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Good agricultural practices for sustainable cocoa production: a guide for farmer training

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By Richard Asare and Sonii David

FACULTY OF LIFE SCIENCES
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Contributions from:

The International Institute of Tropical Agriculture

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Good agricultural practices for sustainable cocoa production: a guide for farmer training. Manual no. 1: Planting, replanting and tree diversification in cocoa systems

Authors
Richard Asare and Sonii David

Collaborating Partner
Sustainable Tree Crops Program of the
International Institute of Tropical Agriculture
P.O. Box 135, Accra, Ghana
http://www.treecrops.org
http://www.iita.org
Email: stcp-wca@cgiar.org

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About the Sustainable Tree Crops Program (STCP)

STCP is a public-private partnership and innovation platform that seeks to generate growth in rural income among tree crop farmers in an environmentally and socially responsible manner in West/Central Africa. This is achieved by introducing innovations to enhance productivity, increase marketing efficiency, diversify farmer income, and strengthen the institutional and policy environment. STCP, which is managed by the International Institute of Tropical Agriculture (IITA), provides a framework for collaboration between farmers, the global cocoa industry, local private sector, national governments, NGOs, research institutes, and development investors.

About International Institute of Tropical Agriculture (IITA)

Africa has complex problems that plague agriculture and people's lives. We develop agricultural solutions with our partners to tackle hunger and poverty. Our award winning research-for-development (R4D) is based on focused, authoritative thinking anchored on the development needs of sub-Saharan Africa. We work with partners in Africa and beyond to reduce producer and consumer risks, enhance crop quality and productivity, and generate wealth from agriculture. IITA is an international non-profit R4D organization since 1967, governed by a Board of Trustees, and supported primarily by the CGIAR.

Contributors and acknowledgements

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Others are Dr. L. E. Bidzanga Nomo, Dr. Salomon Nyassé and Dr. Luc Dibog (Institut de Recherche Agronomique pour le Developpement –IRAD, Cameroon), Jean Yves Couloud (STCP and ANADER Cote d'Ivoire), and Peter van Grinsven (Masterfoods, the Netherlands).

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Preface

While cocoa has been grown in West and Central Africa since the early 1990s, using participatory approaches to train cocoa farmers is relatively new in this region. Cocoa extension programs have used traditional top down approaches such as the training and visit approach based on the »technology transfer« model. Typically, the results have been disappointing, with relatively few farmers adopting the promoted practices. By the 1990s, most national cocoa extension systems had collapsed.

To meet the objective of training farmers to become »experts« in their own fields, STCP has developed a series of manuals on specific topics:

Manual no. 1: Planting, replanting and diversification in cocoa systems
Manual no. 2: Integrated crop and pest management for mature cocoa farms
Manual no. 3: Conservation and biodiversity in and around cocoa farms
Manual no. 4: Preventing and reducing injuries and ill health in cocoa production
Manual no. 5: Methods for training farmers on sustainable cocoa production

In addition, two illustrated guides, *Improve your cocoa production* and *Protecting your safety and health on cocoa farms*, designed for use by low literacy farmers are available.

All manuals and related extension materials can be downloaded from the STCP website (www.treecrops.org). Many are also available in French.

The curricula outlined in the STCP manuals can be adapted to different training methodologies including, but not limited to, farmer field schools (FFS), farmer learning groups (FLG) and participatory demonstrations. Regardless of the training method used, the objective should be to allow farmers to make their own discoveries about the topic concerned through carrying out field and discovery leaning exercises. It is therefore important that training programs adopt a participatory approach whereby farmers' existing knowledge is acknowledged (and corrected where necessary) and used as the starting point for learning. Learning should be facilitated by a trained facilitator and where possible, farmers should have the opportunity to be involved in selecting the training topics.

The STCP training manuals are intended as guides for trainers involved with participatory training of cocoa farmers. Trainers may be extension agents or farmers who have gone through a comprehensive training of trainers (ToT) program on participatory training of cocoa farmers. Although the exercises contained in the manuals have for the most part been field tested, they should be treated as guides to be used flexibly and creatively by trainers. The content of each curriculum should be adapted to the context and situations of farmer training by, for example, changing the names of case study characters, currencies, pesticide dosage etc.

Acronyms

ANADER	Agence National d'Appui au Developpment Rural
BC	Bark collar
CGIAR	Consultative Group on International Agricultural Research
CRIG	Cocoa Research Institute of Ghana
CRIN	Cocoa Research Institute of Nigeria
DCT	Damaged cocoa trees
FFS	Farmer Field School
FLD	Forest and Landscape Denmark
FLG	Farmer Learning Group
IITA	International Institute of Tropical Agriculture
IRAD	Institut de Recherche Agronomique pour le Developpement
NGO	Non Governmental Organization
R4D	Research-for-Development
STCP	Sustainable Tree Crops Program
USAID	United State Agency for International Development
WCF	World Cocoa Foundation

Glossary

Abandoned cocoa farm: a cocoa farm that has been left idle for a long period of time not less than 10 years

Biomass: organic materials such as wood, plants, and organic wastes

Block planting: dividing a piece of land into blocks and gradually planting each block with cocoa over a period of time

Branch collar: this is a swelling situated at the point where the branch attaches to the trunk and it acts as a valve that closes off the cut

Budding: this is a method of attaching a bud eye (scion) onto the rootstock of another tree (seedling)

Canopy: the layer containing the crowns of trees in a particular area

Cocoa agroforest: a complex shade grown cocoa system in which forest tree species and food crops are integrated with cocoa for their economic, social and environmental benefits

Cocoa Agroforestry: A dynamic, ecologically based cocoa growing management system that, through the deliberate integration of permanent shade trees and food crops in the farmland diversifies and sustains the production for increased social, economic and environmental benefits for farmers at all levels

Cocoa establishment/re-establishment: planting cocoa in a new area/ replanting on a land that previously had cocoa trees on it

Cocoa intensification: a new vision of the cocoa economy whereby the crop is grown with the objective of increasing productivity while at the same time ensuring sustainability by protecting the environment

Cocoa systems: farming systems dominated by cocoa trees, which are intended to serve as the main cash crop

Enrichment planting: replacing dead trees or filling in gaps with good planting materials

FLG Approach: this is a structured group based learning approach that teaches farmers specific skills and practices

Gradual replanting: planting cocoa on blocks or strip of land over a period of time

Grafting: this is the act of joining two plants together; the upper part of the graft (the scion) becomes the top of the plant; the lower portion (the rootstock) becomes the root system or part of the trunk

Hardening off: this is the process of preparing plants in the nursery for the change in environmental conditions they will encounter when permanently moved to the field.

Humus: this is a term used to described soils that contain high levels of organic matter

Humus: this is a term used to described soils that contain high levels of organic matter

Improved planting material: good quality seeds or seedlings

Jorquette: this is a point on the cocoa stem where a branch is formed

Mature cocoa farm: a cocoa farm between the ages of 4 to 20 years

Mulch: this any cover or materials placed on the surface of the soil in order to reduce evaporation (loss) of water from the soil, prevent soil erosion and control weed growth

New planting: planting cocoa on a piece of land, which has never been planted with cocoa before

Old cocoa farm: a cocoa farm beyond 20 years

Permanent nursery: a nursery established mainly for commercial purposes

Permanent shade: shade for mature and old cocoa trees

Pruning: removal of branches and stems from a tree to give them a desired shape

Rootstock: this is a term applied to the part of the graft that produces the root system of the grafted plant

Scion: a piece of detached twig or shoot that usually contains two or three buds, although it may contain more. When the scion is only a single bud, the form of grafting is known as budding

Selective burning: burning debris from land clearing in small heaps

Soil characterization: an analysis of the soil to determine its physical and chemical properties

Soil conservation: this is a process of protecting and maintaining the integrity of the soil

Soil erosion: this is the washing away of topsoil due to actions of wind and rain; it occurs when the surface of the soil is bare

Soil fertility: the ability of the soil to provide nutrients to support crop production over a long period of time

Soil structure: this is the shape that the soil takes based on its physical and chemical properties

Soil texture: this is the relative proportion (amount) of sand, silt and clay in the in the soil

Strip replanting: dividing a piece of land into strips and planting on every other strip with cocoa over a period of time

Temporal nursery: a nursery mainly for a household with no commercial intention

Temporary shade: shade for young cocoa trees

Tree diversification: tree diversification in cocoa farms is a process that involves the strategic integration in time (at various stages in the establishment and management of cocoa farms) and space (the three-dimensional arrangement of trees on the ground and into the canopy) of suitable and valuable non-cocoa tree species and other plants into a cocoa farm

Tree stock: total number of trees per unit area of land

Under planting: replacing unproductive cocoa trees with good quality trees over a period of time

Water holding capacity: this is the ability of the soil to store moisture and supply it to plants

Young cocoa farm: a cocoa farm between the ages of 0 to 3 years.

Introduction to planting, replanting and diversification in cocoa systems

Cocoa production in West and Central Africa is low (200-700 kg per ha), as a result most cocoa farmers are not getting the full benefits from growing the crop. Studies conducted by the Sustainable Tree Crops Program indicate that at present, a large number of farmers (as much as 40% of farmers in the region) make a loss from growing cocoa. To turn this situation around, farmers need to intensify their cocoa cultivation.

Cocoa intensification is a term used to describe a new vision of the cocoa investment whereby the crop is grown with the objective of increasing productivity while at the same time ensuring sustainability by protecting the environment. To do this requires that farmers, governments and the private sector (cocoa buying companies, input dealers, banks, and other credit institutions) make some significant changes and discard the »business as usual« «attitude.

In the case of farmers, conscious efforts need to be made to rehabilitate old and non-producing farms and/or establish new cocoa farms using best agronomic practices. In order to help farmers intensify cocoa farms through best agronomic practices, the Sustainable Tree Crops Program in consultations with the Cocoa Research Institutes across West Africa initiated a process to develop a comprehensive manual that provides technical guidance for farmers to establish and maintain cocoa farms using recommended guidelines. The result of this is the planting, replanting and diversification (PRD) manual, which is based on participatory learning and demonstration processes that promote mutual learning between farmers and experts.

The objective of the PRD manual is to improve farmers' knowledge and skills in order to carry out the necessary best practices in revamping old farms and/or start new ones. The manual uses the farmer learning group (FLG) approach, which is a structured group based learning approach that teaches farmers specific skills and practices using demonstrations, field exercises and discussion as the key training and learning tools. The training is based on five areas, which involve training on how, farmers:

1. Analyze their current farm situation,
2. Select sites for new cocoa establishment,
3. Acquire clean improve planting materials for both cocoa and non-cocoa species,
4. Prepare the field for planting of cocoa and non-cocoa species,
5. Under go plant diversification.

The manual is divided into two sections. Section I contains bulletins that provide technical information on topics related to the five areas mentioned above and section II deals with corresponding demonstration learning ex-

ercises for participatory farmer training. These exercises could be used in training farmers on cocoa certification of voluntary schemes. There is a separate guide for using this manual and it is entitled »Implementing guide for planting, replanting and tree diversification in cocoa systems«. This manual is a work in progress and so feedback and comments on this publication are sincerely welcome and should be sent to:

Richard Asare
Email: *qra@life.ku.dk*; *r.asare@cgiar.org*; *stcp-wca@cgiar.org*

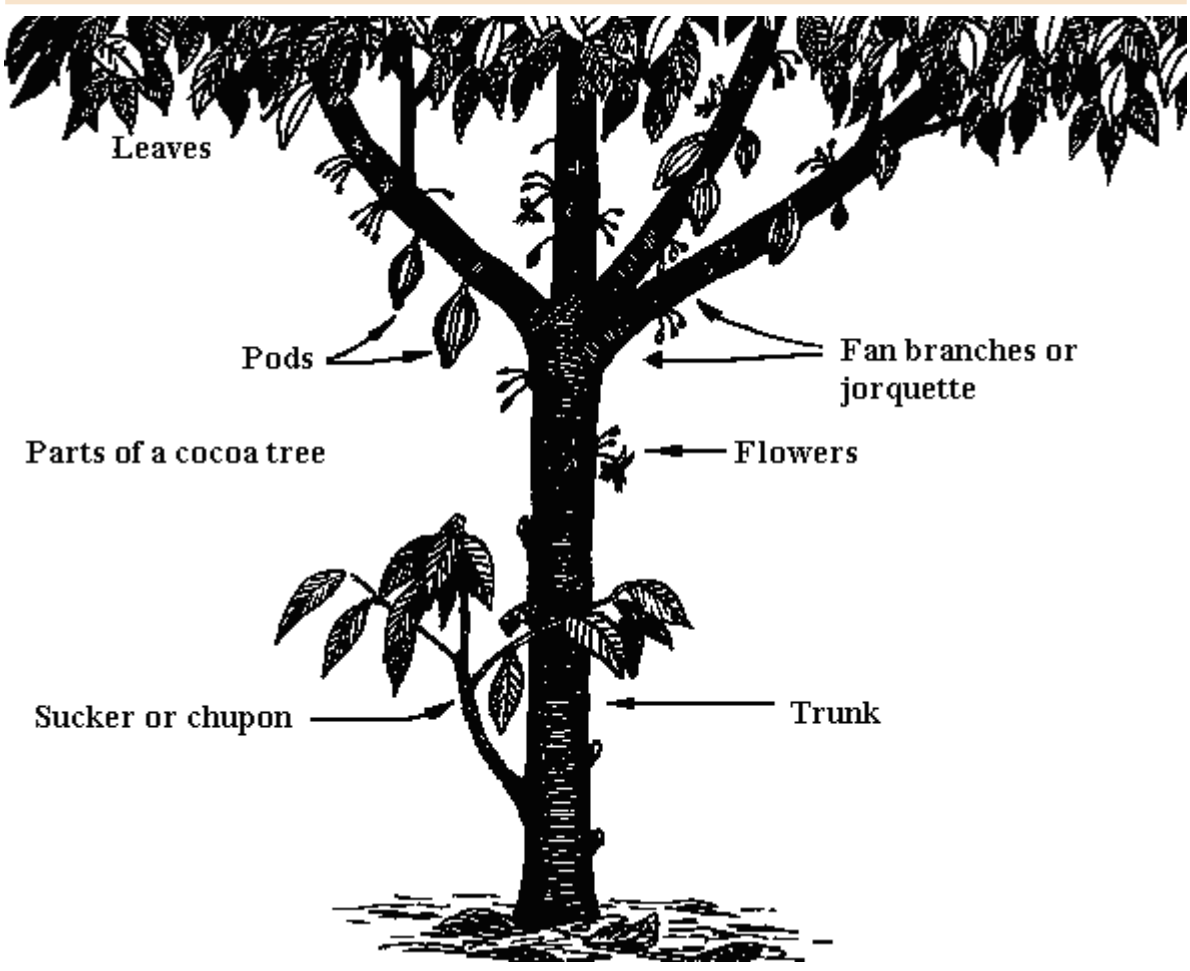
As we incorporate new materials as a result of new research findings and recommendations, this manual will be updated periodically.

Richard Asare
Accra, Ghana
July, 2011

Content

Part 1

Technical bulletins for trainers



The Cocoa Tree

Cocoa intensification

Situation of cocoa in West and Central Africa

Although cocoa is an important crop in many countries in West and Central Africa, production per unit area is low (200-700 kg per ha) and most cocoa farmers are not getting the full benefits from growing the crop. Factors responsible for this situation include:

Tree stock:

- Old age of trees (most farms are over 40 years old)
- Widespread planting of traditional varieties: limited use of improved planting materials (e.g., hybrids)
- Use of planting materials of poor genetic quality
- Small farm size due to fragmentation

Farm management

- Limited and irrational use of fertilizers, fungicides and insecticides
- Poor farm management practices
- Overly tall cocoa trees (10-15 m) that make it difficult to manage

The environment

- Expansion of cocoa areas by cutting down forests
- Total removal of shade trees in cocoa farms and growing the crop in full sunlight which results in yields declining over time
- Other factors:
- Limited access to credit
- Poor access and availability of inputs such as pesticides and fertilizers
- Labour shortage
- Old age of farmers

At present, due to these factors, a large number of farmers (as much as 40% of farmers in the region) make a loss from growing cocoa. In other words, growing cocoa is not profitable for many farmers.

What can be done?

If the cocoa sector is to survive in West and Central Africa, action needs to be taken to improve the present situation. A future vision of the cocoa sector should include the following:

- Most cocoa farmers have planted hybrid cocoa on an average of 4-5 ha
- Cocoa trees are 2-3 meters tall
- Cocoa yields are at least 1000 kg/ha
- Farmers apply approved fertilizers, fungicides and insecticides (where needed) in the recommended dosage at the right time and

these inputs are readily available and accessible at village level
- Farmers have access to credit for purchasing inputs
- Farmers plant improved food crop varieties (plantain, cassava, etc.,) using fertilizers where needed, before cocoa is planted
- Farmers integrate shade and fruit trees (using good quality planting materials) that grow well with cocoa and that can be used by the household or sold

If this vision is achieved, cocoa farmers will have a much higher standard of living, cocoa production will be more sustainable, farmers will no longer have to cut down forests to expand their cocoa farms and the economies of cocoa production in the countries will improve.

Cocoa intensification is a term used to describe a new vision of the cocoa economy whereby the crop is grown with the objective of increasing productivity while at the same time ensuring sustainability by protecting the environment.

To intensify cocoa production farmers, governments and the private sector (cocoa buying companies, input dealers, banks, credit institutions) will need to make some changes.

Farmers will need to change in the following ways:

- Run cocoa farming as a gainful business
- Stop growing cocoa if they cannot do so profitably and sustainably
- Plant improved materials (hybrid cocoa)
- Use approved inputs (fertilizer, fungicide, insecticide) at recommended dosages
- Follow best management practices (for example, land preparation, nursery establishment, planting requirements, pruning, weeding, fermentation etc.)
- Use fallow for new farm instead of forest
- Be experts on their own farms
- Provide assurance to the buyer and to the consumer of sustainable production and consumption

Governments will need to:

- Provide a reliable source of improved planting materials and support the setting up of seed distribution systems that reach the majority of farmers
- Find ways to lower the price of inputs
- Employ an efficient input delivery system
- Increase support to cocoa research
- Make cocoa extension more effective
- Improve existing land and tree tenure laws
- Support intensification of agriculture in general to reduce pressure on existing forests
- Take the lead to develop locally relevant, comprehensive, holistic

standard and indicators (common language with achievable goals) for the sector.

- Provide a holistic set of benefits to farmers, including ecosystem payments, supply chain sustainability and market recognition
- Provide financial incentives to producers and the supply chain actors to ensure sustainability in the industry

The private sector will need to:

- Develop more effective ways to provide credit to farmers
- Play a more active and effective role in delivering services and inputs to farmers
- Provide markets for traditional agricultural commodities
- Help farmers to access information on cocoa markets
- Partner with governments to develop enabling policies for developing rural markets
- Assure governments of a sustainable demand for crop.
- Support government with the development of market-driven (certification) supply chains and to developing a credible system of assurance and traceability.
- To commit to integrity, ethical and responsible trading relationship with producers, government and the entire supply chain.
- To link corporate social responsibility and other donations to their business operations

Deciding to plant or replant cocoa

Importance

- Many cocoa farms in West and Central Africa are old (more than 40 years) and have low yields due to the age of the trees, poor management, pests and diseases problems and soil fertility
- A healthy cocoa tree produces at least 25 pods per year which provides approximately 1 kg of dry cocoa. Yields per tree in a year can be classified as:

    - Good (25 or more pods)
    - Average (15-24 pods)
    - Poor (14 or less pods)

Farmers who have unproductive trees (producing 10 or less pods per year) should think about what they can do to improve their productivity. There are options for where to plant or replant cocoa. These include:

- ***Under-planting:*** planting new cocoa trees in an existing farm, removing some but not all cocoa trees
- ***Gradual replanting:*** removing all cocoa trees in a section or block of an existing farm and planting new cocoa trees in that section
- ***Complete replanting (re-establishment)***: removing all cocoa trees and completely replanting the whole field
- ***New planting (establishment)***: Planting cocoa on fallow land or an area where cocoa has not been planted before (not a forest area)

Regardless of which option a farmer chooses, it is important to plant improved cocoa planting materials (hybrids) from approved sources in order to get high and reliable yields.

Under-planting

This method of planting is best when trees are old (over 30 years). Cocoa trees left in the field provide shade to the newly planted trees. This method is not recommended where cocoa swollen shoot virus is a problem.

Method: Identify diseased/old and unproductive cocoa trees based on annual yields (see the exercise »Deciding which cocoa trees to rehabilitate or eliminate«). Survey the farm, looking for large open areas where there are no cocoa trees. Remove diseased/old/unproductive trees and plant new improve cocoa planting materials. Where gaps are large and there is not enough shade, plant food crops before or at the same time as the cocoa seedlings.

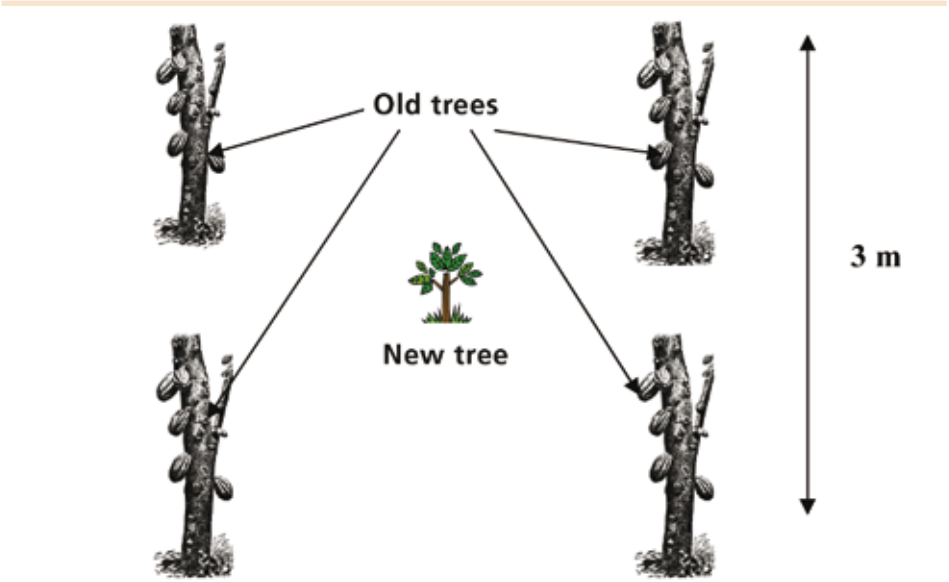


Figure 1: Arrangement for under-planting

Advantages: farmers still get income from existing trees; old tree stock provides initial shade for the newly planted trees; it does not require additional land area, less expensive than other methods.

Disadvantages: possibility of old diseased trees infecting the newly planted trees; damage to young trees when removing old trees.

Gradual replanting

Two methods can be used for gradual replanting. These are block and strip replanting. Block replanting involves dividing the farm into blocks and gradually planting each block. Strip replanting involves dividing the farm into strips and planting cocoa trees in every other strip. Gradual replanting is not recommended where cocoa swollen shoot virus disease is a problem.

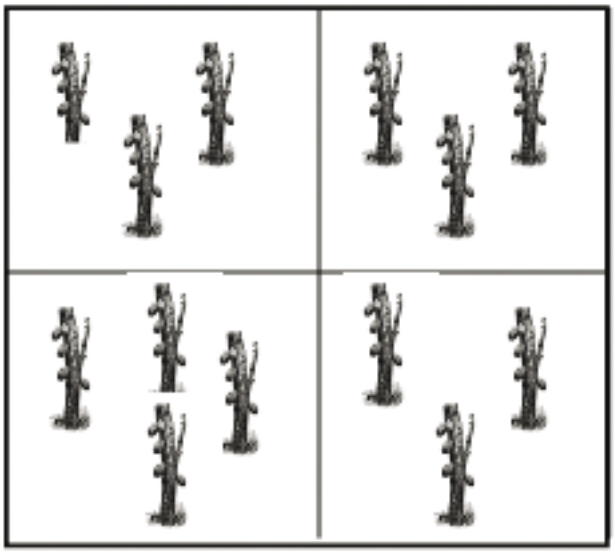


Figure 2: Block showing old cocoa trees

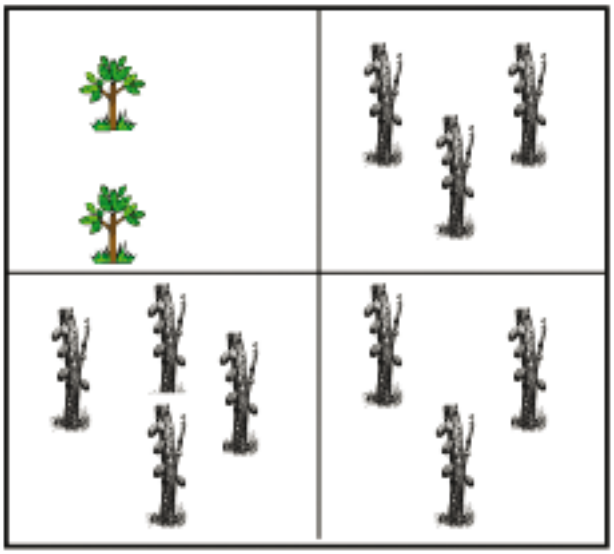


Figure 3: Showing newly under-planted cocoa trees

Block replanting: Divide the farm into four equal sections or blocks. You can use fewer blocks if you want to replant quickly. With 4 blocks, it will take 4 years to replant the farm.

