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SMALLHOLDER COFFEE PRODUCTION IN PAPUA NEW GUINEA – FARMER TRAINING GUIDE

UNIT 2: MANAGING YOUR COFFEE GARDEN

MODULE 3:
SHADE MANAGEMENT

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SHADE MANAGEMENT

The Smallholder Coffee Production in Papua New Guinea Training Program

The training program contains modules prepared in partnership with the 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

George Curry, Geraldine Tilden, Leo Aroga and Jonah Aranka

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The knowledge of the following contributors has been invaluable in the development and writing of this module:

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INTRODUCTION

Aim of Module:

The aim of this module is to enhance farmers' understanding of the multiple benefits of shade trees and appropriate techniques of shade management in order to maximise coffee tree health and production.

To produce healthy and productive coffee trees it is recommended that shade trees be established in coffee gardens. Shade trees provide numerous benefits for coffee trees as well as reducing labour demands on the farmer. They are also a valuable resource providing timber for construction, fencing and firewood as well as a source of income. It is important to establish and manage shade trees appropriately in order to maximise their benefits in the coffee garden.

LEARNING OUTCOMES:

By the end of this module you will understand:

- Understand the benefits of appropriate levels of shade in your coffee garden
- Know the effects of too much or too little shade on coffee production and coffee tree health
- Be familiar with the types of temporary and permanent shade trees and know their advantages and disadvantages
- Know when to prune shade trees to increase coffee flowering and cherry production

LESSON PLAN:

The module has three parts:

Sections 3.1 to 3.4	Understanding the types of shade trees, and advantages and disadvantages of shade trees in coffee gardens
Sections 3.5 and 3.6	Understanding shade levels
Sections 3.7 to 3.10	Establishing and maintaining optimum shade

TIME REQUIRED TO COMPLETE THIS MODULE: 3-4 DAYS

LIST OF SYMBOLS:

Information relating to CBB

Farmer notes, brochures & factsheets

Information for farmers that must be taken very seriously

For the Extension Officer

TEACHING AIDS:

- Farmer notes (one copy for each farmer plus spare copies)
- The coffee calendar and stickers
- Butchers' paper and marker pens
- Coloured white board markers and white board eraser
- Laminated plan of a coffee garden
- Green and red berries (to represent temporary and permanent shade trees)
- Yar branches
- Shade poster
- For field exercise
  - **a.** coffee garden with no shade
  - **b.** coffee garden with appropriate shade

PRE-TRAINING ACTIVITIES:

- Confirm number of training participants
- Find a garden that will have green and red berries available for collection on the training day
- Arrange a visit to coffee gardens for all training participants: one with no shade and one with an appropriate shade level

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

The coffee calendar lists the main events and activities occurring 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.

Annual coffee production events and activities (stickers)

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

Using the stickers for each of the annual coffee activities listed above, work with the farmer group to attach them to the appropriate rows 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
- Complete the remaining sections linking each activity with the different stages of berry development
- For this module, integrate the activities relating to shade management listed below

Shade management activities (stickers)

In a new coffee garden

1. Plant the shade trees, both temporary and permanent
2. Gradually remove temporary shade trees
3. As they mature, thin permanent shade trees until they are at the recommended spacing
4. As they are growing, remove some of the limbs on the shade trees so that there is sufficient clearance above the coffee trees
5. When the coffee is 3 years old, prune shade trees just prior to the main flowering period to increase flower production

In an established coffee garden

1. Prune shade trees just prior to the onset of the main coffee flowering period to increase flower production
2. When pruning the shade trees, prune the branches to a height of 2-3 m above the coffee trees to permit good airflow around the coffee trees
3. If recycle pruning coffee trees, prune shade trees just beforehand

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

3.1 WHY ARE SHADE TREES GROWN IN COFFEE GARDENS?

Shade trees reduce the amount of sunlight flowing directly into the coffee garden. Coffee trees evolved in the understorey of forests in Ethiopia and consequently have a natural adaptation to shade. Shade trees are planted in coffee gardens for the following reasons:

1. They reduce labour demands
2. Coffee trees grown under an appropriate shade level are healthier, stronger and more resistant to some pests and diseases
3. Coffee bean size is larger and better quality under an appropriate shade level
4. In general, they increase the overall productivity of your coffee, and therefore income

Too much or too little shade can stress your coffee trees. To maximise the benefits of shade trees it is firstly important to select the most **suitable type of shade tree** then plant and manage them appropriately.

Shade trees protect coffee

3.2 TYPES OF SHADES TREES

There are two types of shade trees – **Temporary** and **Permanent**

Temporary shade trees

- Temporary shade trees are planted prior to transplanting the coffee seedlings
- They are particularly important in a new coffee garden as the young coffee trees are a little weak and require protection from extremes of weather like hot sun and heavy rain
- They should be fast growing and provide shade until the permanent shade trees are established
- Temporary shade trees are planted **between** the rows of coffee
- They are planted at a higher density than permanent shade trees and kept for only the first 2-3 years of coffee establishment until the permanent shade takes over

Young Yar trees (permanent shade) with bananas in the background. Bananas provide good temporary shade while the Yar are becoming established (*Source: Susan May Inu*)

Common shade trees – temporary

Shade tree	Local or common name	Nitrogen Fixing	Other characteristics
***Acacia* spp.**		Yes	
***Calliandra* spp.**		Yes	Produces high quality firewood and thrives in a range of soil and climatic conditions. Does not tolerate waterlogged soils
***Crotalaria* spp.**	Rattlepods	Yes	
***Flemingia* spp.**		Yes	
***Leucaena* spp.**	Lomantro	Yes	
***Musa* spp.**	Banana	No	The most commonly grown temporary shade tree. Banana provides fruit for the household while also shading the coffee trees
Psophocarpus tetragonolobus	Asbin (winged bean)	Yes	Can be used as temporary shade if staked. Will also provide food for the household
Saccharum officinarum	Sugarcane	No	May host green scale
***Senna* spp. (or *Cassia* spp.)**	Smooth Senna	Yes	A very common temporary shade tree; repels some insects
Tephrosia vogelii	Fish poison	Yes	
Tithonia diversifolia	Wild Mexican Sunflower	No	Has a high concentration of nutrients (N, P and K) in its leaves and when pruned decomposes quickly making it an effective organic fertiliser. A lot of labour required for pruning
Zea mays	Kon, Corn	No	May host green scale

