Australian Government

Australian Centre for International Agricultural Research

SMALLHOLDER COFFEE PRODUCTION IN PAPUA NEW GUINEA – FARMER TRAINING GUIDE

UNIT 1: BECOMING A COFFEE FARMER

MODULE 2:
COFFEE NURSERY DEVELOPMENT

Curry G, Tilden G, and Aroga L (2023) *Smallholder coffee production in Papua New Guinea: A training package for extension officers and farmers*, ACIAR Monograph No. 220, Australian Centre for International Agricultural Research, Canberra.

ACIAR Monograph Series No. 220 (MN220)

Australian Government

Australian Centre for
International Agricultural Research

SMALLHOLDER COFFEE PRODUCTION IN
PAPUA NEW GUINEA – FARMER TRAINING GUIDE

UNIT 1: BECOMING A COFFEE FARMER

MODULE 2:

COFFEE NURSERY DEVELOPMENT

The Smallholder Coffee Production in Papua New Guinea Training Program

The training program contains modules prepared in partnership with Australian Centre for International Agricultural Research (ACIAR) and by CARE-International.

The structures of the Extension Officer Training Program and the Farmer Training Program are shown in the table below.

Some modules also contain references to additional training that learners are encouraged to complete as part of their training.

ACIAR Resource

Monograph MN220 Smallholder Coffee Production in Papua New Guinea: a training package for extension officers and farmers. This package contains the modules for both the extension officer training guide and the farmer training guide. The ACIAR monograph is available online from **www.aciar.gov.au**

Hard copies of the ACIAR training package may be available by contacting ACIAR or the Coffee Industry Corporation (CIC)

CARE Resources

Organisational Strengthening Training
CARE Family Money Management Training

The CARE modules are available online from **https://pngcdwstandard.com/resources-for-use-by-cdws-working-with-wards-communities-groups-and-smes**

Hard copies of the CARE modules may be available by contacting the CIC or CARE-International.

Extension Officer Training Program

Title	Module reference
Introduction to smallholder coffee production in Papua New Guinea	ACIAR Smallholder Coffee Production in Papua New Guinea Training Package
Extension Principles	
Introduction to the Coffee Extension Officer and Farmer Training Guides	ACIAR Extension Officer Training Guide Unit 1 Module 1
The extension officer - roles and effectiveness	ACIAR Extension Officer Training Guide Unit 1 Module 2
Knowing Your Farmers	
Getting to know our coffee smallholders	ACIAR Extension Officer Training Guide Unit 2 Module 1
What factors affect smallholder coffee production?	ACIAR Extension Officer Training Guide Unit 2 Module 2
Strongim grup: course facilitator guide	CARE Organisational Strengthening Training

Farmer Training Program

Title	Module reference
Becoming a Coffee Farmer	
Knowing your coffee tree	ACIAR Farmer Training Guide Unit 1 Module 1
Coffee nursery development	ACIAR Farmer Training Guide Unit 1 Module 2
Establishing a new coffee garden	ACIAR Farmer Training Guide Unit 1 Module 3
Managing Your Coffee Garden	
Weed control	ACIAR Farmer Training Guide Unit 2 Module 1
Maintenance pruning and rehabilitation	ACIAR Farmer Training Guide Unit 2 Module 2
Shade management	ACIAR Farmer Training Guide Unit 2 Module 3
Drainage	ACIAR Farmer Training Guide Unit 2 Module 4
Pest and disease management	ACIAR Farmer Training Guide Unit 2 Module 5
Coffee berry borer management	ACIAR Farmer Training Guide Unit 2 Module 6
Soil fertility and nutrient maintenance	ACIAR Farmer Training Guide Unit 2 Module 7
Intercropping in your coffee garden	ACIAR Farmer Training Guide Unit 2 Module 8
Harvesting and Processing Coffee	
Coffee harvesting and processing	ACIAR Farmer Training Guide Unit 3 Module 1
Coffee grading systems and pricing	ACIAR Farmer Training Guide Unit 3 Module 2
Establishing a mini wet factory	ACIAR Farmer Training Guide Unit 3 Module 3
Coffee Marketing	
Understanding the domestic coffee market	ACIAR Farmer Training Guide Unit 4 Module 1
Kamapim ol praioriti	CARE Organisational Strengthening Training
Kamapim ol eksen plen	CARE Organisational Strengthening Training
Setim gutpela kastom bilong ronim grup	CARE Organisational Strengthening Training
Wok bilong meneja na memba na lida	CARE Organisational Strengthening Training
Coffee certification	ACIAR Farmer Training Guide Unit 4 Module 2
Fairtrade certification	ACIAR Farmer Training Guide Unit 4 Module 3
Family money management	CARE Family Money Management Training

CONTENTS

MODULE TOPICS

CONTRIBUTING AUTHORS

Leo Aroga, George Curry, Geraldine Tilden, Rauke Buimeng, Michael Kaugam and Tim Sharp

ACKNOWLEDGEMENTS

This module is part of a series of modules developed specifically as a resource for extension officers for training smallholder farmer groups and the training of extension officers. The knowledge of the following contributors has been invaluable in the development and writing of this module:

Coffee Industry Corporation Ltd
Michelle Bafeo, Linda Bina, Matilda Hamago, Jenny Bekio, Jonah Aranka, Emma Kiup, Mark Kenny, James Rui, Bernard Tabuli, Nelson Simbiken, Matei Labun, Barth Apis, Reuben Sengere and Bob Kora (illustrations)

Curtin University
Gina Koczberski and Sarah Mandich

CSIRO
Mike Webb

Industry Partner
John Leahy

Australian Centre for International Agricultural Research
The development of this module was supported by the following ACIAR-funded projects:

Improving livelihoods of smallholder families through increased productivity of coffee-based farming systems in the highlands of Papua New Guinea (ASEM/2008/036)

Improving Livelihoods of Smallholder Coffee Communities in Papua New Guinea (ASEM/2016/100).

Most of the information provided in this module is from the findings of ACIAR project Improving livelihoods of smallholder families through increased productivity of coffee-based farming systems in the highlands of Papua New Guinea (ASEM/2008/036) and *The Papua New Guinea Coffee Handbook* (2nd Edition), Coffee Industry Corporation Ltd.

INTRODUCTION

Aim of Module:

The aim of this module is to provide farmers with information about how to establish and maintain a coffee nursery so that farmers have healthy and tough young coffee plants ready for transplanting into their coffee garden.

To establish a highly productive coffee garden it is important for farmers to begin with planting strong, healthy seedlings which have grown from the seed of high yielding healthy trees. The best seedlings are produced in a nursery and are given regular care so that they are ready for planting into the coffee garden at the start of the wet season.

LEARNING OUTCOMES:

By the end of this module you will be able to:

- Choose the best seed to sow and know where to source it
- Choose an appropriate site for your nursery
- Choose whether to have a bare root or polybag nursery
- Prepare the soil bed or soil mix for sowing the seed
- Sow the seed
- Maintain the seedlings until they are ready for transplanting into the coffee garden

LESSON PLAN:

The module has three parts:

Sections 2.1 to 2.4	Seedling nurseries, sourcing seed, selecting a site and choosing the type of nursery
Sections 2.5 to 2.7	Preparing the nursery beds or polybags and sowing the coffee seed
Section 2.8	Nursery maintenance

TIME REQUIRED TO COMPLETE THIS MODULE: 5 DAYS

LIST OF SYMBOLS:

Additional information for the extension officer

Information relating to CBB

Farmer notes, brochures & factsheets

Information for farmers that must be taken very seriously

For the Extension Officer

TEACHING AIDS:

- Coffee calendar
- Coffee varieties poster (for selecting varieties when purchasing seed)
- A 1 kg bag of certified seed (preferably a tall variety, e.g., Mundo Novo)
- Seed collected from a farmer's coffee garden that has been selected from high performing trees
- Bright red cherries from a high performing tree that would be suitable to use as a source of seeds for the coffee nursery
- A coffee plant from a bare root nursery bed with soil removed from roots and a coffee plant well established in a polybag that can be removed to show the soil-root mass
- Soil sieve – bamboo and strong mesh to construct a soil sieve
- 1 bucket of pre-prepared composted coffee pulp, 2 buckets of river sand, and 3 buckets of dark topsoil
- A bucket full of non-sieved compost, sand or topsoil
- Shovel for mixing components of soil mix
- 5 small polybags (1.5 L)
- Blunt edged scoop for filling polybags
- Two young germinated seedlings in a polybag
- Stick for transplanting a seedling
- Shade display – a frame and Yar branches to show full shade and progressively reduced amounts of shade
- Pests and diseases of coffee poster
- Farmer notes – one copy for each farmer and a few spare copies
- Video of cherry and bean development
- Butchers' paper and marker pens

PRE-TRAINING ACTIVITIES:

- Source certified seed. Provide three packets of seed for the group
- Source seed collected from high performing trees in a farmer's coffee garden
- Germinate two seeds in a polybag to demonstrate how to carefully remove a seedling when thinning
- Source components for the soil sieve – cheap, strong mesh (0.7 m x 1.5 m), bamboo, and a hammer and nails
- Prepare a frame to represent a section of the roof frame of a seedling nursery
- Source Yar branches or kunai grass to lay over the frame to demonstrate the progressive reduction of shade over the seedling growth period
- Research the costs of items for Exercise 9 'Budgeting for polybag and bare root nurseries'

EQUIPMENT REQUIRED BY THE FARMER GROUP

To establish a coffee nursery you will require the following equipment:

- Certified seed or healthy seeds from your best performing coffee trees
- Spade
- Sieve (optional)
  - Bamboo and strong mesh (0.7 m x 1.5 m)
  - Timber or bamboo for the frame of the sieve
  - Bag of nails and a hammer
- Bucket
- Polybags (if establishing a polybag nursery)
- Wheelbarrow (recommended but not essential)

PRELIMINARY ACTIVITIES

The farmers will complete two exercises prior to undertaking the module topics. These include the coffee calendar and the quiz. The purpose of these exercises is for the extension officer to assess the level of knowledge of farmers in the group prior to completing the module.

The Coffee Calendar

- Complete this exercise if the group has not had training within the past 12 months
- The coffee calendar lists the main events and activities undertaken during an annual cycle of coffee production. The first item on the calendar is coffee berry development. All other activities are linked to the stage of development of coffee berries from flowering through to overripe cherry

The annual coffee production cycle

1. Flowering and berry development
2. Harvesting coffee
3. Pulping and drying coffee
4. Maintenance – weeding, pruning, mulching, shade management, digging and maintaining drains, and maintaining fencing
5. CBB control measures
6. Sucker selection
7. Intercropping

- Working with the farmer group, attach stickers to complete each row of the coffee calendar
- Begin by attaching the progressive stages of coffee berry development from flowering through to bright red cherry ready for harvest and to overripe cherry
- Attach a CBB sticker on the berry development row to indicate where berries can begin to become susceptible to CBB
- Complete the remaining sections linking each activity with the different stages of berry development
- For this module, place emphasis on activities relating to coffee nursery development

Coffee nursery activities (stickers)

1. Select a site for the coffee nursery
2. Clear the site
3. Source coffee seed
4. Prepare the beds for a bare root nursery. For a polybag nursery, source the components of the soil mix, prepare the mix and fill the polybags
5. Construct shade for the nursery beds
6. Sow the coffee seed
7. Thin the new coffee seedlings
8. Maintain the nursery – watering, weeding, nutrient management, pest and disease control
9. Adjust shade to two-thirds
10. If a polybag nursery, re-stack the polybag seedlings to a wider spacing as they develop
11. Adjust shade to one-third
12. Harden off the seedlings

Quiz

- Refer to the Quiz located at the end of this module and have farmers complete the questions
- Repeat the Quiz on completion of the module topics

2.1 THE COFFEE NURSERY

Starting your coffee garden with the best planting material helps ensure that the garden has the potential to be highly productive and generate a good income. This means using good quality seed and appropriate soil and nursery management practices to ensure that the seedlings are healthy and ready for transplanting at the beginning of the wet season.

