

9-14 COCOA



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Learning targets for farmers:

- › Understand that cocoa trees require a diversity of shade trees of different sizes and thus species forming a stratified forest system.
- › Recognize the relevance of maintaining a conducive environment for cocoa growth through regular pruning of the cocoa and shade trees.
- › Understand that the appearance of pests and diseases is a sign of a poorly managed or unbalanced agroforestry system and that control should start with the establishment of a well-managed and balanced agroforestry system.
- › Recognize that cocoa plantations under proper management can remain productive for a long period of time.

1. Introduction

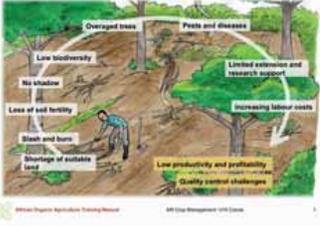
Cocoa (*Theobroma cacao*) plantations are one of the most important forms of land use and are of enormous economic importance to developing countries in the humid tropics. The main cocoa producing countries in Africa include Cameroon, Ivory Coast, Ghana and Nigeria in West Africa. However, organic cocoa is mainly produced in Madagascar, Tanzania and Uganda. FAO reports that the world dry cocoa bean production has increased in the last 30 years from 1.54 to 4.16 million tonnes. To reach this total production, the world average yields in dry beans have increased from 350 kg per hectare to 500 kg per hectare during that time and the area under cocoa was substantially increased. However, the International Cocoa Organisation reports that there are big differences in yields between regions. While farmers in West Africa attain yields of 200 to 300 kg per hectare, farmers in Latin America and Indonesia harvest between 500 and 600 kg of cocoa beans per hectare on average.





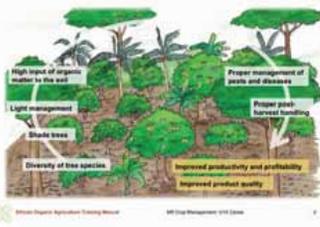
TRADITIONAL COCOA PRODUCTION

Traditional cocoa production



IMPROVED COCOA PRODUCTION SYSTEM

Improved cocoa agroforestry system



Common challenges facing cocoa production in Africa

- > **Limited extension and research support** - Most cocoa in Africa is grown by small scale farmers, who are mostly relying on traditional production practices. There is limited or non-existent extension support, and improved production technologies often do not reach the farmers.
- > **Shortage of suitable land for expansion of cocoa production** - Traditionally, primary forests, which have fertile soils and give a conducive forest environment for cocoa production, were often cut through the practice of slash and burn. Since forest land is no longer available as in the past, new cocoa plantations must be established on agricultural land. Additionally, laws and regulations limit access to natural resources in some countries. In some countries governments own all primary forests with timber trees. As a result, farmers are not motivated to protect them or to establish timber trees in their gardens since the land is not theirs.
- > **Low productivity and profitability of cocoa plantations** - Many cocoa plantations in Africa are poorly managed and trees are overaged. In some cases, cocoa is grown in monocultures under largely unshaded conditions. Such a production system enhances loss of soil fertility and biodiversity. Poor soil fertility has led to poor growth and premature aging of the cocoa trees, and hence to low productivity. Unfavourable climate changes through irregular rainfall patterns and droughts have also contributed to increased stress for cocoa trees rendering the cocoa trees more susceptible to pest and diseases. Most cocoa farmers are experiencing low farmgate prices for their produce. Yet all input prices such as labour costs are increasing. There are increasing industry concerns about using child labour as a cheap source of labour.
- > **Quality control challenges** - As a result of many factors including pest and disease damage, poor postharvest handling and limited processing infrastructure, the majority of the produced cocoa is of poor quality.

The diversification of cocoa plantations and the production of high quality cocoa beans are important strategies in order to improve the economic and social situation surrounding cocoa production.

The most important intervention today is to improve production of the existing cocoa plantations in order to minimize the continuous search for fertile soils in primary forests. This requires implementation of more diversified agroecosystems that satisfy the ecological requirements of the cocoa trees. Increased



Assessment of the local cocoa production practices

In order to gain a better understanding of the main characteristics of the cocoa farming system in the area, ask the following guiding questions to the farmers:

- > What are the main characteristics of a cocoa plantation?
- > What kind of crops are grown with cocoa and how?
- > What are the challenges facing cocoa production in the area? Are there opportunities for increasing cocoa production?