Crotalaria sp. (Rattlepods)

Flemingia sp. *(Source: Jeffrey Yapo, NARI)*

Musa sp. (Banana) shading coffee *(Source: Leo Aroga)*

Senna sp. (Smooth Senna) *(Source: Jeffrey Yapo, NARI)*

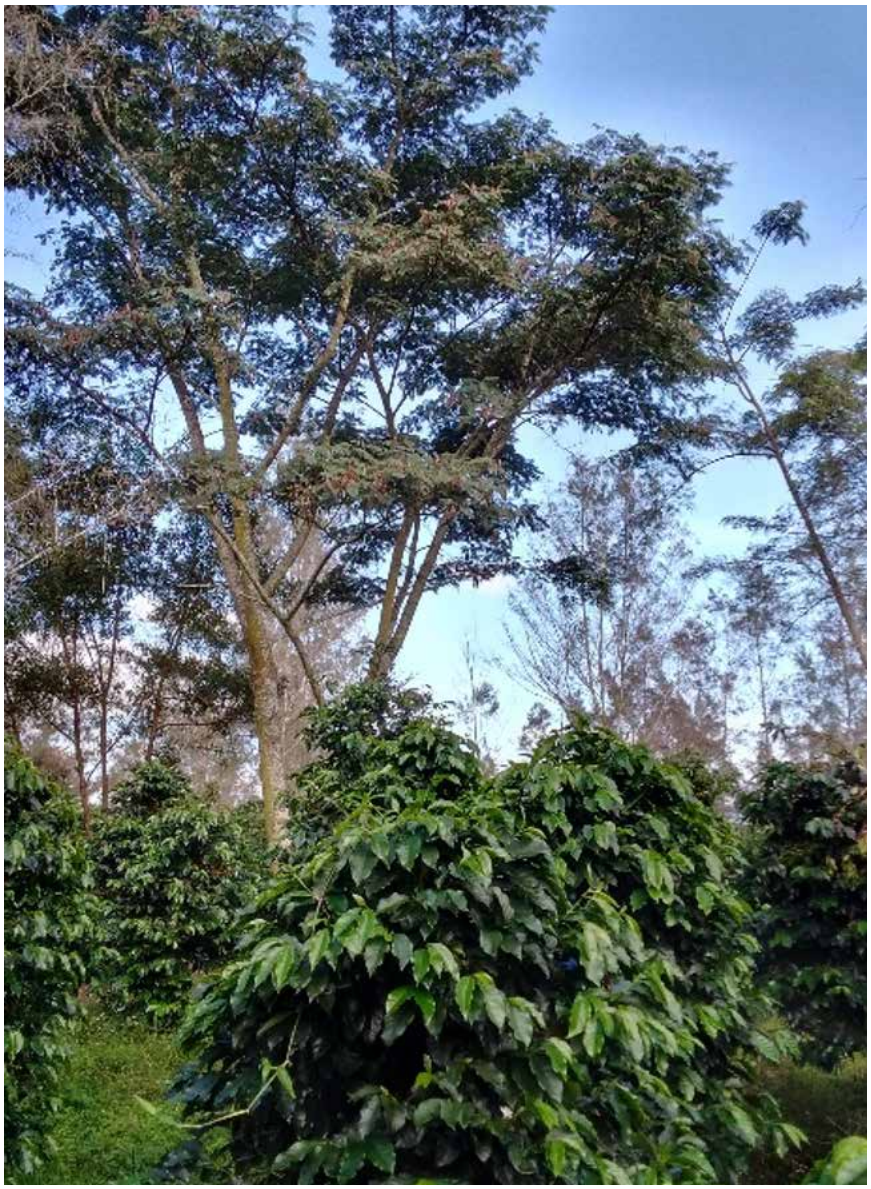
Tephrosia sp. (Fish poison) *(Source: Jeffrey Yapo, NARI)*

Tithonia sp. (Wild Mexican sunflower) *(Source: Jeffrey Yapo, NARI)*

Permanent shade trees

- Permanent shade trees are ideally planted 3-4 months prior to planting the coffee but they take some time to establish. Therefore, they do not provide much shade for young coffee seedlings, so temporary shade is required
- As they mature they provide increasing shade and have a long lifespan
- Permanent shade trees are planted **within** the rows of coffee so as not to obstruct movement between the rows
- They are planted at twice the recommended density and then thinned over time so that they reach the correct spacing by full maturity
- The choice of shade tree will depend on climate and altitude. Some shade trees do well in a range of altitudes and climates whereas others may have characteristics making them more suitable for specific conditions such as areas prone to extended dry periods
- The most common permanent shade trees used in the PNG highlands are Yar (*Casuarina*) and Marmar (*Albizia*)

Yar *(Casuarina oligodon)* shade trees



Marmar *(Albizia stipulata) (Source: Leo Aroga)*

Common shade trees – permanent

Shade tree	*Albizia stipulata*	*Casuarina oligodon*
Local name	Marmar	Yar
Height (m)	30	30
Plant spacing (when planted)	20 m x 20 m	10 m x 10 m
Recommended plant spacing (final)	40 m x 40 m	20 m x 20 m
Recommended plant density (trees/ha) (final)	6	25
Nitrogen fixing	Yes	Yes
Other characteristics	Good in areas where there is a strong dry season. Broad canopy	Suitable in most areas where there is not a marked dry season. Narrow canopy. Produces high quality firewood

Activity: Shade trees and plant spacing

Refer to the shade trees poster to illustrate the different types of shade trees

Objective:

To understand the types of shade trees and their application in a new coffee garden

You will need:

The shade poster, butchers' paper and a marker pen

EXERCISE 1

Types of shade trees

Discuss:

1. The differences between temporary and permanent shade trees
2. When should temporary shade trees be planted in a new coffee garden? When are they removed?
3. When should permanent shade trees be planted in a new coffee garden? When are they thinned?
4. List examples of temporary and permanent shade trees (use the shade poster as an aid)
5. Which are the most suitable shade trees for this area (the area in which the module is being presented)?

Objective:

To understand how permanent shade trees are spaced in a new coffee garden.