Starting with block 1, completely remove all the trees in that block, including shade trees that are known to have negative influence on cocoa. Leave shade trees that grow well with cocoa. Prepare the land following recommended practices (lining and pegging etc). Establish a nursery of 3-6 months old cocoa hybrid seedlings, food crops and timber species. Following recommended spacing, plant hybrid cocoa, food crops and shade trees at the beginning of the wet season. The following year, cut down the trees in block two and repeat the cycle. Repeat this cycle until you have completed all 4 blocks.

One hectare of land (10,000 m^2) will require 1,111 cocoa trees (planted at a distance of 3m x 3m apart); therefore one hectare divided into two blocks is 555 trees, three blocks 370 trees and four blocks 277 trees. You should therefore plant about 277 trees each year over a period of four years. Using four blocks and 3-6 months old hybrid cocoa seedlings from the nursery, it will take 6-7 years until the trees are in full production and providing a minimum yield of 1000 kg/ha.

Strip replanting: Demarcate 1 hectare of old cocoa farm. Divide the land into 10 vertical strips with a width of 10 meters and a length of 100 m (10 m x 100 m). In year 1, remove all old cocoa trees from the first strip and repeat the planting procedure as described above this time placing cocoa at 2.5m x 3m. In year 2, remove cocoa trees in the third strip leaving the strip between strips 1 and 3 intact. Continue this pattern until you have replanted every other strip. Note that you can clear 2 or more alternate strips of cocoa and replant with hybrids at the same time. You can remove old cocoa trees as part of land preparation activities between January and March, in order to plant new cocoa between May to June.

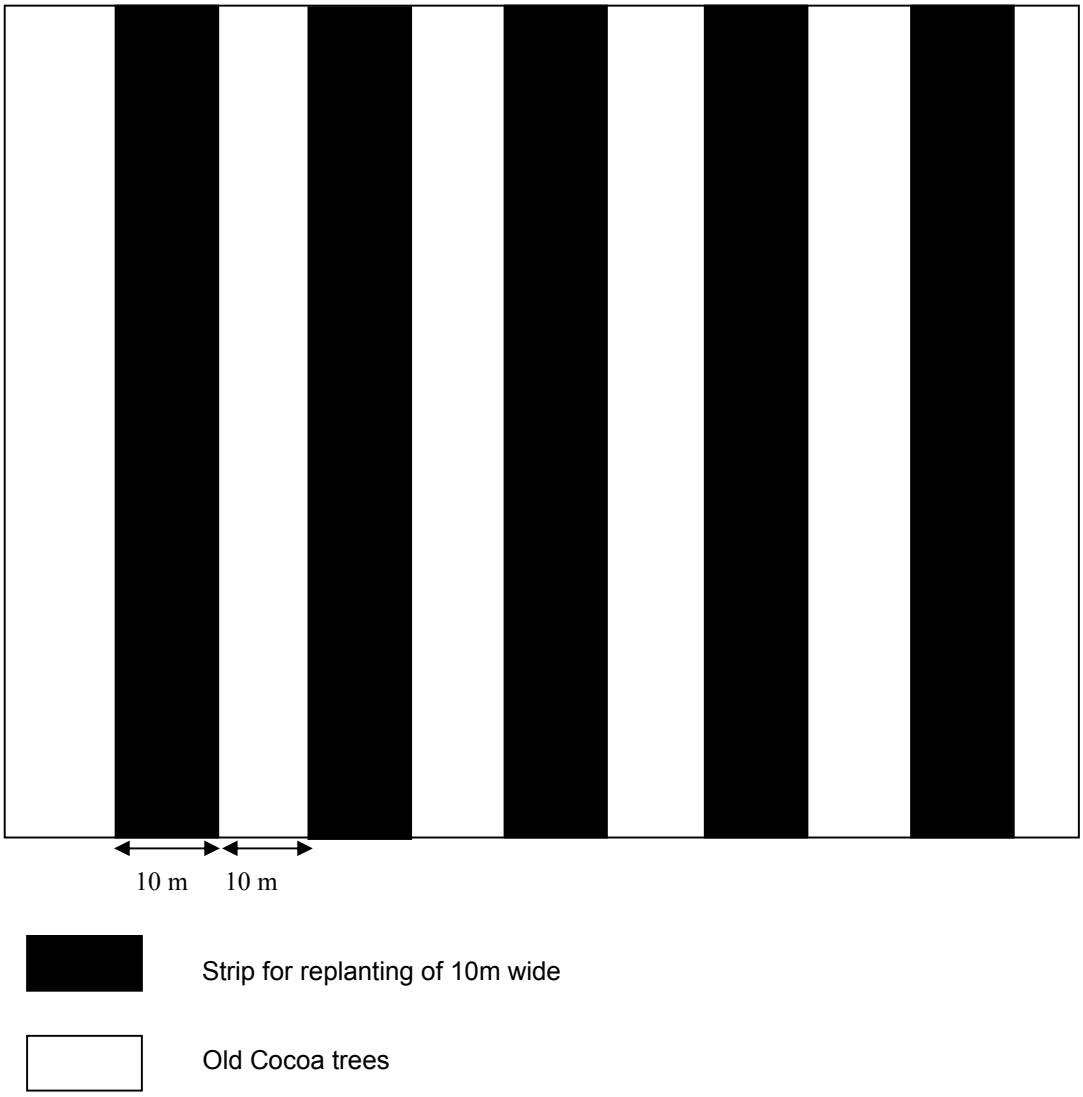


Figure 4: Land showing strips for replanting

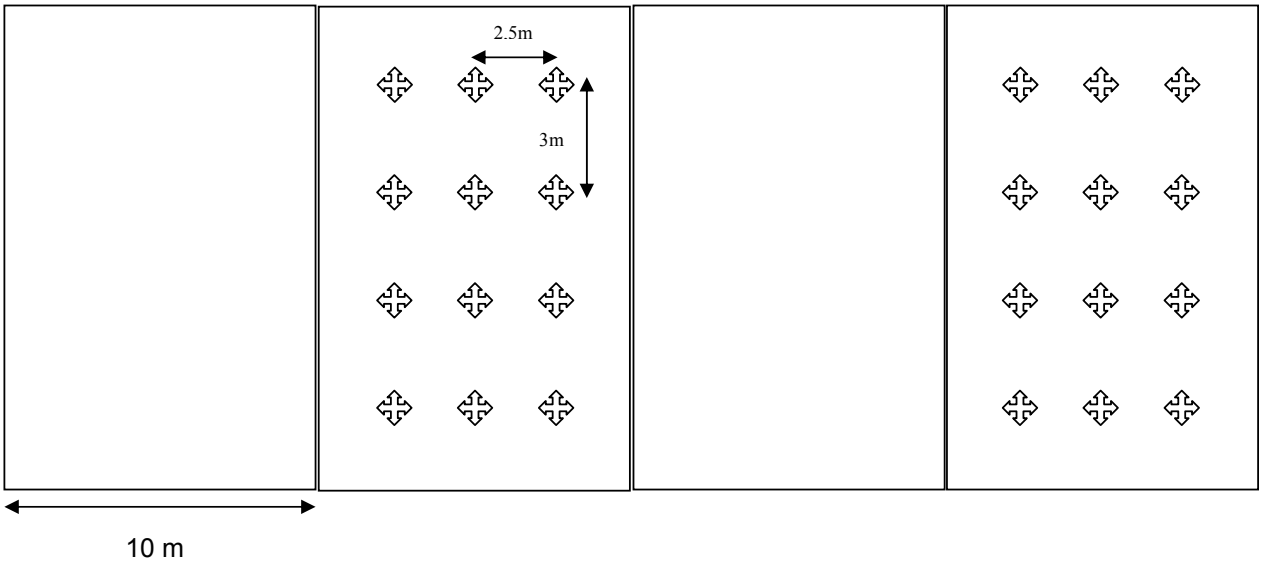


Figure 5: strips of land showing cocoa planted at 2.5 m x 3 m

Things to consider:

Avoid gradual replanting on very old farms since these farms might have accumulated diseases and pests, which could affect newly planted materials. Also because soil fertility may be a problem on such farms, there may be the need to apply fertilizer when replanting.

Advantages: farmers still obtain income from existing trees; there is no additional land area involved.

Disadvantages: where cocoa swollen shoot virus disease exists on the farm, there is the possibility of spreading to newly planted trees. It requires a lot of labour since the farmer will have to combine a lot of activities on each block or strip.

Complete replanting

This is best applied when most trees on the farm are unproductive due to old age, diseases and pest and there is not much the farmer can do to make the farm more productive.

Method: Cut down all the trees on the farm including shade trees that are not compatible with cocoa. To avoid spreading of cocoa swollen shoot virus and to improve soil fertility, leave the area fallow for at least 3 years before replanting cocoa. In such situation, farmers may improve soil conditions and increase organic matter in the first year by preserving and/or planting timber trees (e.g., *Terminalia sp. Khaya sp* etc) and nitrogen fixing trees (*Gliricidia sp.*) at 12 x 12 m triangular spacing. In March of the third year, thin the fallow and plant food crops at 3 x 3 m. Plant cocoa at the same spacing in May, when the rains have stabilized.

Advantage: Where swollen shoot disease is prevalent, complete replanting disrupts the cycle of disease transmission by preventing old trees from re-infesting the new ones.

Disadvantage: it is costly and requires a lot of labour, loss of income from cocoa

New establishment: see planting cocoa

Which option is best?

Things farmers should consider before choosing whether to replant or plant a new farm:

- ✓ Are my trees still productive?
- ✓ Is my farm affected by cocoa swollen shoot virus disease?
- ✓ Can I afford to live without income from cocoa for 3 years?
- ✓ How much labour do I need for each option?
- ✓ Do I have enough labour?

- ✓ Do I have land of my own for a new farm or can I easily get access to land for planting cocoa?
- ✓ Is the available land suitable for cocoa production?
- ✓ Where is the land located?
- ✓ Does my farm have a serious soil fertility problem?

Choose under-planting if:

- Cocoa swollen shoot virus disease is not a problem
- You do not have access to more land
- You do not have sufficient funds/labour for gradual replanting
- More than half of the cocoa trees are unproductive

Choose gradual replanting if:

- Cocoa swollen shoot virus disease is not a problem
- You do not have access to more land
- You cannot afford to live without income from cocoa for 3 years
- Half of the trees are unproductive

Choose complete replanting if:

- Cocoa swollen shoot virus disease is a problem
- You do not have access to more land
- Most trees are unproductive
- You can afford to live without income from cocoa for 3 years
- Your farm is old and has a serious lack of soil fertility

Choose new establishment if:

- Most trees on your existing farm are unproductive
- You have access to suitable land (fallow, not forest) for growing cocoa
- You have sufficient funds and labour to start a new farm

Where to plant cocoa

Importance

Farmers need to consider several factors before planting cocoa in a new area to make sure that they make the best use of land, labor and inputs in order to get the highest production. Factors to consider include:

- Climate
- Soil fertility
- Type of vegetation
- Source of improved planting material

Climate

Cocoa needs a high amount of rainfall: 1,250 – 3000 mm per year. It grows best in areas where the dry season last for not more than three months. Cocoa grows best in warm temperatures: between a high of 30-32^{o}C and a low of 18-21^{o} C.

Soil fertility

Cocoa is a forest crop and so it is suited to forest soils. Hence, it is exceptionally demanding in its soil requirements. Most tropical forest soils consist of accumulated plant nutrients in the top few centimeters. When forests are cleared, the nutrients are rapidly released, giving the soil a high fertility for a few years.

Hence, when planting cocoa in a field that has been used to grow other crops, farmers should remember to apply recommended mineral fertilizer or compost to the planting hole to improve soil fertility.

Not all soils are suitable for cocoa cultivation. Cocoa trees grow well only in good quality soil. It is therefore important to select an appropriate site before establishing a cocoa farm. To select a site look for the presence of earthworms in the soil since this gives an indication for humus soils. After the inspection for earthworm and humus, conduct a careful analysis of the soil in order to characterize the soil.

Soil characterization

An adequate internal drainage
The soil layers should have the same colour. Having a similar soil colour indicates water can circulate freely in the soil. Fertile soils are mostly dark in colour (dark red or dark brown). The dark colour indicates the presence of lots of organic matter. Soils for cocoa cultivation should be well drained (not waterlogged – without gray and green or blue spots). When the colour of the soil is not uniform, it is difficult for water to circulate in it. As a result, required nutrients and water uptake by the plants cannot take place,

causing them to die. Soils for cocoa vary from loamy sands to friable clays red or reddish brown in color.

The proportion of coarse elements in the soil
Avoid steep slopes, stony or rocky soils and marshy or swampy land. Where there are large-sized stones, they should not be more than 50%, of the total soil sample for cultivation.

Good soil texture (sandy-clayey mixture)
The soil should be made up of a good mixture of sand and clay and should have a depth of 120 cm. This depth is essential because it allows the roots to develop properly in the soil and allows for a longer exploitation of the farm.

How to take soil sample
It is important to know the soil type before establishing a cocoa farm. To do this an instrument called an Augur is used to collect soil samples up to a depth of 120 cm. To collect soils drive the augur into the soil by placing a thick plank or a piece of wood on the welded plate, (See the material). Then, hit the plank with the hammer until the cylinder of the augur sinks to the desired depth (1.20 m).

To withdraw the cylinder from the soil, pass an iron rod through the two holes located below the welded plate. Then turn the cylinder by pulling on the two ends of the iron rod. If it turns with ease, we should withdraw it by holding it upright. (Show the demonstration). If there is a difficulty of penetration of the cylinder, then open up a rectangular trench oriented in the East - West direction, that is, in the direction of the rising and setting sun.

Collect from at least 8 different sites of the same piece of land and put the various soil samples together for testing.

How to test
Put a handful of the bulk soil sample in your palm and add a few drops of water on it till the soil is moist but not wet. Roll the soil into a small stick by rubbing it between your palms and observe the following as presented on table below:

Table 1: soil characterization

Soil condition	**Soil type**	**Suitability for cocoa**
If soil particles do not stick together but fall apart	Sandy	not good for cocoa farming
If soil particles do not stick together to form any shape	Silty	not good for cocoa cultivation
If soil particles stick together to form a shape and can be folded like a paste for moulding	Clayey	not good for cocoa farming
If soil particles stick together into a shape but can easily break into pieces in the palm	Loamy	ideal for cocoa cultivation

Land type and Vegetation

Cocoa thrives well in areas where the land is relatively flat but will also do well in areas where the land is not flat. Cocoa can therefore survive in areas of slopes between 0 - 8º and on altitudes from 1-300 m. Cocoa is an understorey crop which means it grows well under shade. As a result, cocoa trees need enough shade cover for two purposes:

- To provide adequate initial (0-3 years) and permanent (after 4 years) shade and organic matter
- To improve soil fertility.

When clearing a field to grow cocoa, farmers should leave permanent shade/timber trees and other vegetation that grows well in association with cocoa and which have economic or household value. In areas where there are no permanent shade/timber~~forest~~ trees, farmers should plant forest trees (e.g., *Terminalia sp.*, *Milicia excelsa*, *Khaya ivorensis*, etc.,) and traditional agoforestry tree species that can fix nitrogen (e.g., *Gliricidia sp.*, *Albizia sp.*, *Acacia sp.*, etc.) to improve soil nutrient content.

When establishing a new cocoa farm, farmers should also plant certain recommended food crops such as plantain, cassava, coco yam, maize, etc., to provide initial shade for newly planted cocoa seedlings and also serve as source of income. In selecting which crops to plant, it is important to choose varieties that provide maximum shade. When an effective initial shade is provided for newly planted cocoa seedlings it protects the seedlings from intense sun light and Mirid attack.

Raising a nursery

Importance

Establishing a successful nursery requires that there is a reliable source of planting material (i.e. seed source) and water close to where the nursery is to be sited. The seed source can be a seed garden where improved planting materials are produced. Seedlings should be raised in the nursery for at least 3 to 6 months. Farmers can establish 2 types of nurseries:

1. Temporary or own use nursery and;
2. Permanent or commercial nursery.

A temporary nursery is appropriate for raising small quantities of seedlings, suitable for a household. A permanent nursery is more appropriate for raising large quantities of seedlings, for commercial use. Therefore, the intended purpose of the seedlings will determine the type of nursery to establish. The following should be taken into consideration when raising a nursery for cocoa and other tree seeds:

Location

- Determine the size of land to be cultivated (for temporary nursery)
- Determine the demand for seedlings and which species are required (for permanent nursery)
- Select a flat area;
- Look for a place closer to sources of water and planting materials;
- There should be a good drainage system;
- Must have access to fertile soil or you should apply fertilizer or compost;
- It must be easily accessible to the nursery operator.
- If possible it must be near the farm

Management

- The nursery needs to be fenced to prevent strangers or animals from entering;
- It also needs to be shaded and maintained very well.
- The nursery needs to be weeded to avoid competition

Nursery equipment

The following equipment can be used in establishing and operating a nursery:

- Pickaxe
- Measuring tape
- Nylon ropes
- Spade or shovel
- Sieve (1,5 cm)
- Ladle for filling in media
- Watering can

- Water hose (rubber pipe)
- Wheelbarrow
- Scissors cut
- Poly bags
- Potting medium
- Seeds

Nursery conditions:

- The soil must be loose and fine structured: this will ensure good contact between the seed and soil; allow water to be supplied continuously, while providing adequate air for respiration by the roots. Most plants germinate well in loamy soils, i.e., soil particles that are not too sandy and not too clayey.
- The medium can be obtained by mixing sand (river sand) and peat (material with high organic matter) and any available soil to provide the desired soil for the seed beds or poly bags
- In large scale nurseries, soils from previous year's seed beds may be contaminated by pathogens and so should be sterilized before use. This may be done by heating or fumigating and requires that the soil be removed and put back after it has been sterilized
- Note that an area of about 9 m x 9 m may accommodate approximately 2,500 seedlings, depending on the size of t he poly bags
- Note that 2,500 seedlings may use an average of 450 liters of water (0.18 liter/seedling) a day if there is no rain
- The thickness of the shade or shed must be adjusted according to type of plant, e.g., if dense shade is used for light demanding plants, seedlings may be thin and weak. On the other hand too little shade may provide inadequate protection against direct sunlight, large temperature changes, drying out, and heavy rains

How to construct a nursery bed

The first step in constructing a nursery bed is to weed, and remove all old plant debris and work the soil thoroughly to root depth. This is easiest when the soil is slightly damp but not wet. Once the seed bed is ready avoid any physical compaction such as walking on the soil.

- Dig, loosen and turnout the soil about half a meter wide. This will loosen the clods in the soil and also allow watering of the bed without stepping on it. The soil surface should have a texture that will not form a crust since this will restrict air circulation and also block emerging seedlings. Soils for sowing small seeds should have finer and more compact soil particles than soils for sowing larger seeds;
- Start the bed with gravel before adding the soil, this will allow water to filter through the soil and make picking of seedlings very easy;
- Raise the bed to a height of about 10 cm to 20 cm, 120 cm wide

and a length of about 2 m in other to allow water to filter through the bed;
- The nursery bed must be leveled;
- The distance between each bed should be 60cm, if more than I bed is constructed;
- Provide shade of about 30-60 cm above seed beds;
- Provide furrows in-between the beds to drain excess water.

Sowing seeds on nursery beds

- Before sowing, water the nursery beds
- Use a string to make lines 60 cm apart along the entire length of each bed
- On each line make holes twice the size of the seed (fresh beans for cocoa) at 5 cm apart
- Sow seeds in the holes
- For cocoa, place beans into the holes with the pointed end up
- Cover the holes and water the nursery beds again
- From then on water the beds twice daily

Using poly bags in the nursery

The soil or materials used in filling poly bags in the nursery is called a planting medium. The medium can be artificial potting materials or soil based potting materials. The importance of the medium is to help the seedlings to grow. Hence, the media should support a healthy root system with enough oxygen, nutrient and water.

Artificial potting materials (mixes)
This involves a typical mix of about 20% by volume of each of the following ingredients:

- Soil,
- Shredded coconut fibre,
- Composted rice husk,
- Burnt rice husk,
- Sand, and
- Dried manure.

If one cannot find rice husk, other materials like cocoa pod husks, coffee pulp, banana peel, and sugar cane bagass can be used instead.

Soil based potting materials (mixes)
Forest soil with good physical properties can be used. Mix about 10% dried manure and 10% organic matter with 80% of sieved soil. Make sure the soil is will loosened and sieved in order to get rid of all the stones and large lumps.

How to sterilize the medium
The potting material can contain a lot of potential harmful diseases and

pests. In order to eliminate these, the medium should be sterilized to get rid of these harmful agents. To achieve this, the following can be done:

- Spread the medium onto a clear plastic sheets and cover with more clear plastic sheet and leave it in the sun for a day or two
- Wet the medium lightly so that steam is produced inside the plastic cover
- Make sure that the medium is not more than 7 cm deep
- The temperature in the medium should reach about 56º C for at least 30 minutes (use a thermometer to check this)

Type of poly bags

Use thin wall black poly bags as the preferred bags for the medium. Use smaller bags (5 x 8 cm) for short nursery periods of less than 4 months and use bigger size (8 x 25 cm) if the seedlings to be raised will be 5 months and longer in the nursery. This is important since the more the soil the more roots come into contact with water and nutrient for healthy growth.

Preparing to sow in poly bags

- Open each poly bag and fill it with the preferred medium and press the mixture so that the poly bag stands firm;
- Make sure that the poly bags are standing upright;
- Arrange the bags in packs of 5 or10 bags wide and 100 bags long under the shade;
- Allow about 50 cm space between two packs. This will serve as paths when the nursery operator is watering and weeding the poly bags

Shade provision

Seed beds and poly bags must be shaded during germination and early seedling stages. For seed beds, shade should be about 30-60 cm high and about 2 m for poly bags to allow for people to easily work under it. Shade or shelters protect seeds and young plants from:

- Direct sunlight;
- Wide temperature changes;
- Drying out;
- Heavy rains.

Fertilizer application

Where fertile forest soil is used for seed beds or as potting soil in poly bags, there is no need to apply fertilizer. But if the planting soil is relatively poor in nutrients, apply fertilizer. The need to apply fertilizer and the specific type depend on:

- The nutrient content of the soil;
- The age and size of seedlings;
- The length of time they will spend in the nursery.

The following must be observed when applying fertilizer:

- Apply liquid fertilizer for young seedlings with a watering can;
- For seedlings in poly bags, apply a few granules to each bag;
- Ensure that granules do not remain on the leaves since this can cause damage;
- Seedlings should be watered thoroughly after applying granule fertilizer to dissolve the granules and ensure root contact.

Hardening off and transplanting

Two weeks before seedlings are planted in the field, watering of seedlings should be reduced to once a day. The addition of fertilizer should also be stopped under nursery conditions to harden the seedlings to enable them withstand field conditions. Shade or shelters can be removed to expose seedlings to full sun light.

Improved planting materials

Importance

Cocoa can be grown by either sowing the seeds or by budding and grafting using other vegetative parts (rootstock, bud woods, etc.) apart from the seeds. A healthy cocoa pod contains at least 30 good seeds for sowing. Clean improved cocoa seeds (Hybrid materials) can ONLY be obtained from a certified seed source, usually a government cocoa seed garden, research institutions and projects.

In the case of rootstocks, farmers can use any tree so long as the tree is healthy looking and the pods are also healthy with good healthy looking seeds (good size and shape) inside. Rootstocks can be obtained from a few trees (rootstock trees), which produce good size seeds from which fast growing and healthy seedlings emerge. When using bud woods as planting material, it should be obtained from recently hardened flushes.

Using seeds as planting materials for cocoa

Farmers are required to use hybrid seeds for new sowing. This means that only seeds from approved mother trees are required since seeds from pods harvested from hybrid trees grown on a farmer's field cannot produce hybrid trees. Trees from these seeds will have lower yields compared to true hybrids obtained from a certified cocoa seed source. Farmers need to know where certified cocoa seed sources are located and obtain seeds from these sources. Note that seeds from hybrid pods are usually available from September to January.

Things to consider when picking good pods

- Look for pods that are healthy and ripe
- Cocoa pods and for that matter seeds cannot be stored for a long time and so seeds should be used 4 days after opening the pod
- Cocoa seeds are easily destroyed by heat and in dry weather

How to prepare the seeds before sowing
In order to get access to the seed the following must be carefully done to ensure safety:

- Open the pod with a wooden mallet or a blunt machete (avoid using a sharp edged tool as this may damage the seed)
- Remove the seed from the pod by separating it from the pulp
- Discard small seeds, damaged seeds and flat seeds

Pre-treatment of seeds before sowing
Seeds can be pre-treated before sowing. This process helps to clean the seeds of foreign materials and also protect it from diseases and pests before and during sowing. To do these seeds, the following can be done:

- Rub the seeds in saw dusts to remove the remaining pulp covering the seeds
- Wash the resulting seeds in clean water and drain
- Seeds may then be soaked in fungicide solution (e.g., Benlate or Dithane) for about 1 minute
- Drain the seeds and place them on a dry tray in a shaded and cool area protected from rain and wind

How to prepare seeds for a short period in storage

Cocoa seeds can stay in storage for a short period say 2-5 days before sowing in the poly bags. In order to do this the seeds should be »washed« using rough saw dusts and cleaned in a process as described below.

