any woody material of suitable moisture content and size supports its survival. Some of the alternate hosts in Uganda include Cocoa, Avocado, and shade trees Musizi (*Maesopsis eminii), Albizia chinensis* and Musambya *(Markhamia lutea).*

6.6.2 Damage and symptoms

The beetle bores holes on the lower side of the Coffee twigs to access the inside of the twigs and lays eggs inside those twigs as shown in Figure 54. The hollow sections made inside the twigs shown in Figure 55 block translocation of water and nutrients to the branches resulting in drying of infested twigs thereby causing crop yield loss. The beetle multiplies more under shade conditions and resultant damage is higher during the dry season especially in Coffee bushes under shade trees or Coffee bushes with un-harvested suckers.

Figure 54: Black Coffee Twig Borer eggs laid in a Coffee twig

Figure 55: Black Coffee Twig Borer attack and damage symptoms on a Coffee mother plant twig

6.6.3 Management and control

Management of Black Coffee Twig Borer should integrate the cultural, biological, physical and chemical measures for greater impact and cost-efficiency. The following cultural control measures should be observed:

- Alternate host trees of the Black Coffee Twig Borer like Musizi *(Maesopsis eminii)* and Musambya *(Markhamia platycalyx)* should be avoided as shade trees.
- Also, regular inspection/monitoring of fields to identify any Black Coffee Twig Borer infestation.
- Infested materials should be trimmed off and burned.
- Farmers must also enhance plant nutrition through soil fertility and moisture management as the highest BCTB infestation occurs where phosphorus is limiting.
- Shade management, done by periodical pruning of the shade trees is also recommended.

The NARO-Uganda Beetle Trap' Technology shown in Figure 56 involves the use of non-colored water bottle. The traps are placed in an area comprising two-thirds from the bottom of the tree and filled with 30% ethanol lure concentration in dispenser vials. A trap density of 15-traps/ha is recommended. Traps are best used at the beginning of the rainy season and replenished every 2 weeks.

Figure 56: NARO-Uganda Beetle trap technology for the Black Coffee Twig borer

Chemical control measures may be used in cases of heavy infestation apply a mixture of systemic pesticides such as Imidacloprid, Kohinor or Imax pesticides to kill the pest. The pesticide is diluted at 4ml/L of water. Another chemical Tebuconazole can be used at 6ml/L to kill the hatched larvae.

6.7 Green Coffee Scale

6.7.1 Characteristics and description

The Coffee scale, *Coccus celatus* belongs to the Hemiptera (sap-sucking bugs) order of insects and it is a member of the soft scale family Coccidae. Green Coffee Scale is a common and serious problem in Coffee nurseries. Scales suck the plant sap resulting in reduced growth of suckers. The adult scale insect is of a glossy pale green colour with black internal markings that are visible through the body wall. As shown in Figure 57, it has a flattish elongated oval dome shape and is about 3mm in width. The front end is rounded while the rear end has a distinctive groove. Adults retain their legs and antennae but mostly remain sedentary. The nymphs are a flattish oval shape, yellowish green, with six short legs. The nymphs shed their skin three times and each instar is larger and more convex than the previous ones.

Figure 57: Green Coffee Scale on leaves

6.7.2 Damage and symptoms

Nursery and young trees are weakened by the attack, and the leaves turn yellow. The scale produces honeydew as it feeds on plant sap, and it is excreted in large amounts onto the foliage. Honeydew contains sugary substances favoured by sooty mould fungi, and their growth turns leaves and stems black. The scales are attended by ants that are attracted to the honeydew.

6.7.3 Management and control

Green scale is transported to new areas by infected planting materials. Planting materials should be inspected thoroughly for scale and other insects before it is introduced into a nursery or field. Another effective cultural control measure is the growing pumpkins in the Coffee blocks to attract ladybird beetle species. The pumpkins are often infested with aphids, and the ladybird beetles are attracted to them; at the same time, they will be attracted to the Coffee scales.