EXERCISE 2

Spacing of permanent shade trees

Discuss spacing in the coffee garden of the following permanent shade trees:

1. Yar
   a. Plant spacing when first planted?
   b. Plant spacing when thinned?
2. Marmar
   a. Plant spacing when first planted?
   b. Plant spacing when thinned?

3.3 THE BENEFITS OF PLANTING SHADE TREES IN YOUR COFFEE GARDEN

There are many benefits of growing coffee under shade:

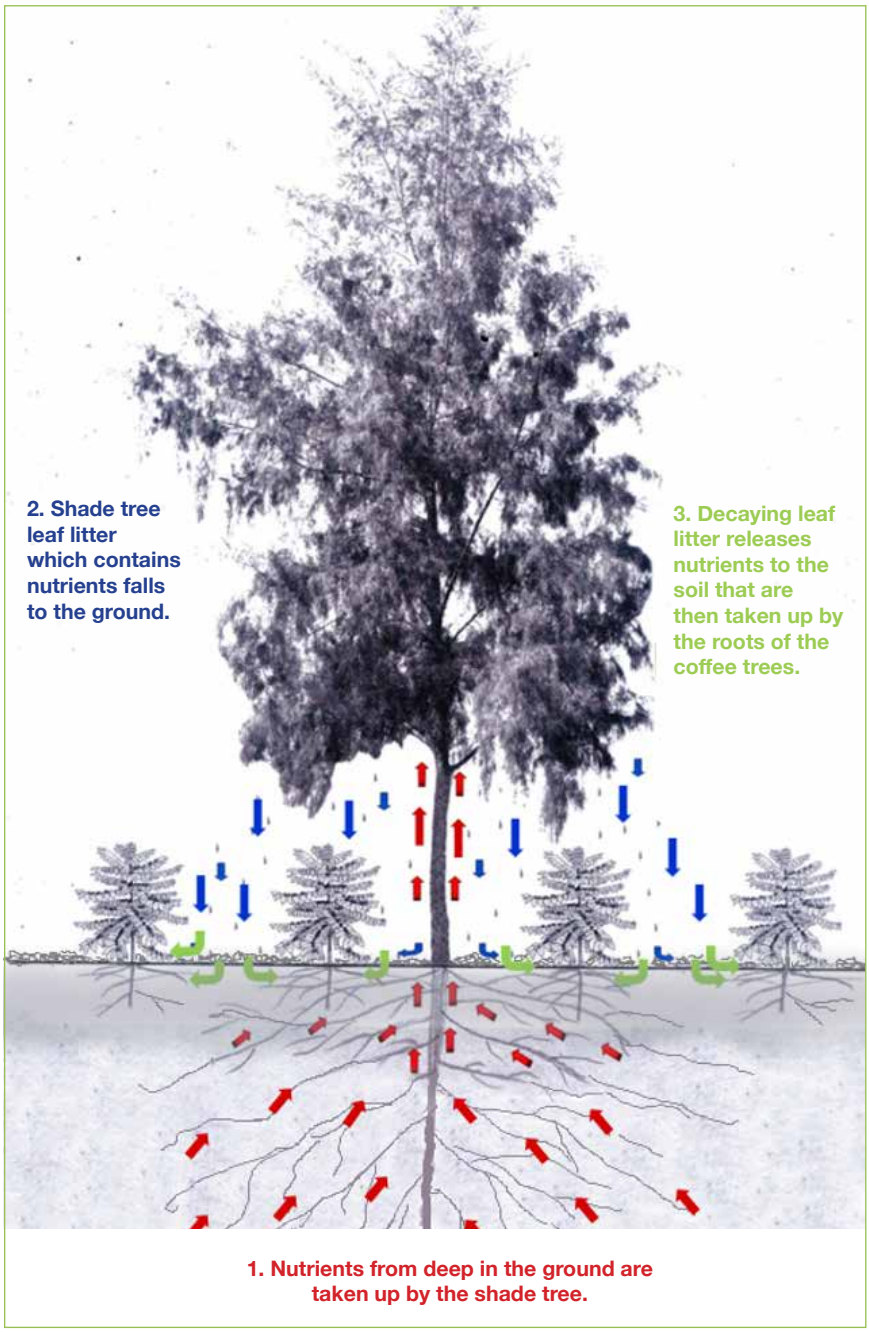
Shade trees replenish many of the nutrients exported in harvested cherry

Nutrient cycling

- Coffee **cherries** contain a high concentration of nutrients so when they are harvested the nutrients are removed from the coffee garden
- Shade trees have deep root systems that **pump nutrients** up from below the roots of the coffee trees and replace many of the nutrients taken from the garden in harvested cherry
- Nutrients that are washed deep down into the soil during heavy rain can be **'pumped' back up** by shade trees and made available to coffee trees via leaf litter
- There is a lot of leaf fall from shade trees which is called **deep litter**. As the deep litter breaks down it provides the coffee trees with **nutrients** like a slow release fertiliser
- Shade reduces the **rate of breakdown** of organic matter in the soil
- Deep litter improves the entry of **water and nutrients** into the soil making these more accessible to the coffee trees
- Deep litter improves the soil's water and nutrient retention properties; it also encourages soil microbes which makes nutrients more available to coffee roots

Leaf litter from Yar trees

Nutrient cycling and permanent shade trees



Nutrient cycling in a coffee garden with shade trees

Nitrogen fixation

- Some shade trees like Yar and Marmar **add nitrogen** to the soil through the process of nitrogen fixation. They take nitrogen from the air and convert it into a form that can be taken up by the coffee trees. This acts as a natural fertiliser

With the right **level of shade** and the right **type of shade** tree, there is less need for farmers to buy expensive fertilisers to replace nutrients lost in harvested cherry *(Refer to Farmer Training Guide Unit 2, Module 7 'Soil fertility and nutrient maintenance')*

Shade prevents heavy flowering and overbearing dieback

- Coffee trees without shade are exposed to direct sunlight
- Direct sunlight initiates heavy flowering which can lead to production of a lot of small and light cherries
- If cherries produced on unshaded coffee trees are not supported with extra nutrients (i.e. fertiliser), the coffee trees will suffer from overbearing dieback and a higher rate of tree death than if the coffee trees were shaded
- If coffee is grown under shade, flowering and berry bearing is controlled naturally

Removing shade trees to enable intercropping with food crops

If shade trees are removed from areas in the coffee garden to enable intercropping with food crops, the coffee trees will require the application of fertiliser. This will minimise the occurrence of overbearing dieback and the production of poor quality, low value coffee beans.