1. Spread some rough sawdust on the floor
2. Break each pod and scoop the seeds on the spread sawdust
3. Examine the seeds and remove all bad seeds from the lot
4. Wash the seeds by rubbing them in the rough saw dust to remove the mucilage and seed moisture.
5. Place the seed- sawdust mixture in a basket with holes big enough to separate the seeds from the sawdust
6. Wash the seeds again by rubbing them in fresh rough sawdust and sieve them using the same basket as before to obtain a second stage washed seeds
7. After the second round of washing clean the seeds in a sieve tray using a clean cloth or handkerchief
8. Also hand pick minute dust or foreign particles to clean seeds
9. Smooth sawdust is mixed with water in a mixing tray to moist them. The cleaned seeds are now added to the moist sawdust and mixed evenly
10. The cleaned seed- moist sawdust mixture is now packed in appropriate weight for transport, delivery or storage.

Picture1: Washing of cocoa in saw dusts

Note that in doing the washing, seeds should be in small quantities, e.g., 5-10 pods. This may take about 20 minutes when properly done. Also avoid saw dust with wood chippings and other hard materials since these may damage the seeds. The following materials will be needed to wash 5-10 pods:

- 5-10 Cocoa pods
- Wheel barrow or mixing trays
- Rough sawdust (½ of size 34 bucket – 17 liters)
- Smooth sawdust (½ of size 34 bucket)
- Sieving tray
- Plastic basket
- Bucket of water (½ volume of the bucket)

What is grafting

Grafting is the process in which two plant parts are joined together to form one plant. The upper part of the resulting plant (called the scion) becomes the top of the plant and the lower portion of the plant (called the root-stock) becomes the root system or part of the trunk. The importance of grafting includes the following:

- It changes a large, old tree into a small new tree
- It uses a root system better adapted to soil or climate than that produced naturally by an un-grafted plant.
- By using special rootstocks, grafting is a way to produce dwarf plants with the same qualities as the original trees.

How to do budding in cocoa

This is a method of attaching a bud eye (scion) onto the rootstock of an-other tree (seedling). This is the common method in clone multiplication in cocoa. In order to do budding do the following:

Picture 2: Bud eye from budwood

- The budwood is harvested from a reliable and disease free cultivar.
- The leaves are shorn off (cut off carefully) to have only the bud eyes.
- A healthy rootstock is selected and a transverse cut is made on the rootstock few centimetres (cm) below the joint (coty-ledon).
- A bud eye with same dimension is taken from the prepared budwood and inserted onto the cut made on the rootstock.
- The joint is then tied with a polythene tape to prevent water and air contacts for 14 days (2 weeks).
- The budded plant is placed under a waterproof shade to pre-vent rain disturbances.
- The tape is removed after 14 days and the successful ones are removed and brought into a new shade which is non water-proof to allow rain.

Picture 1: Budded rootstock

Note that: The success is known when the union is intact. After the removal of the polythene tape, the bud eye will begin to develop new shoots. The leaves on the rootstock should be removed to encourage the growth of the new shoot. As the new shoot grows, the rootstock must be cut from the top gradually to a point where it will be only the new shoot which will be seen growing. Young shoots that will sprout on the rootstock **MUST** be removed (rip off) so that there will be no competition.

Grafting techniques

There are two basic grafting techniques. These techniques are determined by the size of the rootstock.

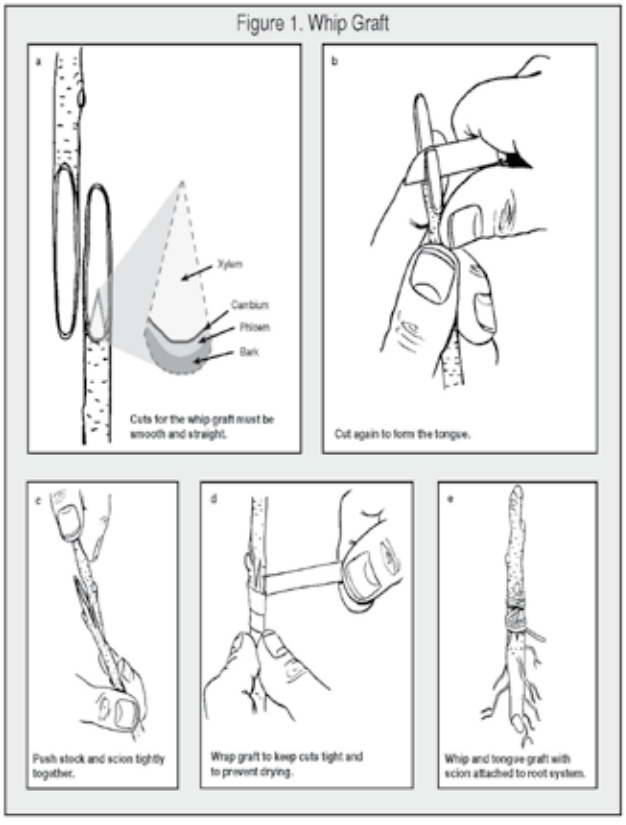
1. Grafting can be done by joining a scion and a rootstock of nearly the same size
2. Grafting by joining a small scion to a much larger rootstock

When the scion and rootstock have the same size

This is possible when the rootstock and scion have a similar diameter, preferably between 1⁄4 and 1⁄2 inch. The rootstock can either be a plant growing in the field or an idle bare-root plant. The rootstock should be smooth and erect. Do not graft near a point where side branches have developed. The scion should be 1-year-old wood, preferably the same size as the rootstock. The scion should never be larger than the stock (see figure 1).

Preparing the rootstock and scion

In preparing both the rootstock and the scion, the cuts made in either of them scion should be the same. On both parts, make a smooth sloping cut 1 to 2.5 inches long depending on the thickness of the material (Figure 1a). Make the first cut with a single, smooth cut with no waves. Use a good-quality, sharp knife for the cut.



Picture1: Figure 1. Whip graft

Cutting the rootstock

The rootstock can be a stem and root system of a seedling or a young plant or a piece of root. To cut, make a slanting cut about 2 inches from the butt (start of root system) of the young whip. The graft is made with a union of two slanting cuts, the strongest graft results from a whip-and-tongue system. To create the **tongue**, hold the one-sided, slanting cut facing you and support it with your finger. About one-third down from the tip of this cut, make a downward cut about 1⁄2 inch long as close to parallel with the grain of the wood as possible.

Cutting the scion

The cutting procedure should be exactly the same as that for the stock. The only difference is that the cuts are made at the bottom of the scion piece, whereas they were made at the top of the stock. The more similar the cuts on the two pieces, the greater chances of a successful graft union.

Fitting the stock and scion

After the cuts are made on both parts, push them together tightly enough so that the cut surfaces match as closely as possible. The area immediately under the bark of both pieces must be aligned for a union to develop.

Wrapping the graft

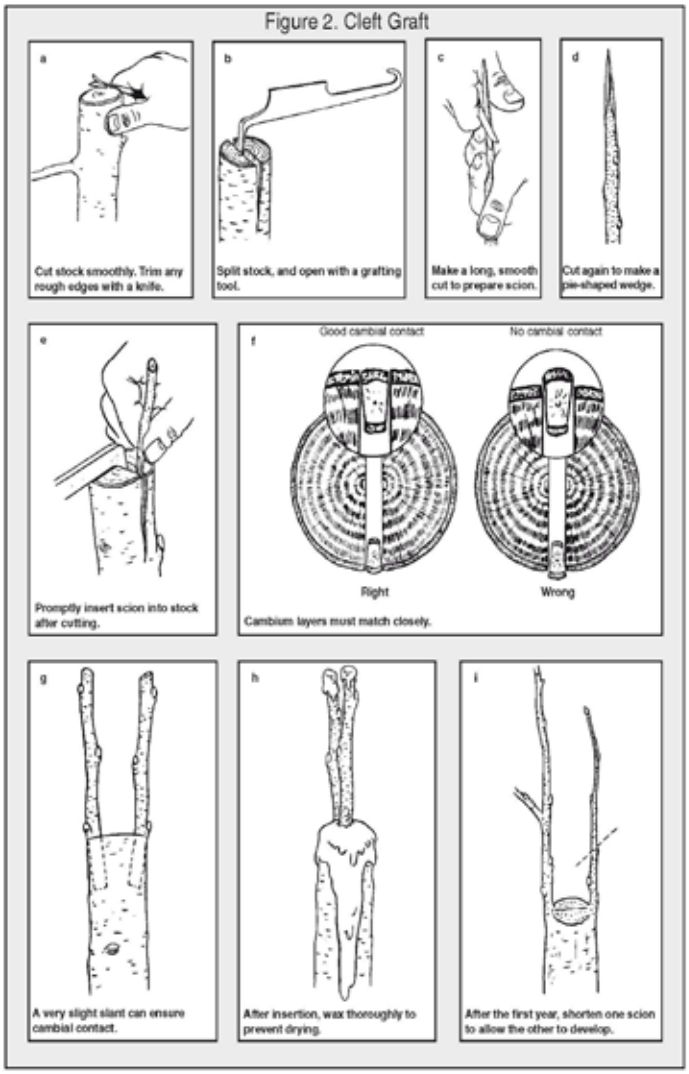
It is important to wrap the graft to keep it tight and prevent it from drying. To do this, wrap the graft with a rubber budding strip, grafting tape or a plastic tape. If the wrapping material does not decay naturally after 1 month, cut it after growth begins.

Waxing

To prevent the graft union from drying, the area should be waxed. Cover the wrapped area with wax as uniformly as possible. In wrapping and waxing, be careful not to disturb the union made.

Grafting of small scion and a large rootstock

This grafting technique (also called cleft grafting) is mostly used to change tree from one variety to another (see figure 2). It can be used on either young or mature trees. Young trees may be cleft grafted on the trunk, while older trees are grafted on branches not more than 21⁄2 inches in diameter.



Picture 2: Figure 2. Cleft graft

Preparing the stock

Branches on large trees or the trunk of a small tree should be cut off to provide a rootstock for the scions. To do this, select a smooth section of the tree. Cut the branch off at a right angle to the grain. Use a knife to trim off the rough edges. Using a grafting tool, or a heavy knife, drive the blade into the stub with a mallet to split the rootstock through the middle so as to create a gap that extends about 2 inches into the branch.

Preparing the scion

The scion for the graft should be made from 1-year-old wood about 1⁄4 inch in diameter. Cut the scion long with three buds so it can be inserted with the lowest bud just above the rootstock - do not use more than three buds; if wood is scarce, two buds should give good results. In doing so, note which part is top and bottom of the scion stick. This is because a scion will not grow if inserted upside down. Start below the lowest bud, and make a long, smooth cut toward the base (Figure 2c). The cut should have a surface 1 to 1.5 inches long. Turn the scion to the opposite side and make a second smooth cut of the same length so that one side (the side containing the lowest bud) is slightly thicker than the other side (Figure 2d). The wedge that is formed does not need a sharp point; a blunt point is preferable.

Inserting the scion

With a grafting chisel or a small wedge, open the crack wide enough to insert the scion easily (Figure 2e). Insert the scion with the thicker side toward the outside (Figure 2f). When inserting, give it a slight slant to help ensure contact (Figure 2g). The best contact point is about 1⁄4 inch below the shoulder of the stock. After properly positioning the scion, remove the wedge or chisel from the opening. Insert two scions in each opening made, one at each side. This gives a better chance for getting at least one graft to grow.

Waxing the cleft graft

The graft should be waxed so that all cut surfaces are covered (Figure 2h). Cracks sometimes develop as the wax sets. Check wax after a few days and again after several weeks to ensure that all surfaces are kept covered.

Caring for the graft

After the graft begins to grow, it must also be given attention. During the first season, don’t prune branches that grow. Grafts that grow vigorously may need to have the tips taking off to stimulate branching. Cleft grafts should grow vigorously and need only light pruning to shape their development (Figure 2i). Never prune heavily. If both scions in a cleft grow, shorten one to allow the other to develop and become dominant. Do not remove the second graft until later, because it will help to cover the wound faster.

Grafting on large trees

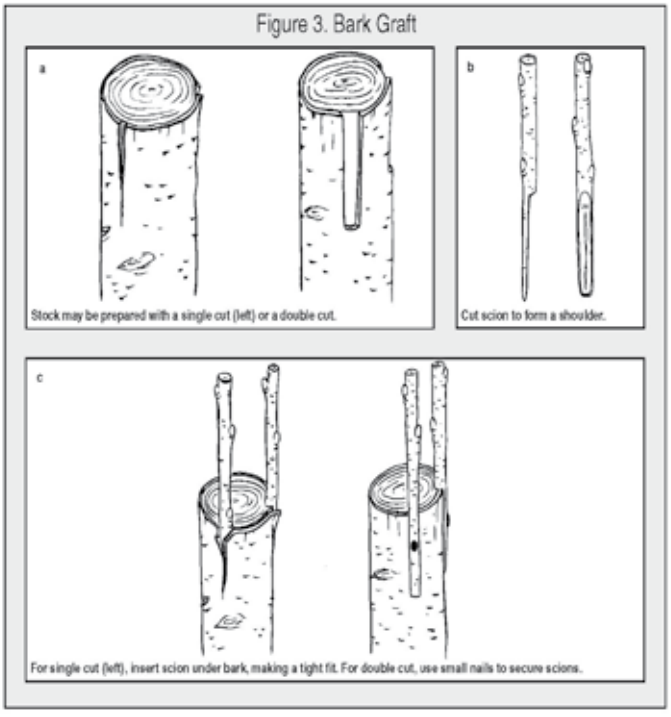
To graft on a large tree (**topworking) t**he best time is just as growth begins in the beginning of the rain season. However, it can also be done several weeks earlier or later.

Bark graft

Bark grafting (Figure 3) is relatively easy and requires no special tools. It is similar to cleft grafting and may be done on branches ranging from 1 inch to several inches in diameter.

How to prepare the Rootstock
The branch or trunk is cut off at a right angle in the same manner as described for cleft grafting. The bark graft can be made only when the bark slips or easily separates from the wood. This usually is in early spring as growth begins. Different techniques can be used on the rootstock for the bark graft (Figure 3a). These include:

Making an opening in the bark about 3⁄4 inch long
Making two openings in the bark separated by the width of the scion.



Picture 3: Figure 3. Bark graft

How to prepare the scion

Collect bud woods (scions) and wrap them in paper towel to prevent drying. The scion should be 4 to 5 inches long with two to three buds. Prepare the base of the scion by cutting inward 1.5- 2 inches from the base then downward, forming a shoulder and long, smooth cut (Figure 3b). The long cut should extend about one-third through the twig, keeping its base strong

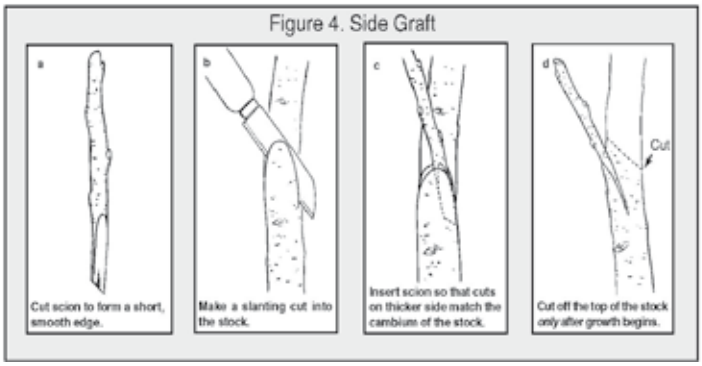
enough to insert but not too thick. On the side opposite the long cut, make a short cut to give the base of the scion a wedge shape for easier insertion.

Inserting the scion

Use a knife to lift the bark at the top of the opening. Push the scion down the middle in the opening. Insert the scion until the shoulder rests on the stub (Figure 3c). If the scion is large enough, one or two small nails may be used to tighten the scion to the stock. Use tape to pull the surfaces tight. If the bark does not split or tear, nailing or wrapping is not necessary. In all cases, the graft should be thoroughly protected with wax over all open surfaces after it is completed.

Side graft, stub graft

Side grafting is suitable for plants that are too large for a whip graft but not large enough for cleft or bark grafts (Figure 4). The plant or branch that will serve as the rootstock should be between 1 and 2 inches in diameter. The material for the scion should be about 1⁄4 inch in diameter.



Picture 4: Figure 4. Side graft

How to prepare the scion

The scion should contain two to three buds and be about 3 inches long. Make a wedge at the end of the scion similar to that made for cleft grafting, but it should be shorter (Figure 4a). Make one side slightly thicker than the other. It is not necessary to make the cuts more than 1 inch long. The cuts must be made straight and smooth, with a single movement of a sharp knife.

How to prepare the rootstock

Select a smooth area near the base. Use a sharp knife to make a slanting cut into the rootstock cutting (Figure 4b). The cut should angle downward and extend about halfway through the branch.

Inserting the scion

Pull the upper part of the stock back to open the cut. Insert the scion into the open cut with the slightly thicker side. Put the scion at a slight angle to give maximum contact (Figure 4c). When the top is released, the scion should be held in place, so no tacking or wrapping is necessary. The rootstock or branch should then be cut off 5 to 6 inches beyond the graft. Also, remove any lateral branches on the stub that might crowd the graft as it be-

gins to grow. Wax the graft carefully so that all cut surfaces are covered. The tip of the scion, as well as any open wounds made by removing lateral twigs on the branch, should also be waxed. After several weeks, when the scion has started growth, the remainder of the stock should be carefully cut closer to the graft, and the new cut should be waxed (Figure 4d).

Reasons for graft failure

The following reasons will account for graft failure:

- The rootstock and scion were not compatible
- The scions were inserted upside down
- Grafting was done at the wrong time
- The rootstock or scion were not healthy
- The scions were dried out or injured by bad weather
- The scions were not dormant
- The graft was not properly covered with grafting wax
- The scion was displaced by storm, birds or other means
- The graft was shaded too much by other growth
- The graft was attacked by insects or disease
- The graft union was girdled because tape was not cut or released in time.

Collecting bud woods for grafting and/or budding

It is important to follow key practices when grafting to ensure that grafting is done well in order to get a high success rate. Grafting can be done in the latter part of the dry season or early parts of the rainy season before new growth begin. Avoid grafting in very hot and very dry days, and also in very wet days. Make sure the rootstock is of the right age before grafting. Before grafting:

- Collect bud wood from green brown wood (recently hardened flush) and wrap with paper towel or jute sack and store in a cool, moist place
- Do not collect bud wood from trees that are recovering from heavy cropping (harvest)
- Make sure that the bud wood is of the right age and thickness for the rootstock
- Use bud wood within 2 days of harvest
- Use bud wood with active buds

Equipment for grafting/budding

Grafting tool. Specially designed tools have been developed for grafting. It has a blade used to split the stub and a wedge to hold the split open while the scions are inserted. If this tool is unavailable, use a heavy knife and a fairly wide wedge, at least 2 inches long, for cleft grafting. Use a mallet or hammer to pound the grafting tool or heavy knife into the stub. Split the stub and insert the wedge to open the split.

Knife. A good-quality knife is the key to good grafting. Although special grafting and budding knives are desirable, you can use almost any good pocketknife. Obtain another material to sharpen the knife always.

Picture 7: Tools for grafting/budding

Grafting wax. After the graft is made, it is important to cover it so that it does not dry out. Either hand wax or brush wax may be used. A hand wax is most commonly used for home grafting. It is softened by the heat of the hand and can be easily applied. Heated waxes may be brushed on, but make sure the wax is not too hot. Heat could damage some of the plant tissues.

Grafting tape. This is a special tape with a cloth backing that decomposes before girdling can occur. Tapes may be used for binding grafts where there is not enough natural pressure. Electrical and masking tapes are also used. Masking tape is suitable where little pressure is required.

Budding strips. Budding strips are elastic bands that are used to secure several types of grafts with small stocks and scions.

How many cocoa seeds do I need for sowing?

Number of seedlings needed in the field is determined by the following factors:

- Size of land (planting area)
- Tree spacing and planting design
- Percentage of seedlings survival during transplanting in the field
- Percentage of seedlings establishment in the field

Hence, to plant a given area, e.g., 1 hectare of land (equivalent to 10 000 m^2) with cocoa, farmers need to know how many pods and for that matter seeds they need to use. This requires converting the number of acres or hectares

to be planted annually to amount of seeds to be used. In order to know the quantity of seeds to be used, the farmer needs to know the definite planting distances, which is an indication of the number of trees per unit area that will result in the quantity of seeds needed.

For instance, to plant a hectare of land using a recommended planting distance of *se* 3 x 3 meters, the following calculations can be made:

Assuming we choose a planting distance of 3 x 3 m, and each seed represents a tree, then it implies that each tree will occupy a space of 9 square meters (m^2)

i.e., 3 m x 3 m = 9 m^2/plant

Note that a hectare of land is 10 000 m^2, hence at a planting distance of 3 x 3 m, the number of trees will be

(10 000 m^2) / (9 m^2) = 1111 plants/ha

Note that it is important to sow more seeds than is required, as not all seeds will germinate. It has been proven that 15-30% of seeds sown will not survive. Let us assume that the figure is 20%, and then the number of seeds to be sown to produce the required number of trees will be

(1111 plants/ha) + (1111 plants/ha x 20/100) =
1111 plants/ha x 1.20 = 1333 plants/ha

Note that not all seeds sowed on nursery beds germinate. This may be due to trampling, pricking out or transplanting and culls. Therefore, nursery losses may require sowing of at least 1.5-2 times the number of plants required per unit area. Assuming only 50% of the good seeds become trees, then

1333 plants/ha x 2 = 2666 good seeds/ha

Every quantity of seeds (seed lot) has its average germination percentage and purity. Germination percentage (GP) gives an indication of how viable a given amount of seed is. It is simply how many of a given quantity of seeds will germinate out of the total quantity and it is expressed as:

GP = SEEDS GERMINATED/TOTAL SEEDS X 100

Assuming the given seed quantity has germination percentage of 70% and purity to be 90%, then the amount of viable seeds will be

(2666 good seeds/ha) / (0.7 x 0.9) = 4231 seeds/ha

Now, knowing that to plant a hectare of land at a planting distance of 3 m x 3 m will require 1111 trees. To plant 1111 trees/ha will require 4231 healthy seeds that will germinate and survive. In order to know the number of

pods, we assume that one healthy pod contains 30 healthy seeds. This then puts the number of pods needed per ha as

(1 pod x 4231 seeds/ha) / (30 pods) = 141 pods/ha

Table 2: species conversion from spacing to kg seeds per ha

species	Spacing m x m	No. of plants/ha	Field mortality %	No. of plants/ha + replacement	Nursery Mortality %	No. of good seeds to sow/ha	Germination %	Purity %	No. of seeds/ha	30 Seed/pod	No. of pods
T. cacao	3 x 3	1111	20	1333	50	2666	70	90	4231	1	141

Preparing to establish cocoa in a new field

Importance

In order to establish cocoa farms, most farmers clear and/or burn existing forest, and in the process either thin or completely eliminate the over-story trees to make growing space for their cocoa and food crops. Most farmers who establish their farms this way often do not follow the appropriate recommended planting arrangements of the different components of plants per unit area. As a result, it limits the yield potential of the various crops, especially cocoa.

Hence, before planting cocoa in the field the following activities should to be carried out properly:

- Land preparation
- Lining and pegging
- Spacing
- Planting temporary shade
- Shade management

Land preparation

Cocoa can be planted on fallow land or land occupied by other food and tree crops. Where farmers use fallow areas, the underneath vegetation should be cleared at the end of the wet season or as soon as the dry season starts. This initial clearing makes it easy to fell undesirable trees before cocoa is planted. The resulting debris (biomass) can be burned or left to rot.

Burning however can destroy a great deal of potential humus in the soil since it results in the release of large amounts of ash causing imbalance of nutrients in the soil. It also exposes the soil to erosion, which can lead to losses of organic matter. In many situations burning causes the invasion of some obnoxious weeds like *Imperata cylindrical* and *Chromolaena odorata*, which turn to negatively affect the productivity of the land.

Farmers can do selective burning (i.e., burn in small heaps) or avoid burning completely and manage the debris (biomass) such that after most of the big trees have been cut into pieces and carried away as fire wood the remaining is left to rot in the soil to add organic matter to improve the soil.

Lining and pegging

Lining and pegging at the recommended spacing will give more income on cocoa yield per unit area. To do 'Lining and pegging' on a field, place a peg at a reference point and with a rope tied to the peg make a horizontal

base line to the edge of the land, about 100 m. From this peg, and on the horizontal base line, mark the recommended spacing for each crop to be planted and put a peg at every mark. Repeat the process vertically till the whole farm is pegged.

Spacing

Every country has adopted a recommended spacing regime for planting food crops, fruit and timber trees. These recommendations are related to the climate, type of planting material, shade conditions and soil type. In Ghana for instance, recommended spacing for planting hybrid cocoa seeds and plantain is 3 x 3 m resulting in 1111 cocoa trees and 1111 plantain per hectare. Spacing affects the shade conditions on cocoa farms. Spacing also plays a role on certain diseases (Black Pod) and pests (Mirid) in cocoa.

For instance, when seedlings are widely spaced and there are gaps in the canopy, there is a higher chance of *Mirid* attack on trees. Black pod is more likely to develop when cocoa trees are closely spaced resulting in high humidity under the dense canopy.