At the end of the session, you should be able to identify potentials and constraints for improving productivity and quality of cocoa.





NATURAL SUCCESSION

Development of a succession-based forest system



yields have been reported in organic cocoa cultivation, where a sustainable multistorey agroforestry system was properly established and is well managed. Additionally, a system based on high diversity holds enormous potential for environmental conservation in cocoa producing regions.

2. Establishing a new cocoa plantation

The natural habitat of cocoa trees is the tropical rainforest in South and Central America, where the tree predominantly grows in alluvial forests within the sphere of influence of the rivers. Both the annual floods and the higher wind speeds above the water lead to a regular rejuvenation of these ecosystems. With a height of up to 9 m, the cocoa plant is a small understorey tree of the primary forest. It is associated with a vast mixture of tree species providing a stratified forest structure and a constantly high input of organic matter, when the upper storey trees such as the Cotton tree *Ceiba pentandra* lose their foliage for some weeks or months. The resultant higher light penetration through the canopy induces flowering of the understorey cocoa trees.

Succession-based forest system

Vital processes are very dynamic and they are subject to a permanent flow of energy, water and nutrients. In nature, these processes happen all the time and allow for the development of dynamic and stable life systems. Due to their particular climate, topography and soil, humid tropical forests are home to diverse forms of flora and fauna that respond perfectly to the conditions in the regions. The regeneration, recovery and renovation of these systems take place through succession processes. Within these processes, each species occupies, for a certain period of time, a given space, in which it contributes to improve and optimize conditions around it resulting in a diverse and more complex system. Generally, the following phases – each with its particular level in the multistorey structure – can be distinguished:

Phase 1 – Pioneer phase: Following the removal of the forest canopy, the forest floor is covered by pioneer plants within a few weeks. These pioneer species have a short life cycle of only a few months. The species composition depends on the site conditions such as soil type, slope, solar radiation and rainfall patterns.



Discussion on establishing a cocoa plantation

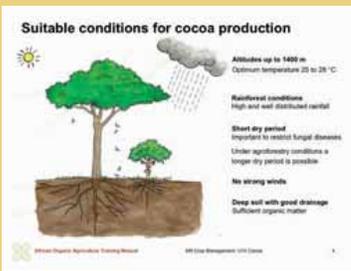
Engage the farmers into a discussion in order to identify, what they normally consider when they are establishing a cocoa plantation, by asking the following questions:

- > What are most suitable conditions for producing cocoa?
 - > What kind of site is conducive to growing cocoa trees?
 - > What kind of varieties do you grow? Are there any preferred varieties, which are most suited for the local conditions?
 - > How do you prepare seedlings for planting?
 - > How is planting done?
- Record all the contributions and make reference to them, as you present the recommendations in this section.





SUITABLE GROWING CONDITIONS



Phase 2 – Secondary forest phase (up to 15 years): A multitude of tree species with a variety of life cycles and ultimate heights germinate at the same time as the pioneer species. This phase is characterized by some fast growing tree species dominating the pioneers after 1 or 2 years. The dynamism of these fast growing species literally drags all the other species in the system along. The resultant high biomass production enhances soil dynamics and thus the recycling of nutrients and organic matter.

Phase 3 (up to 80 years): Secondary forest phase – medium and long cycle: During this phase the forest tree species develop that are characteristic of the site and can reach ages of up to 80 years.

Phase 4 – Primary forest: All the preceding phases ultimately lead to the dominance of those tree species which characterize the mature primary forest with species, whose life cycle can span centuries and up to a thousand years. Mostly all of the timber tree species belong to the primary forest.