Shade regulates flowering and increases bean production, size, density and quality

- The rate of flowering can be increased by pruning shade trees **just before** the main flowering period
- This stimulates the tree to produce more flowers and eventually more coffee beans
- Rather than putting energy and nutrients into continual flowering the coffee trees can cope with this one-off increased flowering and increased production
- Controlled flowering means a more **concentrated harvesting season**. It is more efficient to have a high input of labour to harvest a lot of cherry over a short period than continually allocating labour to harvest small quantities of cherry over a longer period
- Bean ripening on shaded coffee trees is slowed, therefore, improving bean size and density (weight) and cup quality (Note: heavier bean weight and improved quality = more money)

Shade helps control pests and diseases

- Healthy trees are more **resistant** to pests and diseases
- With a more **concentrated season for cherry production**, there are fewer coffee cherries on the tree during the off-season to host and feed CBB. This will help break the life cycle of CBB
- Shade trees support **natural enemies** of CBB such as birds, predators (ants and beetles), and parasitoids. Shade increases the presence of *Beauveria bassiana* used to control CBB
- Coffee trees grown under shade have some degree of tolerance of **green scale**
- If shade is removed, **cicadas** and **grasshoppers** may become a problem. As a long-term control measure, the deep litter from shade trees may prevent the nymphs from entering the ground and attacking the rootlets. Leaf litter also provides a habitat for predators of these pests
- Shade management is also an important method of cultural control of **coffee leaf rust** (CLR)
- *Refer to the modules, Farmer Training Guide Unit 2, Module 5 'Pest and disease management' and Farmer Training Guide Unit 2, Module 6 'Coffee berry borer management' for more information on shade measures for control of pests and diseases*

Shade suppresses weeds

- Shade and leaf litter suppress and reduce the amount of weeds in the coffee garden
- The leaf litter from Yar trees contains chemicals that suppress germination of weed seeds
- Fewer weeds means less labour is required for weeding

Weed growth: (1) Weeds present under little shade; (2) Few weeds under appropriate shade *(Source: Leo Aroga)*

Shade reduces soil temperature and moisture losses

- Both shade and leaf litter help stabilise soil temperature and prevent the soil from becoming too hot or too cold. This reduces evaporation and hence moisture loss from the soil. Coffee gardens are therefore better able to cope with dry periods

Shade protects coffee trees from extremes of weather

- Shade trees reduce temperature variation in areas where there is a marked difference between day and night temperatures
- Coffee trees are protected from low temperatures and frost, high sun intensity, strong winds, heavy rain and hail
- Humidity levels are more stable under shade
- Shade trees reduce the percentage of fallen cherries as the shade tree canopy protects ripe fruit from the impact of rain drops. This is possibly also because the coffee trees have increased capacity to retain the cherries due to better nutrition

Shade improves the cup quality of the coffee bean

- Shade trees enhance the formation of compounds in the coffee beans that contribute to the production of good quality coffee

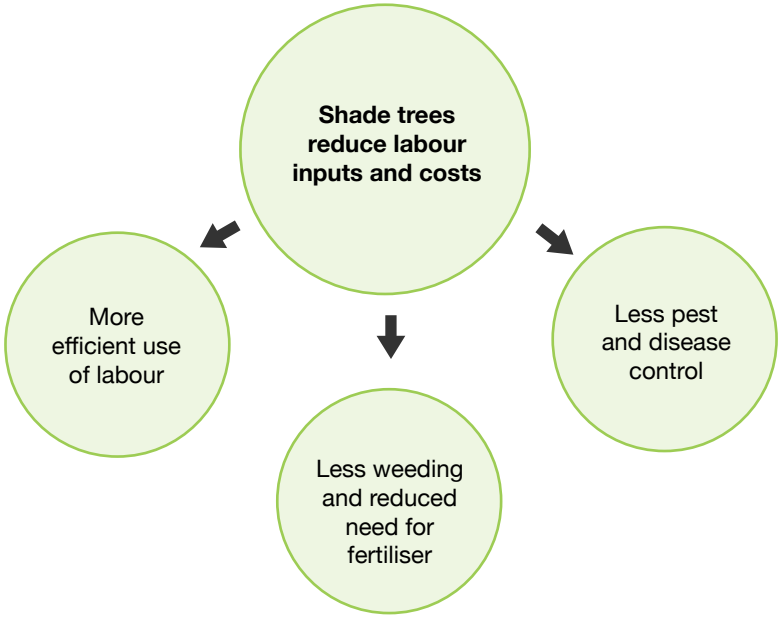
Shade trees provide firewood and timber

- When shade trees are pruned or thinned, the cut wood can be used for firewood or as timber for the construction of houses and fences
- Firewood and timber can also be an important source of supplementary income

Shade trees stabilise the soil and reduce erosion

- Shade trees help stabilise the soil; they assist in breaking up hard pans and improve drainage
- Water run-off and soil erosion are reduced, thereby reducing the risk of land slips

Shade reduces labour demands



Objective:

To gain an understanding of the benefits of having shade trees in a coffee garden.

You will need:

Butchers' paper and a marker pen

EXERCISE 3

Benefits of shade trees

1. For each of the following, list the benefits of having shade trees in a coffee garden:
   a. Pest and disease management, in particular CBB
   b. Nutrient management
   c. Flowering
   d. Weed control
   e. Labour input
2. What are some other benefits of shade trees?

3.4 DISADVANTAGES OF SHADE TREES

What are the negative impacts of shade trees on coffee?

Shade has multiple benefits but there are some disadvantages of having shade trees in the coffee garden:

1. Branches falling when pruning the shade trees can damage the coffee trees
2. If not planted at the correct density or appropriately maintained, shade trees can create competition for space, light, moisture and nutrients and may encourage the presence of pests and diseases

If shade is too dense:

- It can create weak stems as coffee grows tall, thin and weak as it looks for light
- The internodes on the coffee trees are longer, that is, the distance between the branches on the main stem and the distance between the flower/berry clusters on the branches. This will mean fewer flowers and less cherry production

Coffee tree (var. *Typica*) producing long internodes under heavy shade *(Source: Leo Aroga)*

- Coffee trees produce too many leaves and less cherry
- With higher humidity, the leaves may remain wet for longer attracting fungal diseases
- It creates an environment suitable for pests and diseases like CLR and pink disease

Dense shade & CBB

Lack of regular pruning creates a situation where many cherries are too high to reach during harvesting. These are therefore left behind, providing a food source for **CBB**

Internode length: (1) long internodes under heavy shade *(Cora Moabi)*; (2) shorter internodes and a more compact tree under appropriate shade *(Source: Leo Aroga)*

3.5 SHADE LEVELS AND COFFEE PRODUCTION

What are the effects on coffee production of different shade levels?