High quality, healthy seedlings grown in the correct environment with good management will lead to healthy, high producing coffee trees.

There are two nursery options recommended for coffee growers. These are bare root and polybag nurseries. Bare root nurseries are much cheaper than polybag nurseries and so are the preferred option for smallholders. They will be the focus of this module.

What is a coffee nursery?

A coffee nursery is an area where young plants are grown from seed to a size where they can be transplanted into the coffee garden.

Why bother establishing a nursery when you can plant directly into the coffee garden?

- Seeds can be sown in a small protected area close to the house
- Seeds can be sown into good quality soil mix that contains nutrients and is best for root growth
- If good quality seed is purchased there is a cost saving as less seed is required when sown in a nursery
- It is much easier to monitor seed germination, soil moisture and infestations of weeds, pests and diseases
- Seedlings can be protected from foraging animals
- Shade requirements can easily be controlled during development of the seedlings
- More labour efficient – close to the house for maintenance (watering, weeding, etc.)
- Young plants will be more uniform and are transplanted into the coffee garden at a stage where they are strong and resilient and less susceptible to pests and diseases, and damage caused by bad weather

What is involved in setting up a coffee nursery?

- The reason for having a coffee nursery is to produce good quality seedlings ready for transplanting at the beginning of the wet season
- This will mean planning ahead so that you have good quality well composted soil mix, a simple nursery structure where the shade level can be adjusted, a water supply nearby and, very importantly, good quality seed
- Seedlings are ready for transplanting when they have 2-3 primary branches or 8-9 leaf pairs
- The time taken from sowing to when the seedlings are ready for transplanting into the coffee garden is 6-9 months
- It is important to be ready to sow the seed at the appropriate time so that the seedlings are ready for transplanting when the rains arrive at the start of the wet season

Objective:

To identify the advantages of setting up a coffee nursery and the process involved.

You will need:

Butchers' paper and a marker pen.

EXERCISE 1

Coffee nursery - advantages and planning

List

- The advantages of setting up a coffee nursery

Discuss

- The process of setting up a coffee nursery
- Why it is important to plan ahead when setting up a coffee nursery

2.2 PLANTING MATERIAL

PLANTING MATERIAL & CBB

Any planting material used in your coffee garden **MUST** be free of CBB

When establishing your coffee garden it is important to use planting material that is going to produce **strong**, **healthy** and **high producing** coffee trees.

There are three options for selecting planting material:

1. The **best option** is to grow your seedlings in a nursery using certified seed
2. The **second best** option is to grow your seedlings in a nursery using seed collected from your best performing coffee trees
3. The **least preferred** option is to use seedlings that have germinated below coffee trees in an existing coffee garden

Option 1: Certified seed

- The Coffee Research Institute of the Coffee Industry Corporation produces very good coffee seed which is called **certified seed**
- It has been selected from high yielding, disease-free trees

CERTIFIED SEED:

- Is from seed gardens of different coffee varieties and has been tested for quality. Poor quality and small beans are rejected. Only the best of the best seeds become certified seeds
- Is very uniform
- Germinates well
- Grows well
- Bags of certified seed do not contain damaged or immature seeds or pest and disease affected seeds

1 kg of CIC certified coffee seed *(Source: Leo Aroga)*

Note: A requirement for organic certification is that farmers grow a diversity of coffee varieties

Show the farmers:

1. A Certified seed packet
2. Some certified seeds

- Select certified seed of a coffee variety that is suitable for your area; if a disease is prevalent in your area, choose a variety that can tolerate that disease; if your area can sometimes be unusually dry choose a variety that can tolerate long dry periods
- Your extension officer will help you choose certified seed of a coffee variety that is most appropriate for your area
- It may be advisable to grow more than one coffee variety to increase biodiversity and sustainability, and reduce risk. For example, different varieties can vary in their nutrient requirements and uptake and their susceptibiliy to pests and diseases

Where do you source CIC certified seed and how much does it cost?

- Certified seed can be ordered through your extension officer, from Aiyura, Eastern Highlands Province, or other **CIC** research stations (Western Highlands CIC sub-station, CIC Omuru Station, Madang and CIC provincial centres)
- Certified seed is a very **reasonable price**. In 2024 1 kg of certified seed from CIC cost K5.50

How much seed will you require?

- 1 kg of seed will contain approximately 4,500 seeds and will produce between 3,000 and 3,500 viable seedlings. When using the rectangular spacing of 2.5 m x 1.5 m, 1 kg of seed will produce sufficient seedlings to plant 1.25 ha of coffee
- Any surplus seedlings could be used for infill in existing coffee gardens where trees have died or they could be shared with relatives so that there is no wastage

Growing Catimor:

Catimor may be suitable for business-minded farmers who apply best management practices and who have sufficient labour.

With a higher planting density, maintenance pruning and harvesting for CBB control are more difficult.

1 kg of certified coffee seed contains approximately 4,500 seeds, depending on the variety. Allowing for non-viable seeds and nursery culling about 75% (3,375) will grow into transplantable seedlings.

Coffee tree spacing and seed requirements

Spacing type	Spacing	Tree density /ha	Area planted using 1 kg of seed	Seed quantity /ha	Situation
Rectangle:	2.5 m x 1.5 m	2,667	1.25 ha	0.80 kg	Tall varieties. In pest & disease prone areas
Rectangle:	2.5 m x 2.0 m	2,000	1.70 ha	0.60 kg	Spacing for long-term intercropping with food crops
Triangle:	2 m x 2 m x 2 m	2,873	1.20 ha	0.85 kg	Steep slopes
Rectangle:	2.0 m x 0.9 m	5,555	0.6 ha	1.7 kg	Catimor (dwarf variety), single upright per tree

Show farmers the coffee varieties poster pointing out the advantages and disadvantages of the different varieties.

Arabica coffee varieties

Variety	Height	Description	Hardiness	Pest & disease susceptibility	Ideal altitude (masl)	Labour Input requirements	Drought Resistant	Other considerations
Typica:	Tall	Horizontal branching Bronze tips on young leaves Small narrow leaves Small cherries	Hardy	Susceptible to Coffee Leaf Rust (CLR)	800-1700 m	Low	Yes	One of the preferred varieties for smallholders in areas where CLR is not prevalent. Level of management inputs required: Low-Medium
Bourbon:	Tall	Erect branching Green tips on young leaves Large leaves Small cherries	Not as hardy as Typica	Susceptible to Coffee Leaf Rust (CLR)	800-1700 m	Medium		Level of management inputs required: Medium
Arusha:	Tall	Originates from Bourbon but has: Bronze tips on young leaves Broader leaves Larger cherries Greater vigour (growth & yield)	Not as hardy as Typica	Susceptible to Coffee Leaf Rust (CLR)	800-1700 m	Medium	Yes	Level of management inputs required: Medium
Mundo Novo:	Tall	Erect branching Green tips on young leaves Broad leaves Small cherries	Not as hardy as Typica	Susceptible to CLR and Pink disease	800-1700 m	Medium		One of the preferred varieties for smallholders in areas where CLR is not prevalent. Level of management inputs required: Medium
Caturra:	Dwarf	Compact habit Green tips on young leaves Large leaves Large cherries	Not hardy	Not resistant to CLR Poor access for CBB control	400-1500 m	High		Not recommended in areas where CLR is a serious problem. Level of management inputs required: High
Catimor:	Semi-dwarf	Compact habit Bronze & green tips on young leaves Large dark leaves Large cherries	Not hardy	CLR tolerant Poor access for CBB control	400-1500 m	High		Recommended in areas where CLR is a serious problem. Level of management inputs required: High

Arabica coffee is largely self-pollinated so the seeds are likely to have the same characteristics as the parent tree. The percentage of seed resulting from natural cross-pollination is usually less than 10%. This is not true for Robusta coffee which is mostly cross-pollinated.

Demonstrate the differences in seed uniformity between
- Certified seed
- Seed collected from a farmer's own coffee garden

Show large, very ripe, bright red cherries from a high performing tree to demonstrate the size and colour of cherries suitable to use as a source of seed.

Option 2: Seed from your best and highest producing coffee trees

- Seeds from your **most productive**, and **healthy** trees may be used to establish a new coffee garden
- The good qualities of the parent (mama) trees will be in the new plants
- If the parent tree produces a lot of cherry and is resistant to pests and diseases then it is likely that the new trees that grow from the seeds will also be high producing and resistant to pests and diseases
-  **The seed must <u>NOT</u> come from a CBB infested coffee garden**

Certified vs. non-certified seed

- Although the seed is collected from your highest yielding trees it will not have the same qualities as certified seed. It will not be as uniform and will not germinate and grow as well as certified seed

How do you obtain seed from trees?

- Obtain **large**, very ripe, **bright red cherries** from **pest and disease free**, **high-yielding** trees (if the cherry is not ripe the seed is not ready)
- To ensure the seeds are healthy put the cherries in a bucket of water. Select only the cherries that sink (good ones)
- Remove the pulp by hand or by using a pulper
- Soak the beans in water for 24 hours to remove the mucilage
- Wash the beans
- Air-dry in a shaded area with lots of airflow for at least 4 days. It is better not to dry them in the sun as they may dry too quickly and die
- Remove any pea berries and broken or insect infested beans
- If the beans are dried properly, the outer skin or parchment should peel off easily by hand or by itself
- If air-drying does not remove the parchment it can be removed by rubbing the beans in the palms of both of your hands

How do you store coffee seeds?

- Coffee seeds should not be collected more than three months before they are to be sown as they may die. It is best to collect them just prior to sowing
- Store dried seeds in containers or plastic bags, in a cool area where there is no moisture. If they take up moisture from the air they may germinate before they are sown

GOOD QUALITY SEED: Use only the best quality seed in your coffee garden to produce **healthy**, **high yielding** coffee trees that return lots of **money**.

Air-dry seed in a well aerated, shady location for at least 4 days.

Hull the seed by rubbing the parchment in the palms of your hands.

Store the seed in a dry, cool area, in an airtight container.

Option 3: Selecting seedlings that have 'naturally' germinated below the parent tree

This is the least preferred option for obtaining planting material for several reasons:

- Even if you choose seedlings growing under your most productive tree you cannot be sure that they grew from seed from the tree above. Birds and animals move seeds around so they may not be good quality seeds (birds spread seed in their droppings so they may be carried quite a distance)
- There is a risk that you will damage the seedling, especially the tap root, when removing it from the ground
- Transplanting self-sown seedlings will be much more stressful for the seedling. Survival rates amongst these transplanted seedlings will be lower than if you grew seedlings using the first two options

Note: Think about where your seedlings and seeds come from.