2.1 Selecting suitable growing conditions

Cocoa was originally grown under rainforest conditions, where the rainfall is high and well-distributed, with only a short dry season. A dry period is important in restricting the spread of fungal diseases, particularly the black pod disease. But cocoa plants can tolerate longer dry periods of 3 to 4 months under balanced agroforestry conditions. However, severe shortage of water leads to leaf fall and dieback. The optimum temperature range is from 25 to 28 °C. Low temperatures below 10 °C damage the sprouting seedlings, while long periods of high temperatures above 30 °C affect the physiology of the cocoa trees. Cocoa has been successfully grown at higher altitudes near the equator, such as in Uganda at 1,400 m elevation. Strong winds can damage cocoa severely, therefore, areas that are highly exposed to such winds should be avoided.

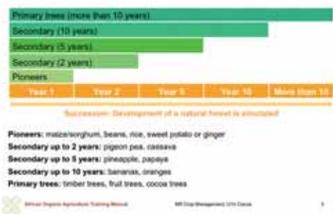
To develop a good root system, cocoa trees require a deep soil with sufficient amounts of organic matter and good drainage. Cocoa is susceptible to longer periods of water logging and poor aeration of soils. Moderate soil pH between 5.0 and 7.0 is preferred.





LIFECYCLE OF INTERCROPS OF COCOA

Lifecycles of different intercrops of cocoa



2.2 Establishment of a cocoa agroforestry system

By understanding and taking advantage of the principles underlying natural succession-based forest systems, abundant agricultural production can be achieved without struggling against pests and diseases. As in the forest, in a well established succession-based agroforestry system, each individual species occupies an appropriate niche and thereby fulfils a particular eco-physiological function within the system. Eventually 'a state of dynamic equilibrium' will be established, where overall there is little gain or loss from among the constituent species.

A dynamic agroforestry system permits a high diversity of crops with different life cycles to grow together with cocoa trees. The selection and combination of crops depends on soil characteristics, market opportunities and food preferences of the farmer. The following groups of crops can be combined or planted together with cocoa on the same day:

- > **Pioneers (with a growing period of several months):** maize/sorghum (1 m x 1 m), beans, rice (0.4 m x 0.4 m), sweet potato (3 m x 3 m), or ginger (1 m x 1 m).
- > **Secondary up to 2 years:** pigeon pea (0.5 m x 0.5 m), cassava (2 m x 1 m),
- > **Secondary up to 5 years:** pineapple (0.4 m x 2 m), papaya (3 m x 3 m) or.
- > **Secondary up to 10 years:** bananas, oranges (6 m x 6 m).
- > **Primary trees, more than 10 years:** timber trees, fruit trees (12 m x 12 m), cocoa trees (3 m x 3 m).

Properly combined crops and trees can grow together in densities as in monocultures without any competition due to the differences in shade tolerance, life cycle and storey level.

2.3 Preparation of good quality planting materials

a. Choice of good varieties

Amelonado is the most cultivated cocoa type in Africa. There are, however, many cocoa varieties and hybrids. Three large groups of cocoa can be distinguished, each with several varieties and strains:

Forastero is the most widely grown type (80 % of total area under cocoa). It gives high yields, but has weak taste. The Amelonados variety is self-compatible.



Discussion on suitable intercrops and trees

Ask the farmers, which food crops, cash crops and native species of forest trees they would select to combine with cocoa. Let them identify crops and trees in the different categories and summarise the most suitable combinations in a table as shown in the transparency.





Criollo has a strong, fine flavour and highest cocoa quality, but the yields are low and, therefore, it is rarely cultivated. It is demanding in its habitat requirements.

Trinitario is a hybrid of the Forastero and Criollo types. It is hardier and more productive than Criollo. It has a share of roughly 10 to 15 % of the total world production and can fertilize self-incompatible species of other groups.

For selection of the most suitable cocoa type and variety for the local conditions proper advice should be sought from the local cocoa farmers, extension advisors or research station. The selected varieties should be good yielding under local climatic conditions, with limited susceptibility to common pests and diseases, and produce the required quality according to the market demand.

b. Multiplication of planting materials

Cocoa can be planted by direct sowing or by raising seedlings from seeds or vegetative parts.