Shade management

Cocoa needs a well established shade level at all stages of its production cycle (young, mature and old) to protect it against:

- Pests
- Diseases
- Drying out

Soil conservation

Importance

Soils have many important functions. One of the major functions is that it serves as a medium for crop growth. This is because the soils natural processes ensure that the soil can provide adequate physical, chemical and biological qualities for crop growth. Hence, when farmers manage the soil well it enhances the natural processes to facilitate adequate conditions to improve crop growth and yield.

However, in perennial crop systems like cocoa cultivation, soil erosion can be considerable with inappropriate land-clearing methods such as complete clear fell of secondary forest and with insufficient soil cover immediately after forest clearance. Soil erosion is likely to occur during land preparation and when the tree crop is immature. Erosion is greater during the initial stages of cocoa establishment than when the cocoa tree canopy is fully developed.

Why soil erosion is bad for your cocoa farm

Soil erosion occurs when wind or water washes away the topsoil from an area of land because it is bare. It is important to prevent soil erosion, because land that has been stripped of its topsoil will not support any kind of plant life.

The negative effects of soil erosion are many. When the topsoil is washed away, it takes with it nutrients that plants need to grow well. It can also cause gullies in the field, which makes it harder to create a level planting area. The surface of the soil that is left will crust more easily, which makes it hard for seeds to germinate, and hard for rainwater to be absorbed by the soil. Soil erosion can also damage water bodies. This is because when excess soil is washed into rivers and streams, it can disturb the delicate balance that is needed for the aquatic ecosystem to survive. The soil may also contain herbicides and pesticides, which can be very harmful to fish and animals that live in these bodies. This can go a long way to affect the health of humans depending on these water bodies.

How to control soil erosion

The amount of soil erosion that occurs in an area depends upon three factors, which are

1. The slope of the land – steep slopes promote intense erosion;
2. The density of plants growing on the soil – the more plant cover there is on the soil, the less intense the erosion and;
3. The speed with which water and wind travel across the soil surface.

Plants protect topsoil in many ways, allowing for soil to be conserved. This is because they reduce the heavy impact of rain drops on soil. Plants also prevent the soil from drying out as quickly, thereby protecting soil particles

from being blown away by strong winds. The roots of the plants hold the soil in place, so it's not washed away as easily. Fortunately, there are several well established measures to prevent and control soil erosion on farms.

These include:

Conservation tillage: This simply means to leave a portion of vegetation on the ground, instead of stripping everything away.

Contour farming: Do not plant cocoa on steep slope (slopes beyond 15º) since this will hasten soil erosion. However, if the land happens to be on a slope practice contour faming since it helps to prevent and control soil erosion by water runoff. This is done by planting trees or hedges along the slope of a hill, following the natural contours of the land, instead of straight up and down or across.

Planting cover crop: This protects the soil and sometimes provides nutrients to the soil when nitrogen-fixing crops are used.

Planting wind break: This protect the soil against strong winds. It involves planting rows of trees, and hedges around the field or in the field.

Improving soil nutrient: improving the soil fertility prevents soil erosion. Soil that is rich in organic matter has better structure and is less susceptible to being washed or blown away. To keep your soil healthy, add plenty of compost each year and don't over-till when you are planting.

Adding mulch to the soil: putting a layer of mulch on the surface of the soil prevents the soil from being blown away or washed away by erosion.

Whatever it is, it is better to prevent soil erosion than to control it. This is because. Once an area of land has been eroded, it's sometimes impossible to correct it.

Soil fertility management on young cocoa farms

Making compost

Composting involves using waste materials from the household such as cocoa pod husks, cassava, yam, sweet potato peelings) to make a type of fertilizer. Making compost takes a lot of work and transporting the compost from where it is made to the cocoa farm may be a problem for some farmers. Composting may therefore be appropriate for farmers who have small cocoa farms near their homes or who can make compost on the farm. Compost can be applied to the planting hole when planting cocoa or to mature farms if you can produce enough compost.

You can make compost with a mixture of many materials including cocoa pod husks, empty oil palm fruit bunches, wood ash, charcoal dust, rice straw, poultry dropping, cattle manure, sheep manure, corn stubble or any other waste available in large quantities. Cocoa pod husks contain a lot of

potassium which the cocoa trees remove from the soil. One way of getting potassium back into the soil is to make compost using pod husks and other materials. Normally pod husks are just left on the farm in huge piles. By making compost with this material, you can improve soil fertility. If you are using cocoa pod husks, you need to mix the husks with other materials. Do NOT use newspaper or other types of paper.

You can decide whether you want to make a hot compost pile or a cold compost pile. Hot compost »cooks« faster, but you do have to turn it and monitor it. The heat that is created during the composting process kills diseases (for example, black pod), weed seeds and other harmful materials. This is why it is important to only use mature compost. Making cold compost takes a longer time.

Procedure for making compost
It is best to make the compost heap near the cocoa farm.
Select a location that is sheltered from the sun and rain.
Cut or shred all raw materials into smaller pieces/sizes (5-10 cm). Do not use too much of one material.

Compost heap
The simplest method for making compost is the heap method. If you are composting cold and not using a container, build a bottom framework of sticks and larger twigs. Alternate layers of green materials (kitchen scraps, freshly cut grass and fresh manures) and brown materials (shredded cocoa pods, leaves and straw). You can continue to add layers to the pile, occasionally building in a layer of sticks. The layer made of sticks allows oxygen into the pile that helps the bacteria and other soil organisms that will eventually break down the materials in the pile.

Compost bin
Construct a rectangular bin (1m x 2m x 0.8 m) using strong sticks at the corners and use palm fronds sticks to form the horizontal crosses. Insert palm fronds in between the horizontal cross

Compost pit
Measure an area of 1.5- 2 m wide and any convenient length, depending on how much material is available. It is best to dig a shallow trench, about 30 cm deep. Put the top soil to one side of the trench.

Heap the moistened raw materials into the structure in layers, starting with a layer of plant material if available. The first layer should be about 30 cm. Following layers can be about 10-20 cm thick. You can put some of the top soil between one or two of the layers. To complete the pile, cover it with a layer of top soil and a cover with dry vegetation. Make sure that the cover does not cut off air circulation. The final pile should be 1-1.5m.

Preparing compost
Check the pile to make sure it stays moist but not wet. Add water if necessary.

Mix the raw materials every two weeks to mix in air and check the temperature.

To check the temperature, insert a long, sharp stick into the middle of the compost heap for about 5 minutes. If the stick is hot or warm, the compost is not matured. If the temperature of the stick is cool, the compost is matured. Well matured compost should smell like fresh earth and none of the raw materials except for stalks or branches should be visible. It takes about 3-4 months to prepare compost.

Applying compost on a cocoa farm
Broadcast the compost around the trunk of cocoa trees in March-April (before the rainy season starts) or in July-August. Never apply compost during the dry season. You can apply both mineral fertilizer and compost at the same time. If you do not have enough compost to cover the whole farm, apply compost to one part of the farm one year and then to the other part of the farm the following year

Mulching

Mulch is any cover or item placed on the surface of the soil in order to reduce evaporation (loss) of water from the soil, prevent soil erosion and control weed growth. Mulching is important in young cocoa farm (up to 3 years) but is not necessary in mature farms where fallen leaves act as mulch. A nice, thick layer of mulch will perform the following functions.

- It covers the soil and prevent weeds from germinating
- Mulch helps to hold and retain soil moisture
- It keeps the soil cooler in hot weather
- It provides the soil with nutrient
- Protects the soil against erosion

Types of mulch
Most types of mulch are organic in nature, so they provide nutrient to the soil while suppressing weeds and maintaining soil moisture. Examples of mulches are:

Shredded or chipped bark
This material does not break down easily and so it takes a long time before new ones can be added. Any wood when chopped into pieces can be used to create this type of mulch. Bark mulches can be used in many ways; however it is especially useful around trees and shrubs.

Chopped leaves or whole leaves. They break down fairly quickly and provide plenty of nutrition to the soil.

Straw. It breaks down fairly quickly.

Grass clippings. They break down very quickly, and, because they break down so fast, can actually heat up the soil rather than cooling it down.

Cocoa husks. This provides good mulch except that it has the tendency to develop mould in humid or wet weather. Avoid using diseased husks.

Compost. This can also serve a mulching material. It provides more nutrients to the soil and increases microbial activity. It will need to be replenished fairly often (at least once a year).

How to apply mulch
When using mulch, it is important to apply enough. To smother weeds and retain soil moisture, a two to three inch layer of mulch is necessary. Less than two inches of mulch will let enough light through to allow weed seeds to germinate. In addition to applying the right amount of mulch, it is necessary to make sure that it does not come into contact with cocoa seedlings or other plants in the field.

Pull the mulch back from stems of the trees. Allow an at least an inch of space between the plants and the mulching material. When mulch is applied up against a plant, it can hold moisture and cause the plant to rot. It can also attract termites which can damage the plants. Use organic mulches, because they break down and improve the soil.

Planting temporary and permanent shade in cocoa

Importance

In order to establish a good and reliable temporary and permanent shade cover for cocoa, food crops like cassava and plantain, and timber trees should be planted a year before the cocoa seedlings are planted. By so doing it reduces the risk of losing seedlings due to harsh field conditions like heat and mirid attach.

However, if farmers are faced with time constraints, food crops and timber trees can be planted 3 months before cocoa with the first rains in early March to ensure that they establish well before cocoa seedlings are transplanted to the field in June the same year.

Young cocoa trees (0-3 years) require shade levels of about 70% (30% sunlight) and mature and old cocoa trees (4 years and beyond) need about 30-40% shade (70% sunlight). To create a well established shade level, use the following spacing regimes for the corresponding crops and trees:

- Plantain : planted at 3 x 3 m rectangular spacing, resulting in 1111 plantain suckers per hectare
- Cassava: planted at 2 x 2 m rectangular spacing, resulting in 2500 cassava cuttings per hectare
- Timber trees: planted at 12 x 12 m triangular spacing, resulting in 69 timber seedlings per hectare
- Nitrogen fixing trees like *Gliricidia sp.* : planted at 6 x 6 m triangular spacing, resulting in 277 *Gliricidia* seedlings per hectare

Note that food crops such as plantain and cassava can be planted together with *Gliricidia sp.* (planted at 6 m x 6 m) to provide temporary shade (70% shade) for the young cocoa trees.

For plantain, dig holes at 3 m x 3 m intervals from each other in the same row where you intend to plant the cocoa and place the cocoa seedlings at 1.5 m from the plantain. Holes for the plantain should measure 20 x 20 cm in width and depth. Put the first 10 cm of the top soil at the bottom of each hole and place a sucker in it. Cover the sucker with the rest of the soil.

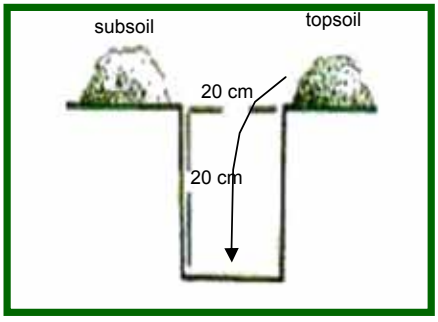


Figure 5: hole for planting plantain

In between the plantain and cocoa rows, plant cassava cuttings at a dimension of 2 x 2 m from each other and 1.5 m in between rows of the plantain and cocoa.

If you plant both plantain and cassava or two other food crops, the farm should look like the following diagram:

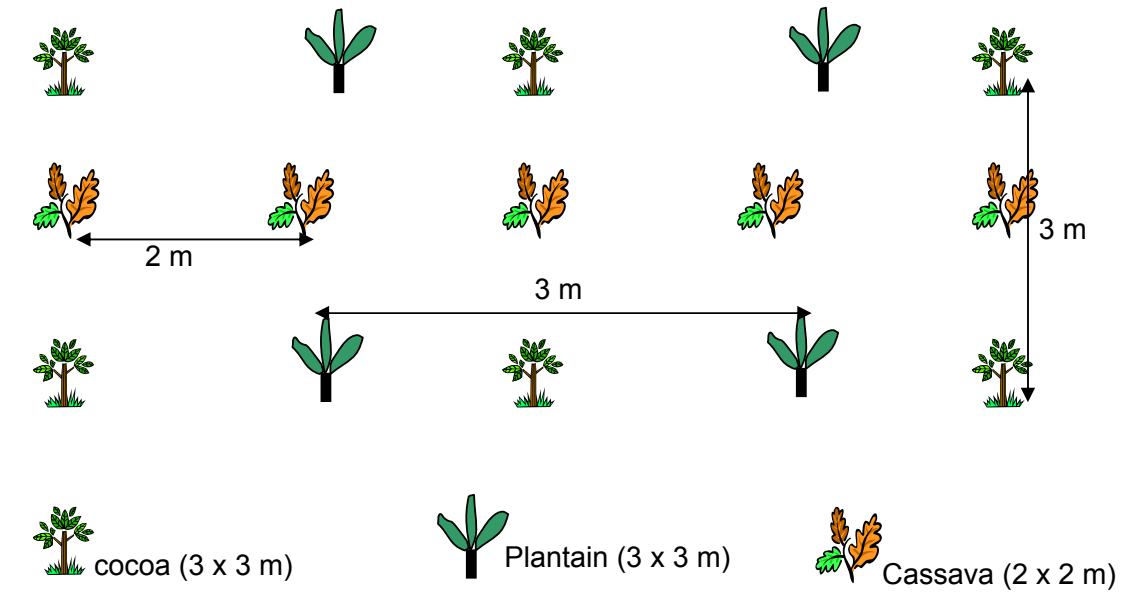


Figure 6: Food crop arrangement with cocoa

Planting of high value timber trees (see section on tree diversification) to provide permanent shade at 12 x 12 m alongside food crops is crucial. In situations where farmers can not afford to plant permanent timber trees, they can thin the existing vegetation before planting cocoa.

However, the use of thinned or reduced forest trees for shade in cocoa has some disadvantages. Firstly, shade provided by existing forest is not uniform and is more difficult to control and adjust than planted shade. Secondly, existing forest trees do not fall into planting lines and this causes problems if one wants to move between rows with a tractor or a spraying machine.

Treating plantain suckers before planting

Fill an empty oil barrel/drum with water to ¾ of its capacity and place it on a furnace until the water starts to boil. Carefully remove any rotten materials attached to the plantain suckers with a machete.

Tie each end of 2 ropes in the middle of each pole, leaving a 10 cm gap between the ropes. Fix the loose ends of the ropes to one end of the basket with 10 cm gap between the ropes corresponding to the same distance on the pole. Repeat the same process with the second pole and fix the loose ends of the remaining 2 ropes on the opposite side of the same basket.

Figure 7: Removing rotten materials with a machete

PHOTO: S. HAUSER

Figure 8: Placing suckers into boiling water

Hold the poles at each ends and lift the basket. Place the plantain suckers in the basket. Lower the basket with the suckers into the boiling water. While the basket is in the boiling water, count up to 30 seconds. Make sure not to keep the suckers in the water longer than 30 seconds as this will destroy them. After 30 seconds, lift the basket from the boiling water and place it on the ground. Repeat until you have completed all the suckers. Plant the suckers after the hot water treatment.

Treating cassava cuttings for planting

To select healthy cassava sticks for planting with cocoa, pick plants that have:

- Robust stems and branches
- Erect stems and have higher branches
- Abundant leaves (foliage) especially in the dry season
- Minimal stem and branch damage by pest and disease
- Good ground storability, i.e., the ability of the mature cassava roots to stay in the ground for a long time (2 years) without spoiling

Before planting, use a machete to make cuttings from the middle brown-skinned portion of the original stem. Cut each stem into 20-25 cm long pieces. Each piece should have at least 5-8 nodes. If the stem cuttings are slightly infected with a stem-borne disease, immerse them in heated water (12 liters of boiling water plus 12 liters of normal water) for 5-10 minutes in the 28 cm^3 plastic bucket.

Planting cocoa in the field

Importance

Cocoa seedlings should be planted from the month of April to July (during the rainy season). However, hybrid pods (improved planting materials) obtain from seed gardens are mostly available from September to January. Therefore to plant improved planting materials requires that the seedlings have to be raised in a nursery for a period of 3 to 6 months before transplanting to the field. Cocoa farms can be established from:

- Seedlings raised in poly bags in nurseries
- Seedlings raised on nursery beds and transplanted as bare-roots
- Planting seeds at stake, directly in the field.

Planting seedlings raised in poly bags

Transplanting seedlings from poly bags is hard work and requires a lot of labour, especially when seedlings have to be transported over long distances from the nursery to the field due to the bulkiness of the bagged seedlings.

When planting cocoa seedling from a nursery, make sure that the shade conditions in the nursery are approximately the same as in the field where they are to be planted. If there is less shade in the field compared to the nursery, reduce the shade the nursery 2 weeks before transplanting the seedlings.

Method:

- Water the seedlings heavily the day before transplanting
- In the field and at a spacing of 3 x 3 m, dig holes, which are large and deep enough to contain the poly bags used
- Dig holes (bigger than the poly bag) well in advance (at least 2 weeks) before planting seedlings. This will allow the holes to settle (siltation) properly to ensure that seedling fits properly in the hole. This will maintain the same soil level in the field as nursery conditions
- Remove the bags carefully in order not to lose too much soil around the roots and place the seedlings in the holes
- Cover each hole firmly with the same soil dug from it and make sure that the soil level is the same as under nursery conditions
- Do not heap soil around the stem of the seedling above the stem collar to prevent moisture getting in contact with the stem which will lead to rotting of seedlings in the field
- Planting bare-root seedlings
- Transplanting seedlings raised direct on nursery beds (bare-root seedlings) cuts down on labour and inputs costs.

Method:

- In the field dig planting holes just as described above
- Remove the seedlings with plenty of soil around the roots using a machete and carefully place them in the holes
- When transporting seedlings for transplanting, ensure that the roots have enough moisture around them until they are planted. One way of doing this is to dip the roots in a container filled with mud or cover the roots with wet jute sacks.

Planting at stake

Fresh cocoa beans can be planted direct in the field. This method is often used by farmers who lack the resources to buy inputs for raising seedlings in the nursery or who are late in raising seedlings in the nursery due to time constraints. The initial performance of such seedlings is generally lower compared to seedlings raised in nurseries since they suffer from competition with weeds and rodent damage.

Method:

- Dig a hole twice the size of the fresh beans with a hoe or cutlass
- Put 1 or 2 beans in each hole and cover with soil
- Remove one of the seedlings at the four leaf stage and plant in a different hole at the correct spacing

Managing a young cocoa farm

Importance

Young cocoa farms (0-2 yeas) are vulnerable. Hence there is the need to proper manage the trees and soil by managing shade and weeding; mulching to conserve soil; formation or structural pruning; managing pests and; applying fertilizer.

Managing shade/weeding

- Provide adequate temporary shade (70%)
- Brush the undergrowth as often as possible (4-6 times a year) to protect the young trees from weeds and pests
- Replace all dead seedlings within the first two years of planting

Mulching

It is important to protect the soil during the early establishment of cocoa. Materials that can be used as mulch include cocoa pod husks that have been cut up into small pieces, grass, branches pruned from cocoa trees, weeds and straw. When using cocoa pod husks, make sure to use only pods that are not affected by black pod disease. Cut the mulching material into small pieces with a machete. Spread the material 1 meter or more from the trunk of cocoa trees.

Pruning

In young cocoa, formation or structural pruning is done to make sure that the tree has the right shape and height so that field operations (such as harvesting and spraying) can be easily carried out. Cocoa trees form the first jorquette after 2 years at a height of about 1.5 m.

Remove the first jorquette after the second has formed – this is called raising the skirt. This results in smooth tree trunks, easy access to pods and free movement in the cocoa field. In addition, remove all side shoots (chupons) that grow on the main stem before first jorquette formation. This will lead to the growth of a strong and robust main stem.

Managing pests

Mirids **(capsids)**
Mirids are insects that damage young shoots and cocoa pods thereby reducing the yield of cocoa. Young cocoa trees are very vulnerable to mirids attack. To reduce mirids damage, ensure that there is adequate shade on very young cocoa (see previous sections on the description of shade).

Termites

Termites attack young cocoa trees between 6-36 months during the dry months of the year (December to March). During this period examine cocoa trees for the following signs of infestation:

- The presence of runways, which are often covered along healthy-looking stems
- The presence of deep bites on fresh stem, often reaching the woody portion
- Stems filled with soil after the termites have eaten away the inner wood
- Wilting leaves hanging on infested plants
- Presence of termites, including small ones in the roots
- Fallen seedlings suspected to have been cut down by termites

To control termite attack:

- Avoid mulching in areas where there are a lot of termites
- Maintain general farm hygiene by weeding and pruning
- Destroy termite hills within and around the farm location
- Apply termicides (chemicals to kill termites) in severe cases

Applying insecticides

- Where and when necessary protect the young trees from *Mirids* damage by spraying with recommended insecticides at the right time (e.g., spray in August, September, October and December)

Applying fertilizer

- In previously used soils apply Nitrogen based fertilizer
- For trees 6-18 months old apply 70g or a match box full of Sulphate of Ammonia fertilizer on the soil surface in a circular band about 15 cm from the base of the seedling – the best time of application is the beginning of the rains (April/May)

Tree diversification in cocoa

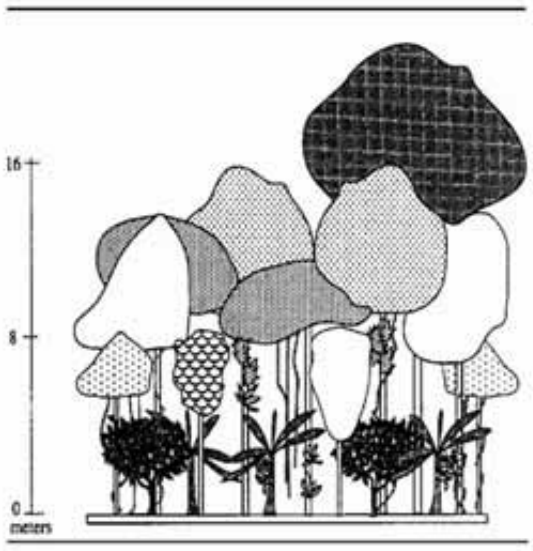
Importance

Tree diversification is the active planting and/or retention of non-cocoa plants in cocoa fields at various ages and stages of the cocoa farm for economic and environmental gains (Picture 6 below). Tree diversification in cocoa can occur in different forms in different agro-ecological zones depending on:

- Market for tree products,
- Planting material availability and
- Cultural practices

To diversify cocoa farms, farmers can go through the following five-step demonstration learning process with the help of experts (facilitators) to integrate non-cocoa tree species in a definite pattern at different stages and ages of a cocoa farm. The five-step process includes the following:

1. Identifying tree diversification options
2. Selecting desirable non-cocoa trees for cultivation
3. Developing a tree diversification farm map
4. Accessing planting materials for non-cocoa trees
5. Preparing farm for tree planting and planting selected desirable non-cocoa trees.



Picture 6: Cocoa farm with different canopy levels

Tree diversification steps in cocoa

1. Identifying tree diversification options

To identify a good tree diversification option, farmers need to understand the basic concept behind the process. This implies that the facilitator together with farmers need to define tree diversification as it pertains to cocoa farming in the particular area, and also translate terminologies and technical expressions into local dialects to ensure easy understanding. This process can take place at a workshop with key informants (facilitators and farmers) with local knowledge on trees in the particular area.

Box 1: some useful technical terms related to tree diversification

Tree diversification
Tree diversity
Desirable tree
Bad trees in cocoa
Good trees in cocoa
Good shade cover for cocoa
Shade tree
Temporary shade trees
Permanent shade trees
Early/New cocoa establishment
Young cocoa establishment
Mature cocoa establishment
Old cocoa establishment
Abandoned cocoa farm
Soil moisture
Soil fertility
Weeds
Damage to cocoa
Windbreak
Air circulation
Good timber value
Beneficial products from shade trees

Farmers can have three major options for tree diversification when growing cocoa. These may depend on the:

- Age and stage of the cocoa trees,
- Markets for products, and
- The availability of planting materials
- Suitability of a tree as companion tree

The options include food crops, other fruit trees apart from cocoa, and/or timber trees, non-timber forest product (NTFP etc.,) all with cocoa. The options can be for agronomic and economic gains. In whatever form these options may occur, the crops and other plant species exist in a sequence and are not necessarily mutually exclusive.

Diversification with food crops occur in the early stages of cocoa farm (from year 0 to 3) when farmers plant food crops like plantain, cocoyam, yam cassava, maize, etc. with cocoa seedlings. This can provide cocoa seedlings with temporary shade and prevent weeds from growing since food crops grow faster to suppress the weeds. It also provides income and food for the household in the short term until the cocoa is ready for harvest. Food crops can also be planted in mature cocoa fields during enrichment planting when gaps created as a result of dead cocoa trees are filled with new cocoa seedlings (under planting) and food crops are planted to provide shade for these seedlings. In planting the food crops with cocoa, farmers should follow recommended planting arrangement per unit area.

Another option is to plant or retain fruit trees (fruit bearing trees other than cocoa) like Mango, Oranges, Avocado, Cola nuts, Oil palm etc., with cocoa. Farmers may plant fruits for food and for income. The fruits may be planted or retained in cocoa right from the first year or as a replacement for food crops after the third year.