6.8 Coffee Aphids

6.8.1 Characteristics and description

Aphids *(Toxoptera aurantii)* may occur in large numbers on new Coffee shoots in the Coffee nurseries especially in the rainy season. They occur as large numbers of small black aphids (2-3 mm long), which concentrate their feeding activities on new shoots of the Coffee plant. Aphids suck sap from young shoots and cause damage to them. Infested shoots are often associated with black sooty mould.

6.8.2 Damage and symptoms

Aphids, as shown in Figure 58, can occur in large numbers on new shoots in the rainy season. Aphids suck sap from young shoots and cause damage to these developing shoots.

Figure 58: Coffee Aphids damage symptoms on leaves

6.8.3 Management and control

Aphids can be managed by physical and chemical control means. Coffee nursery attendants may pick aphids off infested shoots by hand, crush them up, and throw them into compost. It is also important to get rid of ants because they protect the aphids from predators. Chemical control of aphids involves the use of Cypermethrin at a rate of 70ml in 20 litres of water sprays.

Chapter 7

MANAGEMENT OF CLONAL COFFEE DISEASES

7.1 Introduction

Clonal Coffee in nurseries is affected by two major diseases. These are (a) Damping-off disease and (b) Brown eye spot disease.

7.2 Damping-off disease

7.2.1 Characteristics and description

Damping-off severely affects Coffee plantlets in nurseries. It is caused by a complex of soil-inhabiting fungi such as *Rhizoctonia solani* and *Pythium spp*. Factors that predispose plants to Damping-off attack include over watering, over shading and acid soil.

It is most severe when soil is too wet and the weather is dump/cloudy with no sunshine and accelerated by too much shade (insufficient drying of soil). These conditions predispose plantlets to pathogenic infections.

7.2.2 Damage and symptoms

Damping-off is largely a consequence of overwatering and over-shading that results in the rotting of stem and root tissues at and/or below the soil surface. The pathogen survives in the soil in the form of sclerotia, which is the source of primary inoculum.

The pathogen is dispersed as sclerotia by means of wind, water or soil movement between plants. Damping-off disease is more common in plantlets grown from seeds as shown in Figure 59 compared to the ones propagated by clones.

Figure 59: Coffee seedlings affected by Damping-off disease

7.2.3 Management and control

There is no cure for plants that already have damping-off. However, you can easily prevent the problem by providing good air circulation. Cultural control measures for preventing damping-off include the following:

- At the start of the propagation process, use good organic potting soil or sterilize the potting mixture. Use new soil for potting.
- Reduce on the overhead watering of the plantlets in nursery.
- Never water past noon so that the soil surface and the plants are given enough time to drain by evening.
- Avoid overwatering tender plantlets.
- Reduce the density of plantlets in the cage/ nursery. Do not overcrowd plantlets – they should be planted with spacing of at least 1 inch (2.5 cm) and in rows of 4 inches (10 cm apart).

Damping-off disease can be controlled by the use of chemicals available on market such as Metalaxyl 80g/Kg + Mancozeb at 50gms in 20 litre of water or Carbendazium+ 56 litre ethylene glycol at 1ml per litre of water or Metalaxyl-M and S-isomer, and copper oxy chloride, and Mancozeb 64% + Matalaxyl 8%.

7.3 Brown Eyespot disease

7.3.1 Characteristics and description

Brown Eyespot disease also known as *Cercospora* leaf spot is a fungal disease that occurs on nursery Coffee plantlets leaves when plantlets are under stress. As for elite seedlings nurseries, the fungus can develop both in seed beds and after plantlets have been transplanted in polypot bags. It is the most common nursery disease and it occurs when the soil is too wet and/or there is too much shade. Lack of air movement and lack of nitrogen and potassium are factors that favour this disease and its spread.

7.3.2 Damage and symptoms

The first signs of infection include the appearance of brown spots on leaves gradually expanding with reddish-brown margin as shown in Figure 60. The spots appear on both sides of the leaf and when they are too many, leaves appear to have been burnt.