IMPORTANT MESSAGES
Never use seeds or seedlings from under your poor performing trees
Never use seeds or seedlings from a CBB infested coffee garden

Talking point for extension officer:

CHOOSING SEEDLINGS AND CHOOSING PIGLETS

Many farmers complain that their coffee trees do not yield well. Often this is because farmers use low quality volunteer seedlings obtained from under the worst trees in their coffee gardens. These poorly performing trees are often not harvested or maintained (no grass slashing) so coffee seedlings grow under them from unharvested beans that have fallen on the ground. The best trees are fully harvested and well maintained so often there are no seedlings underneath them. So farmers doing in-fill often use seedlings from under their worst trees so that through time the coffee garden is transformed from a high producing coffee garden to a low producing one.

Farmers have to think about seedling selection in the same way they think about choosing a piglet to buy and raise. Farmers don't buy just any piglet. They will look at the mama pig and ask: is the mama pig healthy and big? Does she carry plenty of healthy piglets each time she gives birth? Is the papa pig from good stock? In other words, they choose piglets from the best parents to ensure that the piglet they purchase is likely to be a good producer, grow strong and healthy, and put on weight quickly.

Farmers must look at their coffee seedlings in the same way as they choose piglets. If they are not able to obtain certified seed from CIC, they must select seedlings or seeds from their **highest yielding and healthiest** coffee trees and use these for infill. In this way the productive capacity of the coffee garden remains high and even improves through time as low producing trees are gradually replaced by high producing trees.

(John Leahy)

Objective:

To identify and discuss seed selection practices and the characteristics of a tree most suitable for providing good quality seed.

You will need:

Butchers' paper and a marker pen.

EXERCISE 2

Coffee seed selection

Discuss:

- Farmers' current practices of seed selection
- How good seed selection results in better quality coffee and, therefore, a better market price
- Why it is important to grow coffee varieties that suit the climatic conditions of the location in which they are being grown

List:

- The key characteristics of a coffee tree from which the best quality seed will be collected

Objective:

To understand the process of seed collection from your best performing coffee trees through to storage of the seed until it is sown.

You will need:

Butchers' paper and a marker pen.

EXERCISE 3

Coffee cherry selection, processing and seed storage

List the steps involved in seed collection from your best performing coffee trees to storage of the seed using the following as a guide.

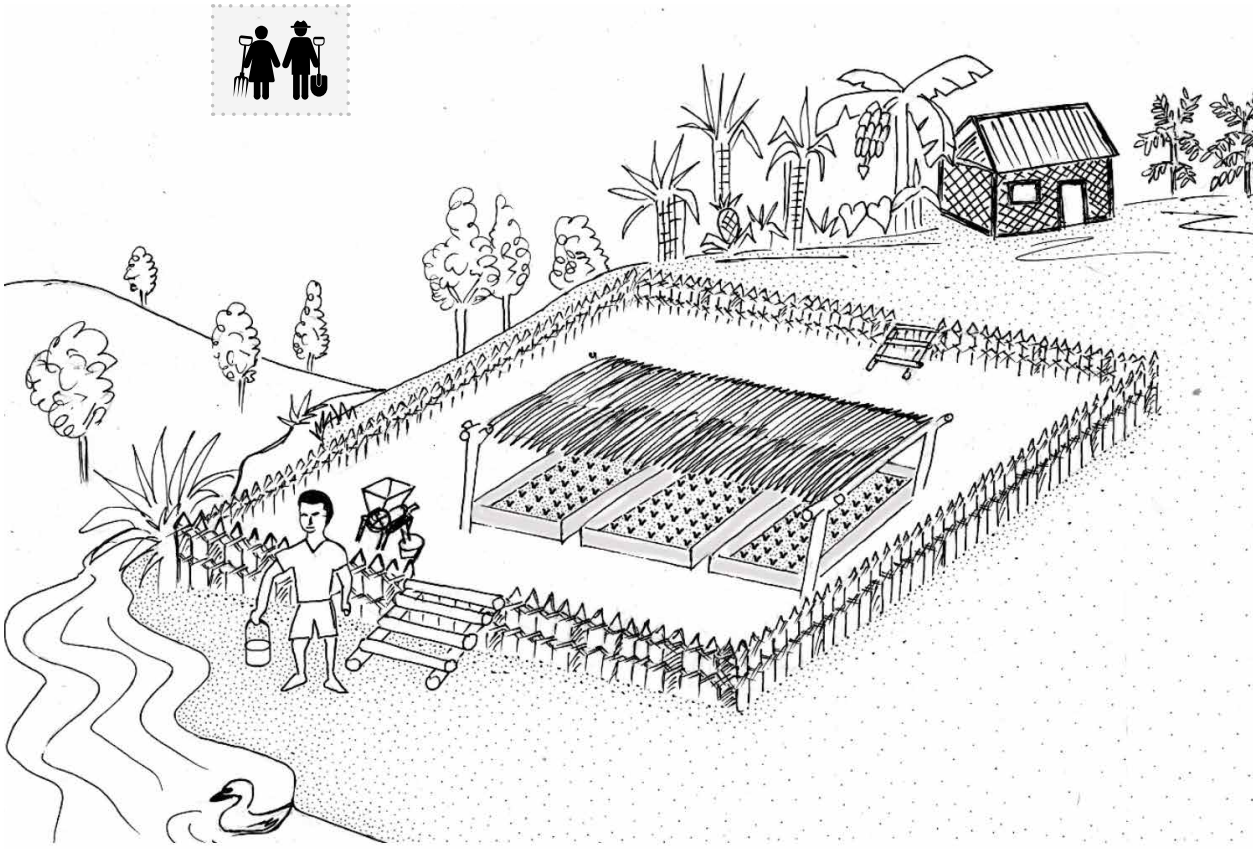
- How long prior to sowing should the seed be collected from your best performing coffee trees?
- How do you choose which cherries to collect from the trees?
- How do you determine if the cherries are healthy?
- How do you remove the mucilage?
- What do you do with the beans once the mucilage has been removed?
- How is the parchment removed
- What should the dried seeds be stored in?
- What are the best conditions for seed storage?

2.3 SELECTING A NURSERY LOCATION

Where is the best place to locate your coffee nursery?

To produce good quality seedlings some planning has to go into where the nursery will be located. A good nursery site is one that is:

1. Close to the house, easy to access and away from potential thieves and animal damage
2. On ground that is flat or gently sloping and not prone to flooding
3. On good soil that is dark brown and well drained (extremely important for a bare root nursery)
4. Near a permanent water supply
5. Away from hollows where cold air settles at night
6. On pest and disease free soil (use a new location for your nursery each year to prevent build-up of pests and diseases). For example, do not select a location where any crops have had damping-off disease *(see Section 2.8 'Pest and disease control')*
7. Not in green scale affected areas
8. Sheltered from strong winds
9. Fenced off to prevent animal damage
10. Located so that shade can easily be erected or provided
11. Close to a source of sand if you are going to use your own sand
12. Close to the coffee pulper so that composted pulp can be easily accessed



'A suitable location for a coffee nursery'

Objective:

To understand the significance of choosing the correct site for a coffee nursery.

You will need:

Butchers' paper and a marker pen.

EXERCISE 4

Site selection

List:

- The critical factors to be considered when selecting a nursery location

Discuss:

- Why the nursery should be easy to access

2.4 TYPES OF NURSERIES

Bare root vs. polybag seedings

Display bare root and polybag seedings

- Bare root coffee plant with soil removed
- Polybag coffee plant removed from the polybag showing the soil-root mass.

There are two types of nurseries:

1. Bare Root Nurseries

Seeds are sown directly into a constructed nursery bed. When the young coffee plants are ready to be transplanted they are gently dug up from the nursery bed, most of the soil is removed from the roots and they are carried in a wet cloth or wet newspaper to the coffee garden for planting.

A bare root nursery *(Source: Michael Kaugam)*

2. Polybag Nurseries

Seeds are sown into small plastic bags and grouped together in a nursery. When the young plants are ready, the polybags are transported to the coffee garden for planting.

A polybag nursery

Advantages and disadvantages of bare root and polybag nurseries

There are advantages and disadvantages of both systems but the **bare root nursery is the better option for smallholders** because it requires:

- Less labour
- No expense for purchases of bags or soil
- Low transport costs

BARE ROOT NURSERY

Advantages:

1. Cheapest method to produce seedlings
2. Use own soil
3. Can easily add compost and other organic material to the soil
4. Soil in a bed is better at holding moisture
5. Low labour demands - requires labour only for shade management and maintenance
6. Plants are light to carry when ready for transplanting. Road transport is not required

Disadvantages:

1. Seeds are exposed to pests and diseases within the soil
2. Germination can be slower
3. Rain can expose developing roots
4. Soil used in raising seedlings may be used only once to avoid build-up of pests and diseases
5. Seedlings require immediate transplanting when uprooted
6. Seedlings are exposed to shocks which may slow establishment in the field and reduce survival rates
7. Establishment rate in the field is less than that of polybag seedlings

POLYBAG NURSERY

Advantages:

1. Seedlings can be easily managed
2. Seedlings can be transported safely
3. Seedlings establish fast once transplanted into the coffee garden
4. Planting out can be delayed if the weather is unfavourable
5. Polybag seedlings can be sold

Disadvantages:

1. Polybags must be purchased. For example @ 10t each, 1 ha costs 2667 x 0.10 = K267
2. Polybags may be difficult to acquire in remote villages
3. Large quantities of topsoil and sand are required and may have to be purchased in some locations
4. High cost of transporting sand and soil to the nursery
5. Hard work preparing soil mix and filling bags
6. When ready to transplant, polybags are very heavy to carry to the coffee garden. Transport is often required which can be expensive
7. Road access is required to transport sand and soil to the nursery and to deliver polybags to the coffee garden

Objective:

To understand the different characteristics of polybag and bare root nurseries and identify which one is most appropriate for smallholders.

You will need:

Butchers' paper and a marker pen.

EXERCISE 5

Polybag vs. bare root nurseries

List and discuss the advantages and disadvantages of:

- Bare root nurseries
- Polybag nurseries

Identify which type of nursery is better for the smallholder based on the advantages and disadvantages of each.

Discuss with farmers how they currently grow their coffee seedlings.

2.5 BARE ROOT NURSERY

For a bare root nursery, seed can be sown directly into well prepared beds. For better germination rates, however, it is preferable to germinate the seed in a small pre-germination bed and then transplant the young seedlings into the prepared beds when at the butterfly stage.