Similarly, farmers can also plant or retain timber trees like *Milicia excelsa, Ceiba pentandra, Terminalia ivorensis, T. superba, Alstonia boonei, Khaya ivorensis, Triplochiton scleroxylon* etc as permanent shade in cocoa for medium to long-term economic and agronomic gains. Mature or relic timber trees can be left during initial establishment of cocoa or planted after the cocoa is established. Seedlings may also be allowed to regenerate naturally together with the cocoa.

2. Selecting desirable non-cocoa trees for cultivation

Although farmers are knowledgeable about trees and should make the decision about tree characteristics, facilitators also need to have good knowledge about trees and their characteristics. Important characteristics of trees grown in association with cocoa include:

- shade quality
- soil fertility
- moisture stress
- weed growth
- wind breaks
- air circulation
- branch shedding (that might damage cocoa trees)
- host to pests and diseases,
- economic value
- social value

Shade quality

- For crown size use the diameter to describe it – relatively large crowns have a negative shade effect
- Crown density should be determined by number and size of the leaves per unit area on the branch - relatively broad leaves and extensive branches negatively affect shade quality
- For compactness of the canopy use the size of leaves on the branches. Relatively small leaves with a lot of space between them promote an open canopy that allows enough sunlight to penetrate to crops beneath the canopy. Broad, closely spaced leaf arrangements block most of the sun light resulting in a close canopy that promotes high humidity under the canopy. This condition can create optimal conditions for Black Pod.

Soil moisture

- Deep rooted trees which can facilitate recycling of water to the soil surface compared to shallow rooted trees, which will compete with cocoa for soil moisture

- Leaf shedding pattern of the tree: trees that maintain most of their leaves in the dry season and shed them in the wet season control desiccation in the dry season and high humidity in the wet season

Soil fertility

- The rate of leaf shedding: high rate of leaf shedding promote organic matter accumulation in soil
- Time it takes for leaves to decompose. A short period for decomposition means that nutrients will be released into the soil quickly
- Softness or hardness of the leaves: a tree that has a high rate of leaf shedding and has soft leaves that decompose quickly promotes soil fertility.

Other characteristics are described in the table below:

Table 3: Some tree characteristics

	Weed suppression	**Mechanical damage to cocoa**	**Wind break ability**	**Good aeration for cocoa**
What to look for	How frequently a farmer weeds around that particular tree	The self pruning ability of the tree and how often this occurs. Trees with this characteristic can be described as having soft or hard branches	The strength of the root system and the softness or hardness of branches	Height of the tree
Notes	Trees that drop a lot of leaves are good at reducing weeds since the leave act as mulch and prevents weed germination	Self pruning trees tend to have soft branches while trees that are not prone to self pruning have hard branches	Deeply rooted trees with hard branches serve as a good wind break for cocoa.	Relatively tall trees allow for better aeration under the canopy and are suitable as permanent shade while relatively short trees restrict.

To enable farmers identification of desirable timber trees in cocoa, a decision-support matrix is helpful. This is because it can help farmers evaluate their knowledge and reasoning on specific cocoa-shade tree interactions.

In developing the decision matrix, the facilitator should consider farmers' knowledge of trees in terms of characteristics like shade quality, soil fertility, moisture stress, weed growth, wind breaks, air circulation, branch shedding (that might damage cocoa trees), host to pests and diseases, and economic and social value.

However it is up to farmers to determine the final list of characteristics. These characteristics are termed as 'attributes'. These attributes are then numerically rated against different shade trees according to the group or individual farmer's judgment. In the process, farmers should be allowed more time to debate on the figures they assign to the shade trees so that knowledge about the trees is shared and picked up by everyone in the group.

After farmers complete the rating process, the attributes of the trees should be compared with known scientific findings on the trees and advice given accordingly. By meeting farmers in their various geographic locations ensure that majority of the tree species mentioned are local species and known to them.

Table 4: decision-Support Tool for identifying desirable trees

Attributes	Tree species				
	Species 1	Species 2	Species 3	Species 4	Species 5
Shade quality					
Moisture					
Soil fertility					
Weed suppression					
Mechanical damage					
Wind break					
Allows good aeration					
Alternative host for D&P					
Good timber value					
Good NTFP value					

Source: Asare (2006). Rating as 1,3,5,7,9 – 1 being the least and 9, highest. NTFP – Non timber forest products

3. Developing a farm map as a tool for documenting tree planting activities

Identify and select the land to be used for tree diversification exercise. On this plot identify a reference point at a spot on the fringes of the farm. Standing at this spot, indicate the direction of the morning sun (sun rise) and evening sun (sun set) to represent East and West respectively. Use landmarks to indicate North and South. This then gives the cardinal points, which gives an orientation of the farm.

With the cardinal points in place and standing at the reference point an outline of the farm should be drawn showing any major landmarks that exist. These include slope direction, water bodies, paths, farm settlements, relic trees etc. Still standing at the reference point, an indication should be drawn on the map showing the spot where the first non-cocoa tree will be planted and the direction and pattern for planting. This paper then becomes the plan of the farm showing how planting and arrangements of non-cocoa species will be made. In essence this document represents an initial evidence of tree planting and nurturing by farmers.

It is important that farmers document timber trees that they plant or nurture in order to prove ownership. Farm maps can help farmers do this documentation. In developing a farm map, farmers need to provide the following information; age of cocoa trees, name of farm location, and date for planting trees.

4. Accessing improved planting materials

Planting the right trees in the cocoa fields can provide both environmental and economic benefits for cocoa farmers. Improved planting materials for preferred species can be obtained from sources such as farmlands, forests, nurseries of district forest offices, commercial tree seed nurseries, private tree seed nurseries etc. Farmers can transplant wildlings from farmlands and nearby forests to their designated plots, if the genetic quality of such materials can be proven.

There are distinct advantages in basing such plantings on species native to the planting area, since these are usually well suited to local conditions and in harmony with the landscape and wildlife. Such plantings also help to conserve genetic resources for future generations. However, this does not rule out the introduction of exotic species that can provide similar benefits and are suitable and available in the area.

How many tree seeds do I need?

To calculate number of seedlings to plant, refer to the section on planting material. In order to plant 1hectare of land at a planting distance of 12 m x 12 m will require 69 trees. To plant 69 trees/ha will require 263 healthy seeds that will germinate and survive. In order to know the weight of this seed lot, we assume that the average weight of 1,000 seeds of the species is 35 g. This then puts the weight needed per ha as

(35 g x 263 seeds/ha) / (1,000 seeds) = 9.21 g/ha = 0.00921 kg/ha

Table 5: species conversion from spacing to kg seeds per ha

species	Spacing m x m	No. of plants/ha	Field mortality %	No. of plants/ha + replacement	Nursery Mortality %	No. of good seeds to sow/ha	Germination %	Purity %	No. of seeds/ha	1000 Seed Weight g	g seeds needed/ha	Kg seed needed / ha
T. superba	12x12	69	20	83	50	166	70	90	263	35	9.21	0.009

Collecting seed

Seed collection is a very basic practice for tree growing. It is important to collect seeds from the »right« trees as well as collect from the best-looking mother trees. The following are things to consider when collecting seeds for planting:

- Never collect seed from a single isolated tree on a farmland;
- Avoid trees which flower at a different season from the other trees of its kind;
- Choose plantations where the origin of the trees is known.
- Find a good stand of trees with many nice trees;
- Collect seed from several trees in the stand - at least 10 individuals for small collection, and from 25 individuals for large collection;
- Collect from widely dispersed trees in a stand, let there be at least 50 m to next seed tree.
- Avoid collecting seed from neighboring trees since trees that grow closely together in a forest stand may be closely related even though they may look nice – seed often share the same father.

Seed collection method

Natural seed fall
Large seeds or fruits, which fall to the ground when mature, can be collected on the forest floor from mats laid beneath the trees. This technique is useful with certain forest species but is unsuitable for trees with fine seeds dispersed by wind.

Seed from low branches
Fruits on low branches can be hand picked into a container or stripped on mats laid beneath the tree.

Seed from higher branches
If branches of preferred trees are out of reach, a variety of long handled tools like saws, secateurs, rakes and pruners, can be used for collecting fruits or seeds.

Climbing
Climbing taller trees may be possible but agility and special attention to safety are required. Common aids include climbing irons, safety belt and portable or sectional ladders

Felled trees
Trees should not be felled simply for harvesting seeds. However, if a tree is being cut down for other reasons, any seeds present can be salvaged from it. In areas where timber is being harvested, this will provide an easy and cheap way to collect large quantities of seed. Obtain permission beforehand and select good parent trees. The quantity of seeds would worth the effort.

5. Preparing farm for tree planting and planting desired trees
Prior to planting of timber species on field, the facilitator should demonstrate to farmers the planting procedure as enumerated in 1-4 above. With the aid of a forest technician demonstrate how to plant selected tree seedlings in a triangular pattern at a planting distance of 12 x 12 meters that could later be thinned to 24 x 24 meters in the future when shade is perceived to be too much. Thus, on a hectare of cocoa farm there could be an initial density of 69 timber species and a final density of 18 trees per hectare at the later stages of the cocoa farm.

Pruning forest trees

Importance

This is the strategic removal of branches and stems from a large tree to give them a desired shape and make them healthy. In the case of cocoa farming, pruning can be practiced to reduce shade and to allow air to move above and between cocoa trees. Pruning trees on a regular schedule improves tree health, controls growth, and enhances flowering, fruiting, and appearance.

When to prune

Pruning should be done for the first time 2 to 5 years after planting and thereafter, every 5 to 7 years. Pruning should be carried out towards the end of the dry season to the early parts of the rainy season, before new growth starts. This is because wounds close quickly as growth starts at the onset of the rains and insects and diseases infestation are less prevalent. Branches and stems that are removed may be used for firewood and the leaves used as mulch on the farm or on nursery beds.

How to prune

Closely assess the tree to be pruned and imagine it larger than it seems now. Bear in mind that the branches on the tree will only increase in diameter and length and will not move upwards on the trunk as the tree grows. Hence, the following should be observed when pruning:

- Do not cut more than 25% of the tree canopy since this will only serve to starve the tree, causing it to develop fast growing, weakly attached sucker growths, which will increase maintenance cost and break off easily in strong winds;

- Make the final pruning cut just outside the Branch Collar (BC) as indicated in the diagram below. The BC is a swelling situated at the point where the branch attaches to the trunk and it acts as a valve that closes off the cut. It contains a chemical zone that inhibits the spread of decay in the trunk. When decay occurs in the branch, it spreads down towards the base until it reaches the protected chemical zone (BC). Once there it forms a protective shield when the branch falls off. The BC functions only when the final cut is made just outside the BC perpendicular to the branch. If stubs are left after cut, the valve will not function and insects, diseases and rot will attack the core of the tree and weaken it against any form of strong wind;

When removing large branches (see diagram below), make three or four cuts. Make the first cut on the underside of the branch about 18 inches from the trunk. Undercut one-third to one-half way through the branch,

stopping before the saw binds. The second topside cut should be made 20 inches from the trunk. This cut cuts all the way through the branch. The third cut removes the stub by cutting next to the branch collar.

Branch bark ridge and branch collar

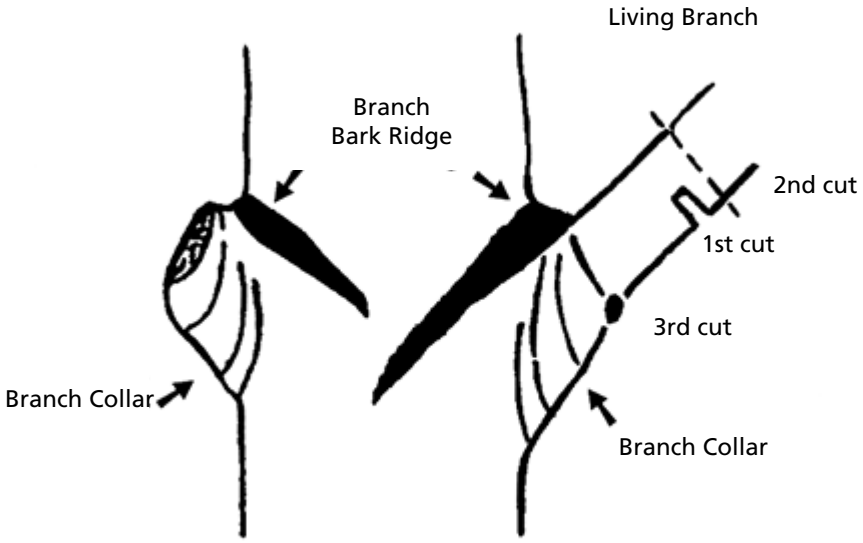


Figure 9: How to remove a large branch from a tree

This involves cutting back a tree to about 50 cm from the ground to encourage re-growth of new shoots. This procedure is beneficial for old trees and is also a useful method of natural regeneration. Coppiced trees can live longer than if the tree was not cut down at all. In newly established cocoa farms, coppicing of large old trees help to provide much needed initial shade as well as permanent shade.

Part 2

Training exercises

Exercise 1: Understanding cocoa intensification

Learning objectives

- To introduce farmers to the concept of cocoa intensification
- To increase farmers' understanding of what needs to be done to intensify cocoa and agricultural production in general
- To increase farmers' awareness of the benefits, outcomes, potential conflicts and issues associated with cocoa intensification

Materials

- Flip chart paper
- 3 boards for putting the paper on
- Markers of different colours (enough for 4-5 groups)

Procedure

Describe the present situation of cocoa production in the country using the following points as guidelines. Note that it is important to adjust some of the characteristics in the present situation to country level realities.

The present situation

- Cocoa yields are 350 kg/ha
- Average farm size is 1 ha
- Cocoa prices are low
- Most trees are old (35 years and above)
- Cocoa trees are 10-15 meters tall
- Farmers remove all shade trees
- For one hectare, farmers use recommended quantity amount of fertilizer, fungicide and insecticide, which is below the recommended dosage
- When starting cocoa farms, farmers plant local varieties of plantain or cassava

Facilitate a discussion using the following guide questions:

Guide questions for discussion

1. What are the reasons for the present situation of cocoa production?
2. How does the present situation affect our families and the community?
3. How does the present situation affect the future of the cocoa system?

Ask the group to divide into 4-5 small groups to make a drawing showing what needs to happen to get cocoa yields increased by three times the present yields.
Ask each group to present their drawing and facilitate a discussion of the points raised using the guide questions. Make sure to discuss the following factors:

- Planting hybrid cocoa
- Farm size of 4-5 ha on average
- Cocoa trees of 2-3 meters tall
- Cocoa yields of at least 1000 kg/ha
- Farmers use fertilizer, fungicide and insecticide (where needed) in the recommended dosage and these inputs are readily available at village level
- Farmers have access to credit for purchasing inputs
- When starting cocoa farms, farmers plant improved plantain or cassava varieties with fertilizer
- Farmers integrate trees that could be used in the household or sold using good quality tree planting materials
- Farmers integrate trees that grow well with cocoa

Guide questions for discussion

1. What needs to happen/change to move cocoa farming from the present situation to the future situation?
2. If the future scenario existed, how will our families, the community and the future of the cocoa system be affected?

Exercise 2: Deciding which cocoa trees to rehabilitate or eliminate

Not all cocoa trees are productive. Farmers should evaluate the productivity of their cocoa trees to decide which trees should be rehabilitated or removed.

Learning objective

- To show farmers a method for systematically evaluating the productivity of cocoa trees on their farms in order to make decisions about which trees to rehabilitate or eliminate

Timing: the week before the first harvest of the main campaign

Location for exercise: mature cocoa farm

Materials

- Paper/flip chart
- Markers
- Calculators (if available)
- Notebooks and pencils
- Materials for marking trees (paint, palm fronds or string)

Procedure

A. Pod counting

Introduce the objective of the exercise. Start a discussion on the productivity of participants' farms and on the productivity of individual trees. Agree on the average yield per hectare of cocoa farms in the community.

Ask participants to give their opinion and experiences about how many cocoa pods produce one kilogram of cocoa beans. As a guideline, on average about 25-30 pods gives 1 kg of marketable cocoa beans.

Identify and select about 50 cocoa trees. Ask participants to form pairs and to identify two cocoa trees that they will observe. Each pair should count and record the number of large pods on the cocoa trees.

B. Analysis of pod counting results and charting

After the counting exercise, meet in one place to look at the results. Collect the pod count results from each pair of participants. Draw a chart like the one below showing the number of pods on each tree.

Ask participants to give their opinion and experiences about how many cocoa pods produce one kilogram of cocoa beans. As a guideline, on average about 25-30 pods gives 1 kg of marketable cocoa beans.

Table 6: number of trees and corresponding pods

Tree number	Number of pods
1	
2	
3	
4	

Using the chart, develop a table like the one below which divides the trees observed into the following 5 groups based on the number of pods counted:

- More than 25 pods
- 10-24 pods
- 5-9 pods
- 1-4 pods
- 0 pods

Table 7a: productivity of cocoa trees

Pod count groups	Number of trees observed	Number of trees as a percent of 50 trees	Number of pods	Kg of cocoa beans produced	Percent of cocoa produced
Group 1: (More than 25 pods)					
Group 2 (10-24 pods)					
Group 3 (5-9 pods)					
Group 4 (1-4 pods)					
Group 5 (0 pods)					
TOTAL					

Fill out the table as follows:

Number of trees observed in each pod count group: For each pod count group, add up the number of trees observed.

Percent of trees observed in each pod count group: For each pod count group, calculate the number of trees observed as a percentage of the number of total number of trees counted. For example, if participants observed 10 trees of the 50 trees in group 3, divide 10 by 50 and multiply by 100.

Example: 10/50=0.20 .20 x 100=20%

Number of pods counted in each pod count group: Calculate the total number of pods counted on all the trees in each pod group.

Below is an example of a completed table.

Table 7b: productivity of cocoa trees

Pod count groups	Number of trees observed	Number of trees as a percent of 50 trees	Number of pods	Kg of marketable cocoa beans produced	Percent of cocoa produced
Group 1: (More than 20 pods)	9	18	315	11	50
Group 2 (10-20 pods)	12	24	194	7	30
Group 3 (5-9 pods)	15	30	122	4	16
Group 4 (1-4 pods)	10	20	24	1	4
Group 5 (0 pods)	4	8	0	0	0
TOTAL	**50**	**100%**	**655**	**23**	**100**

Using the guide questions, discuss differences in production between trees producing ten or more pods (pod count groups 1 and 2) and trees producing less than 10 pods (pod count group 3 and 4). Discuss participants' views on what they consider as unproductive. Indicate to farmers that a productive tree of improved planting material should produce **25 or more pods per year**.

C. Identifying trees to be removed

Ask participants to mark (using paint, palm frond or a string) which trees they would begin with if they were to replant their farms based on the results of this exercise. Count the number of trees to be removed.

Guide questions for discussion

1. How many pods make 1 kg of cocoa?
2. How would you determine which cocoa trees are productive and 3. which ones are not?
3. How many of the trees are responsible for producing most of the total yield of the cocoa from the plot?
4. What number of pods would you use to classify a tree as unproductive tree? Why?
5. How much would this farmer gain if he/she removed all trees that produced less than 20 pods?
6. Which trees would you remove first if you were to rehabilitate this farm?
7. How does the situation in your own cocoa farm compare to the situation in the plot we worked on?
8. What have you learned from this exercise? Is rehabilitation a good solution for your farm?

Exercise 3: Soil characterisation

Cocoa does not grow everywhere and on any soil. The success of a cocoa farm therefore depends on the quality of the soil, thus it is important to properly select a good site before setting up a farm.

Learning objectives
To help farmers select a suitable soil for cocoa cultivation

Timing: beginning of the dry period

Location: demonstration plot, new area for cocoa planting

Materials

- Soil samples in different plastic bags (sandy, loamy and clayey soils)
- 1 liter of water
- Pick axes
- Two sampling cylinders (Augur)
- Shovels
- A hammer of at least 2 kg
- A machete
- Water

Procedure

A. Taking soil samples
Demonstrate how to use the augur to take soil samples from the site intended for the cocoa farm.

Guide questions

1. Why do you need to take soil from many points on the site before bulking them?
2. What will happen if the desired 1.20 m depth is not reached before the soil sample is taken?

B. How to recognize a soil with a good texture (mixture)
Discuss the properties of a good site and soil type for cocoa cultivation. After the discussion ask each participant to take a handful of each of the soil samples (sand, clay and field soils) in their palm and add a few drops of water on it until the soil is moist but not wet. Ask them to try to roll the soil into a small stick by rubbing between their palms. Use the table below to present the soil properties and their suitability:

Table 8: Soil characterization

Soil type	Describe soil properties	Suitability for cocoa
Sandy		
Clay		
Loam		
Soil sample from field		

Guide questions

1. Why is it important to properly select a good site before setting up the cocoa plantation?
2. What are the properties of the sandy, clayey and field soils?
3. Which of the 4 soils samples is good for cocoa?
4. What is the good depth of soil for cocoa cultivation?
5. Is a rocky site good for cocoa cultivation? Give reasons for your answers.
6. Why is the colour of the soil sample for cocoa cultivation important during a selection analysis?
7. Describe a loamy soil and state why it is good for cocoa cultivation?
8. What will happen if a suitable soil is not used for cocoa cultivation?

Exercise 4: Making the decision about where to replant cocoa

Learning objective
To expose farmers to different options for planting/replanting cocoa and the factors they need to consider in making that decision

Materials
- Flip chart paper
- Markers
- Sample of pod counting results from exercise 3

Timing: after exercise no. 2

Procedure

A. Discussion of factors contributing to low cocoa production
Facilitate a discussion to review the factors leading to low production using the guide questions below.

Guide questions for discussion
1. What is the average cocoa yield in this village (per ha/acre)?
2. Do you know the average yield of good farm?
3. Are farmers satisfied with this yield or could it be higher?
4. Why are cocoa yield so low?
5. What needs to happen to increase cocoa yields by two or three times the present yields?

B. Planting/replanting options
Discuss different locations where farmers can plant/replant cocoa in the community. The options should include all or some of the following:

- ***Under planting:*** planting new cocoa trees in an existing farm, removing some but not all trees
- ***Gradual replanting:*** removing all trees in blocks or strips of an existing farm and planting new trees in that section
- ***Complete replanting (re-establishment):*** removing all trees and completely replanting the whole field
- ***New planting (establishment)***: Planting cocoa on fallow land or area where cocoa has not been planted

Discuss the steps in doing under planting, partial replanting and complete replanting by drawing on the flip chart where necessary. Discuss the negative and positive aspects of each option and list the points on the flip chart.

Under planting, remember:

- Cocoa trees left in the field provide shade to the newly planted trees.
- Not recommended where cocoa swollen shoot virus is a problem.
- Where there are large gaps in the field, plant food crops to provide shade to young cocoa

For gradual replanting, remember:

- Not recommended where cocoa swollen shoot virus is a problem
- Using four blocks, it will take 6-7 years until the trees are in production
- Make strips of 10-12 meters and remove all trees in the strips.
-

For complete replanting, remember:

- To avoid spreading cocoa swollen shoot virus and to improve soil fertility, leave the area fallow for at least 3 years before replanting cocoa.
- Preserving and/or planting timber and nitrogen fixing trees (e.g., *Terminalia sp. Khaya sp., Gliricidia sp.*) at 12 x 12 m triangular spacing to improve the fallow and increase soil organic matter.

For new establishment, remember:
Ask farmers to select the options they prefer and discuss the factors they need to consider when deciding where to plant/replant cocoa. These should include:

- ✓ Are my trees still productive?
- ✓ Is my farm affected by cocoa swollen shoot virus? Is this disease a problem in the area?
- ✓ Can I afford to live without income from cocoa for 6-7 years?
- ✓ How much labour do I need for each option? Do I have enough labour?
- ✓ What do I have to pay for, to implement each option (seed/seedlings, poly bags, labour)? How much will it cost?
- ✓ Do I have land of my own for a new farm or can I easily get access to land for planting cocoa?
- ✓ Is the available land suitable for cocoa production?
- ✓ Is available land fallow or forest?
- ✓ Where is the land located?

Draw conclusions about which option is best under what conditions.

Guidelines for choosing planting//replanting options

Choose under-planting if:

- Cocoa swollen shoot virus is not a problem
- You do not have access to more land
- You do not have sufficient funds/labour for partial replanting
- More than half of the cocoa trees are unproductive

Choose partial replanting if:

- Cocoa swollen shoot virus is not a problem
- You do not have access to more land
- You cannot afford to live without income from cocoa for 3 years
- Half of the trees are unproductive

Choose complete replanting if:

- Cocoa swollen shoot virus is a problem
- You do not have access to more land (not forest nor high value ecosystem)
- Most trees are unproductive
- You can afford to live without income from cocoa for 3 years

Choose re-establishment if:

- Most trees on your existing farm are unproductive
- You have access to suitable land for growing cocoa
- You have sufficient funds and labour to start a new farm

Exercise 5: Killing undesirable shade trees in a cocoa farm

Undesirable shade trees in cocoa farms can be harmful. Farmers should remove undesirable or unwanted trees gradually by causing their slow death. Farmers already know traditional methods for killing trees and should be encouraged to use them.

Learning objective

To show farmers a method for gradually killing unwanted shade trees

Timing: at the end of the dry season or at the beginning of the rainy season

Location for exercise: new establishment site or old farms with undesirable trees

Materials

- 1 litre of palm wine
- 1 handful of kitchen salt
- A piece of old cloth
- A 4-litre barrel or gallon
- Plastic gloves

Procedure

Pour the palm wine into the 4-litre barrel or gallon Add the kitchen salt to the palm wine and allow the mixture to ferment for one week.