Figure 60: Brown spots on Coffee plantlets leaves caused by the Brown Eyespot disease

7.3.3 Management and control

An effective cultural control measure requires the nursery attendant to keenly open the cages/remove sheets for at least 2 hrs in the early morning from 6.00 - 8.00am, and thereafter return the sheets. Other cultural control measures include:

- Avoiding overwatering
- Maintaining 50% shade cover
- Proper fertilizer utilization

Chemical control measures include the use of copper-based sprays for prevention of further spread. If the plants have been attacked use any of the three fungicides 500gms/litre of Carbenduzium + 56g/litre of ethylene alternate it with Metalaxyl 80g/Kg +Mancozeb.

Chapter 8

CLONAL COFFEE NURSERY AS A BUSINESS

8.0 Introduction

Clonal Coffee Nursery business has the potential to transform household economic status and livelihoods in a short period of time as payback period is around 3 to 4 years. The return on investment and profitability on Coffee nurseries are all high.

8.1 Importance of Coffee nursery records

A Coffee nursery is a business that earns the nursery operator income. This implies that the operator has the obligation to keep proper and accurate records of the business. She/he has the duty to prepare the income statement that shows the incomes and all costs expended in the financial year/business period. To do so the operator must have a proper record all transactions. Coffee nursery records assist in the following ways:

1. They help the manager to know and evaluate the performance of the Coffee Nursery over a period, which aids in decision-making.
2. They provide basic information for planning and budgeting.
3. A proper record helps in determining resources requirements, commitments, including possibilities for credit, borrowing, and credit repayment.
4. They help to periodically review/evaluate the nursery's financial status i.e. its worthiness and necessary changes required. In doing so it guides management on production costs reduction and profit maximization
5. They provide information on physical inputs on the Farm e.g. number of mother bushes, equipment, their status/utility.
6. They help Managers/Advisors and entrepreneurs in problem identification and analysis
7. They also help to keep information that could have escaped the Managers mind; and this makes work easy even in absence of a key worker.

8.2 Characteristics of a good Coffee nursery record

Given its importance to the performance of the business, good Coffee nursery records should have the following characteristics:

1. They should be simple, clear, up to date and easy to read and understand.
2. Easily interpreted by the writer or any other person reading it. Known symbols should be used.
3. Up-to-date i.e. should be put down in time as soon as the observation is done e.g. when recording sales do it immediately after selling.
4. Must not be biased or based on one's desire.
5. Should be standardized in order to carry out comparison.

A record is therefore a set of Nursery activities written down in words, figures, symbols for future references. Therefore, a record should be simple and easy to understand.

8.3 Types of Coffee nursery records

1. Nursery inventory records (This is a list of all that the Coffee nursery owns and owes at a

time, usually at the beginning of the year and end of each financial year).
2. Financial and Expenditure records
3. Labour use records
4. Production records - a record of cuttings/ plantlets in shade at various stages

8.4 Pre-conditions for a successful Coffee nursery business

The Coffee nursery operator must be equipped with good management skills. She/he must have startup capital. The target market for his/her clones must be adequate and capacity should exist for the mother garden. The operator must also be acquainted with updated practices that other practitioners use and be able to develop participatory technology development sites.

8.5 Coffee Nursery productivity and profitability measurement

8.5.1. Productivity of mother garden (yield of cuttings) and finally plantlets

After a period of 6 months, the mother bushes are trained and start producing suckers. In the first 2 years, the production of suckers is minimal because the mother bushes are still young. At 3 years the mother bush is said to be mature and at its optimal level of production. On average, under good management, the productivity is 30 cuttings per bush every six months (this implies 60 cuttings per bush per year).

Mother gardens have varied number of bushes. NaCORI has released 10 varieties of which currently only 7 varieties are in circulation. Mother gardens can therefore be of varied bushes e.g. 700, 1400, 2100, 2800 and so on. Take for example a mother garden of 700 bushes. This will have capacity to yield 60 x 700 cuttings (42,000 cuttings) for potting per year if properly managed. Survival rate of cuttings however will depend on the level of skill and efficiency of the Coffee nursery operator.