Shade levels and coffee production			
	Unshaded (0%)	**Appropriate shade (30%)**	**Heavy shade (≥ 70%)**
Fruiting	The tree fruits heavily using maximum nutrients – heavy fruiting is unsustainable. Dieback is a problem. Bean size is smaller and less dense	Trees fruit at a healthy rate. Larger bean size and density	Trees produce more leaves and fewer berries. The length of branch in between berry clusters (internodes) increases which decreases the yield of cherry
Plant growth	Grows rapidly	The tree grows in a more controlled manner	Coffee trees that have too much shade become tall, weak and thin and can break
Weather tolerance	Exposed to environmental extremes. The stress from this exposure makes them vulnerable to pests and diseases	Medium levels of shade and shade trees protect the coffee trees from wind and heavy rain and extremes of temperature	Heavy shade protects the coffee tree from climatic extremes
Pests and diseases	Low humidity environments are less attractive for CLR but are preferred by green scale	Medium shaded coffee is more resilient to all manner of pests and diseases. Birds are attracted and they deter pests	Constantly wet leaves due to heavy shading creates ideal conditions for infections such as CLR & pink disease
CBB	Less of a problem	CBB may be more of a problem in conditions of optimum shade, however, these conditions also favour the pest's natural enemies. Encourages *Beauveria bassiana* which is used in the control of CBB	Encourages *Beauveria bassiana*
Weeds	Like the tree itself with no shade, weeds grow more rapidly and they compete with the coffee for nutrients water and space	Shade trees suppress weeds through leaf litter and shade	Shade trees suppress weeds through leaf litter and high shade levels

Shade levels and coffee production

	Unshaded (0%)	Appropriate shade (30%)	Heavy shade (≥ 70%)
Soil moisture	Low soil moisture due to high evaporation	The roots of shade trees improve drainage. Their shade cover and leaf litter reduces evaporation rates	Excessive soil moisture (waterlogging) can depress yields
Micro-climate	Evapotranspiration is highest when unshaded. This means that trees are exposed more often to stress caused by dry conditions	Evapotranspiration is moderated. More air circulation reduces humidity, and provides a more stable micro-climate for coffee	In cooler areas shade can alter temperatures and keep leaves wet. This can result in more pests, fungal spores and diseases
Erosion	Less protection against erosion	Protection against erosion through canopy cover, leaf litter and roots of shade trees	High protection against erosion through canopy cover, leaf litter and roots of shade trees
Labour	Coffee trees require more frequent pruning than shaded coffee. Like the tree itself, weeds grow more rapidly and demand more labour. Coffee trees producing year-round, so more difficult to organise labour	Shade trees require regular maintenance and pruning. However, the benefits of shade trees (e.g. weed suppression) mean reduced labour demands overall. Cherry production concentrated in coffee season so easier to plan labour harvesting strategies	Pruning can damage the coffee trees. Access for harvesting and maintenance of coffee is more difficult and time consuming, therefore increasing labour costs
Nutrient requirements	As trees grow and fruit rapidly they have high nutrient requirements which if not met through additions of fertiliser can result in dieback and high mortality rates	Some shade trees fix nitrogen. Shade trees also have deep roots that are able to take up nutrients from deep in the soil and provide them to the coffee through leaf litter	Densely planted shade trees can compete for nutrients with coffee trees undermining their nutrient recycling abilities
Climate change	Higher temperatures result in a reduction in bean quality and an increase in the populations of CBB	Appropriate shade can make coffee trees more resilient to the negative impacts of climate change	Heavy shade can increase the impact of climate change as increased temperature and humidity creates ideal conditions for diseases such as CLR

Shade in a changing climate

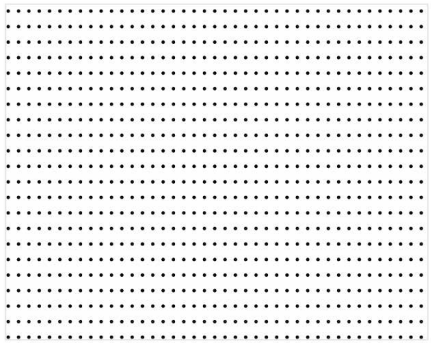
As climate change progresses, it may become necessary in the future to increase shade levels. This recommendation may be made by CIC in future, based on research.

Activity: Shade levels

If it is a sunny day, use Yar branches to demonstrate different shade levels by observing the shadow on the ground cast by the following:

1. No branches – no shadow (no shade)
2. A single branch producing a dappled shadow (appropriate shade)
3. A few branches bunched together casting a full shadow (heavy shade)

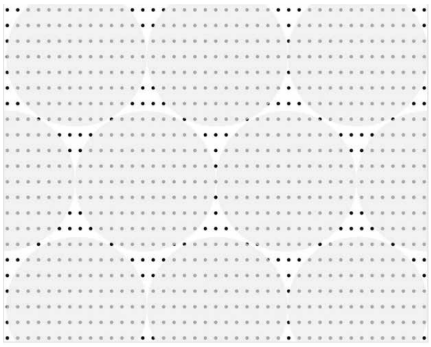
Shade levels



Coffee garden with no shade

(0% shade)

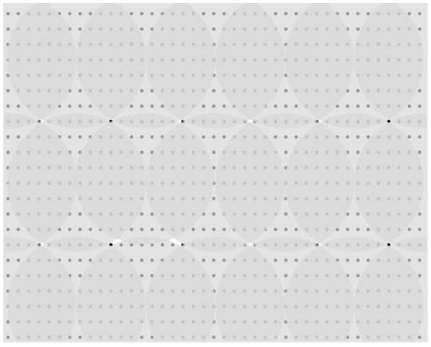
Coffee trees are exposed to full sunlight



Coffee garden with appropriate shade

(30% shade)

Coffee trees are exposed to 70% sunlight



Coffee garden with heavy shade

(≥70% shade)

Coffee trees are exposed to less than 30% sunlight

Field exercise

Objective:

To observe the general conditions of coffee gardens and the health of the coffee trees when under different levels of shade.