Recommendations to farmers for seedling production:

- > Identify cocoa trees that have had, over several years, high and consistent yields. The trees should preferably be selected in the same region in which the plantations are going to be established. Ensure that most of the neighbouring trees are of the same type and quality, to be sure that the seeds have the same quality.
- > Harvest healthy and mature pods only. Good quality hybrid seeds obtained from local research stations can also be used for seedling production.
- > For the cocoa nursery make sure there is enough shade, ample water and protection from wind.
- > Plant the fresh beans of ripe pods directly into black polythene bags. This is the normal practice.
- > A fertile, loam topsoil is ideal for filling the bags. It is recommended to prepare a special soil mixture for the nursery composed of 40 % top soil, 30 % compost and 30 % sand. The different components have to be mixed carefully and filled into the black polythene bags. If polythene bags are not available, it is possible to use self made bags of local material such as palm leaves or banana fibres. The size of the bags should be about 10 cm x 25 cm. Relatively dense initial shade is recommended (more than 50 %). But shade must be decreased, as the seedlings grow. Apart from watering, the plants do not need much attention in the nursery. However, too much watering may promote fungus attack. Seedlings can be kept in the nursery for up to 6 months.

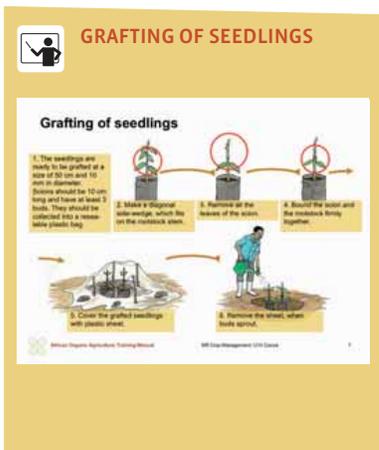


Field Work: Assessment of a cocoa plantation

Take the farmers to a cocoa plantation and analyse the following aspects of the plantation working in groups:

- > Plant diversity
- > Soil and (spontaneous) soil vegetation, organic matter
- > General appearance of the cocoa trees such as height and density of the canopy, color of the leaves, size of fruits, signs of pest and disease attack, parasitic or epiphytic plants on the cocoa trees, etc.
- > What aspects of the plantation can be improved and how?





Recommendations to farmers for grafting:

- > The seedlings are ready to be grafted with other desired varieties when they are about 50 cm in height and 8 to 10 mm in diameter.
- > Scions should be selected from healthy and superior plants, which are well adapted to local conditions. Trees that show tolerance to pests and diseases are preferable.
- > The length of the scions should be about 10 cm with at least 3 buds, and same size as the root stock. The scions should be harvested and collected into a resealable plastic bag after having removed all the fully formed leaves from them.
- > For grafting a diagonal side-wedge is made of the scion in such a way that it just fits the diagonal side-wedge made on the rootstock stem.
- > Scion and rootstock are then bound together firmly with a polythene wrap or rubber band in an upright position.
- > Cover the grafted seedlings with a transparent polyethylene sheet to encourage quick sprouting of the scion.
- > As soon as the buds of the scion start sprouting, slowly remove the sheet and leave the seedlings grow in a shaded area.

2.4 Land preparation

Different land preparation practices are used depending on the slope, the preceding crop or previous use of the site, existing vegetation and other factors. Burning the vegetation for field preparation is not recommended. Instead the site should be cleared by slashing and chopping or shredding the hard plant materials and by distributing them homogeneously on the soil surface.

2.5 Planting

Since cocoa is a shade-loving crop, all other crops to be mixed with cocoa should either be planted beforehand or at the same time as the cocoa. If the area had any natural growth, then some trees should be left standing during land preparation. On the other hand, fast-growing trees which will rapidly provide cover, such as bananas, pawpaw or castor oil trees should be planted before cocoa is planted.



The biological activity of the soil needs to be maintained by ensuring sufficient soil ground cover so that the cocoa mycorrhiza can develop immediately.

With direct sowing, three cocoa beans are planted in the planting holes at a spacing of 1 meter. After 2 to 3 years the strongest and best formed plants are selected to continue developing. This method can be successful and requires little labour. But it requires a high quantity of seeds and bears considerable risk of rodent damage. Therefore, most cocoa is planted using nursery-raised seedlings.