8.5.2 Cash flows, gross margins and payback period

The foremost challenge for any entrepreneur is raising capital funds. Robust cash flow is essential for survival of nursery operators. They have to strike a balance of cash in and out flows to cater for payment of the following recurrent expenses:

i. Wages and other causal laborers
ii. Utility bills such as water, electricity, telephone
iii. Nursery materials such as soil, lake sand, clear sheets, polypots, rooting hormone

It is therefore critical for all nursery operators to do proper budgeting and planning to maintain a favorable cash flow. The nursery operators have to balance credit and cash sales of their outputs. The gross margin analysis in Annex 1 shades light on incomes and possible inflows over a period (i.e. 5 years). It comprehensively showcases out the financial threshold for each year, for example:

a. The startup capital required in year 1
b. The cash out flows in years 2, 3, 4 and 5
c. The time taken to break even (payback period)
d. The cash in-flows in years 3, 4, and 5
e. The amount reserved funds to keep the Coffee nursery running.

These periodic cash in/out flows will enable the nursery operator plan her/his utilization of incomes. Tools such as cash flow and its management, budgeting and planning are crucial decision criterion indicators for any successful Coffee nursery operator.

a. As per Annex 1, the analysis is indicative that the Coffee nursery operator with 2,100 mother bushes would only be able to break even in the 3rd year of operation. The start-up cost required up to 3rd year is Ushs 36,303,000 = (28,613,000 + 7,690,000).
b. The analysis indicates that for such a Coffee Nursery to break even, it must produce at least 24,202 CWD-r clones per annum, and sell at a rate of Ushs 1,500 per plantlet.

c. In the fourth year, the Coffee nursery starts to bring in good returns.
d. From the analysis, clonal Coffee nurseries that fail to reach an output of over 24,202 plantlets per year, are not self-sustainable and would fall into bankruptcy in the long run. This implies that, they cannot pay for their running costs.
e. The payback period for the Coffee Nursery Intervention/Business is three (3) years
f. In year 2, the cost of production of a plantlet that was Ushs 15,807, this goes down to Ushs 1,228 in year 3. If the going price per clone is Ushs 1,500. In year 3 the Nursery operator can break-even
g. Note that the price of plantlet is determined by market forces of demand and supply. If the supply of nurseries outputs increase, Coffee nursery operators will reduce the cost of production per plantlet and to survive in the business, they have to cut costs. In the long run the going price of the plantlet would continue to go down but must not go below Ushs 433 such that starting in year 5, the cost of production per plantlet stabilizes at Ushs 433.

Annex 1: Gross Margin Analysis of a Clonal Coffee Nursery on 0.5 acres with a mother-garden of 2,100 bushes planted on 0.25 acres of land.

Description		Costs						
Activity	**Physical measure costing**	**Units**	**Rate**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Bush clearing	1-acre (150,000 per acre)	1	150,000	150,000				
Land opening 1st and 2nd	200,000 per acre	1	200,000					
Coffee Nursery laborer wage	150,000 per month	12 per year	150,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000
Well fermented cow dung	2 trucks per year	2	300,000	300,000	300,000	300,000	300,000	300,000
Field marking	2,100 holes marking	2100	50	105,000				
Digging planting holes	2100 holes	2100	500	1,050,000				
Refilling holes with manure/soil mixture+ pegging	2100 holes	2100	300	630,000				
Purchase of 2100 CWD-r clones	2100 CWD-r clones	2100	1500	3,150,000				
Transport of 2100 CWD-r clones				400,000				
Planting	2100 CWD-r	2100	100	210,000				
Field acclimatization	2100 CWD-r	2,100		250,000				
Provision for gap filling	300 CWD-r	300	1,500		450,000			
CCA Practices/irrigation	2100			400,000	400,000	400,000	200,000	
Mulching	Banana/straws			250,000	250,000			
Erosion control/fertigation trenches/ditches	10 man-days per year	10	8,000	80,000	80,000	80,000	80,000	80,000
Sub total				8,775,000	3,280,000	2,580,000	2,380,000	2,180,000
Inputs								