You will need:

Access to two coffee gardens: one with very little or no shade and another with appropriate (approximately 30%) shade.

EXERCISE 4

Observing coffee garden conditions under different shade levels

Discuss what you observe in each of the gardens:

1. Are there flowers on some or all of the trees?
2. Are there coffee berries at all stages of development? How can this affect overall production and management?
3. Are the coffee trees healthy? Are there signs of pests and diseases? Is CBB present? How can too little shade encourage pests and diseases? What can be done to improve the health of the coffee trees using shade?
4. Are there weeds present? What types of weeds can be seen? Describe the growing conditions for these weeds? Can the weeds be controlled? How can these weeds be controlled? In an effort to prevent or control an infestation by CBB, how easy would it be to find berries dropped while harvesting?
5. What would you expect to observe if the shade cover was very heavy? How would this impact flowering, berry development, weed growth, and pests and diseases?

3.6 CHARACTERISTICS OF A GOOD SHADE TREE

What makes a good shade tree?

Not all trees are suitable as shade trees. The following are desirable characteristics to consider when choosing shade trees. They:

- Provide light and even shade which reduces light intensity by about one-third
- Grow tall so that there is good airflow through the coffee trees below them. This creates conditions less favourable for pests and diseases, such as CBB
- Provide consistent shade cover year round
- Have feathery leaves that filter the sun
- Add nitrogen to the soil
- Are deep rooted and do not compete too much with coffee trees for nutrients and moisture
- Have good leaf fall producing lots of mulch
- Are well adapted to local conditions
- Are long living and produce good timber that can be used for building, fencing and firewood
- Should not host pests and diseases of coffee
- Do not have the capacity to become a weed

Shade trees recommended for planting in coffee gardens are **Yar** and **Marmar**.

Trees and other plants that may host pests and diseases of coffee

Some trees that are planted for shade in coffee gardens may be hosts for pests and diseases of coffee. The following table lists trees and other plants that have been reported to host pests and/or diseases of coffee.

Plants that may host pests and/or diseases of coffee

Host plant	Pest or disease
Bamboo	Green scale
Citrus	Green scale & pink disease
Guava	Green scale
Hibiscus	Pink disease
Sugarcane	Green scale

Objective:

To be able to identify all of the characteristics of a good shade tree

You will need:

Butchers' paper and a marker pen

EXERCISE 5

Choosing a shade tree

List:

1. All of the characteristics of a good shade tree

Discuss:

1. Why each characteristic is important
2. Which characteristics would be of the highest priority when choosing a shade tree

3.7 HOW TO OBTAIN PERMANENT SHADE TREES

Yar seedlings

- Yar seedlings readily self-germinate not far from existing Yar trees
- If Yar seedlings are difficult to find, prepare a small germination bed as you would for a bare root nursery
- Cover the germination bed with Yar branches containing seed cones
- Keep the germination bed moist
- As the seed cones dry and crack the seed will fall down onto the germination bed and self-germinate
- The Yar branches will provide shade to protect the young seedlings
- Remove the shade (Yar branches) as the seedlings become established
- When strong and healthy, the seedlings can be transplanted into the coffee garden at the recommended spacing of 10 m x 10 m for a new coffee garden and later thinned to 20 m x 20 m

Marmar seedlings

- Marmar seedlings can be easily found growing under or nearby to mature Marmar trees
- The seedlings can be transplanted into the coffee garden at the recommended spacing of 20 m x 20 m to begin with and later thinned to 40 m x 40 m

Young Yar trees ready for transplanting into a coffee garden.

3.8 PLANTING SHADE TREES IN A NEW COFFEE GARDEN

Activity: Shade tree planting then thinning over time

- On the laminated plan of a coffee garden, place green and red berries where temporary (green) and permanent (red) shade trees would be planted
- Note that permanent shade tree spacing will depend on the type of permanent shade tree recommended for the area in which you are presenting the module
- To illustrate how shade trees are gradually thinned over time remove berries as applicable

Temporary and permanent shade trees should ideally be planted **3-4 months** prior to planting out new coffee seedlings in the coffee garden. This gives temporary shade time to get established and provide sufficient protection for the tender coffee seedlings.

- Mark out the new coffee garden including location of coffee trees, shade trees and drainage as described in the module *'Establishing a new coffee garden'*
- Permanent shade trees are planted **within** the rows of coffee trees and temporary shade is planted **between** the rows
- Like coffee trees, shade trees establish and grow better in well-drained soils. Drainage should be in place prior to planting shade trees
- Plant the shade trees, both temporary and permanent, as soon as possible

3.9 EXISTING SHADE TREES IN A NEW COFFEE GARDEN

If a new coffee garden is being established and shade trees are already present they will most likely require some attention so that they provide appropriate shade for the new coffee seedlings.

- If the existing shade trees are very old and too tall they should be ring barked and preferably cut down
- Mark out the new coffee garden including the location of shade trees, coffee trees and drainage as described in the module *Farmer Training Guide Unit 1, Module 3 'Establishing a new coffee garden'*
- Dig a new drainage system or restore existing drainage
- If the existing shade trees are healthy and suitably located they can be retained. To keep good clearance between the shade trees and coffee trees, the existing shade trees may require pruning. The lower branches on the shade trees should be maintained at no less than 2-3 m above the coffee trees
- If required, plant additional shade trees as described in Section 3.8

3.10 SHADE MANAGEMENT

Establishing and maintaining optimum shade in a coffee garden

The following shade management practices are necessary for maintaining appropriate shade:

1. A 30% level of shade is recommended. This is when about two-thirds of sunlight is passing through to the coffee trees, that is, shade should block about one-third of the sunlight from reaching the coffee.
2. Permanent shade trees need to develop deep root systems. This helps with nutrient pumping from deep in the soil as described earlier, and reduces competition for nutrients with the coffee trees.
3. As the permanent shade trees get larger and provide effective shade cover, the temporary shade trees can be gradually removed to maintain the appropriate shade level.
4. As the permanent shade trees grow larger they can be thinned until the recommended spacing is reached.
5. Remove the lower limbs of young shade trees as they grow. To allow sufficient air circulation the branches of established shade trees should be at least 2-3 m above the top of the coffee trees.