In planted cocoa spacing between cocoa is commonly strongly based on traditions. Spacing can vary between 2.5 m x 2.5 m (1600 plants per hectare) and 5 m x 5 m (400 plants per hectare). The spacing of cocoa largely depends on companion crops. Although closer spacing usually produces higher yields in the first years after planting, once the canopy forms, the plantation becomes dense. Cocoa can also be planted close and thinned later. Especially under conditions of high humidity, it is advisable to thin the canopy to reduce risks of pest and disease infestations. A moderate spacing of 3.5 m x 3.5 m or of 4 m x 4 m supplemented with regular pruning can be recommended.

Recommendations to farmers for planting:

- > First, mark the planting holes with long sticks, based on the chosen spacing.
- > Secondly, plant the banana rhizomes between the sticks. The planting distances for banana depend on the varieties used, the soil properties and the planting distances for cocoa. Generally between 400 and 800 rhizomes per hectare are planted.
- > Tree seedlings are also sown between the banana rows. A mixture of middle and upper storey trees should be planted.
- > If cocoa is to be sown directly, it should be sown at the same time as all the other plant species. If the cocoa seedlings are raised in a nursery, then planting should only be carried out when the other tree species can shade the cocoa plants.
- > Planting holes only need to be big enough to allow the cocoa seedlings to be easily planted.



3. Improving existing cocoa plantations into agroforestry systems

The lifecycle of a cocoa tree can span well over 100 years. Even already existing cocoa plantations can be converted into a dynamic agroforestry system to improve the cocoa yields. The best approach, however, will depend primarily on the current status of the plantation. The following points with recommendations are given:

a. Mature but unproductive trees under shade trees:

- > Identify all the unproductive cocoa trees. Cut some completely down, while adjoining ones should be heavily pruned.
- > Prune back all the shade trees in the sphere of influence of the cut trees to the remaining crown. Shred the prunings and disperse them evenly on the ground.
- > Plant new cocoa seedlings into the gaps. If the area is big enough, pioneer plants such as maize and rice may be planted. In this case, it is better to use seedlings prepared in the nursery than sowing seeds.
- > This procedure builds an 'agroforestry island' in the plantation. Several of such 'islands' will have a positive effect on the growing conditions in the entire plantation.

b. Old but still productive plantations with shade trees of the secondary forest system:

As long as such plantations are of good productivity and do not have pest or disease problems, no major interventions are necessary. Such plantations can be converted to organic production just by abandoning the use of synthetic inputs and by correctly carrying out all maintenance operations.

c. Old unproductive plantations and plantations prone to diseases, with shade trees:

Plantations which used to be productive and now display problems such as poor productivity, and pest and disease infestations, should be rejuvenated entirely.

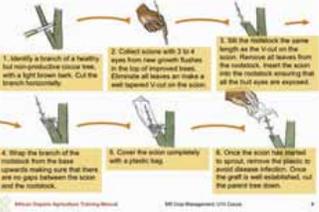
- > Completely remove any existing trees which are pest and disease-prone or of low productivity, and replace them. Or rejuvenate them by grafting with new suckers.





GRAFTING NEW SUCKERS ON OLD TRUNKS

Grafting new suckers on old trunks



Most preferred shade trees in cocoa plantations

Tree species	
<i>Acacia mangium</i>	<i>Rauvolfia vomitoria</i>
<i>Azadirachta indica</i>	<i>Ternstroemia africana</i>
<i>Albizia boonai</i>	<i>Ternstroemia</i> spp.
<i>Cecropia peltata</i>	<i>Triplaris schimperiana</i>
<i>Cola nitida</i>	<i>Pycnanthus angolensis</i>
<i>Entandrophragma angolense</i>	<i>Girardinia sepium</i>
<i>Elaeis guineensis</i>	<i>Mangifera indica</i>
<i>Ficus elastica</i>	<i>Persea americana</i>
<i>Ficus</i> spp.	<i>Coccoloba</i>
<i>Khaya senegalensis</i>	<i>Ricinus communis</i>
<i>Millettia excelsa</i>	<i>Psidium guajava</i>