Description		Costs						
Activity	**Physical measure costing**	**Units**	**Rate**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Fertilizer CAN/DAP/NPK		50	150,000	150,000		750,000	750,000	750,000
Fertilizer application costs	Ushs 8000 per man-day	8,000	80,000	80,000		80,000	80,000	80,000
Farm tools and equipment	Hoes, pangs, secateurs			60,000		100,000		100,000
Pesticides/Insecticides				60,000	120,000	120,000	120,000	120,000
Fungicides				50,000	50,000	100,000	100,000	100,000
Plastic drums	6 drums @ 200 litres	6	100,000	600,000				
Metallic drums	6 drums	6	50,000		300,000		300,000	
Gum boots	3 pairs	3	30,000	90,000				
Farm overall	3 pairs	3	50,000	150,000				
Watering can/Jerican/spade/ garden fork				80,000				
Wheelbarrows	4 wheelbarrows	4	180,000	360,000			360,000	
Black forest soil			100,000		100,000	300,000	600,000	600,000
Lake sand					100,000	300,000	600,000	600,000
Pipes	50 pcs @ of 20ft		120,000	6,000,000				
Black fibre net guage 70% shade	400sq m @ 8000 per sq m	400	8000	3,200,000				
Green Net 40% to 50% shade	400sq m	400	5,000	2,000,000				
Sub total				12,880,000	670,000	1,750,000	2,910,000	2,350,000
Others filling in pots labour	At Ushs per pot			15,000	180,000	240,000	480,000	480,000
Others Alignment of pots in cages	At Ushs 2 per polypot			3,000	60,000	120,000	160,000	160,000

Description		Costs						
Activity	**Physical measure costing**	**Units**	**Rate**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Others Harvesting of suckers & prep of cuttings				50,000	300,000	400,000	800,000	800,000
Others Water cost	At 2m per year			2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Sub total				2,068,000	2,540,000	2,760,000	3,440,000	3,440,000
Field maintenance								
Training of Coffee pegging				100,000	100,000			
Weeding of Mother garden	100,000 per weeding round			600,000	600,000	600,000	600,000	600,000
Sub total				700,000	700,000	600,000	600,000	600,000
Total variable cost				24,423,000	7,190,000	7,690,000	9,330,000	8,570,000
Expected income								
Plantlets out put					2000	30,000	40,000	60,000
Gross income Coffee					3,000,000	45,000,000	60,000,000	90,000,000
Gross margin				-24,423,000	-4.190,000	37,310,000	50,670,000	81,430,000
Break-even/payback period Analysis row				(24,423,000)	(28,613,000)	8,697,000	59,367,000	140,797.000
Cumulative costs					31,613,000	39,303,000	48,633,000	57,203,000
Costs of production per plantlet 9use cumulative)					15,806	1228	675	433
Coffee plant per year	Cuttings potted	Clones out put						
Year2	2,500	2,000						
	40,000	30,000						
	55,000	40,000						
	80,000	60,000						

Annex 2: Coffee Nursery plantlets record

No of mother bushes harvestable:

No of bushes still young:

Overall total mother bushes:

Period / Month	Balance of cuttings B/F	Number of Cuttings potted	Number of cuttings potted	Number of cuttings dead	Number of Cuttings in cage	Number of Cuttings at Hardening	Number of Cuttings ready for despatch to farmers	Number of Cuttings Sold	Comment /Remarks
January									
February									
March									
April									
May									
June									
July									
August									
September									
October									
November									
December									

Annex 3: Nursery Inventory Record

There are two steps in making the inventory

- Physical count of all assets. This includes a complete listing of all assets, verifying their weights, measurements and numbers.
- Valuing of physical assets e.g. tractors and Farm implements. Calculation of depreciation due to wear a tear.

Nursery Inventory Record Sheet

Date	Particulars of asset/Item	Description	Value in Ushs	Date of purchase/ construction	Remarks
14.02.2019	Knap sack sprayer	One 20 litre	300,000	14.12.2014	
14.02.2019	Water Dam	One dam of capacity 2,000,000 litres of water	10,000,000	June 2013	
14.02.2019	3 roomed Building	One room for office, one for manager, and one room for store	25,000,000	Jan 2014	