Note: Remember safety first: use a harness when climbing trees.

6. Once shade trees are established they will require regular pruning to remove all branches to a height of 2-3 m above the coffee trees.
7. From when coffee trees are three years old, prune the shade just prior to the main flowering period to increase flower production.
8. If recycle pruning of the coffee trees is planned, it is better to prune shade trees beforehand so that any coffee trees damaged by falling branches can be cleaned up during recycle pruning.

Note: To maximise your income grow your coffee under one-third shade

9. When the correct spacing has been reached for permanent shade, any further shade trees removed for firewood or timber must be replaced with new shade trees. It is best to plan ahead for this by planting new shade trees before ringbarking the older trees.

Pruning large branches on shade trees

- Care must be taken when pruning shade trees
- Large branches from well-established shade trees may damage the coffee trees and any smaller shade trees. They may also obstruct movement within the coffee garden
- The timber can be used for building, fence maintenance or firewood and the leaves and small branches can be spread on the ground amongst the coffee trees

LIGHT OR NO SHADE

HEAVY FLOWERING

Not enough nutrients

Pests and diseases

HIGH CHERRY PRODUCTION
(if fertiliser applied; otherwise smaller and lighter beans)

Trees stressed

Over-bearing dieback

DRY COFFEE CHERRIES
(Floaters)

LESS INCOME FOR LOTS OF HARD WORK

High labour demands - more weeding

High labour demands - more pruning

OPTIMUM SHADE LEVEL

GOOD FLOWERING

Enough nutrients

Trees more resistant to pests and diseases

HIGH CHERRY PRODUCTION
(Larger and heavier beans)

Healthier trees

Concentrated coffee season

BETTER QUALITY CHERRIES
(Few floaters)

MORE INCOME FOR LESS WORK

Low labour demands - less weeding

Low labour demands - less pruning

Objective:

To understand the importance of practising correct techniques of shade management

EXERCISE 6

Shade management

Discuss the following:

1. When is the best time to prune shade trees in order to increase flower production on the coffee trees? Refer to the coffee calendar to assist you in working out the best time
2. Discuss the correct techniques used to prune and manage shade
3. Discuss the implications of not managing shade trees so that the coffee garden becomes too shaded

3.11 KEY MESSAGES

What are the important messages for the farmer?

1. Coffee trees grown under recommended levels of shade cover are healthier, stronger and more resistant to pests and diseases, meaning higher productivity and income for the farmer.
2. Shade trees have many advantages including:
    - moderating weather extremes and suppressing weeds, pests and diseases;
    - extracting nutrients from deep in the soil and making them available to coffee trees through leaf litter;
    - regulating flowering and fruiting of the coffee trees;
    - stabilising and improving the soil;
    - reducing moisture loss and erosion; and
    - providing timber and firewood as well as an additional income source
3. Shade trees reduce labour demands in almost all aspects of coffee production including in maintenance, pest and disease control and harvesting.
4. Fast growing temporary shade trees can be planted along with permanent shade trees before the coffee seedlings are planted. Temporary shade trees will provide protection for young coffee seedlings and can be removed as the permanent trees become established.
5. A good shade tree should:
    - fix nitrogen in the soil;
    - provide the recommended amount of shade;
    - provide consistent shade cover;
    - be deep rooted and not compete too much with coffee for nutrients and moisture;
    - produce a lot of mulch
    - not host pests and diseases of coffee
6. Manage shade to regulate flowering and hence berry production by the coffee trees. This can help with CBB control by breaking the life cycle of the pest (few berries in the off-season for the CBB to survive in).
7. Regularly maintain the shade trees to prevent shade from becoming too dense.
8. Yar and Marmar are recommended permanent shade trees.

3.12 QUIZ

Place a '✓' in the correct box.

1. Which of the following is a characteristic of a good shade tree?

- A Has a deep root system so it doesn't compete too much with the coffee trees for nutrients and water
- B Has a shallow root system at the same depth as the roots of the coffee trees
- C Has little leaf fall so it doesn't make a mess in the coffee garden
- D Provides heavy even shade

2. Which of the following characteristics should be avoided when selecting a shade tree?

- A Increases nitrogen in the soil
- B Can be used as a source of firewood
- C Provides constant shade cover even in the dry season
- D May host pests and diseases of coffee

3. What is the appropriate shade level recommended for smallholders?

- A 0% shade
- B 30% shade
- C 50% shade
- D 70% shade

4. If there is too little shade, what effect can this have on the coffee trees?

- A Grow healthy and strong
- B Be pest and disease free
- C Have all-year flowering, resulting in poor yields if no supplementary fertiliser is applied
- D Be protected from weather extremes

5. When preparing a new coffee garden what should be done with existing shade trees that are very old and tall?

A Leave them in the coffee garden to provide shade for the new coffee trees
B Prune all branches up to 2-3 m above the coffee trees
C Ring bark them and preferably cut them down before planting the new coffee seedlings
D Ring bark them and cut them down after the new shade trees have established

6. When is the best time to plant shade trees in a new coffee garden?

A When digging the drains
B 3-4 months prior to planting the coffee trees
C When planting the coffee trees
D 3-4 months after planting the coffee trees

7. When shade trees are fully established, to what height should their branches be pruned?

A 1-2 m above the coffee trees
B 2-3 m above the coffee trees
C 4-5 m above the coffee trees
D 5-6 m above the coffee trees

8. When is the best time to prune shade trees in an established coffee garden?

A Six months prior to the onset of the main flowering period
B Just before the onset of the main flowering period
C Just after the main flowering period
D Just before harvesting has been completed

9. What effect does an appropriate level of shade have on the coffee harvesting period?

A Extends the harvesting period so there is year round production of high quality cherries
B Extends the harvesting period so there is less labour required for harvesting
C Concentrates the harvesting period so that there are less berries produced in the off-season
D The harvesting period is the same regardless of the level of shade

10. What effect does an appropriate level of shade have on coffee bean quality compared to unshaded coffee?

A Bean ripening is slower therefore increasing bean size and density
B Bean ripening is faster therefore increasing bean size and density
C The coffee trees produce a lot of pea berries (one bean inside each cherry)
D Appropriate shade has no effect on bean quality