- > Plant the bananas, the pioneer plants and the entire tree species of the various storeys before the old shade trees are felled.
- > If possible, leave the plant material resulting from felled trees in the plantation.
- > Coppice the cocoa trees to a height of about 40 cm.
- > Chop, shred and spread all the branches on the ground.
- > Correct the spacing between the old cocoa trees, if needed.
- > Select one sucker growing from the coppiced cocoa trees that shall produce fruits after about 3 years and remove all other suckers.

d. Still productive plantations without shade trees:

Many plantations have been established without any shade, or the shade trees have been removed over time. Improvement of such plantations should begin with the establishment of shade trees. This can be achieved by introducing 'agroforestry islands'. Depending on the age of the plantation, the cocoa trees will be pruned, coppiced or completely rejuvenated from suckers.

Another common way to renew a plantation is to graft the new suckers. Here only suckers which can form their own root system are selected. This is especially carried out in order to introduce new varieties into the farming system. The grafting for a new crown structure can also be made directly in the trunk, where it is possible to graft various cocoa cultivars on the same rootstock.

e. Low productive plantations with a high cocoa tree density and few shade trees:

Many cocoa farms in West Africa are over 40 years old and produce low yields mainly due to the age of the trees and poor maintenance. If cocoa trees have several trunks, which grow in competition without forming a real canopy, it would be necessary to rehabilitate the plantation as described in (c). Cocoa trees ideally have one stem and only 3 to 5 main branches, with enough side branches and leaves to capture most of the sunlight.

f. Low productive plantations with a high cocoa tree density without shade trees on depleted soils:

Most of the West African cocoa plantations consist of weak cocoa trees that grow on depleted soils with a very low content of organic matter. Many farmers replant cocoa on the same site between the rows of the old cocoa trees. But there are no results to be expected without implementation of measures that

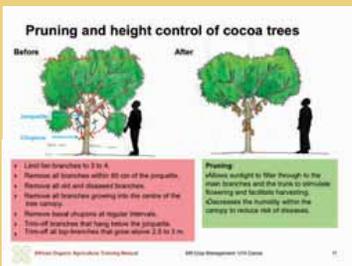




EXAMPLE OF A POORLY MANAGED PLANTATION



PRUNING AND HEIGHT CONTROL



improve soil fertility. Improvement of soil fertility can be achieved by reestablishing a high production of organic matter growing robust native legume herbs and bushes.

4. Maintenance of cocoa plantations

Proper maintenance of cocoa trees during the early stages of growth improves later yields of the plantation. For good development young cocoa plants need favourable growing conditions with the soil protected from the sun, little competition from weeds, proper pruning, adequate shade and improved soil fertility.

4.1 Soil protection and weed management

In a sustainable cocoa plantation the soil is covered mainly by spontaneous vegetation and cocoa leaves, which protect the soil against erosion. However, leguminous cover crops can also be grown in between the cocoa trees. Weed control is critical in the early stages of establishment in order to avoid competition with young cocoa plants for soil nutrients and water. Weeding also increases air circulation and reduces relative humidity and thereby reduces the incidence of black pod disease. Normally when the canopy is formed, weed growth is completely suppressed. Traditionally weeding is done manually by slashing around trees.

4.2 Pruning and height control

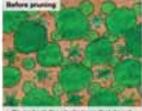
The basic aim of pruning cocoa trees is to encourage a tree structure that allows sunlight to filter through to the main branches and trunk (what is known as a jorquette) to stimulate flowering and facilitate harvesting. Young plants should develop a jorquette at a height of about 1 meter. However, the jorquette-height varies significantly from tree to tree. It has been found that increasing light intensity decreases the jorquette-height. If a jorquette is considered too low, it can be cut off. The strongest of the re-growing chupon can be selected and all others removed. In due course, this chupon will produce a jorquette at a higher level. Vegetatively propagated plants generally form a jorquette at ground level. Fan





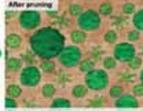
SHADE MANAGEMENT

Shade management in cocoa plantation



- Prune back the shade trees that do not shed their leaves during the dry period.
- Regularly remove old banana and de-suckering surplus shoots of banana.
- After harvest of the banana, split the pseudostems lengthwise and lay them on the ground as ground cover.
- Prune or remove any harvested tree stumps.