Whether sowing directly or pre-germinating the seed, there are two very important tasks that must be undertaken prior to sowing the seed:

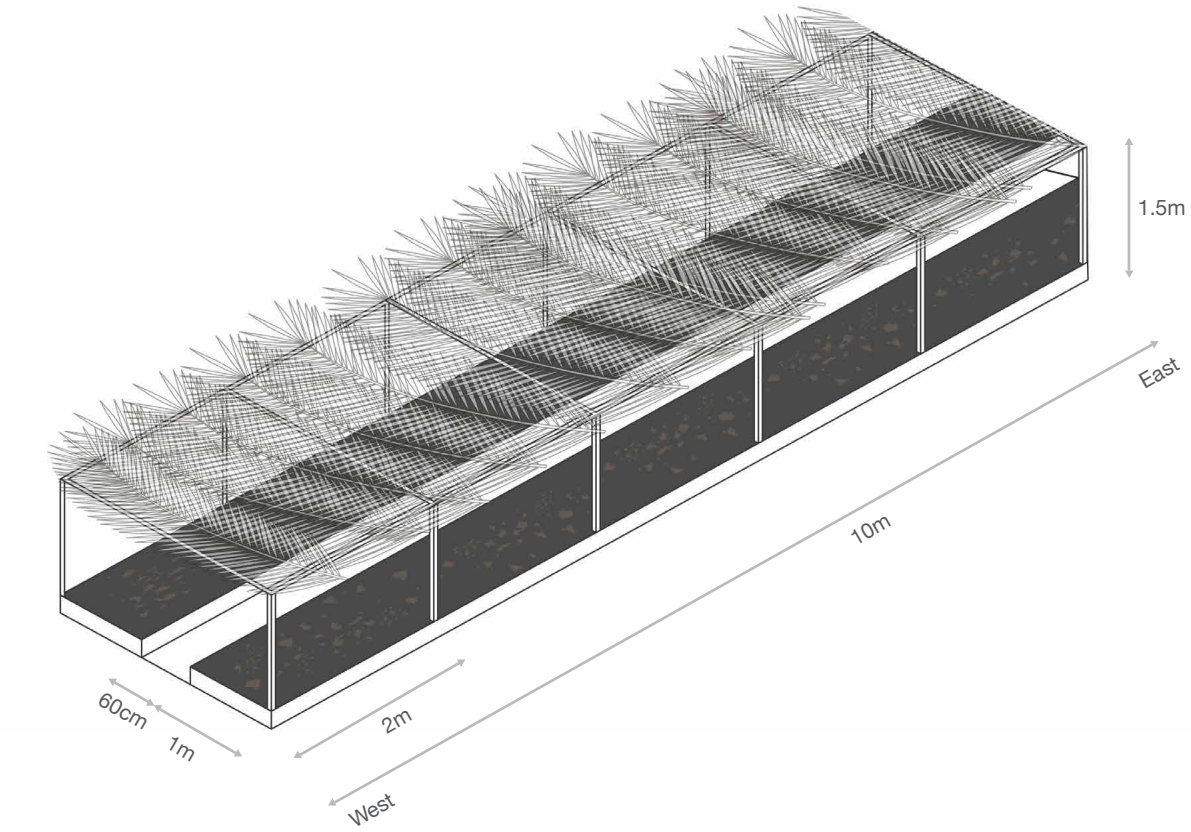
- Prepare the beds well with good **quality soil mix**
- Construct **shade**

Beds should be ready for the seeds to be sown just before the main coffee harvest period begins. The seed is sown at this time so that the seedlings have sufficient time to grow healthy and strong and be ready for transplanting at the beginning of the next wet season.

Requirements for a bare root nursery

1. Compost
2. Sand is optional. If the site is chosen well, drainage will be good and there will be no need for sand to be added to the soil mix
3. An area that has healthy, disease-free topsoil which has not been impacted by pests, such as green scale, or diseases, such as damping-off
4. Tools to remove weeds, cultivate soil and mix in compost and sand
5. Bucket
6. Soil sieve (optional) made from bamboo and mesh
7. Short pieces of split wood to support beds
8. Split wood and plant materials for shade cover (Yar branches, kunai or pitpit)
9. Coffee seed (preferably CIC certified seed or seed from your best performing coffee trees)
10. Mulch
11. Water supply nearby

Bare root nursery beds:



The soil mix

Display buckets of components of the soil mix

- Composted coffee pulp/ manure
- Clean river sand
- Dark topsoil

The soil mix

For good seedling growth it is preferable to mix in compost with the topsoil at the site.

1. Compost

Compost is **well decomposed** or decaying organic matter such as animal manure, coffee pulp, and other plant material. For the coffee seedlings to grow strong and healthy it is best if compost can be added to the nursery beds.

Why is it important to add compost to your nursery beds?

- Provides nutrients for the growing seedlings
- Helps retain soil moisture
- Improves the structure of the soil so that roots can easily grow through it and obtain nutrients
- Suppresses diseases in the soil
- Encourages faster growth of the seedlings

Items that can be used to make compost include:

- Coffee pulp
- Debris from your food garden including weeds and harvest debris
- Debris from clearing the site for the coffee nursery or the new coffee garden
- Kitchen waste like kaukau peelings and black ash from the fire
- Animal manures - large particles of animal manure may burn the roots of seedlings and therefore should be broken into finer particles. Animal manure is very high in nutrients so use only half the quantity you would use if using coffee pulp

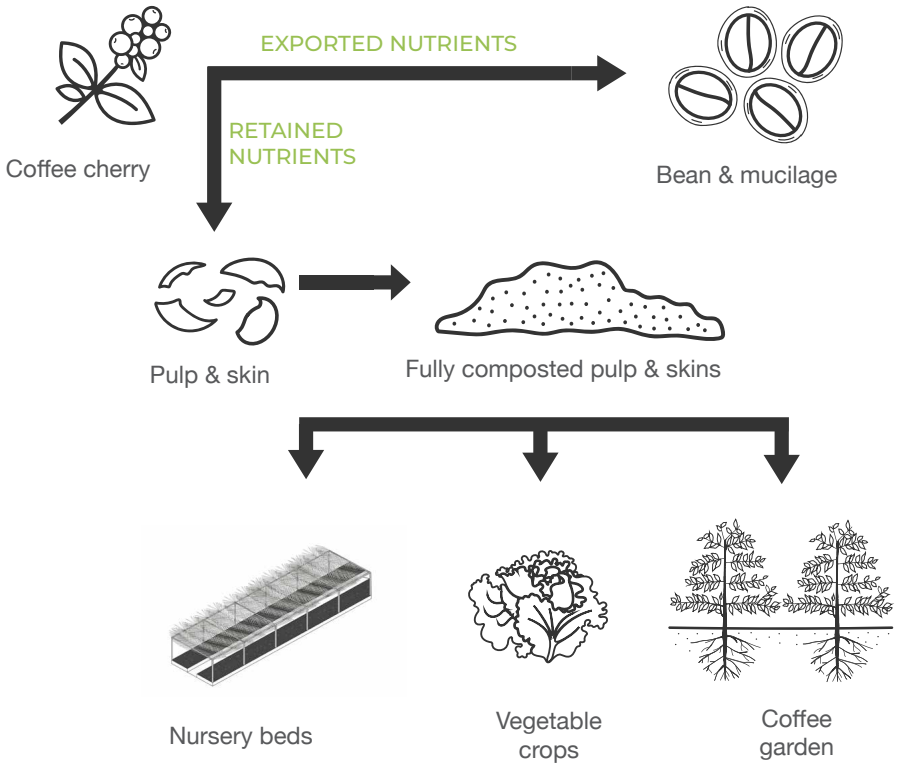
COMPOST:
Compost must be well broken down
• Compost should be prepared at least 2 months before it is to be used in the nursery. It must be well decomposed so that it does not burn the roots of the young coffee seedlings
• Raw or unfinished compost, particularly if containing animal manures, may **burn the roots** of seedlings
• Compost is ready when it is dark and crumbly and has a pleasant, earthy smell. Other indicators are when weeds begin to grow in it and/or worms are present
• Raw or unfinished compost will **use** nutrients and **not** provide nutrients for the seedlings

Composted coffee pulp

Well composted coffee pulp is ideal for the soil mix in the nursery beds

- Coffee pulp and skin contain many nutrients which are very important for plant growth
- Fresh pulp should be heaped and then turned and mixed every 3-4 days. Cover the heap with banana leaves to help retain the heat but allow some air to escape
- Nutrients can be quickly lost from decomposing coffee pulp. Covering the heap will also help minimse the loss of nutrients
- If the above procedures are **strictly followed** coffee pulp takes approximately 4-6 weeks to break down sufficiently to use in the soil mix in your coffee nursery
- You will know when your coffee pulp is ready for use in the nursery as weeds will begin to grow in any parts that are not covered

Cycling nutrients in coffee pulp:



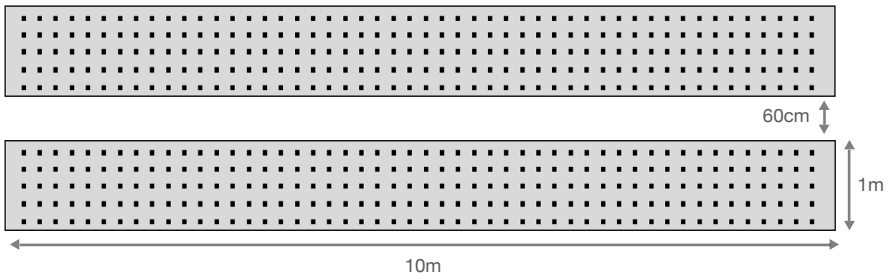
2. Topsoil

The nursery beds will be prepared on existing topsoil so it is important that the soil is healthy, well drained and free of pests and diseases. An indicator of healthy soil is that other crops have grown well in the location.

Construct a soil sieve

Bed preparation

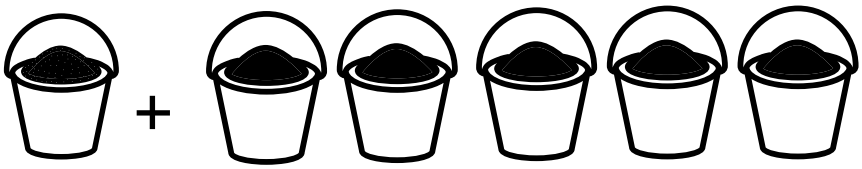
- Remove all roots, stones and weeds from the area where the nursery beds are to be established. Take extra care to remove all of the roots of weeds such as kunai grass, couch and nut grass as they will continue to grow back and compete with the seedlings
- Use a sieve to breakdown large clumps of soil and manure and to remove stones that may limit root growth
- For the most effective shading, construct the beds in an east-west direction, that is, the narrow ends of the beds are at the ends where the sun rises and sets
- Make the beds large enough so that you will have some spare seedlings if some die in the nursery or for infilling in the coffee garden if seedlings die after planting
- Mark out the beds. Make the beds 1 m wide and 10 m long in order to produce around 200 transplantable seedlings per bed. It is best to sow the seeds 20 cm apart, so a bed this size will accommodate 5 rows of seedlings with 50 in each row, totalling 250 seedlings. This will allow for some excess seedlings for infilling



- Make a pathway between each bed of about 60 cm so that there is enough room to carry out maintenance tasks such as weeding and checking for the presence of pests and diseases. This will also allow for some air flow around the beds which will assist in preventing infection by disease
- Place soil from the pathways on the nursery bed
- Cultivate beds by digging to a depth of at least 30 cm
- Make the beds to a height of about 15 cm. Support the sides with long pieces of split bamboo, Yar (Casuarina) or banana stems. Stake these in place with short pieces of wood or branches

Soil Mix

- Seedlings grow well in a bare root nursery when compost and manure are mixed into the cultivated topsoil
- For the best growing medium, mix approximately **1 part compost** or manure **to 5 parts topsoil**



1 x Compost

5 x Topsoil

- Spread decomposed compost (and/or manure) over the top of the beds then thoroughly mix in with the cultivated soil

A prepared soil bed in a bare root nursery (*Source: Bob Kora*)

Shade

It is very important to protect the young coffee seedlings from the hot sun by providing shade. Shade also reduces the nutrient demands of the coffee seedlings making them stronger and healthier, and more resistant to pests and diseases.

- A shade frame can be constructed from any wooden material such as Yar or bamboo
- Make the posts approximately 1.5 m high and place them 2 m apart
- Construct a shade cover frame using bush materials like bamboo
- Lay the shade material, like Yar branches, pitpit, kunai or banana leaves, on top.

Once the beds have been prepared and the shade has been constructed the coffee seeds can be sown and covered with mulch *(see Section 2.7 for information on sowing seeds).*

Shaded bare root nursery seed beds covered with mulch (*Source: Bob Kora*)

Note: A pre-germination bed can be prepared from washed clean sand without the addition of compost or soil. While germination rates are higher and more uniform using a sand bed they require regular watering because the sand will not hold water.