11. High inputs of fertiliser and labour are required for which level of shade?

A No shade
B 30% shade
C 50% shade
D 70% shade

12. Tall thin coffee trees at a greater risk of attack by CLR and pink disease are associated with which level of shade?

A No shade
B 30% shade
C 50% shade
D >70% shade

13. How do appropriate shade trees benefit the nutrient status of coffee trees?

A Take nitrogen from the air and make it available to the coffee trees via their roots
B Pump nutrients up from deep in the soil making them available to the coffee trees
C Drop leaf litter which decays releasing valuable nutrients into the soil
D All the above

14. The most suitable permanent shade trees to grow in coffee gardens in the highlands are:

A Marmar and banana
B Banana and Yar
C Yar and Marmar
D Yar and Leucaena

15. Marmar is most suited to areas where there is:

A. No marked dry season
B. An extra cold dry season
C. A strong wet season
D. A strong dry season

16. The typical coffee production sequence when using the recommended shade level for smallholders is:

A. Extended heavy flowering -> high cherry production -> dry coffee cherries -> less income for lots of work
B. Concentrated flowering -> high quality cherry production -> more income for less work
C. Extended heavy flowering -> high inputs of fertiliser -> high cherry production -> less income for lots of expense and hard work
D. Little flowering -> low cherry production -> lots of pests and diseases -> little income for little work

Answers to quiz questions

Multiple choice

1. Which of the following is a characteristic of a good shade tree?

   Answer = A. Has a deep root system so it doesn't compete too much with the coffee trees for nutrients and water

   Section 3.6. What makes a good shade tree?

2. Which of the following characteristics should be avoided when selecting a shade tree?

   Answer = D. May host pests and diseases of coffee

   Section 3.6

3. What is the appropriate shade level recommended for smallholders?

   Answer = B. 30% shade

   Section 3.5. A 30% shade level has benefits in maintaining soil moisture, preventing erosion, moderating the microclimate around the coffee trees, reducing labour and nutrient requirements, and improving climate change resilience.

4. 4. If there is too little shade, what effect can this have on the coffee trees?

   Answer = C. Have all-year flowering, resulting in poor yields if no supplementary fertiliser is applied

   Section 3.3. Coffee trees without shade are exposed to direct sunlight which initiates heavy flowering and eventually production of a lot of cherries on the tree. If the cherries are not supported with extra nutrients (i.e. fertiliser), the coffee trees will suffer from overbearing dieback and a higher rate of tree death than if the coffee trees were shaded. If coffee is grown under shade, flowering and cherry bearing is controlled naturally. Shade regulates flowering and increases bean production, size, density and quality.

5. When preparing a new coffee garden what should be done with existing shade trees that are very old and tall?

   Answer = C. Ring bark them and preferably cut them down before planting the new coffee seedlings

   Section 3.9. In a new coffee garden, if the existing shade trees are very old and too tall, they should be ring barked and preferably cut down prior to planting the new coffee seedlings.

6. When is the best time to plant shade trees in a new coffee garden?

   Answer = **B**. 3-4 months prior to planting the coffee trees

   Section 3.8. Temporary and permanent shade trees should ideally be planted 3-4 months prior to planting out new coffee seedlings in the coffee garden. This gives temporary shade time to get established and provide sufficient protection for the tender coffee seedlings.

7. When shade trees are fully established, to what height should their branches be pruned?

   Answer = B. 2-3 m above the coffee trees

   Section 3.10. Once shade trees are established, they will require regular pruning to remove all branches to a height of 2-3 m above the coffee trees.

8. When is the best time to prune shade trees in an established coffee garden?

   Answer = B. Just before the onset of the main flowering period

   Section 3.3 and 3.10. The rate of flowering can be increased by pruning shade trees just before the main flowering period. When coffee is three years old, prune the shade just prior to the main flowering period to increase flower production.

9. What effect does an appropriate level of shade have on the coffee harvesting period?

   Answer = C. Concentrates the harvesting period so that there are less berries produced in the off-season

   Section 3.3. Shade regulates flowering. Controlled flowering means a more concentrated harvesting season. It is more efficient to have a high input of labour to harvest a lot of cherry over a short period than continually allocating labour to harvest small quantities of cherry over a longer period.

10. What effect does an appropriate level of shade have on coffee bean quality compared to unshaded coffee?

    Answer = A. Bean ripening is slower therefore increasing bean size and density

    Section 3.3. Bean ripening is slowed, therefore, improving bean size and density (weight), and cup quality.

11. High inputs of fertiliser and labour are required for which level of shade?

    Answer = A. No shade

    Section 3.5. Unshaded coffee trees require more frequent pruning than shaded coffee. Like the tree itself, weeds grow more rapidly and demand more labour. Coffee trees produce year-round, so it is more difficult to organise labour. As trees grow and fruit rapidly, they have high nutrient requirements which if not met through additions of fertiliser can result in dieback and high mortality rates.

12. Tall thin coffee trees at a greater risk of attack by CLR and pink disease are associated with which level of shade?

    Answer = D. >70% shade

    Section 3.5. Constantly wet leaves due to heavy shading creates ideal conditions for infections such as CLR & pink disease and favours CBB infestation.

13. How do appropriate shade trees benefit the nutrient status of coffee trees?

    Answer = D. All the above

    Section 3.3. Shade trees 'pump' nutrients up from deep in the soil making them available to the coffee trees. They drop leaf litter which decays, releasing valuable nutrients into the soil. If shade trees have the capacity to fix nitrogen, they can take nitrogen from the air and make it available to the coffee trees via their roots.

14. The most suitable permanent shade trees to grow in coffee gardens in the highlands are:

    Answer = C. Yar and Marmar

    Section 3.2. The most common permanent shade trees used in the PNG highlands are Yar (Casuarina) and Marmar (Albizia). Banana and Leucaena are suitable temporary shade trees.

15. Marmar is most suited to areas where there is:

    Answer = D. A strong dry season

    Section 3.2. Permanent shade trees

16. The typical coffee production sequence when using the recommended shade level for smallholders is:

    Answer = B. Concentrated flowering -> high quality cherry production -> more income for less work

    Section 3.10 Optimum shade level diagram

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Google Shade app
https://shademap.app

Note: Other shade maps are available by searching the app store on a mobile device

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