Just before applying the tree killer, peel off the bark of the tree until you reach the wood. Make cuttings of 30 to 40cm high and leave »receptacles« so as to better retain the tree killer.

Shake the properly fermented palm wine/salt mixture. After wrapping the piece of cloth on a stick, dip it into the mixture. Wearing gloves to avoid burns, smear the tree killer at the level of the cut with the palm wine/salt mixture using the pieces of old cloth. You can also use the peduncle of banana leaves or palm tree to smear the tree.

Note: wash all materials immediately after use.
For each tree killed, another or even more must be planted to ensure that the cocoa has the desired shade level to assure sustainability.

Exercise 6: Preparing to start a cocoa nursery

To establish a cocoa nursery, farmers need to make good decisions regarding where to put the nursery, where to obtain good quality seed and how much seed to purchase.

Learning objectives
To increase farmers' awareness of factors they need to consider when selecting a site for a nursery

Timing: September-October

Location for exercise: proposed nursery site

A. Selecting a site for a cocoa nursery

Procedure

Start a discussion about what is the best place for setting up a nursery and describe the importance of »Black soil« or humus soil using the following guide questions

Guide questions for discussion

1. What should you look for when looking for a place to put a nursery?
2. Why is finding a place near a source of water important?
3. Why is finding a place (if possible) near to the farm important?
4. Why is it important to fence your nursery?
5. What kind of soil do you need for your nursery?
6. Why is good drainage important for the nursery?
7. How do you know if the soil is fertile?

B. Identifying the use of the various implements used in nursery preparation and operations

Procedure

Line up the various tools used in nursery establishment and operations and discuss and demonstrate their uses. The following guide questions may be used to guide the demonstrations and discussions.

Guide questions for discussions

1. Mention names of implements that can be used in nursery establishment and operations?
2. Take the implement one-by-one and ask participants to mention their uses and demonstrate how they are used?
3. How are the implements cleaned and stored?

4. How do you store the various implements?
5. How are the various implements cleaned after use?

C. Identifying the best potting medium for use in the poly bags

Procedure

Have a discussion on the importance of good and clean soil for sowing when using poly bags. Mention sand, organic matter, compost and the relevance of the nutrient content of the soil to be used. As part of the discussions, demonstrate how to perform the following activities:

- How to mix an artificial potting medium
- How to mix a soil based potting medium
- How to sterilize a given potting medium

Guided questions for discussions

1. Mention the different types of potting media and describe the mixes?
2. How do you mix each of the potting medium?
3. Describe the importance of a potting medium?
4. Describe how you can sterilize a given potting medium?
5. Why is it important to sterilize the potting medium before sowing?

D. After participants have demonstrated a good understanding of the above activities proceed by constructing the nursery

Exercise 7: Using improved planting materials

It is important to use good planting materials since farmers who use these types of materials have over 50% more yield than those who do not. This is because good planting materials have higher resistance to diseases and pest and have high yielding properties.

Learning objectives

- To help farmers understand the difference between old and new hybrids and the risks of replanting seeds from hybrid trees
- To improve farmers' understanding of the importance of using certified/known seed suppliers
- To help farmers select good pods (seeds) and prepare them for sowing

Timing: October-November

Location of exercise: Proposed nursery site

Materials

- Pods numbering about 16
- Four bowls full of saw dusts
- A bucket of water
- Tray
- A restrainer
- Four wooden mallet or a blunt machete
- Fungicide solution of either Benlate or Dithane

A. Where to obtain good improved planting materials

Procedure

Using the guide questions, start a discussion about hybrid cocoa and how it differs from traditional cocoa varieties (old hybrids). Discuss the importance of where you get cocoa seeds from. Discuss the quantity of cocoa seeds needed to plant a certain area of land (for example 1 acre or 1 hectare). In the process explain the relevance of considering how many seeds sown and those that germinated and how many will survive for transplanting.

Guide questions for discussion

1. What is a hybrid cocoa? How is it different from a traditional cocoa variety?
2. Is it a good idea to plant seeds from pods produced by hybrids growing on your farm? Why or why not?
3. Why is it important to get pods from approved seed source?
4. Do you know where you can have improved planting materials?
5. Why is it important to select ripe and healthy pods for their seeds?
6. Why is it important not to store cocoa pods for a long time?
7. How many pods do you need to plant 1 acre?
8. How many seedlings do you need to plant 1 acre?
9. Why is the number of pods not necessarily associated with the number of seedlings?

B. How to prepare seeds before sowing

Procedure

Divide the participants into 4 groups with each group getting 4 pods. Ask each group to do the following:

- Open the pod with the wooden mallet or a blunt machete
- Remove the seed from the pod by separating it from the pulp
- Discard small seeds, damaged seeds and flat seeds
- Rub the seeds in the saw dusts to remove the remaining pulp covering the seeds
- Wash the resulting seeds in clean water and drain using the restrainer
- Soak the resulting seeds in the fungicide fungicide solution for about 1 minute
- Drain the seeds and place them on a dry tray in a shaded and cool area protected from rain and wind

Guided questions for discussions

1. Why is it important to use a wooden mallet or a blunt machete to break the pod for the seeds?
2. What happens to small, flat and damaged seeds found in the pods?
3. Why do we need to rub the seeds in the saw dusts?
4. Why is it important to store the seeds under shade and in a cool place?
5. Why is it important to use clean water after rubbing the seeds in saw dusts?
6. Why is it important to soak the seeds in fungicide solution after cleaning?

Exercise 8: Understanding grafting

Grating techniques have been used a lot to improve the performance of tree crops but in West Africa these techniques have not been widely applied. In order to improve yields and also make planting materials accessible to cocoa farmers, grafting techniques need to be encouraged to enable farmers master the art.

Learning objectives

- To introduce farmers to grafting techniques in cocoa
- To train farmers in grafting techniques

Timing: March April

Location: Proposed nursery site

Procedure

Describe the grafting techniques and explain the various terms involved mentioning and translating rootstock, scion, bud woods etc to suit the local language. List the importance of grafting and give the differences between the 2 grafting techniques. Compare and contrast the importance of using seeds and grafting as planting materials. Use the questions below to aid the discussions.

Guide questions for discussions

1. What is grafting?
2. Mention the importance of is grafting?
3. Mention and describe the parts of the plant that are used in grafting?
4. How will you get rootstock and from what type of cocoa trees?
5. How will you get scions and from which parts of the cocoa tree?
6. Give 10 reasons that will lead to a failed graft?
7. Mention 4 conditions in which to look for when collecting bud woods for grafting?
8. Name the equipments used in grafting?

Exercise 9: Sowing cocoa seeds in poly bags

To establish a cocoa nursery, farmers need to make good decisions regarding the type of soil they use in the poly bags. They also need to follow good practices when sowing seeds in poly bags.

Learning objectives

- To improve farmers' knowledge on which soils are good for nursery
- To improve farmers' knowledge on direct seed sowing

A. Preparing soil for sowing in poly bags

Materials

- Sandy soil (river sand)
- Black soil (soil with high organic matter)
- 20 poly bags
- Watering can
- Shovel

Procedure

Introduce the topic and discuss how and where farmers obtain soil for filling poly bags. Show participants the two soil samples. Discuss the properties of each type and whether or not they are appropriate for use in poly bags. Lead a discussion using the guide questions.

Divide farmers into groups of 5-6. Ask each group to fill 2 poly bags, one with sandy soil and the other with the black soil and make a small hole beneath each of the poly bags. The poly bags should be firmly filled with the different soils.

Ask 2 members from each group to raise the 2 poly bags with the different soil above the ground. Let one person from each group pour 2 liters of water onto the 2 poly bags and observe the rate at which the water runs through the different soil types. Observe the content in the 2 poly bags and note which of the soils dry up easily.

Guide questions for discussion

1. Where do you/farmers usually get soil for filing poly bags?
2. What do farmers look for when selecting soil for nursery beds?
3. Where do you think these soil samples come from?
4. Which soil is best for filling poly bags? Why?
5. Why does water runs through sandy soil faster than black soil?
6. What will happen if you use the sandy/clay soil in poly bags?
7. Where can one get black soil?

8. Do farmers ever use soil from refuse dumps for filling poly bags? Is this type of soil good or bad? Why?
9. Why are some other types of soil not good for nursery beds?

B. How to sow cocoa seeds in poly bags

Materials

- 1 cocoa hybrid pod
- Prepared soil
- Sixteen 7 x 10 inches poly bags
- Watering cans filled with water
- Measuring tapes
- Sticks
- Palm branches

Procedure

Before the exercise, have participants prepare a shelter/shade with the palm branches.

On the day of the exercise, demonstrate the following procedure using one poly bag:

- Make a hole with a stick in the poly bag and fill it with the prepared soil and press it to stand firmly
- Make sure the poly bag is straight so that arrangement of seeds can be easily done
- Water the filled poly bag.
- Plant one seed in the poly bag by putting it flat and covering it lightly with soil (with 1 cm of soil)
- Water the poly bag with the watering cans

Ask participants to organize themselves into groups to prepare the poly bags and plant the seeds.

- After all the poly bags have been filled, arrange them on the ground under a shed, making sure there are paths for sowing, watering and pruning. Use the measuring tapes to measure 30 cm between groups of arranged poly bags.

Guide questions for discussion

1. Why is it important to sow at the beginning of the rainy season or when enough water is available?
2. Why is it necessary to leave spaces between poly bags?
3. How many seeds do you put in a poly bag when sowing and why?
4. Why do you need a distance between each arranged group of poly bags?
5. Why is watering of the soil in the poly bags necessary before and after sowing?

Exercise 10: The effects of poly bag size on seedling survival

Many cocoa farmers in West and Central Africa prefer to use poly bags smaller than the recommended size of 18 cm wide and 25 cm high (7 inches x 10 inches) for raising cocoa seedlings because they are cheaper and easier to transport to the field. But these farmers may not be aware of the effect of poly bag size on seedling survival rate.

Learning objective

To show farmers the advantages of using large poly bag and the effects of small bags on seedling survival rate

Timing: before and during poly bag filling

Location for exercise: proposed nursery site

Materials

- An example of farmers' commonly-used poly bags for planting cocoa seedlings (allow farmers to select the different sizes by asking them to bring samples)
- Flip chart stand and paper
- Markers

NOTE: introduce the topic the previous session and ask farmers to bring samples of 2-3 different types/sizes of poly bags

Procedure

Session 1

Start a discussion about poly bags using the guide questions. List the main points on the flip chart paper comparing different types of poly bags.

Explain the objective of the exercise and discuss the types of poly bags to be used in the experiment. On the day when participants are filling poly bags, divide the 2-3 farmers' commonly used poly bags to 2-3 groups of participants. Ask them to fill the bags in the normal way. Put 18 cm x 25 cm normal size poly bags and the farmers' commonly used poly bags aside from the other bags and label them: normal size poly bags and farmers' commonly used poly bags (specify sizes). Ask each group involved to observe the experiment for 6 months, making observations on the following:

- Root formation in the different poly bags (tap root, secondary roots and tertiary roots)
- Size of the roots in the different poly bags
- Volume of roots in the different poly bags

Guide questions for discussion

1. What are the different types of poly bags farmers' use for planting cocoa?
2. What size are they? Where do you get them from?
3. What are the advantages and disadvantages of the different types of poly bags?
4. Which type of poly bag do farmers prefer? Why?
5. Does the size of the bag matter? How and why?
6. Where can farmers get the recommended poly bags for cocoa nursery?
7. Why is it not advisable to use »pure water« bags?

Session 2

After 3-6 months, ask the groups involved to report their findings to the larger group. Facilitate a discussion using the guide questions.

Guide questions for discussion

1. What differences are there between the seedlings in the 3 groups of bags?
2. What might explain these differences?
3. What are likely to be the effect of these differences when we plant the seedlings in the field?
4. Do the advantages of the small bags more important than the advantages of the large bags? Why or why not?
5. What have you learned from this exercise?

Exercise 11: Monitoring a cocoa nursery

Learning objectives

- Introduce farmers to guidelines for daily monitoring of nurseries to improve their observational and decision making skills on nursery management activities

Materials

- A newly planted cocoa nursery
- Watering can
- A duty roster
- Nursery monitoring forms

Procedure

After sowing the seeds in the poly bags, ask participants to select one person who will be responsible for managing the nursery on a daily basis for the next 7 months. This person (called the nursery leader) will also be responsible for making sure that all other participants visit the training nursery on time between training sessions (every two weeks).

A. Observations to be made by participants

All participants should visit the training nursery once every two weeks together with the facilitator and observe the following:

First two weeks after planting only:

- Review nursery monitoring form filled in by the nursery leader to check germination rate

Action to be taken:

- Count and indicate number of poly bags that have germinated seeds
- Calculate the number of germinated seeds as a percentage of the total number of seeds sowed, i.e., germination percentage=(number of seeds germinated/total number of seeds sowed) x 100

- ***Soil moisture:*** Is the soil in the poly bags dry or moist?

Action to be taken: water the poly bags:

- Dip one finger into the poly bags to feel if there is sufficient moisture in the soil or not
- Check the duty roster to find out the last time the poly bags were watered

- ***Amount of weeds in the poly bags:*** Is the poly bags free of weeds?

Action to be taken:

- Observe all the poly bags and look for and remove any weed

    - ***Insect damage:***

Action to be taken:

- Observe all the leaves and if there is insect damage on the leaves and tips of 50% or more of the seedlings, apply insecticide

Guide questions for discussion

1. How many days did it take for 90% of seedlings to germinate?
2. How many seeds did not germinate?
3. What causes delayed or poor germination?
4. What factors affect soil moisture in the poly bags?
5. What factors reduce insect damage in nurseries?

B. Activities to be performed by the nursery leader

The nursery leader is responsible to monitor the nursery **EVERY DAY** and carry out the following activities:

Monitor germination of the seeds

Three days after sowing the nursery, randomly select 3 lots of 100 poly bags from different parts of the nursery. Count the number of seeds that have germinated. Calculate an average in percent for the 3 lots and record the results on the nursery monitoring form.

Repeat this count with another lot of 300 poly bags until all seeds have germinated (about 2 weeks after sowing).

Report to the group at each session, the germination percent recorded that week.

Monitor moisture of the soil in the poly bags

Check the level of moisture of the soil in the poly bags daily by sticking one finger in the soil of at least 5 randomly selected poly bags from different parts of the nursery. If the soil is dry, water all the poly bags in the nursery. Indicate on the nursery monitoring form by making an x under the days watering was carried out.

Monitor weeds in the poly bags

Look out for any unwanted plant that has germinated in the poly bag and continuously remove them.

Monitor emergence of new leaves

The emergence of new leaves is a sign that the seedlings are healthy. On a daily basis, look over the whole nursery to check for new leaves. For every day that you observe new leaves on at least 50% of seedlings, make an x on the monitoring form. If there are new leaves on less that 50% of seedlings, do not record anything on the form.

Monitor insect damage

On a daily basis, inspect the whole nursery for insect damage on the leaves and tips of the seedlings. The most common insects are worms and psylle. If you observe damage on 50% of seedlings, apply insecticide as soon as possible (not later than 5 days after making the observation).

Table 8: FORM FOR MONITORING A COCOA NURSERY

Name of Nursery Leader: _____ Month : _____ Village : _____

Use an x to indicate the activities carried out

Table 8: activity sheet for nursery monitoring

	Days after sowing																													
OBSERVATIONS / ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Germination																														
Watering																														
Weeding																														
Presence of new leaves																														
Use insecticide																														

Observations:

Exercise 12: Planting plantain and cassava as temporary shade for cocoa

Planting food crops in newly established cocoa farms provides temporary shade, income and food and helps reduce weeds in the first three years. To ensure high yields of food crops, farmers need to use clean planting material and apply the appropriate planting arrangement.

Learning objectives

- Train farmers on using hot water treatment to obtain clean plantain planting material
- Train farmers how to obtain healthy cassava cuttings for planting
- Train farmers on the correct arrangement for intercropping cocoa with food crops

Timing
Location

Materials

- Sixteen plantain suckers without rot on the corm
- Eight cassava stem cuttings (2 m long)
- One 28 cm ^{3} plastic bucket
- One 28 cm ^{3} basket
- Four ½ m long ropes
- 1 empty oil barrel/drum
- Furnace
- Firewood
- Machete
- Two poles (2 m long)

Procedure

A. Treating plantain suckers before planting

Demonstrate how to treat plantain suckers and cassava cuttings. Facilitate discussions using the guide questions.

Guide questions for discussion

1. Why do you have to dip suckers in boiling water?
2. Is it advisable to leave the suckers in the barrel for more than 30 seconds? Explain why.
3. Name 5 features you need to select a cassava plant for planting with cocoa and explain why?
4. Why should food crops like plantain and cassava be planted a year before cocoa?
5. Why is it important to plant food crops at least 1.5 m away from cocoa?
6. Explain the importance of planting clean planting materials

Exercise 13: Soil conservation

A. Understanding soil conservation

It is important to protect the soil to allow the cocoa trees to obtain the maximum growth conditions necessary for improved yield. Leaving soils bear make them prone to erosion.

Learning objective

To help farmers understand the importance of soil conservation and erosion

Timing: March to April

Location: Newly cleared land for cocoa cultivation

Procedure

Explain the importance of selecting a relatively flat land not in a forest for planting cocoa. Allow participants to examine if there a slope in the newly cleared land. Also discuss the mode of land clearing and indicate the importance mulching, cover plants and other soil conservation practices relevant for that particular land.

Guide questions for discussion

1. Why is it important to conserve soils for cultivation?
2. Why is it important to consider the slope of the land before using it for cultivation?
3. What causes soil erosion and how can that be prevented?
4. Name and explain 4 practices to prevent soil erosion?
5. Name and describe 3 types of mulch?

B. Mulching

Learning objectives

- Expose farmers to the advantages of mulching
- Show farmers how to apply mulch on a cocoa farm

Materials

- Mulching material (cocoa pod husks, grass cuttings, weeds etc)
- Machete
- Young cocoa farm (up to 3 years)

Procedure

Using the guide questions for discussion, start a discussion about evaporation of water from the soil and soil erosion when soils are exposed in young cocoa farms. Discuss what can be done to prevent this problem and introduce the concept of mulching.

Demonstrate how to chop up cocoa pod husks and spread them between the cocoa trees. Remind farmers to use pods that are not infected with black pod disease.

Demonstrate how to spread out grass cuttings

Guide questions for discussion

1. In a young cocoa farm, what happens when the soil is not covered? What prevents the soil from being exposed in a mature cocoa farm?
2. What effects do water evaporation and soil erosion have on soils and on young cocoa trees?
3. Does leaving the soil bare increase the amount of work a farmer does? How?
4. Do farmers apply mulch in their cocoa farms? Why/why not? What are the advantages of mulching?
5. What materials can be used as mulch? What materials should not be used as mulch and why?
6. Why is it not necessary to apply mulch to mature cocoa farms?

C. Making compost

Most cocoa farms have piles of pod husks. This potassium rich waste material can be used to improve soil fertility by incorporating it in compost heaps.

Learning objectives

- To teach farmers the proper way to make compost and apply it to the planting hole or on mature cocoa farms for improved soil fertility
- To make farmers aware of a way to dispose of cocoa pod husks
-

NOTE: This exercise can be done on a cocoa farm or in a nearby village

Materials

- Large quantity of cocoa pod husks
- Other waste materials such as oil palm empty fruit bunches, rice or maize straw, animal manure, household rubbish
- Machetes
- Water
- Sticks, plank or other materials to construct a rectangular structure (1m x 2m x 0.8 m) (if making a compost bin)
- Shovel (if making a compost pit)
- Measuring tape (if making a compost pit)

- Wheelbarrow to transport the materials (optional)
- Long, sharp stick

Procedure

Preparing the compost heap/pile
Facilitate a discussion about cocoa pod husks using the guide questions for discussion. Mention the importance of potassium, found in cocoa pod husks, for soil fertility. Introduce the idea of composting.

Ask participants to cut up the composting materials. Demonstrate the steps in preparing a compost heap using a bin or pit.

Guide questions for discussion

1. What do farmers do with cocoa pods husks?
2. What happens to banana/plantain plants when cocoa pod husks are thrown nearby? Why does this happen?
3. How can we use cocoa pod husks to benefit cocoa tree and improve soil fertility?
4. Have you heard of composting? Do you or anyone you know use compost?
5. What are some advantages and disadvantages of using compost on mature cocoa farms?

Monitoring the compost heap

Demonstrate how to mix the raw materials and check the compost to see if it is ready. Ask the group to assign sub-groups or individuals to monitor and mix the compost heap every two weeks.

Guide questions for discussion

1. Why is it necessary to mix the raw materials?
2. Why is it important to cut all raw materials into smaller pieces?
3. Why does the temperature in the middle of the heap matter? What should it be?
4. How do you check to see if compost is ready? How often should you check?
5. How do you know when compost is ready? How does it look?
6. What could happen if you use compost that is not mature?
7. When should you apply compost to mature cocoa farms? When should you not apply compost?
8. Can you mix mineral fertilizer with compost?
9. What should you do if you do not have enough compost to cover an entire farm?

Applying compost
Demonstrate how to apply compost to the planting hole or on a mature cocoa farm.

Exercise 14: The importance of spacing between cocoa trees

Many cocoa farms in West Africa are planted with close spacing between cocoa trees. This results in competition between trees, leading to low production.

Learning objective

To understand the concept of competition between cocoa trees and the importance of spacing

Timing: implement this protocol when trees are flowering. This protocol should be linked to the protocol on deciding which cocoa trees to rehabilitate or eliminate

Location for exercise: mature cocoa farm

Materials

- Bowl of food (for example, rice, peanuts) not enough for all participants
- String of 3 meters long for each FFS/FLG working group, marked off at 1, 2 and 3 meters
- Paint or other materials to label trees
- Notebooks and pencils

Procedure

Invite participants to share the food in the bowl. After eating, ask whether all participants had enough food.

In the cocoa farm, divide the farmers into small groups of 5-6. Give each group the 3 meter string. Each group should work in an assigned area of the farm. Tie the string to one tree and measure the distance to other trees in a circle. Ask each group to mark trees that are less than 1.5 meters from each other. Each group should make the following observations on the cocoa trees in their assigned area:

- Height of cocoa trees
- Size of stems
- Size and number of branches

After the exercise, discuss the observations made by each group.

Guide questions for discussion

1. Who got enough food and why? Why did some people not get enough to eat?
2. What did you do or what could you have done to get more to eat?
3. What proportion of cocoa trees is planted less than 1 meter apart (all, most, few)?
4. What proportion of cocoa trees are planted at 2-3 meters apart (all, most, few)?
5. When the spacing between cocoa trees is less than 1 meter, what did you notice about height, size of stems, number and size of branches?
6. When the spacing between cocoa trees is 2-3 meters, what did you notice about height, size of stems, number and size of branches?
7. What lessons from the eating exercise apply to cocoa trees that are planted close together?
8. Why do farmers plant cocoa trees close together? Why is this not necessary if you plant improved material (from a recommended source) and provide good initial shade?
9. What have you learned from this exercise? What is the good spacing for cocoa trees?

Exercise 15: The importance of shade for young cocoa trees

A better understanding of effects of too much sunshine on young cocoa plants will encourage farmers to maintain adequate shade on their cocoa farms.

Learning objectives

- To observe the effects of too much sunshine on young cocoa trees
- To better understand the relationship between too much light and mirids

Timing: at the start of the rainy season when planting the cocoa in the field

Location: newly planted cocoa farm/site

Materials

- Record sheets
- Flip chart paper and markers
- Picture/poster of mirids or mirid sample

Procedure

Session 1

Start a discussion about shade and its importance for young cocoa trees. Also discuss mirids and the relationship between too much light and mirids. Use a poster of a mirid to help farmers identify the pest

Select an area for the experiment with 50 plants. Divide the area into two so that there are 25 plants in each side. On one side, remove all temporary shade; on the other area leave the shade. Label the first block »Seedlings with too much light«; Label the second block »Seedlings with the right amount of shade«.

Guide questions for discussion

1. What signs tell you that there is too much sunshine in a cocoa farm?
2. What happens to young cocoa trees if there is not enough shade?
3. Can you recognize mirids?
4. What are signs of mirid damage in cocoa farms?
5. What part of the cocoa plant do mirids feed on?
6. Is there any relationship between mirids and light in a cocoa farm?
7. What happens when there is too much light?
8. Do you know the right spacing for plantain, cassava, timber trees and nitrogen fixing trees?

Observations

Over a period of 4 months, participants should make observations on the seedlings/young trees in the two blocks every two weeks. Individuals or groups of farmers can be assigned the task of making and recording the observations. They should observe the following on each seedling/young tree:

- Number of young shoots damaged
- Number of leaves that are folded or yellowing (a sign of damage) or brownish (dead)
- Tip of the tree to see if it is alive or dead

Record the information on the forms provided.

Session 2

After 4 months, ask each group to write up their results on a flip chart. In field, have each group visit the two blocks. Ask each group to make a report on their observations. Discuss the results and what participants have learned.

Guide questions for discussion

1. Which group of trees have the most damage: those with enough shade or those with too much light?
2. What happens if there is not enough shade/too much light in a young cocoa farm?
3. What have you learned from this exercise?