PRE-GERMINATION BED

- Part of a bare root nursery bed can be used as a pre-germination bed
- An area of around 1 m x 1 m will be sufficient to pre-germinate approximately 1,000 seedlings

Objective:

To have an understanding of what preparation is required in the nursery prior to the coffee seed being sown and at what time of the year these tasks should be completed.

EXERCISE 6

Preparing a bare root nursery

- Identify and discuss the **two** most important tasks to be undertaken prior to sowing the seed in a bare root nursery?
- If the period from sowing to transplanting is 6-9 months, approximately when should the seed be sown in your area? Use the coffee calendar completed by the group to identify when seed should be sown.

Objective:

To learn about the importance of compost as a component of the soil mix and how to prepare it

You will need:

Well composted coffee pulp

EXERCISE 7

Making quality compost

Discuss:

1. What is compost?
2. Why is it important to add compost to your coffee nursery?
3. What items can be used to make compost?
4. The process of making compost
5. The importance of ensuring that the compost has completely broken down
6. How to identify when it is completely broken down
7. The advantages of using coffee pulp in compost

Objective:

To understand the importance of shade cover and what materials are best to use in its construction.

EXERCISE 8

Shade construction

Discuss:

1. Why it is important to construct a shade cover prior to sowing the coffee seed
2. The materials suitable to use for constructing a shade cover and why these materials are suitable

2.6 POLYBAG NURSERY

For a polybag nursery, seed will be sown into a soil mix in a polybag. It is important to prepare good quality soil mix and construct shade prior to sowing the seeds in the polybags. **The filled polybags and shade cover should be ready for the seeds to be sown just before the main coffee harvest period begins**. The seed is sown at this time so that the seedlings have sufficient time to grow healthy and strong and be ready for transplanting at the beginning of the next wet season.

Requirements for a polybag nursery

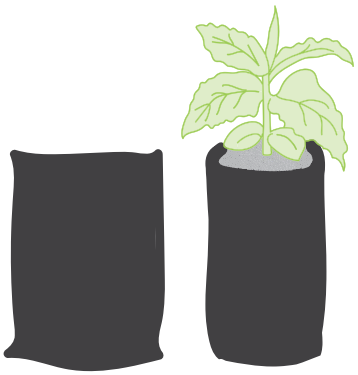
1. Small polybags (1.5 L)
2. Compost
3. Sand
4. Access to healthy topsoil which has not been affected by pests or diseases
5. Soil sieve (optional) made from bamboo and mesh
6. Tools to dig up topsoil and sand, and for mixing soil materials
7. Bucket
8. Large scoop with no sharp edges to fill polybags
9. Split wood to support polybags
10. Split wood and plant materials for shade cover (Yar branches, kunai or pitpit)
11. Coffee seeds (preferably CIC certified seed or seed from your best performing trees)
12. Mulch
13. Water supply nearby

Display some empty polybags

Polybags

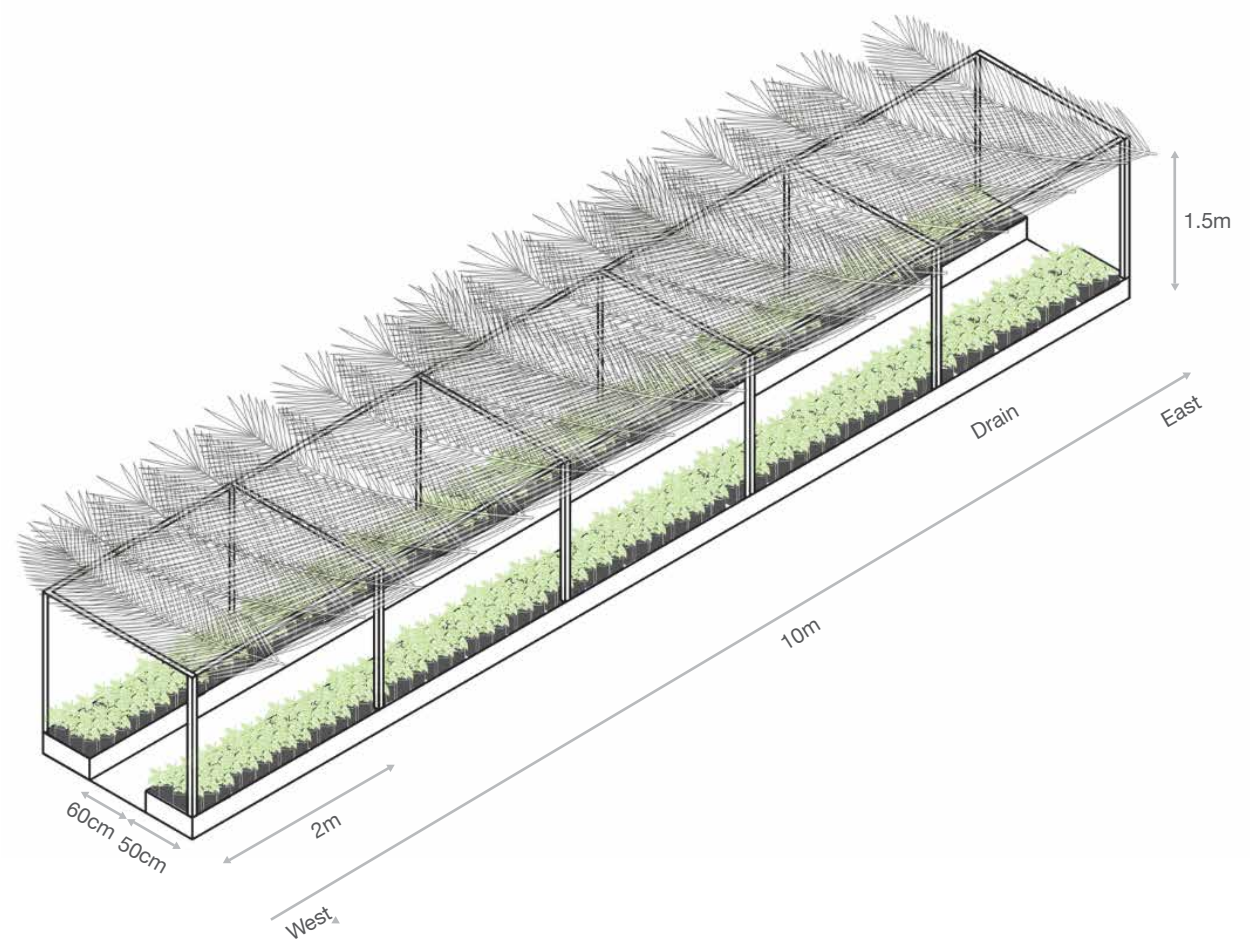
- Polybag nurseries are given their name from the polythene material the bags are made from
- A polybag is a small plastic bag with an opening at one end and closed at the other. At the closed end, there should be at least 2 –3 holes for air and free flow of excess water
- A polybag is filled with well-mixed soil before coffee seeds are sown into the bag
- At the recommended spacing you will require 2,667 seedlings to plant 1 ha of coffee. Allowing for some losses in the nursery it would be best to grow 3,000 seedlings for 1 ha. Polybags cost K100 per 1,000 so the cost of the polybags will be K300
- To grow 3000 seedlings you will require 4.5 cubic metres of soil mix
- 1 bucket (20 L) of soil mix will fill 13 polybags

Coffee seedlings growing in polybags



1.5 L Polybag (15 x 25 cm)

A polybag nursery:



Preparing the site

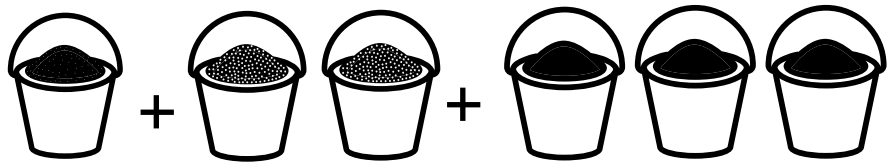
- Clear the site where the polybags will be stacked. Remove sticks, stones and large weeds
- Stack the polybags close together, and as the seedlings grow, the bags should be moved apart to give more space to the growing seedlings
- A bed of 500 polybags stacked 5 wide will take up an area of approximately 50 cm x 10 m. Making the beds this size allows for easy counting and good access for maintenance, such as weeding
- As the seedlings grow the area required for the polybags will double in size (the area of shade required will also double)
- When the seedlings begin to interlock with each other they will need to be moved apart. If they are not moved apart they will grow tall and thin, and be weak
- If a pre-germination bed is to be used, prepare a small bed using the same method as that used for a bare root nursery in Section 2.5 ‘Bed preparation’. A bed approximately 1 m wide by 1 m long will be sufficient to pre-germinate approximately 1,000 seedlings. Ensure shade is constructed for the pre-germination bed

Soil mix

Production of healthy seedlings in polybags is very dependent on the use of a good soil mix. Time must be taken in sourcing the right **components** of the mix, using them in the correct **ratio** and then **mixing** the components well prior to filling the polybags. The best soil mix for polybags is one which is made up of compost, sand and topsoil at a ratio of 1: 2: 3.

Quantities of soil mix components

Use 20 L buckets, or other similar large scoops to ensure the mixture is in the correct proportions.



1 x organic compost matter

2 x sand

3 x topsoil

To fill 1000 polybags you will require 75 large (20L) buckets of soil mix:				
Compost		Sand		Topsoil
13	+	**25**	+	**37**

Preparation of the soil mix

This is a very **labour intensive** task. The material to make the compost has to be collected and the sand and topsoil have to be dug up and transported to where the soil mixture will be prepared. All components then need to be mixed well together

1. Compost

- Prepare as for the bare root nursery *(see Section 2.5)*
- Compost must be well broken down. It is ready to use when it is dark and crumbly, and has a rich earthy smell. Other indicators are the growth of weeds and the presence of worms

2. Sand

- Collect or purchase sand
- Sand is very heavy to carry and expensive to move if a truck is required, so take this into account when locating the nursery
- Sand containing many stones and large pebbles can produce deformed taproots on the coffee seedlings. Stones and large pebbles need to be removed. Sieving is recommended

River sand *(Source: Leo Aroga)*

3. Topsoil

- Topsoil contains more **nutrients** (plant food) than soils at deeper levels and like sand, is good for root growth
- Use topsoil that is **dark in colour**, containing lots of organic matter. Organic matter contains nutrients (plant food) and acts like a **fertiliser**
- Sieving the topsoil will remove roots, weeds, sticks, and stones so that there is nothing in the polybag to obstruct root growth

Preparation of the soil mix

Display components of the soil mix (sieved)

- 1 bucket of composted coffee pulp
- 2 buckets of clean river sand
- 3 buckets of dark topsoil

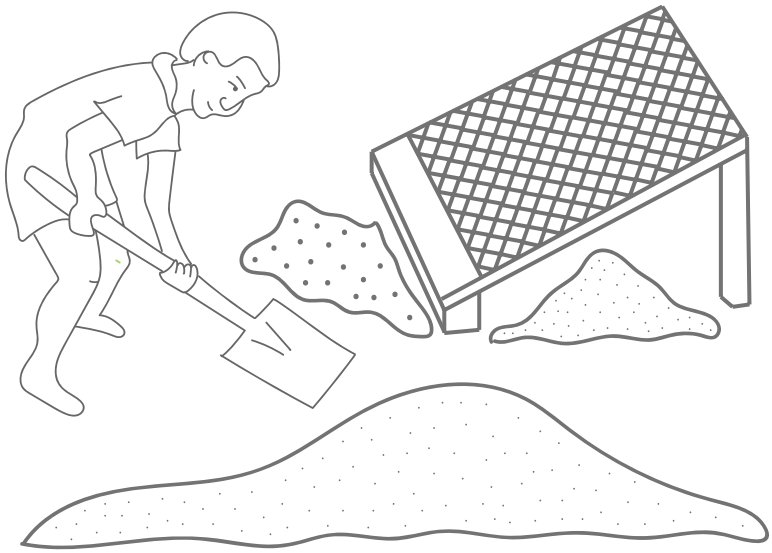
Demonstrate how a sieve is used.