Annex 4: Procedures for production of Nodal Cutting

Activity	Period/Time/Place	Treatment/Application/Practices
1. Establishment of Mother garden.	Done after proposed site meets the criteria for sitting a mother garden (see text)	• Preparation of land and holes done 3 months in advance of planting of mother plants (see text). • Planting of mother plants done at the on-set of rains
2. Management practices of a Coffee mother garden	From planting time and continuous indefinitely (going concern)	• Weed control. • Soil and water conservation practices/structures. • Training of mother plants. • Nutrient and fertilizer application.
3. Construction of Working Shed	Construction of working shed is done when mother Bushes are 6 months old.	
4. Construction of Rooting Shed	Construction of Rooting Shed begins when mother Bushes are 6 to 8 months old.	
5. Construction of hardening shed	Construction of hardening shed begins when mother Bushes are 9 to 12 months old.	
6. Shipment of black soil and lake-sand	3 months in advance	• Separate heaps of Black soil and lake sand are covered with black sheets. • Solarisation of the heaps for 6 to 12 weeks • Sorting out foreign debris, decayed roots/leaves etc. • Sieving of soil and lake sand.
7. Preparation of rooting media	Media prepared when the soil and sand are ready in the working shed	• Thoroughly mix black soil to lake sand in ratio of 3:1. • If the source of these potting media is not free of fungal diseases, it is advisable to steam sterilize the rooting media
8. Placing in Rooting media in the Propagation bins/ polypots	a. Filling in of polypots is done in the working shed, and later the polypots are aligned in cages in the rooting shed. b. For the cage, of propagation bins the rooting media is placed as the top 2" layer (see text)	• After filling in the rooting media, the cages or chambers/bins are treated `with fungicides/pesticides as a fumigation measure (see text) -(normally spray a prepared solution of 50gms of fungicide copper oxychloride in 20 litres of water). Apply this solution just before placement of cuttings. Insect pests in the rooting media can also be controlled using chemicals like Dursban, cypermethrin etc use 2mls per litre of water.

Activity	Period/Time/Place	Treatment/Application/Practices
9. Preparation of Cutting	a. The first suckers are born at 6 to 8 months from time of planting mother-garden and can be harvested when the mother-garden is 8 to 11 months old b. Done when the suckers have matured with internode portions of pencil sizes and length of 6 cm to 9 cm range	• Use very sharp secateurs cutting scissors, as this will prevent damage to the parent plant and to the cutting's rooting edge. • Tools for harvesting suckers and preparation of cuttings must be clean to minimize introduction of pathogens to either part. • Early morning is usually best time to take cuttings because the plant has the most moisture at this time. • The leaves are 1/3 trimmed. • Freshly prepare nodal cutting of 7 to 9 cm length and size of pencil from suckers out of the mother-garden. • Cuttings are trimmed at a slunting angle of 45◦ at the top. • Keep cuttings cool and moist until you have potted them and avoid exposing them to direct sunlight. • Most Plant cuttings root faster if they are kept under warm and humid conditions.
10. Placement of cuttings	After Shed set-up and preparation of rooting structures and media the Cuttings are carefully placed in the rooting cages/polypots/propagation bins.	a. The ready prepared cutting is dipped briefly in the rooting hormone (if the rooting hormone is to be used, it must be a thin film on the cut end). b. The cutting is then placed in the rooting medium, ensuring firm contact with the medium, and pushed into the medium to the point where the leaf petioles (stems) just rest on top of the medium. c. Immediately after placement of all the cuttings, thorough watering is done, and the propagation cage/chamber/bin is tightly covered with a clear sheet. d. Water again only when the condensation on the inside of the polythene begins to disappear. Do not over water, as this will lead to rotting and death of the cuttings. e. The hard stems, which are round in cross section, are discarded.
11. Management of cuttings under chambers/cages/ bins	a. Advised to check/open at least once a week/fortnightly in the early morning/or late evening.	a. Check for disease/pest infestation (once every week) b. Check the moisture/water in the system (once every week) c. Apply Nutrient plant or growth booster once every 14 days at rates of 1mls per litre of water. (Booster/Nutriplant contains macronutrients like NPK and micro nutrients like boron,copper, molybodenum, manganese, cobalt, iron and zinc).
	b. Nutrient application at 2.5 months from placement of cutting	• 14 days after placement of cuttings, start applying nutriplant (contains nutrients like NPK and micronutrients like boron, copper, molebodenum, manganese, cobolt and zinc) or growth booster, once every fortnight at rates of 1 ml per liter of water. • 3 months after placement of cutting, fertilizer application (nutriplant) should alternate with application of 250 gms of N.P.K 17:17:17 in 200 litres of water.