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- Increases light penetration to the understorey.
- Provides additional organic material for the maintenance of soil fertility.
- Prolongs the lifetime of the primary tree species.

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branches should be limited to 3 to 4 to allow more light to enter and decrease the humidity within the canopy. Basal chupons should be removed at regular intervals and all lower branches that form or bend below the jorquette should be trimmed off.

Furthermore all branches within 60 cm of the jorquette, all old and diseased branches and branches growing into the centre of the tree canopy should be removed. This should be done at regular intervals through maintenance pruning. All prunings should be left in the field to rot down, except the diseased ones.

4.3 Shade management

Natural forest systems have an underlying annual rhythm determined by, among other things, temperature and rainfall patterns. A number of upper storey trees of the forest system lose their foliage for some weeks or months during the dry season. In the case of cocoa, this rhythm is the more pronounced, the further away the plantation is from the equator. Thus, all the maintenance work carried out should be in harmony with the developmental rhythms of the entire system.

To further increase light penetration to the understorey plants such as cocoa, the shade trees that do not shed their leaves should be pruned back in this period. In addition to increasing light penetration, pruning also provides additional organic material, which contributes to the maintenance and enhancement of soil fertility. Pruning indirectly improves soil texture and the abundance of earthworms. Periodic rejuvenation by pruning also prolongs the lifetime of the primary species.

If reduction of shade cover and exposure of cocoa trees to light is done about 6 months before the expected main harvest, it positively influences the generative phase of cocoa and stimulates flower formation. Rejuvenation of maturing plants enhances intensive sprouting and accelerates the rate of growth in the whole system. Bananas that are grown as intercrops between cocoa should be regularly maintained by removing old leaves and de-suckering surplus shoots. After banana harvest, the pseudostems should be split lengthwise and laid on the ground as ground cover. Any further harvested tree intercrop should be pruned or removed to contribute to increasing light penetration.





SOIL FERTILITY IMPROVEMENT

Soil fertility improvement in cocoa plantation



4.4 Soil fertility management

One of the most important measures for the improvement and maintenance of soil fertility is the continuous addition of organic material, both woody and fresh plant materials such as mulches. Part of this material comes from pruning of trees and from harvest residues, for example when cocoa pods are returned to the plantation and distributed evenly over the soil surface. By ensuring consistent use of prunings and pods within the plantation, soil fertility can generally be maintained for successful organic cocoa production.

Many palm varieties are in a position to actively make phosphorus and other nutrients available to other plants through symbiosis with mycorrhiza-fungus. It is, therefore, recommended to integrate suitable palm tree species into the cultivation system wherever possible.

Many farmers eliminate big trees by ring barking. This practise is not recommended because the forced slow die back process has a negative influence on the whole plantation.

Application of animal manure and compost is very beneficial in cocoa plantations, as they provide nutrients and improve the soil structure and its capacity to hold water and nutrients.

5. Management of pests and diseases

Cocoa can be affected by many pests and diseases, which thrive well in the warm and humid climates where cocoa is commonly grown. However, with proper understanding and implementation of a natural agroecosystem, pests and diseases can be effectively managed.

Several experiences and research have shown that it is possible to reduce pests and diseases in cocoa significantly, only by modifying a production system to a more dynamic agroforestry system. A series of relationships have been observed between the supply of light, air, water and nutrients to the cocoa system on one hand and the appearance of diseases and pests on the other hand.



Group activity on soil fertility management

Take the farmers to a cocoa plantation and ask them to characterize the following key criteria for soil fertility management:

- > Plant diversity within the plantation
- > Availability of mulch
- > Use of potential mulching materials
- > Organic matter content of the soil (darkness of the soil)
- > Use of other sources of organic material such as compost

Discuss recommendations in the plenum on how the production of organic matter and hence soil fertility can be enhanced within the plantation.