Show the difference between sieved and non-sieved compost, sand and/or topsoil.

Demonstrate how to thoroughly mix the components of the soil mix with a shovel.

Sieving the components of the soil mix:

The compost, sand and topsoil should be sieved separately before mixing to remove grass, stones and large clumps.



Sieving the components of the soil mix.

Sand containing too many stones should be sieved prior to use.

Compost and sand

It is **essential** to mix **compost** and **sand** with topsoil otherwise the soil in the polybags will get very hard

If the mix is very hard:

- The roots cannot grow through the soil
- Water cannot penetrate the soil to reach the roots

Stunted coffee seedlings growing in poorly drained soil mix

Filling polybags

- Ensure the soil mix is free from hard clumps as these may affect root growth
- Ensure the soil mixture has been **thoroughly mixed**
- So as not to cut the polybags, use a blunt edged scoop to fill the bags
- Stack the filled polybags neatly in rows 5 wide (do not make the rows too wide as you won't be able to reach the middle polybags when weeding, etc.)
- Use lengths of split bamboo, banana stems or wood staked in place with short pieces of wood. This will hold the polybags in place in the bed

Filling a polybag

Demonstrate how to fill a polybag with the soil mix using a blunt edged scoop

Shade

- Construct shade as for the bare root nursery *(see Section 2.5)*
- As the seedlings grow the polybags should be spaced further apart, so build the shade structure large enough for when the polybags are spaced apart or build it so that it can be extended later

Once the polybags have been filled and placed under the shade structure the coffee seed can be sown *(see the following section for information on sowing the seed).*

Objective:

To understand the costs associated with both polybag and bare root nurseries.

You will need:

Butchers' paper and a marker pen

Estimates for each item listed in the table

EXERCISE 9

Budgeting for polybag and bare root nurseries

Create a budget to produce seedlings in a bare root and a polybag nursery.

Cost to produce 1 ha (2,667) coffee seedlings		
Item	**Bare root (K)**	**Polybag (K)**
Certified seed (1 kg)		
Seed from best trees		
Polybags		
Compost		
Sand		
Topsoil		
Delivery of sand		
Delivery of topsoil		
Sieve (optional)		
Delivery of seedlings to coffee garden		
Totals		

Guide for the extension officer:

To produce seedlings for an area of 0.2 ha (approximately 500 seedlings)

Bare root nursery

2 nursery beds
Bed dimensions: 1 m x 10 m
Bed depth: 15 cm
Compost: 0.5 m^3

Polybag nursery

Total volume of soil mix (500 x 1.5 L): 750 L or 0.75 m^3
Ratio of compost, sand and topsoil: 1:2:3
Compost 0.125 m^3
Sand 0.25 m^3
Topsoil 0.375 m^3

Sand
If 0.65 m^3 sand = 1 tonne
Wt. sand required (0.25 m^3/0.65 m^3): 0.4 tonnes

Topsoil
If 0.75 m^3 = 1 tonne
Wt. topsoil required (0.375 m^3/0.75 m^3): 0.5 tonnes

2.7 SOWING THE SEED

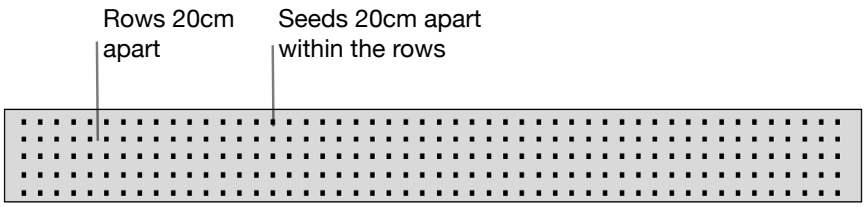
Sowing the seed requires special attention and care. The seed must firstly be prepared correctly then placed and covered in the appropriate way so as to maximise germination.

Preparing coffee seed for sowing

- When sowing certified seed or your own seeds from your best trees, in a pre-germination bed, bare root nursery bed or in polybags, soak the seeds in water for 12 hours (overnight) before sowing, to help germination

Preparing the nursery bed or polybags for sowing

- Thoroughly water the prepared nursery bed or polybags
- In a bare root nursery bed, mark the positions where the seeds will be sown with a small stick. Each bed will have 5 rows, 20 cm apart and the seeds will be 20 cm apart within each row



Marking out the rows in a bare root nursery bed *(Source: Michael Kaugam)*

Pre-germination bed:

- If using a pre-germination bed, prepare the bed as for the bare root nursery, watering it thoroughly
- Use a stick to mark out rows across the bed. Make the rows 2 cm deep and 5 cm apart
- Sow the seeds 2 cm apart within the rows and cover with fine soil or sand and mulch as described above. Lightly water
- Seeds will germinate after 4-6 weeks and can be **transplanted when at the butterfly stage**

Seedlings at the butterfly stage

- If transplanting into a bare root nursery bed or polybags, firstly clean weed and thoroughly water the beds or polybags
- When removing seedlings from the pre-germination bed, use one hand to hold the seedling just below the young leaves and the other hand to lift it with the aid of a small stick; do not pull it out. Discard unhealthy seedlings or those with bent tap roots
- Gently wrap the seedlings in a moist cloth and keep them out of direct sunlight in a cool location to prevent them from drying out. Plant them as soon as possible
- When transplanting into a bare root nursery bed, plant the seedlings 20 cm apart across and along the rows as in the section above on 'Preparing the nursery bed or polybags for sowing'. If transplanting into polybags plant one seedling in each bag
- Make a hole with a planting stick, large enough to accommodate the roots of the seedling. Place the tap root in the hole keeping it as straight as possible. Firm the soil around the seedling
- Water thoroughly

Sowing seed

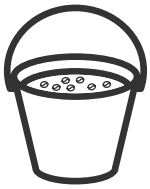
Demonstrate how to sow the seed using a filled polybag

- Thoroughly wet the soil mix
- Make 2 holes, 2 cm deep and 3 cm apart
- Place seed in the holes with the flat side down
- Lightly cover the seeds with fine soil or sand
- Cover polybag with a light layer of mulch
- Lightly water the polybag

Direct sowing of the seed in the nursery bed or polybags:

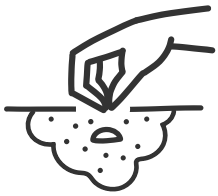
- While it is recommended to germinate the seed in a pre-germination bed it can be direct-sown into the bare root nursery beds or polybags
- Bare root nursery: In the nursery bed, sow **two** seeds in each position just a little bit apart and 2 cm below the soil surface. This is critical to ensure all seeds break the soil surface at the same time. Two seeds are sown in case one does not survive
- Polybag nursery: In polybags, sow 2 seeds 3 cm apart and 2 cm deep in each polybag. As for the bare root nursery, two seeds are sown in case one dies or does not germinate
- The flat side of the seed should be placed down onto the soil with the rounded side on the top. Do not sow them too deep or too shallow – exactly 2 cm
- Cover the seeds with fine soil or sand
- Mulch the bed (or polybags) with a light layer (2-3 cm) of kunai grass or other mulch. Mulching is very important for keeping the seedlings healthy. It provides nutrients, maintains moisture and prevents weed growth
- Lightly water the beds (or polybags)

Sowing coffee seed:



Step 1.

Soak seed in water overnight.

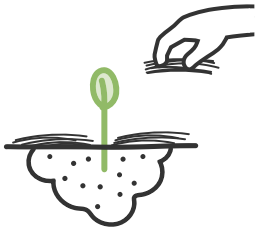


Step 2.

Sow seed flat side down, 2 cm deep into the soil.

Step 3.

Cover sown seed with a light layer of sand or soil. Mulch with a thin layer of kunai grass then lightly water.



Step 4.

When germination begins, gradually remove the mulch. Remove all mulch if in polybags but if seedlings are in bare root nursery beds retain the mulch but ensure it is kept well away from the stems of the seedlings.

Sowing extra seed

Suggest to farmers that they sow more seed a few months after the main sowing event. This will provide them with some newer plants for infilling if some of the seedlings from the original sowing event die in the field after planting. To save space, this could be done in a pre-germination bed, as described above.

Newly sown bare root nursery beds covered with kunai (the same principle applies to a polybag nursery) (*Source: Bob Kora*)

Maintenance during the germination period:

- Give the beds (or polybags) a light watering every day if there hasn't been any rain
- After 4-6 weeks the seeds will germinate
- Gradually remove the mulch from immediately around the new seedlings as soon as germination begins. Retain the remaining mulch in the bed or polybag but ensure there is space between the mulch and seedlings otherwise it may cause them to rot

Newly germinated coffee seedling at the 'soldier' stage

The first leaves to emerge from the coffee seed - the 'butterfly' stage

Thinning seedlings

- Thinning should be done when seedlings are at the 'soldier' or 'butterfly' stages
- The purpose of thinning is to prevent competition between the seedlings for water, nutrients and light and allow more air flow reducing the risk of pests and diseases
- In a bare root nursery, if both seeds germinate in each planting spot, remove one so that there is just one seedling remaining
- In a polybag nursery, if both seeds germinate in each polybag, remove one so that there is just one seedling remaining per bag
- **Carefully** remove the surplus seedling with the aid of a stick so as not to damage it or its neighbouring seedling
- It is best to remove the weaker seedling and allow the stronger one to grow
- If both seedlings are good, transplant one seedling to another location in the nursery bed (or to another polybag) where both seedlings have died
- Unhealthy or damaged seedlings should be discarded
- Water in any seedlings that have been moved to a new location
- **Remove** and **burn** any seedlings that appear to be affected by pests or diseases

Do not pull the seedling out with just your fingers. Always loosen the soil first with a stick

Thinning seedlings

Demonstrate how to remove a seedling when two seeds have germinated side-by-side in a polybag

Removing seedlings:

- Ensure the soil is moist before removing the seedling
- Gently hold the top of the seedling with one hand just below the leaves
- With the other hand carefully place the stick into the soil and gently loosen the soil until the roots of the seedling dislodge
- Carefully lift up the seedling

Objective:

To discuss what tasks should be undertaken just prior to sowing the coffee seed.

EXERCISE 10

Preparing to sow the coffee seed

Discuss:

1. Pre-treatment of the seed (soaking). Why is this necessary?
2. Watering the beds or polybags
3. Marking out the bare root nursery beds

Objective:

To understand that for good germination results the coffee seed must firstly be sown correctly.

EXERCISE 11

Sowing the coffee seed

Discuss:

1. The importance of the depth of the hole in which the seed is sown
2. How to place the seed in the hole (flat side down)
3. Covering the seed (sand/soil)
4. Mulching and watering

Objective:

Identify and discuss the tasks that should be undertaken in the nursery during the seed germination period.