Table 9: Observations on seedlings with enough shade

Seedling	Damage to shoots								Damage to leaves							
	Week 1	week 2	week 4	week 6	week 8	week 10	week 12	week 14	week 1	week 2	week 4	week 6	week 8	week 10	week 12	week 14
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2																
3																
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Rate damage as follows: 0=no damage; 1=some damage; 2= a lot of damage; 3=total or near total damage (nearly all or all shoots/leaves damaged)

Table 10: Observations on seedlings with too much light

Seedling	Damage to shoots								Damage to leaves							
	Week 1	week 2	week 4	week 6	week 8	week 10	week 12	week 14	week 1	week 2	week 4	week 6	week 8	week 10	week 12	week 14
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Rate damage as follows: 0=no damage; 1=some damage (x number of shoots/leaves damaged) ; 2= a lot of damage (x x number of shoots/leaves damaged); 3=total or near total damage (nearly all or all shoots/leaves damaged)

Exercise 16: Lining, pegging and digging holes

Learning objective

To improve farmers' skill in making planting rows at the recommended spacing

Timing: about two months before planting cocoa in the field

Location: new establishment site

Materials

- Shovel
- 12 x 12 m area
- 16 pegs
- Tape measure of 90 meters or more

Discussion

A. Lining and pegging

Discuss how most farmers plant cocoa and the spacing they use.

Describe and demonstrate how to line, peg, and dig holes. Mark the rows for the cocoa trees, leaving 3 meters between rows. Along each row, mark out with pegs the spots where the cocoa trees will go. Leave 3 meters between trees. This spacing allows you to plant 1111 seedlings per hectare (435 seedlings per acre). Divide participants into small groups to carry out the work

B. Digging planting holes

Dig large, deep planting holes that will allow the poly bags to fit in them properly. When digging the holes, keep the soil you dig up in two separate heaps next to the planting hole: soil from the bottom of the hole and soil from the top. Make sure you do not mix the two types of soil together.

Guide questions for discussion

1. Why is it important to create a horizontal base line when doing lining and pegging?
2. Why is it necessary to dig holes that are bigger than the poly bags containing the seedlings?
3. What is the role of lining and pegging in planting cocoa?
4. Explain the importance of separating the soil dug from the holes?
5. How long do you have to wait before planting in the holes?

Exercise 17: Planting cocoa in the field

Learning objective

Improve farmers' skill in planting cocoa correctly

Timing: at the start of the rainy season. It is best to do this exercise on a cloudy day

Location: new planting site

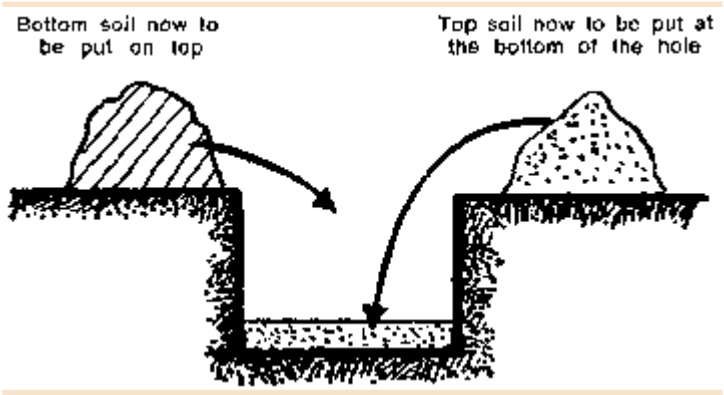
Materials

- 3-6 month old cocoa seedlings from the nursery
- Area of a cocoa farm which has been prepared for planting (by pegging and making planting holes)
- Spade or hoe

Procedure

A. Before you start planting

A few days before planting, fill in the holes you have dug with soil dug from the top, at the bottom of the hole, and put the soil dug out from the bottom on the top. You may mix the soil with manure.



Water the seedlings heavily the day before transplanting to make it easier to remove them

B. On the day you start planting

- Transport the cocoa seedlings to the planting site.
- Remove the poly bags carefully from the seedlings to avoid losing too much soil from the roots.
- Throw away diseased plants
- Carefully place the seedlings with the soil in the holes.
- Cover the seedling firmly with soil.
- During the first two years, replace dead seedlings with new one. After the third year, avoid planting new seedlings because the young plants will be shaded by the older plants.

Guide questions for discussion

1. Why is it important to water the seedlings the day before transplanting?
2. After what period it is no longer good to replace dead seedlings? Why?
3. Explain how you will place a cocoa seedling in a poly bag in the hole?
4. When is it appropriate to dig the holes for planting cocoa?
5. When is it appropriate to plant cocoa in the field? Explain why

Exercise 18: Formation pruning

In many parts of Africa, farmers allow cocoa trees to grow into a large bush with three jorquette. Many trees are overly tall (10-15 m). This exercise focuses on the reasons and corrects procedure for structural pruning.

Learning objective

- To expose farmers to the different types of pruning and their importance
- To show farmers the correct procedure for formation/structural pruning

Timing: just before the rains
Location: any farm with unpruned cocoa trees of 2-3 years

Materials

- Flip chart and markers and/or illustrations of trees that have been pruned correctly
- Sharp machete

Procedure

A. Understanding pruning
Start a discussion about pruning using the guide questions.

Guide questions for discussion

1. Is it necessary for farmers to prune young cocoa trees? If no, why not?
2. What is the purpose of pruning young cocoa trees?
3. What will happen if a farmer does not prune his/her cocoa trees when they are young?
4. Describe how you will prune a 2 year cocoa tree?
5. What are the materials you will use in pruning a 2 year cocoa tree?

Describe the 2 types of pruning (formation or structural and sanitary) that need to be done on young cocoa farms. Make drawings on the flip chart or use illustrations to show the correct shape of a young cocoa tree. Discuss tree architecture using the guide questions

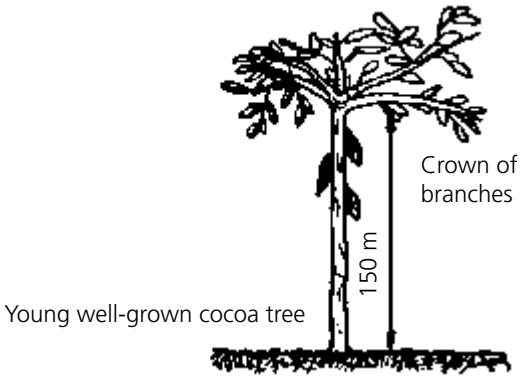
Guide questions for discussion

1. How high above the ground should the crown of a cocoa tree be?
2. What will happen if the crown develops too low down (at less than 1 meter above ground level)?
3. Is it good for a young tree to have several shoots? Why or why not?

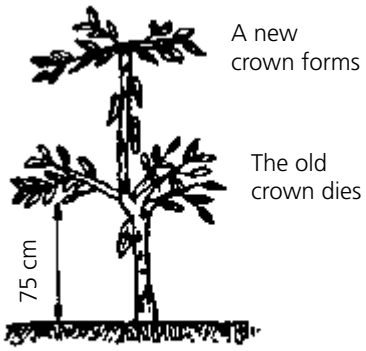
4. How many shoots should a tree have?
5. What do farmers normally do when they see shoots on cocoa trees?

B. Demonstrate correct formation pruning procedures

Walk around the farm and demonstrate how to do tipping and canopy shape pruning. Ask farmers to organize themselves into groups and to prune 2-3 trees per group.



Young cocoa tree with two shoots



Cocoa tree which forms its crown too low down

Exercise 19: Sanitary pruning

Learning objective

To show farmers the correct procedure for structural pruning

-

Timing: Just before the rains

Location: Any farm with unpruned cocoa trees beyond 4 years old

Materials

- Sharp machetes
- Mature cocoa farm (more than 4 years old)

Procedure

Review the reasons for pruning and the different types of pruning.

Demonstrate the three steps in structural pruning: height control, ground clearance and developing the mid canopy.

Ask farmers to organize themselves into groups and to prune 2-3 trees per group. Conclude by reviewing the main points of the exercise.

Guide questions for discussion

1. What are the different types of pruning that should be done on young cocoa farms?
2. What are the steps in structural pruning and why is it important?
3. How tall should a cocoa tree be? What are some disadvantages of tall cocoa trees?
4. What is the purpose of doing sanitary pruning?
5. What would happen if you did not do it?

Planting timber and other forest trees in cocoa farms

Exercise 20: Identifying tree diversification options

Cocoa farmers are usually interested in planting other trees and crops in cocoa farms such as food crops, other fruit trees and timber trees. Often farmers do not use a systematic approach which considers technical, economic and environmental issues when deciding on which trees to plant with cocoa.

Learning objectives

- To provide farmers with a systematic approach for deciding on which trees to plant in their cocoa farms
- To raise farmers' awareness of economic and environmental issues they need to consider when making decisions about which trees to plant in cocoa farms.

Timing

Materials

- Any cocoa farm which has more than 10 tree species
- Flip chart
- Markers

Procedure

Ask participants to think about a cocoa farm (their own or someone else's) which they consider to have many non-cocoa trees. Ask participants to name the tree species found on the farm. Write the names of the species on the flip chart. Using the species farmers identify, make a simple drawing showing a cocoa farm with at least 2 canopy levels of cocoa and non-cocoa plant species as below.

Discuss the relationship between the cocoa trees and the other trees and the advantages and disadvantages of the farm in the drawing.

Make a list on the flip chart of the technical words in the local language used in the farm description. Discuss the various definitions and adopt the one most accepted by the participants. Underline all technical words mentioned both in the accepted definition and farm descriptions and explain, e.g., timber, fruit tree (see Table below).

Draw the table 11 below on the flip chart.

Table 11: tree diversification process

Age of cocoa farm	Tree diversification options		
	Food crops	**Timber trees**	**Other trees and shrubs**
Young cocoa farm (0-7 years)			
Mature cocoa farm (7-20 years)			
Old cocoa farm (over 20 years)			

Ask farmers to identify the possible combination of plant species like food crops, fruit trees other than cocoa, and timber species at different stages of a cocoa farm. Together with farmers identify the most promising combinations in terms of economic gains, planting material availability, market potential and environmental benefits and fill in the table.

Guide questions for discussion

1. Think of a cocoa farm (either your own or someone else's) that has many non-cocoa trees. How many plant species can be found in such a farm?
2. At least how many canopy levels can one find on such a farm?
3. List 5 advantages and disadvantages of having many trees in a cocoa farm?
4. What are the short, medium, and long term gains of such combinations?
5. What is the best combination option and why?

Exercise 21: Selecting desirable non-cocoa trees for cultivation

It is difficult to characterize what farmers perceive a »desirable« non-cocoa/ shade tree in association with cocoa and what they believe to be the beneficial characteristics such trees posses. This exercise stimulates discussion about the precise economic and environmental benefits farmers obtain from shade trees using a combination of farmers' and scientific knowledge about timber tree-cocoa combination.

Learning objectives

To improve farmers' knowledge of desirable tree characters

Timing: August

Location: mature cocoa farm with shade trees

Materials

- Flip chart
- Markers
- Note books and pens for each sub-group

Procedure

Explain the objectives of the exercise. Divide participants into small groups of 5-6 and ask them to walk through the farm, identifying non-cocoa trees on the farm and noting their desirable characteristics.

Draw a table like the one below on the flip chart for each small group.

Table 12: tree species selection

Desirable characteristics	Tree species				
	Species 1	Species 2	Species 3	Species 4	Species 5

Ask each group to do the following:

- List the desirable characteristics of each non-cocoa tree species identified that make them compatible with cocoa
- Arrange the qualities into different headings and present them in the first column of the table under **Desirable characteristics**
- Indicate 5-10 desirable tree species identified on the farm other than cocoa and represent these species in the first row of the same table under **Tree species**. The named species should be agreed upon by all participants so that consensus can be reached with regards to attributes.

After filling in the species names and characteristics on the table, facilitate a discussion to get each group to rate each tree species using numbers from 1 to 9, with 1 being the least desired and 9 the highest.

Complete the rating for each species before going on to the next one. Continue until the table is completed

Show one example before starting group work.

Once the table is completed, ask each group to present their list of species and characteristics to the larger group and facilitate a discussion using the guide questions.

Guide questions for discussion

1. Why are the mentioned trees found on this farm desirable for cocoa cultivation?
2. What is the importance of the rating system?
3. Are you satisfied with the ratings?
4. What do you think about these measures?
5. Has anybody tried out the same measures or are there different ways to ensure positive interactions between cocoa and shade trees?

Exercise 22: Developing a farm map for making decisions about tree planting

Most trees found in cocoa farms in West and Central Africa are left to grow rather than being deliberately planted by farmers. This exercise teaches farmers to make a simple map of their farms to help them make decisions about tree planting.

Learning objective
To encourage farmers to document tree resources on farm

Timing: September

Location: Mature cocoa farm

Materials

- Flip chart
- Markers
- Sample of a farm map (see below)

Procedure

A: Identifying landmarks

Divide participants into small groups. Ask each group to inspect the farm to identify landmarks such as direction of slopes, footpaths, streams or rivers, boundary marks, relic and other non-cocoa trees, huts etc.

After inspection, ask each group to locate a point on the edge of the farm and use it as a reference point (RP) for developing the farm map. Standing at the RP ask each group to locate the direction of the morning sun (sun rise) and evening sun (sun set).

Ask the groups to identify a landmark that indicates north and south in relation to where the farm is situated.

Go through each of the below steps for drawing the map using a sample map. Ask each group to develop a map.

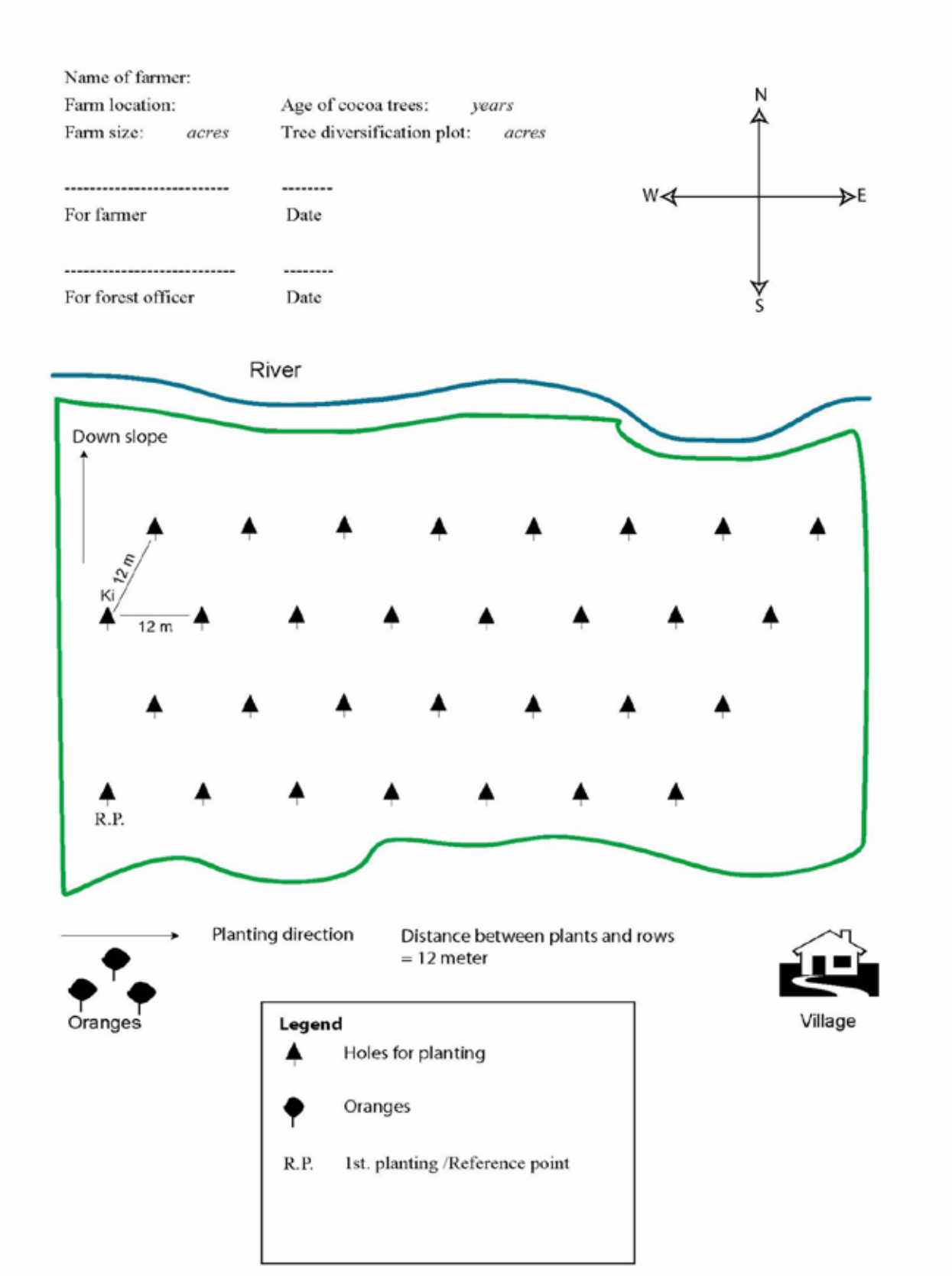


Figure 10: Sample of a tree diversification map

B: Drawing a farm map

On the right corner of the sheet use the directions given to represent the cardinal points of the farm; sun rise (east), sun set (west), other landmarks (north and south).

At the left corner of the sheet provide a space for farm information such as farmer's name, name of farm location, age of cocoa trees, date for tree planting, farm size, farmer signature, and forest officer's signature.

With farm information and the cardinal points in place, make a rough outline indicating the boundaries of the farm using the space below.

In the outline indicate the RP, which will in future represent the point where the first non-cocoa tree seedling will be planted and show the direction for planting. In addition indicate any landmarks identified on the farm on the map.

Things to remember:

- Encourage farmers to include all landmarks during the farm inspection on the map
- The RP should not change throughout the whole exercise;
- Make every indication on the map with reference to the RP;
- It is important to note that the tree diversification exercise is about what farmers want to plant and not necessarily what already exist, hence emphasis should be on what farmers prefer.

C: Making individual farm maps

Ask all farmers in the learning group to make a map of the part of their farm where they will be carrying out tree diversification activities when they go home.

At the next session, ask 3-4 farmers to present their maps.

Guide questions for discussion

1. What do you understand by landmarks?
2. Is RP important for making farm maps? Why?
3. Identify and indicate any landmarks that exist on your farm?
4. How will one go to the nearest town south of this farm?
5. How will one go to the nearest town north of this farm?
6. What non-cocoa trees do you prefer in your cocoa farm?

Exercise 23: Collecting, processing and storing local tree seeds

Farmers can save money by collecting their own tree seeds from best known sources to assure better quality. To do so, they need to know how much seed they need, how to identify good seed sources and how to process and store collected seeds.

Learning objectives

- To appreciate the value and importance of local trees
- To identify the best sources for obtaining local tree seeds
- To improve farmers' knowledge of processing and storage of tree seeds

NOTE: this exercise consists of 2 parts but should be conducted in one session

Timing: Depends on the type of species

Location: A forested area or farm with forest vegetation

A. Collecting tree seed

Materials

- 4 baskets, containers or paper bags
- Ladder
- Scale
- 4 mats
- Knife or saw
- Two 20-30 m ropes for pulling down branches

Procedure

Start a discussion about what methods farmers can use to collect seed from a tree. Make sure to discuss the following 5 methods:

1. Collect seed that fall by themselves from trees: To do this, lay a mat at the forest floor under the particular tree
2. Hand pick fruits on low branches (using hands or ropes) and place them in a container or the fruits can be stripped onto a mat laid under the tree
3. Pick seeds from high branches by using long handled tools like saws and pruners
4. Climb trees with ladders and pick fruits
5. Collect fruits from a tree when it is felled.

Divide participants into groups of 3-5 and ask each group to identify and select one species per group that they would like to plant in a cocoa farm. Ask the groups to do the following:

- Collect fruit/seeds from the selected trees using one of the five collection methods identified
- Collect seed from at least 10 individual trees of the selected species
- Collect seed from widely dispersed trees in the stand that are at least 50 m apart;
- Collect from several different areas if stands are small.
- Collect seeds from the best looking individual trees that look healthy with straight trunk and less branches;
- Collect the same quantity of seed from each individual tree

Ask each group to record the following information on the seed collected

- Species name
- Seed collection method used
- Quantity of seed collected

Ask each group to report briefly back on how efficient they found the seed collection method they used.

Guide questions for discussion

1. What qualities should you look for when selecting a tree for seed collection?
2. What is the effect of selecting from any kind of tree?
3. Why is it important not to select from a few isolated individuals?
4. Is it important to select and collect from trees with similar geographic conditions? Why?
5. Why did you use this collection method and not the others?
6. Which collection method is best/worst? Why?
7. Which collection method is fastest/slowest? Why?

B. Seed extraction and cleaning after collection

Materials

- Collected seeds
- Air-tight containers (enough for the number of species collected)
- Small plastic bags (enough for the number of species collected)
- Mat
- Knife or secateurs
- Rope

Procedure

Step 1: Demonstrate the following steps to the group:

- Remove seeds from dry fruits by drying them on the mat in the sun for some time. If the seeds do not fall out by themselves, break the fruits with your hand
- Remove all unwanted materials such as leaves, stones, deformed or damaged seeds and fruit pods from the seeds
- Divide the seeds by species into smaller quantities and place them in small plastic bags
- Label each bag with the following information: name of species, location where seeds were collected, type of stand (forest plantation, farmland, woodlot, etc.), date of collection and date of processing
- Place the plastic bags and their content in the air-tight containers for storage.
- Put the dried seed in air-tight containers separated
- Remind participants to store the seed containers away from the sun in a place with good ventilation.

Step 2: Ask each group to organize themselves to carry out the seed treatment and storage exercise on the seed they collected. Ask each group to store the containers with seeds until they are ready for sowing.

Guide questions for discussion

1. Describe the steps for processing collected seeds
2. Why is it important to label each bag?
3. What should you look for when sorting seeds?
4. What would happen if you keep the seed in a sunny place?
5. How would you store your seeds to keep them healthy?
6. Where would you store your seeds to keep them healthy before they are sowed?

Exercise 24: Sowing on nursery beds

Direct seeding on nursery beds is a cost effective way of producing seedlings of both cocoa and other types of trees which many farmers do use.

Learning objectives

- To expose farmers to the advantages of using nursery beds to produce seedlings
- To improve farmers' skills in tree nursery bed construction and direct seed sowing

Timing: September

Location: nursery site

A. Constructing a nursery bed

Materials

- Shovels/spades
- Rakes
- Machetes
- Pick axes/mattocks
- Wheelbarrows
- Water cans
- Measuring tapes
- Nylon ropes
- Hoes
- Bamboo planks
- Palm fronds

Procedure

- Ask participants to demarcate the area intended for the nursery beds using the measuring tape and nylon ropes
- Use the mattock or axe to uproot any tree not wanted in the nursery
- Demonstrate the following:

    - Dig, loosen and turnout the soil about half a meter wide.
    - Make sure to loosen the clods in the soil with a rake to avoid crusts on the surface since these will restrict water and air circulation and also block emerging seedling. Small seeds should have a finer and more compact soil than larger seeds;
    - With a hoe, raise the beds to a height of about 10cm to 20cm and a length of about 2 m in other to allow water to permeate through the bed;

- Provide furrows in-between the beds to drain excess water;
- The distance between each bed should be at least 60cm;
- The nursery bed must be leveled
- Raise a shed above the beds using the bamboo planks as pillars and the palm fronds as shed for shade;
- Use the remaining bamboo planks for fence around the beds to prevent intruders

Ask participants organized in groups of 5-6 people, to prepare several nursery beds.

Guide questions for discussion

1. Why is it necessary to locate a seed bed closer to a reliable source of water?
2. What happens when the soil used is not loose but compact?
3. Which soil is good for nursery beds and why is it important to have a good soil?
4. Where can you find good soil here in this village?
5. Why is it important to shade and fence the beds?

B. Sowing seeds on nursery beds

Materials

- Preferred tree seeds
- Watering cans
- Water
- Measuring tapes
- Sticks

Procedure

Divide participants into groups corresponding to the number of nursery beds. Ask each group to follow these procedures:

- Before sowing seeds, water the nursery bed
- Choose and sow seeds either in rows or broadcast seeds on the nursery beds
- Leave a space of 10-15 cm in between seeds if planted in rows using the measuring tape and the stick
- Seeds must not be sowed deep in the soil; the depth of the hole must be twice the size of the seed
- Water the nursery bed after sowing

Guide questions for discussion

1. What are the advantages and disadvantages of sowing in rows instead of broadcasting?
2. Why is it important to water the nursery bed just after sowing?
3. What is the size of the preferred seed?
4. What is the right depth for sowing seeds? Why?
5. What can farmers do to make sure the seeds sown, germinate?

Exercise 25: Preparing to plant non-cocoa trees in cocoa farms

When growing non-cocoa trees in a cocoa farm, farmers need to arrange the trees in a pattern to ensure that the trees will get the necessary nutrients, water and light they need to grow well.