Activity	Period/Time/Place	Treatment/Application/Practices
	c. Watering frequency/moisture regimes	Watering frequency depends on weather and size of polypots. **a. In the dry season (weather characterized by hot and sunny days), watering is done following the regimes below** ● For small polypots of sizes 4" by 7" water at least once every week. (Use at least 40 litres of water for every 2,000 potted cuttings) ● For smaller polypots of 3.5 " by 7". Watering is done once every 10 to 11 days. (Use at least 30 litres of water for every 2,000 potted cuttings) ● For very small polypots of 3" by 6". Watering is done once in every two weeks. (Use at least 20 litres of water for every 2,000 potted cuttings) **b. In the wet season (weather characterized by wet and cool days)** ● For small polypots of sizes 4" by 7" water at least once every two weeks. (Use at least 40 litres of water for every 2,000 potted cuttings) ● For smaller polypots of 3.5 " by 7". Watering is done once every 2 weeks (use at least 30 litres of water for every 2,000 potted cuttings) ● For very small polypots of 3" by 6". Watering is done once in every two weeks. (Use at least 20 litres of water for every 2,000 potted cuttings) **Note**: there is a high survival of cuttings potted in very small polypots. It is therefore recommended to transfer the cuttings to large pots for further growth at after 3 to 4 months
	d. Weekly In cage/propagation bin sanitation	During watering, plucking/ picking out of all dead leaves/ and leaves that have turned yellow in colour or have dropped off is recommended. Such leaves are disease carrying, and once they dry up, the fungal pathogens migrate to cutting stock and destroy it.
	e. Cultural Disease management measure at 3 months from placement of cutting	Fortnightly expose the cuttings/open cages for 1 to 2 hours either (once in 14 days) morning hours from 6.00am to 8.00a.m. This is a cultural control measure that prevents growth of fungal mycelium that causes Coffee leaf spot, which results in death of the young plantlets.

Activity	Period/Time/Place	Treatment/Application/Practices
12. Hardening off and acclimatization	Starts at 3.5 months old	• Sorting of plantlets in the polypots begins at 3.5 to 4.5 months, when the cuttings have developed roots with at least 2 pairs of leaves. • Some cuttings are covered with polythene sheets again, with occasional re-sorting after 3 to 4 weeks. This continues up to 7 months from time of placement of cutting. • Hardening commences with varying the exposure of plantlets to light in the 70% shade. This process of hardening consists of light watering and gradual reduction of overhead shade. • The plantlets are kept in the hardening shade until they are 7 to 8 months old and ready for field planting. The plantlets in the hardening shade are watered at least 2 or 3 times a week. • This shade is completely removed during the last week prior to planting. • Fertigation systems add the correct amount of fertilizer according to the plants' nutrient deficiencies. Liquid and water-soluble fertilizers are required for fertigation. a) For Coffee plantlets at Hardening get 700 gms of N.P.K. (17:17:17), mix it in a bucket/basin of water, stir it and leave to stand for 30 to 60 minutes. Pour the prepared solution in a drum of 200 litres of water and stir thoroughly well b) Scoop in a watering can and apply it directly on the plantlets. This is done once a week for plantlets at hardening. c) In circumstances of attack by pests and diseases apply the recommended pesticides/Insecticides as in Chapter 6 Fertigation systems add the correct amount of fertilizer according to the plants' nutrient deficiencies. Liquid and water-soluble fertilizers are required for fertigation. • For Coffee plantlets at Hardening get 700 gms of N.P.K. (17:17:17), mix it in a bucket/basin of water, stir it and leave to stand for 30 to 60 minutes. Pour the prepared solution in a drum of 200 litres of water and stir thoroughly well. • Scoop in a watering can and apply it directly on the plantlets. This is done once a week for plantlets at hardening. • In circumstances of attack by pests and diseases apply the recommended pesticides/ Insecticides as in Chapter 6

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