You will need:

Butchers' paper and a marker pen

EXERCISE 12

Maintenance during seed germination

What are the nursery maintenance requirements during the seed germination period?

Identify the tasks and discuss in detail how each task is undertaken and the importance of each.

1. Watering regime
2. Removal of mulch
3. Thinning of seedlings
4. Monitoring pests and diseases

2.8 NURSERY MAINTENANCE

The main nursery maintenance tasks include watering, weeding, shading, ensuring there are enough nutrients for the developing seedlings, and pest and disease control. An additional task for polybag nurseries is adjusting the spacing of polybags as the seedlings grow. Maintenance is required until the seedlings are ready for transplanting into the coffee garden, which is about 6-9 months after the coffee seeds are sown.

Watering

It is important to water the seedlings regularly so that they don't dry out and die. The amount given will depend on the weather conditions. The following is a guide:

- Give the seedlings a **light** watering daily to begin with
- After they are established, watering can be reduced
- Check the seedlings regularly to ensure they look healthy. **Under-watering** may cause seedlings to dry out and **over-watering** may cause them to rot. Over-watering in a nursery bed may flood the seedlings and wash them away
- Seedlings growing in polybags will require more water than those growing in nursery beds

Watering guide (for when there is not enough rainfall)		
Growth phase	**Bare Root Nursery Beds**	**Polybags**
Sown seed	Mulched: twice per week; No mulch: once daily	Mulched: twice per week; No mulch: twice daily until seed germinates, then once daily
Butterfly stage	Once daily	Once daily
First true leaves	Every second day	Once daily
8-9 leaf pairs	Once or twice per week	Once daily

Weeding

Weeds should be removed regularly. If they are not removed they compete with the coffee seedlings for:

1. Moisture
2. Nutrients
3. Sunlight
4. Space

Remove weeds carefully so as not to disturb or damage the roots of the coffee seedlings.

Shade regulation

Shade display

Using a frame and yar branches demonstrate the following levels of shade applied from germination through to hardening off:

- Full shade (germination and young seedling)
- Shade reduced by one third (6 weeks)
- Shade reduced by another third (final growth phase)

- Shade cover must be progressively removed as the seedlings grow
- It is important for young seedlings to have full shade to begin with, so that they are not burnt by the sun
- As the seedlings grow the shade level is **gradually reduced** by removing some of the shade cover
- Too much shade results in weak, thin stemmed seedlings with long internodes
- Too little shade results in higher nutrient and water demands and seedlings may be burnt by the sun
- Appropriate shade levels can help **reduce the vulnerability of seedlings to pests and diseases**. For example, if the shade level is too low, seedlings are more susceptible to brown eye spot and coffee green scale
- By the time the young plants are ready to be transplanted into the coffee garden they should be healthy and tough
- If the seedlings are not tough they may suffer from transplanting shock and the leaves may burn when planted in coffee gardens where temporary shade is not yet fully established. This will slow their growth and possibly reduce long term production from the coffee garden
- Shade cover in the nursery in the last month prior to transplanting should be very similar to that in the coffee garden

Nursery shade levels

99% shade cover (germination and young seedling phase, 0-3 months)

Two-thirds shade cover (shade reduced by one-third when seedlings 3-4 months old)

One-third or approximately 30% shade cover (shade reduced by another one-third when seedlings 6-9 months old - to a shade level similar to the coffee garden)

Nursery shade regulation

Growth Phase	Age of seedlings	Amount of shade
Germination period	0-6 weeks	Full shade (90-100%)
Young seedling 2-3 leaf pairs (0-1 primary branches)	6 weeks to 3 months	(60%)
3-4 leaf pairs (1-2 primary branches)	3-4 months	(50%)
4-5 leaf pairs (2 primary branches)	4-6 months	(40%)
Transplanting stage 8-9 leaf pairs (2-3 primary branches)	6-9 months	(30%)

Seedlings 6-8 weeks old with no primary branches.

Seedlings 3-4 months old with 1 primary branch.

Seedlings 5-6 months old with 2-3 primary branches

Poor preparation of soil mix

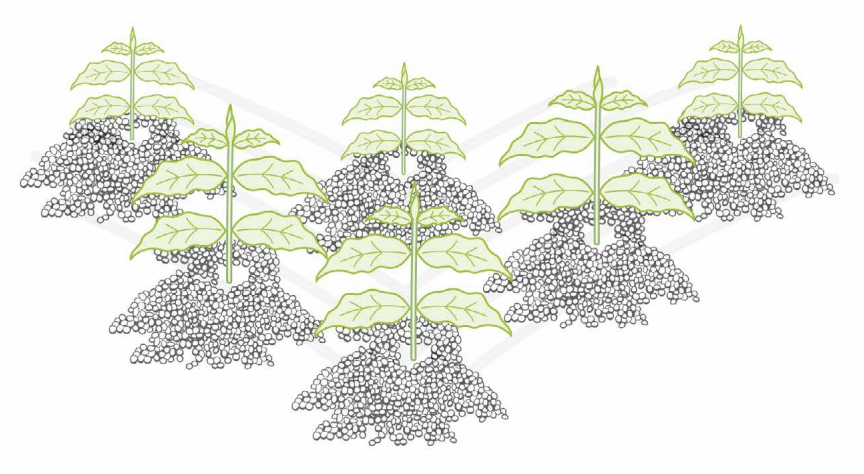
Many seedlings produced in smallholder nurseries do not develop well because the **soil mix was not prepared properly**. This makes the seedlings more susceptible to nutrient deficiencies, as well as to pests and diseases, such as brown-eye spot and green scale.

Seedlings and compost

Do not let the compost touch the stems of the seedlings as it will burn them

Nutrient management

- Additional nutrients should not be required if the original soil mix was well composted and a rich dark topsoil was used
- Appropriate shading will reduce the need for the addition of extra nutrients. Too little shade will increase the demand for nutrients
- If seedlings look like they need nutrients, for example, if the leaves are yellow, apply some **well composted** chicken manure or fresh cherry pulp around the seedlings (but not touching the stems)
- Fresh coffee pulp is very high in nutrients, particularly potassium, which is very important for plant growth. Fresh pulp can be used in the nursery but it must be **kept well away from the stems of the seedlings**
- Place a small amount of compost or fresh coffee pulp on the **soil surface** around the seedlings but it **must not touch the stems**
- Nutrients in polybag soil may become depleted after 6 months. The seedlings may require an application of fertiliser (compound or foliar) if planting is delayed



Cherry pulp surrounding seedlings but **not touching the stems**

Pests and diseases

Use the 'Pests and Diseases' poster to show the common pests and diseases described below.

Emphasise that if any of the pests and diseases are observed they should **ACT IMMEDIATELY** to prevent spread to the rest of the nursery.

Pest and disease alert

If any seedlings have a pest or disease problem **ACT IMMEDIATELY** to prevent spread to the rest of the nursery.

Damping-off disease is caused by the fungus *Rhizoctonia solani*, or by other soil borne pathogens. The seedlings become discoloured and the stem (at ground level) is constricted. The fungus can survive in the soil for many years and can affect any crop.

Note: If you are unsure about how to control a pest or disease contact your local extension officer.

Pest and disease control

- Pests and diseases can be a problem in coffee nurseries
- If the coffee nursery is **well maintained** and kept **clean**, then the seedlings will be healthier and more resistant to pests and diseases
- Ensure there is enough **free flow of air** amongst the seedlings. This avoids the accumulation of moisture for fungal growth. Seedlings in polybags should be moved further apart as they develop to create more space between them
- Carefully remove any seedlings that are affected by disease and burn them
- If the seedling is in a polybag remove the whole polybag from the nursery
- Remove any pests present on the seedlings such as caterpillars by picking them off with your fingers and squashing them
- If a seedling has a large pest problem, for example, if it is covered in green scale, then remove the seedling from the nursery and burn it. If it is in a polybag remove the whole polybag from the nursery

Some of the common pests and diseases are:

Damping-off

- This disease is common in nurseries and is caused by a fungus
- Seedlings become discoloured and the seedling stem will not grow
- The affected seedlings die within a few days
- The fungus can survive for many years in the soil so it is important not to have your nursery in a location where any of your crops (including food crops) have had problems with damping-off

Damping off: (1) a polybag nursery; (2) a young seedling (*Source: Bob Kora*)

Damping-off: (Best methods to discourage infection and development)	
Important factors	**Best practices**
Seed quality	Use clean, healthy seed (preferably CIC certified seed)
Seedbed preparation	Use soil that has not been used previously for growing coffee seedlings unless it has been left for a number of years since it was last used. Add compost to the soil to improve soil texture, water holding capacity and nutrient availability. Establish good drainage.
Sowing time	Sow in the middle of the day when humidity levels are lower. Avoid sowing on warm, wet days.
Sowing density	Use the recommended sowing rate.
Growing environment	Water in the middle of the day when humidiy levels are lower. Avoid over-watering. Follow recommendations for shade regulation.

Brown-eye spot is caused by the fungus *Cercospora coffeicola*. Fungal spores are spread by wind and the disease thrives in warm, humid weather.

Brown Eye Spot

- This disease is caused by a fungus
- It appears as dark brown-black spots near the edges of the leaves. The area around the black spots turns yellow
- The problem can develop if the seedlings are nutrient deficient, there is high humidity and insufficient shade. The correct spacing of seedlings is important to allow sufficient airflow
- **Solution:** Use correct spacing when sowing. Increase the shade level if the fungus develops during seedling growth

Brown-eye spot

Note: Scale can be sprayed with white oil which can be made by the farmer. It is important to cover the underside of leaves, stems and terminal buds as this is where the scales commonly occur.

White oil

Thoroughly mix the following:

1/3 cup cooking oil

1/2 teaspoon dishwashing detergent

4L water

Green scale

- This pest is an insect that sucks the sap from the seedling stem. They can also be found underneath the leaves
- The adults are covered with a slightly curved oval green scale
- Ants will also be present as they feed on the sweet sticky substance called honeydew produced by the scale
- If the seedling has lots of scale you will also see a black sooty mould fungus which also feeds on the honeydew
- Seedlings appear weak and turn yellow
- Seedlings that are weak and nutrient deficient are susceptible to infestation by green scale. Seedlings may become nutrient deficient if they have not been adequately shaded
- **Solution:** Most importantly, provide sufficient shade. Ensure there is good drainage and keep the nursery beds weed free. White oil can be sprayed on the affected area. The oil should be applied as soon as the presence of green scale is detected

Scale insects on a young coffee seedling

Green scale is the soft scale insect, *Coccus* spp. Levels of infestation in PNG are greatest at about 1500 m above sea level.

The adult of the cutworm is a moth, *Agrotis ipsilon*. It is brownish grey in colour and has black markings on the front of its wings.

Cutworm

- This pest is a caterpillar
- Young caterpillars feed on the seedlings and make holes in the leaves
- Older caterpillars hide in the soil and feed at night. They cut through the stems just above soil level. They will sometimes pull the seedlings out
- **Solution:** Check for cutworms on the leaves and in the soil at the base of plants. If cutworms are found, **handpick and kill them**. Ensure good drainage as they are often present in higher numbers if the soil is wet

Cutworm

Damage caused by a cutworm

Spacing

- As the seedlings grow and primary branches begin to develop, self-shading will occur. This is usually from about 3 months old
- In polybag nurseries, the polybags will have to be re-stacked at a wider spacing. This will have to be repeated as seedlings grow to ensure each seedling has sufficient space and sunlight
- If the polybags are not re-stacked, seedlings will compete with each other for light and will grow tall and thin and may bend over. They are also more prone to diseases such as brown spot. If the growing seedlings do not have enough space and light, as well as good air circulation some may die leaving many of the polybags empty, thus wasting the farmer's time and money

For this stage of development, these seedlings are stacked too close together.