Learning objectives

- To improve farmers' skills on preparing seedlings for transplanting
- To demonstrate a pattern for planting tree seedlings in cocoa fields

A. Preparing seedlings for transplanting

Timing: two weeks before transplanting

Location: Nursery site

Materials

- Seedlings to be transplanted
- Watering can
- knife

Procedure

Two weeks before transplanting the seedlings to field, go with participants to the tree nursery site. Start a discussion on how to prepare seedlings for transplanting. Divide participants into small groups of 5-6 and assign each group to a section of the nursery. Ask each group to remove the shade or shelter over the seedlings so that the seedlings will be exposed to full sun light.

Ask participants to reduce watering of seedlings to half the normal watering regime so as to strengthen the seedlings to withstand field conditions.

Discuss root pruning and why it should be done. Ask groups to raise seedlings and see if some of the roots have penetrated through the poly bags. Cut roots that have grown out of polythene bags with a knife.

Guide questions for discussion

1. Why is it important to strengthen seedlings in the nursery before planting on the field?
2. What must one do during the period of strengthening the seedlings?
3. What is root-pruning?
4. Why is it necessary to prune overgrown roots?

B. Lining and pegging

Timing: March

Location: new establishment site

Materials

- Selected non-cocoa tree seedlings
- Machete
- Measuring tape
- Two nylon ropes (12 m each)
- 30 wooden pegs

Note: Remember to bring the farm map that the group prepared

Procedure

Explain the exercise and review the farm map together with participants, taking time to locate the reference point (RP).

Ask participants to clear weeds and other obstacles that might obstruct free movement on the plot.

Locate the reference point (RP) on the map and place a wooden peg there.

Create a horizontal base line by tying the rope to the peg at the *reference point* and stretch it along a straight path following the *direction of planting*. Along the rope, mark intervals of 12 meters with the measuring tape and place pegs at these points to indicate holes for tree planting.

With the baseline in place, create a triangular pattern by tying one 12 meter rope (rope A) to the *reference* peg (peg 1) and a second 12 meter rope (rope B) to the next peg (peg 2) on the baseline.

Ask 4 participants to hold each end of the 2 ropes and stretch them diagonally to their 12 meter limits until they meet right in the middle of pegs 1 and 2. Place a peg at this point to complete the first triangular pattern.

Still moving in the *direction of planting,* remove rope A from peg 1 and place it at peg 3. Here, tie the rope to the peg and ask the farmer at the other end to stretch it diagonally, while the farmer who is holding the other end of rope B stretches his until the two farmers meet at a point between pegs 2 and 3 to create the second triangle.

Remove rope B and place it at peg 4 and repeat the whole process until 27 pegs are staked, corresponding to the different trees that the farmer owner has chosen to plant.

Make holes at all the pegs in which intended tree seedlings will be planted.

Guide questions for discussion

1. What is the essence of planting timber trees in a triangular arrangement in cocoa?
2. Why are the *reference point* and *direction of planting* important in drawing the map?

Name of farmer: *Augustine Achenfour*
Farm location: *Gyeninso* Age of farm: *20 years*
Farm size: *5 acres* Tree diversification plot: *1 acre*

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For farmer Date

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For forest officer Date

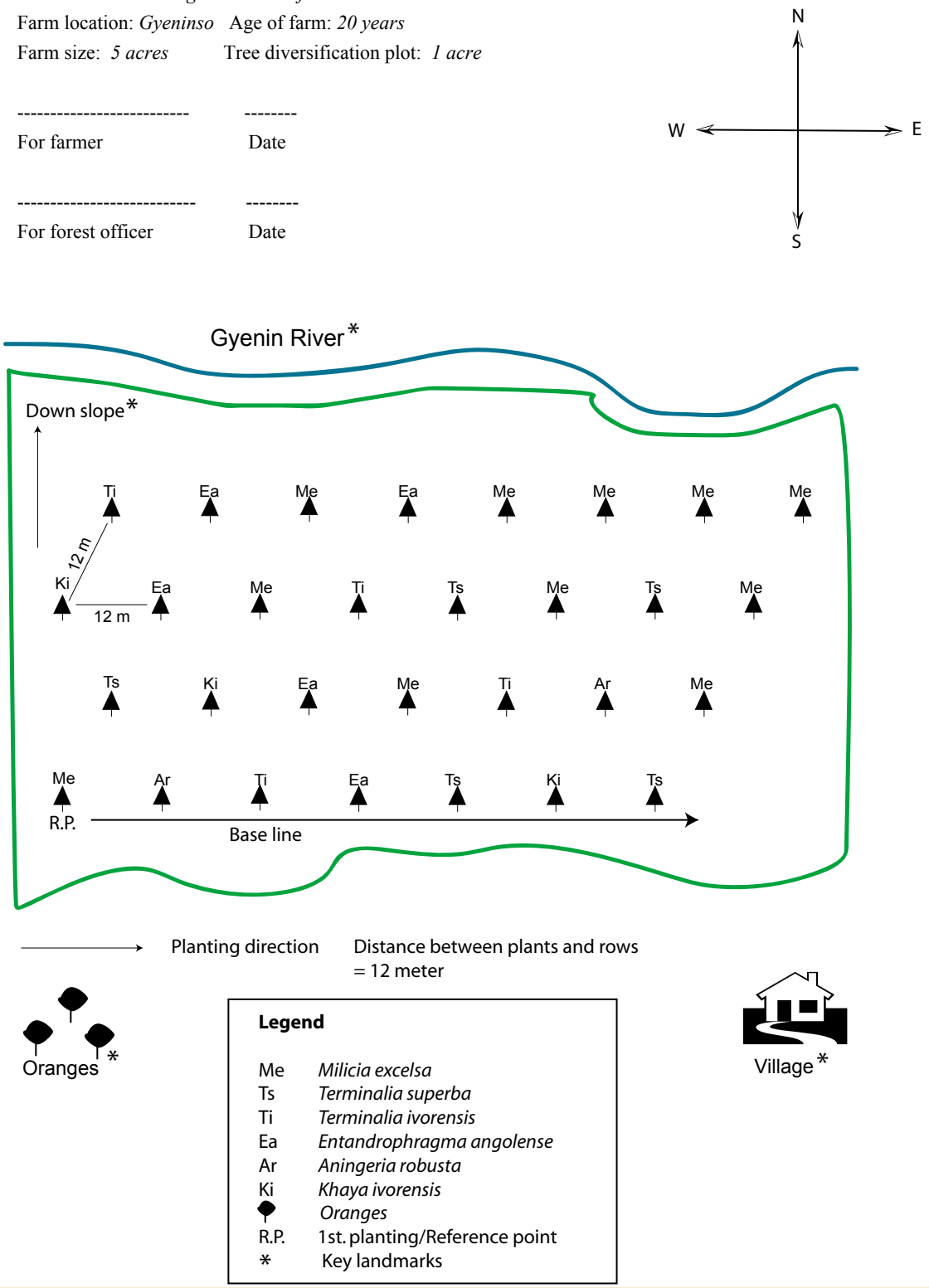


Figure 11: diversification map showing planted non-cocoa tree seedlings

Exercise 26: Planting non-cocoa trees in cocoa fields

Learning objective

To improve farmers' skills in planting non-cocoa trees in cocoa fields

Timing: Beginning of the rainy season

Location: New establishment site

Materials

- Seedlings to be planted
- Cutlass
- Knife

Procedure

Divide participants into groups of 5-6**.** Ask each group to transplant seedlings immediately from the nursery beds and place them in the prepared holes after trimming overgrown roots with a knife. Also use a cutlass to make sure the holes for planting are deep enough to contain the seedling.

Demonstrate the correct way to plant the seedlings, making note of the following:

- ✓ Do not bend the stem of the seedlings when planting
- ✓ Use soil from each hole to fill each hole after seedlings have been planted
- ✓ Use fingers to press the soil around the stem to hold it firm in the ground
- ✓ Do not plant the same species one after each other in the planting line; plant different species in the line
- ✓ Use a knife to remove the poly bag from the seedling before placing it in the hole

After the session, encourage each farmer to plant his/her selected tree seedlings on his/her own farm using the tree diversification map.

Guide questions for discussion

1. What are the steps involved in transplanting?
2. Why is it important to have big holes for planting?
3. Why is it important not to bend the stem when planting?
4. How do you put back the soil dug from the holes after planting?

Exercise 27: Selecting and promoting trees that are already growing in cocoa farms

Natural regeneration provides a cheap source of tree planting material. Farmers can use saplings and wildlings of desirable tree species as temporary and permanent shade.

Learning objectives

- To improve farmers' knowledge of natural non-cocoa tree regeneration regime in cocoa fields
- To select desirable tree species for cocoa farms

Timing: during land preparation (February and March)

Location: demonstration farm or any mature cocoa farm

Materials

- Flip chart
- Marker/pen
- Black soil
- Poly bags as needed

Procedure

Introduce the topic and start a discussion on natural regeneration. Explain the purpose and procedure of the exercise.

Divide farmers into small groups and ask each group to walk around the farm and identify saplings and wildlings of tree species that are desirable for growing with cocoa. Groups should write down the names of these wildlings on flip chart.

Groups should remove any wildlings identified as a desirable species and transplant them into poly bags filled with fertile soil. When this part of the exercise is completed, each group should report to the larger group which species they identified and how many wildings they transplanted.

Each group should assign 1 member to take care of the wildlings for a period of 1 month and then transplant to the FLG cocoa farm for observation

Guide questions for discussion

1. Give the names of the big trees on this farm apart from cocoa?
2. Which of the trees are desirable with cocoa? Why?
3. Why is it necessary to use the seed in the soil and not cut the tree to induce sprouting?
4. What should be the planting distance of the wildlings when planted back in the field?

Exercise 28: Pruning forest trees

It is important to remove branches and stems from forest trees to give them the desired shape, improve tree health, control growth and encourage flowering and fruiting

Learning objective
To improve farmers' skills in pruning forest trees

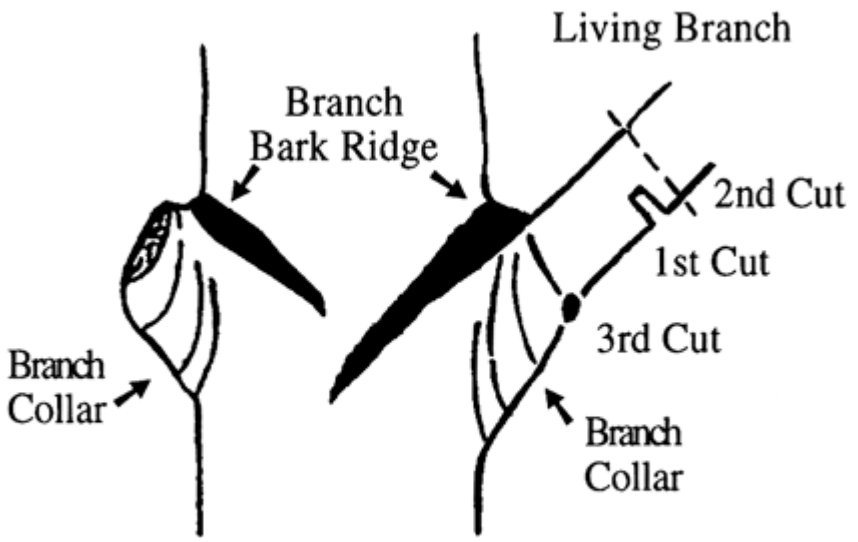
Timing: Just before rains (March-April)

Location: Mature cocoa farm with saplings of unpruned forest trees

Materials

- Machete
- Markers
- Flip chart

Procedure
Using the guide questions for discussion, start a discussion on local beliefs about tree pruning. Write responses on the flip chart. Draw a diagram of a forest tree and label all parts.



Branch bark ridge and branch collar

Figure 12: diagram showing parts for pruning lessons

Guide questions for discussion

1. What is pruning?
2. Why do farmers prune cocoa trees?
3. Do farmers prune forest trees?
4. What are some benefits of pruning forest trees?
5. How often should forest trees be pruned?
6. When and what tools are needed?

Gather participants around a forest tree that needs pruning. Ask participants to closely assess the tree to be pruned and imagine it larger than it seems now. Bear in mind that the branches on the tree will only increase in diameter and length and will not move upwards on the trunk as the tree grows.

Establish which branches need to be cut. Demonstrate the correct way to prune, pointing out the following:

- ✓ Do not cut more than 25% of the tree canopy
- ✓ Make the final pruning cut just outside the Branch Collar (BC)
- ✓ To remove large branches (see diagram below) make three or four cuts.
- ✓ Make the first cut on the underside of the branch about 18 inches from the trunk. Undercut one-third to one-half way through the branch, stopping before the saw binds.
- ✓ Make the second topside cut 20 inches from the trunk. This cut cuts all the way through the branch.
- ✓ The third cut removes the stub by cutting next to the branch collar.

Divide participants into groups and assign each group to a part of the farm. Each group should prune 3-4 trees.

Guide questions for discussion

1. Why is it important to prune forest trees?
2. At what height and age of a forest tree is it appropriate to prune?
3. How much of a tree canopy is allowed to prune in order not to cause any permanent growth damage?
4. What is the importance of the Branch Collar (BC)?
5. Is it necessary to prune a tree even when it has very small canopy?

Exercise 29: Know your rights regarding ownership of trees

Farmers who plant timber species in their cocoa farms need to be aware of the laws on tree ownership and their rights.

Learning objectives

- To create awareness of tree rights and ownership
- To build farmers' confidence on tree rights and ownership
- How to assess damage caused by felled timber trees
- To identify factors involved in determining compensation
- To learn a simple formula for rapidly determining compensation

Timing: August

Location: ~~Mature cocoa~~ farm of about 1 acre that has timber trees

A. Know your rights to timber on cocoa farms

Materials

- Timber regulations
- Case study

Procedure
Introduce the exercise and explain the most important points of the timber law.

These should include:

- Farmers' rights
- Whether farmers can refuse permission for felling timber
- Reasons why farmers can refuse permission for felling timber

Read and discuss the following case study (several times if necessary) ensuring that all the participants understand what it is about. Participants can also be asked to recite the story.

Case study

Opanyin Kwaku Menka has a 10-acre cocoa farm situated on private land in Ashanti Region. His farm sits on a slope and has many valuable timber trees (about 18 per acre) that he left during the establishment of his cocoa farm some 20 years ago.

In recent years the environment has changed and these trees have helped Opanyin Menka to shade and protect his cocoa from the harsh sun, drier conditions, and strong winds that come with erratic rainstorms. When

Opanyin Menka's father became ill, the trees also provided him with medicine that helped to cure his ailments.

One morning, as Opanyin Menka was pruning his cocoa trees two men arrived carrying a piece of paper that they claimed was a concession contract to fell five of the timber trees on his farm—two mahoganies and three Odum. Opanyin protested and pleaded with the men not to cut the trees as they would damage his crop, but the men refused to listen.

The next morning the men returned, and he watched as they felled and dragged away the trees, damaging many of the surrounding cocoa trees. From then on, Opanyin's cocoa field encountered many problems from the loss of shade, including capsid attack and soil erosion.

Facilitate a discussion using the guide questions. Read the case study again. Use the guide questions to facilitate a discussion on farmers' rights. Refer to the law on timber use where necessary.

Guide questions for discussion

1. What can you say about the case study and the conduct of the timber contractors and Opanyin Menka?
2. Is it allowed for timber contractors to fell trees on private farmlands? If yes, what is the normal procedure?
3. Did Opanyin Menka participate in the inspection of the trees on his farm before the concession contract was granted? What should have been the procedure?
4. Could Opanyin Menka have refused to let the men fell the trees? If yes, what would have been his major reasons against the felling?
5. Did Opanyin Menka exhaust all his options to prevent the felling of trees from his farm? If no, what were some of his options?
6. What were the consequences of Opanyin Menka's inability to stop the timber contractor from felling those trees?
7. What are some of the major lessons drawn from this case study?

B. How to estimate compensation for damaged cocoa trees

Learning objective

How to assess damage caused by felled timber trees

Materials

- Calculator
- Average yield per cocoa tree per year (kg) on farm
- Price per kilo of dry cocoa beans
- Records of cocoa variety on farm
- Cocoa sales book of farm
- Flip chart
- Markers

Before the session obtain a record of cocoa varieties planted on the farm from the owner

Procedure

- Divide farmers into 2 groups of between 5-10 participants and apportion each group to 1 side of the farm. Ask each group to do the following:

    - Identify and count timber tree species on their side of the farm.
    - Identify the variety of cocoa on their side of the farm.
    - Ask each group to randomly sample 10-20 mature cocoa trees (ages between 8-16 years) around a timber tree. Using the cocoa sales book of the farm and a calculator, estimate the following:
    - Number of pods obtained from each selected tree per year
    - Number of kilos of dry cocoa beans obtained from each cocoa trees per year

How to estimate the cost of damaged cocoa trees caused by felling *Milicia excelsa* (Odum)

If we assume that a 50 year Odum tree felled by a timber contractor from Opanyin Kwame Minka destroys 30 cocoa trees at the age of 12 years and if each cocoa tree produces 4 kg of dry cocoa beans per year and 1 kg costs GHC 1. If Opanyin spent GHC 500 to establish and maintain 1 hectare of his farm for the first 5 years, then the loss incurred by Opanyin Menka is as follows:

Loss incurred in monetary terms = Price/kg of cocoa x
Number of kg dry beans/tree
x DCT +
Cost of establishing 1 hectare of
1111 new trees for at least 5 years

Where

- Price/kg of cocoa = price of 1 kg cocoa beans;

- DCT = number of damaged cocoa trees

According to the story:

- Damaged cocoa trees (DCT) = 30

- Average cocoa yield per tree = 4 kg

Then

- Loss incurred = (30 X 4) X 1 + (500) = GHC 620

After a brief presentation of group results, discuss any concerns regarding how to calculate the cost of damage.

Guide questions for discussion

1.. Identify valuable timber trees on farm and state how many they are.
2. What can a farmer do to reduce crop damage by timber logging?
3. Of the cocoa trees that could be affected, what is the average pods and beans production per year?
4. How much does it cost to establish a cocoa farm for the first five years?

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The design of tree seed production units. DFSC Series of technical notes. TN60. Danida Forest Seed Centre, Humlebaek, Denmark. 38 pg

Annex

Schedule for planting, replanting & diversification training

Month	Session	Protocols
March	1	Understanding cocoa intensification; Knowing your rights to timber ownership
	2	Soil characterization; Soil conservation
April	3	Developing farm for making decision about tree plant; Lining, pegging and holing; importance of spacing
	4	Importance of shade for young cocoa trees
May	5	Using improved planting materials; Planting plantain and cassava as temporarily shade for cocoa
	6	Understanding grafting and budding
June	7	Identifying tree diversification options; selecting desirable non-cocoa trees in cocoa cultivation
	8	Preparing to plant non-cocoa trees in cocoa farms; Planting cocoa in the field
July	9	Formation pruning; Structural pruning
	10	Pruning forest trees in cocoa
Aug	11	Deciding which cocoa trees to rehabilitate or eliminate
	12	Making decision about where to plant cocoa
Sept	13	Preparing to start a cocoa nursery; Effect of poly bag size on seedling survival
	14	Sowing cocoa in poly bags; Sowing on nursery beds
Oct	15	Selecting and promoting trees that are already growing in the cocoa farm
	16	Collecting, processing and storing local tree seeds for sowing
Nov	17	Monitoring nursery
	18	
Dec	19	Monitoring nursery

The diagram below shows the proposed schedule for cocoa Integrated Crop & Pests Management (ICPM) and Planting, Replanting & Diversification (PRD):

	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
ICPM										
PRD										

Using this manual for cocoa certification training

Many companies purchasing cocoa in West Africa and people who eat chocolate products in developed countries are concerned about the effects of cocoa production on cocoa farmers, their communities and the environment. They want to make sure that cocoa farmers are receiving higher incomes and have a good living standard. One way to make sure this happens is to provide cocoa farmers who produce cocoa following certain requirements such as good agricultural practices, responsible labour practices etc with a certificate. Cocoa farmers and communities that receive this certificate can then get a higher price for their cocoa from buyers. To receive a certificate, farmers must meet all the requirements established by certification bodies. There are currently several cocoa certification systems or standards such as UTZ Certified (www.utzcertified.org), FairTrade International (www.fairtrade.net) and Rainforest Alliance (www.rainforest-alliance.org).

Topics covered by most cocoa certification codes include:

Good agricultural practices

- Good agricultural practices and post-harvest handling
- Cocoa farm maintenance
- Soil management and fertilization
- Integrated pest management

Social issues

- No forced and child labor
- Payment of minimum wage
- Transparent and accountable group management
- Equal opportunities for men and women
- No discrimination, respectful treatment of workers
- Access to health care
- Access to education
- Good relations with the community
- Good living conditions
- Health and safety training
- Safe and healthy working conditions
- Accident and emergency procedures

Environmental issues

- Responsible use of agrochemicals
- Biodiversity protection and strengthening
- Prevention of soil erosion
- Protection of water sources
- No deforestation of primary forest;
- Use of shade trees
- Protection of endangered species
- Conservation plan for natural habitat
- Minimized environmental pollution, waste management

(Adapted and modified from UTZ Certified Code of Conduct for Cocoa-Summary)

Many of the training exercises covered in this and other manuals in the STCP Good Agricultural Practices series address the requirements of certification standards. Topics not addressed by the STCP manuals include labour practices, gender equality, group management, access to education and health care. Using the UTZ code as an example, the following table shows which training exercises correspond to specific control points

Certification codes and STCP protocols

UTZ control points	STCP protocols
1.A COCOA FARM ESTABLISHMENT AND REHABILITATION	
1.A.1 Suitable planting and grafting material is used	Using improved planting materials
	Understanding grafting
	Collecting, processing and storing local tree seeds for sowing
	Preparing to start a nursery
	Sowing cocoa in poly bags
	Effect of poly bag sizes on seedling survival
	Sowing on nursery beds
	Monitoring of nurseries
1.B COCOA FARM MAINTENANCE	
1.B.1 The producer performs good cultural control within the cocoa farm	Formation pruning
	Sanitary pruning
	Deciding which cocoa trees to rehabilitate
	Importance of shade for young cocoa trees
	Preparing to plant non-cocoa trees in cocoa farms
	Planting plantain and cassava as temporary shade for cocoa
	Planting cocoa in the field
	Lining, pegging and holing
	Importance of spacing
1. C SOIL MANAGEMENT AND FERTILIZATION	
1.C.1 The producer uses natural techniques to maintain and optimize soil fertility and structure	Soil conservation
	Soil characterization
	Understanding cocoa intensification
	Making a decision about where to replant cocoa
3. NATURAL RESOURCES AND BIODIVERSITY	
3.A.1 The producer uses techniques to prevent soil erosion	Soil conservation
3.C.1 The producer maintains shade trees on the farm to enhance biodiversity and as protection against weather risk	Identifying tree diversification options
	Selecting desirable non-cocoa trees for cocoa cultivation
	Selecting and promoting trees that are already growing in the cocoa farm
	Developing a farm map
	Planting non-cocoa trees in cocoa
	Knowing your rights regarding ownership of forest trees

Development and Environment

No. 1 • 2005	Seed sources of agroforestry trees in a farmland context - a guide to tree seed source establish ment in Nepal
No. 2 • 2005	The map of potential vegetation of Nepal - a forestry/ agro-ecological/biodiversity classification system
No. 3 • 2006	Conservation of valuable and endangered tree species in Cambodia, 2001-2006 - a case study
No. 4 • 2007	Learning about neighbour trees in cocoa growing systems
No. 5 • 2007	Tree seedling growers in Malawi - who, why and how?
No. 6 • 2007	Use of vegetation maps to infer on the ecological suitablil-ity of species ..... Part I: Description of potential natural vegetation types for central and western Kenya
No. 7 • 2007	Use of vegetation maps to infer on the ecological suitab-lility of species ..... Part II: Tree species lists for potential natural vegetation types
No. 8 • 2007	Do organisations provide quality seed to small holders?
No. 9 • 2007	Sources of tree seed and vegetative propagation of trees around Mt. Kenya
No.10 • 2007	A review of direct sowing versus planting in tropical affor-estation and land rehabilitation
No.11 • 2008	Medicinal plants, their conservation, use and production in southern India
No.12 • 2009	Conservation and biodiversity in and around cocoa farms. Learning about sustainable cocoa production: A guide for particpatory farmer training
No.13 • 2010	Planting, replanting and tree diversification in cocoa systems (Electronic version revised 2011)

DEVELOPMENT AND ENVIRONMENT 13 / 2010

The manual planting, replanting and tree diversification in cocoa growing systems (PRD) is based on participatory learning and demonstration processes that promote mutual learning between farmers and experts. The aim of the manual is to improve cocoa farmers' knowledge and skills in order to carry out the necessary best practices in revamping old cocoa farms and/or start new ones.

The manual uses the farmer learning group (FLG) approach, which is a structured group based learning approach that teaches farmers specific skills and practices using demonstrations, field exercises and discussions as the key training and learning tools. The manual helps to train farmers on how to analyze current farm situation, select sites for new cocoa establishment, acquire clean improve planting materials for both cocoa and non-cocoa species, prepare the field for planting of cocoa and non-cocoa species, and cocoa farm diversification.

Forest & Landscape Denmark
University of Copenhagen
Rolighedsvej 23
DK-1958 Frederiksberg
Tel: 3533 1500
sl@life.ku.dk
www.sl.life.ku.dk

National centre for research, education and advisory services within the fields of forest and forest products, landscape architecture and lanscape management, urban planning and urban design