- Seedlings in bare root nurseries are sown further apart to begin with and will have sufficient space to grow until transplanted into the coffee garden

Seedlings 2-3 months old growing in a bare root nursery *(Source: Michael Kaugam)*

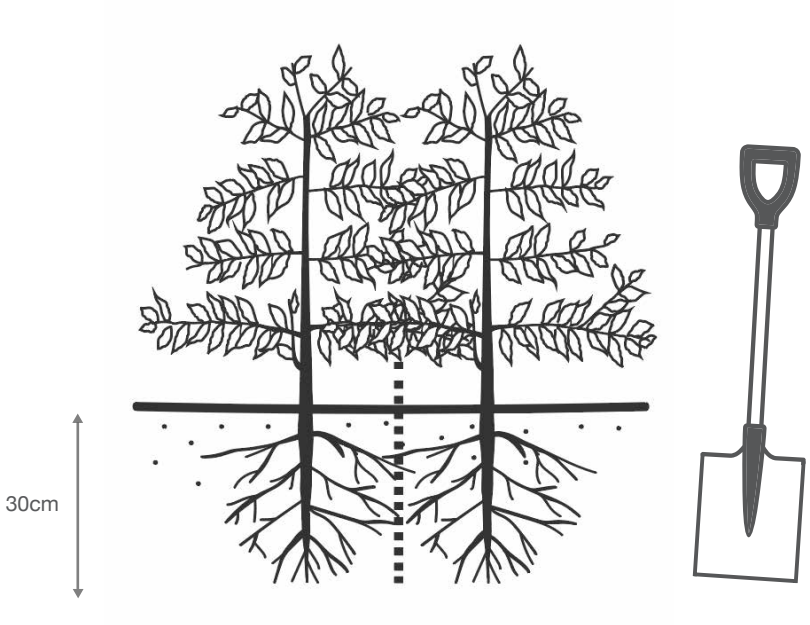
Hardening off seedlings prior to transplanting:

- Seedlings will be ready for transplanting into the coffee garden when they are about 6-9 months old or when they are sufficiently large and strong
- Transplant strong and healthy bare root seedlings **with care** at an **early age**. Old bare root seedlings will not establish well in the field
- It is important that the seedlings are healthy and tough when transplanting so that they do not suffer from 'transplanting shock'
- If seedlings are unhealthy and weak they may not survive planting and all of the farmer's hard work and time spent in the nursery will be wasted

Note: See how to prepare a coffee garden and transplant the new seedlings in the Farmer Training Guide Unit 1 Module 3 "Establishing a New Coffee Garden".

The following factors should help ensure seedlings are healthy and hardened off for transplanting:

- Provide light shade from when seedlings are 5 months old. The level of shade should be very similar to that in the coffee garden
- Water once or twice per week if bare root seedlings (daily for polybag seedlings), once they have 2-3 primary branches
- Ensure they are pest and disease free
- Ensure they are not suffering from any nutrient deficiencies
- In a bare root nursery, 1-2 weeks before transplanting cut around the seedlings in blocks with a shovel to separate interlocking roots between seedlings. This will toughen the seedlings and minimise transplanting shock



Bare root seedlings ready for transplanting

Objective:

Identify the tasks that farmers should undertake in the nursery after the coffee seed has geminated.

You will need:

Butchers' paper and a marker pen

EXERCISE 13

Nursery maintenance tasks

List all of the tasks that have to be undertaken in the nursery after the coffee seed has geminated.

Objective:

To understand the importance of constantly monitoring soil moisture and the presence of weeds.

EXERCISE 14

Watering and weeding

Discuss:

1. How often should the seedlings be watered?
2. Why do polybag seedlings require more watering than seedlings in bare root nurseries?
3. Why is it important to remove weeds regularly?

Objective:

To understand the significance of shade regulation during seedling growth and development, and how shade is regulated.

You will need:

Butchers' paper and a marker pen and the shade display used in the activity in this chapter of the training module.

EXERCISE 15

Shade regulation

Discuss:

1. Why is it important to regulate shade?
2. What are the recommended shade levels to apply in the nursery from germination through to just prior to transplanting the seedlings into the coffee garden?
3. Show the 3 main levels of shade cover using the shade display (frame and Yar branches). What percentage shade cover is provided by each?
4. When hardening off the seedlings just prior to transplanting, why is it important **not** to fully remove the shade cover?

Objective:

To be able to identify which pests and diseases may be a problem in the nursery and how they may be managed.

You will need:

Photos or specimens of potential pests and diseases of a coffee nursery.

EXERCISE 16

Pests and diseases

1. Discuss the pests and diseases that could be a threat to the health of seedlings in a coffee nursery
2. What are some of the measures that can be taken to reduce the risk of pests and diseases?
3. What are some simple control measures that can be used if specific pests or diseases are found in the nursery?

2.9 KEY MESSAGES

What are the important messages for the farmer?

1. Seed selection is very important. It is preferable to use certified seed, otherwise use seed picked from your best performing trees
2. **DO NOT** select seed from CBB-infested gardens
3. Select a nursery site that is located for easy access so that seedlings can be checked and regularly maintained. It would be better to locate the nursery near a water supply and the coffee pulper, for easy access to water and pulp
4. **DO NOT** establish your nursery on a site that has been affected by pests or diseases
5. The soil mix used in bare root nursery beds or in polybags must contain compost that is well broken down (for example, well composted coffee pulp) and dark topsoil to provide nutrients for the seedlings. Sand should be added to polybag soil mix to improve air spaces and drainage
6. Take a lot of care when preparing and sowing seed as this will help speed up germination and ensure that all seeds will germinate around the same time
7. Use mulch around seedlings in a bare root nursery but do not allow the mulch to come into contact with the seedling stems. In polybag nurseries, it is best not to use mulch after the seedlings germinate
8. Maintain the seedlings by watering, weeding, and regularly checking for pests and diseases
9. Be on the lookout for the presence of pests and diseases and if present take immediate action
10. Regulate shade – provide full shade to begin with then gradually reduce the shade level to about one-third over the growing period
11. Seedlings must be healthy and tough when transplanted. Leading up to transplanting ensure that: watering is reduced to a minimum; shade has been reduced to about one-third (similar to that in the coffee garden); and that seedlings are pest and disease free
12. Seedlings should be transplanted when they are about 6-9 months old. It is preferable to transplant at the start of the wet season

2.10 QUIZ

Place a '✓' in the correct box.

1. Which is the best planting material to use in your coffee nursery?

- A One year old seed collected from your best performing coffee trees
- B Seedlings that have germinated under your best performing coffee trees
- C Seed from ripe cherries recently collected from your best performing coffee trees
- D Seed from ripe cherries that have floated when placed in a bucket of water

2. Which type of cherries are suitable to use as a source of seed

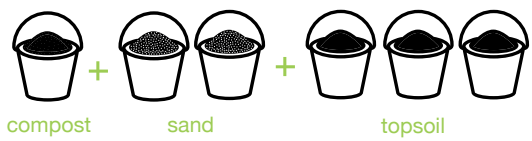
- A Large, very ripe, dry cherries
- B Large, very ripe, bright red cherries
- C Small, very ripe, bright red cherries
- D Large, over-ripe, black cherries

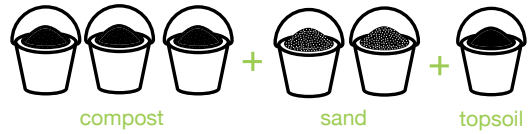
3. Why is sand added when preparing the soil mix for a polybag nursery?

- A To kill soil-borne diseases
- B To reduce the weight of the soil
- C To improve air space and drainage
- D To add nutrients to the soil mix

4. When preparing soil mix to fill polybags, what is the correct ratio of compost, sand and topsoil to use in the mix?

A 

B 

C 

5. Which is the best technique to use when sowing seed in a nursery bed or polybag?

- A Sow the seed flat side down to a depth of 2 cm, cover with fine sand or soil, cover with a light layer of mulch and then lightly water
- B Sow the seed flat side down to a depth of 5 cm, cover with fine sand or soil, lightly water, then cover with a light layer of mulch
- C Sow the seed flat side down to a depth of 2 cm, lightly water, then cover with a light layer of mulch
- D Sow the seed flat side down to a depth of 5 cm, cover with fine sand or soil and a light layer of mulch

6. Seedlings have to be regularly maintained. What does this mean?

- A Regularly check for pests and diseases
- B Keep the seedlings moist but not too wet
- C Adjust shade levels as the seedlings grow
- D All of the above

7. True or false.

	True	False
a. Seed selection is not very important as long as the seed is collected from a bright red cherry.	☐	☐
b. The coffee nursery should be located away from the house so that it is not damaged by foraging pigs.	☐	☐
c. Compost used in the soil mix for the nursery must be well broken down.	☐	☐
d. Locate your nursery in the same place every year to avoid the build-up of pests and diseases.	☐	☐
e. Sand should be added to the soil mix for a polybag nursery to improve air space and drainage.	☐	☐
f. Mulching is encouraged for both bare root and polybag nurseries.	☐	☐
g. To harden off seedlings prior to transplanting, remove all of the shade cover.	☐	☐
h. A good mulch to use on growing seedlings in a bare root nursery is fresh coffee pulp as it is high in nutrients, but it must be kept away from the stems of the seedlings.	☐	☐

2.11 SOURCES OF FURTHER INFORMATION

Aroga, L. (2007). *Coffee Nursery Establishment & Management Notes: A Guide for Coffee Extension Workers & Farmers of the Coffee Industry in PNG*. Ukarumpa, Eastern Highlands Province, PNG: Coffee Industry Corporation Ltd.

CIC (2016) *The Papua New Guinea Coffee Handbook* (2nd Edition)

Curry, G.N., Webb, M., Koczberski, G., Pakatul, J., Inu, S.M., Kiup, E., Hamago, M.R., Aroga, L., Kenny, M., Kukhang, T., Tilden, G. and Ryan, S. (2017). *Improving Livelihoods of Smallholder Families through Increased Productivity of Coffee-based Farming Systems in the Highlands of PNG.* Project Final Report FR2017-08 for ACIAR project ASEM/2008/036. ISBN: 978-1-86320-028-8. Available at: https://espace.curtin.edu.au/handle/20.500.11937/54174 or https://www.aciar.gov.au/publication/asem-2008-036-final-report

Pests and Diseases

Brown Eye Spot

Cooke, T., Persley, D.M. and House, S. (2009) *Diseases of Fruit Crops in Australia*. CSIRO Publishing, Collingwood, VIC.

Cutworm

http://www.pestnet.org/fact_sheets/black_cutworm_297.htm?zoom_highlight=cutworm *Pacific Pests and Pathogens* (ACIAR funded app)

Damping-off disease

Lamichhane, J., Dürr, C., Schwanck, A., Robin, M-H., Sarthou, J-P., Cellier, V., Messéan, A. and Aubertot, J-N. (2017) Integrated management of damping-off diseases. A review. *Agron. Sustain. Dev*., 37(10): 1-25.

Green scale

http://www.pestnet.org/fact_sheets/coffee_green_scale_272.htm?zoom_highlight=green+scale *Pacific Pests and Pathogens* (ACIAR funded app)

Australian Centre
for International
Agricultural Research

Australian
Aid