Most pest and disease infestations have been found to occur under the following conditions:

- › Ignoring the succession sequences of forest systems. Having originated in the primary forest, cocoa can well endure old primary forest tree species as shade trees, but not old secondary trees.
- › Cultivation of cocoa monocultures with a few shade trees and species only.
- › High density of vegetation due to densely-spaced plantation and failure to thin and prune the trees. This creates a conducive, humid environment for the cocoa pests and diseases.

Generally proper management of pests and diseases can be achieved by:

- › **Using disease resistant and pest tolerant varieties** - Cocoa varieties with tolerance to black pod disease and swollen shoot virus disease exists, for example, in West Africa. Local cocoa research institutes may inform about their availability.
- › **Ensuring field hygiene** - This is probably the single most important method for managing key cocoa diseases. All diseased or infected plants, pods and other plant parts should be removed from the plantation and destroyed. It has been shown in West Africa that regular removal of diseased pods can suppress the black pod disease. Another hygiene measure concerns planting materials for establishing new cocoa fields. To ensure healthy planting material shoots should be taken from non-infested trees and plantations only.
- › **Regulating cocoa tree height, pruning and shade management** - Removal of some branches of cocoa and shade trees by pruning and proper maintenance of the height of the cocoa trees will allow light to penetrate to the centre of the tree, and will increase air circulation. Both make the conditions unfavourable for the black pod disease. Removing shade trees with a shorter life cycle than cocoa at the end of their life cycle is an important measure to be undertaken in this concern.
- › **Maintaining soil fertility** - Efforts for improving soil fertility are critical, particularly where cocoa is grown on poor soils with low nutrient levels, to ensure general health of the tree.
- › **Proper weeding** - Weeding increases air circulation and reduces the humidity in the plantation and thereby reduces the incidence of diseases, particularly the black pod disease.



Identification of pest and disease damage in the field

Visit select cocoa plantations and identify any observable signs of pest or disease damage. Ask the farmers, whether they are familiar with the signs of infection and whether they have monitored to see when the pests and diseases attack.





COMMON PESTS AND DISEASES

Common pest and diseases

Pest and Diseases	Impacts
Mirids (capsids)	<ul style="list-style-type: none"> • Sucking insects damaging young shoots and cocoa pods • Brown or black sap lesions, later infested by disease • Young cocoa trees are very vulnerable when grown without shade.
Mealybugs	<ul style="list-style-type: none"> • Vectors of CSSV
Cocoa swollen shoot virus disease (CSSV)	<ul style="list-style-type: none"> • Virus transmitted by mealybugs. • Swelling of roots and stems, red vein banding interveinal chlorosis of leaves, trees becoming yellow, infected trees can die.
Black pod	<ul style="list-style-type: none"> • Caused by several species of the fungi <i>Phytophthora</i> • Pods can be infected at any stage of development. • Symptoms: Small translucent spot turning into a chocolate brown colour, then the whole pod turns black and mummifies. Infected pods have white sporulation on their surface.

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DISEASE CONTROL MEASURES

Common disease control measures

Measures	Effects
Use of disease resistant and pest tolerant varieties	<ul style="list-style-type: none"> • Varieties with tolerance to black pod disease and swollen shoot virus disease
Ensuring field hygiene	<ul style="list-style-type: none"> • Most important method for managing diseases: regular removal of diseased pods can suppress the black pod disease. • Use healthy planting material only.
Regulating cocoa tree height, pruning and shade	<ul style="list-style-type: none"> • Light and air circulation reduce Black pod disease.
Maintaining soil fertility	<ul style="list-style-type: none"> • Improves general health of the tree.
Proper weeding	<ul style="list-style-type: none"> • Air circulation and less humidity reduce diseases, particularly Black pod disease

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5.1 Management of cocoa pests

The most common pests in Africa are **mirids** or capsids (*Distantiella theobromae* and *Sahlbergella singularis*) and **mealybugs** (*Planococcus*, *Stictococcus*). Mealybugs are mainly a problem as vectors of cocoa swollen shoot virus (CSSV). Mirids (capsids) are sucking insects. They damage young shoots and cocoa pods thereby reducing the yield of cocoa. Feeding by mirids is characterized by brown or black sap lesions that are later infested by disease. Young cocoa trees are very vulnerable to attacks of mirids when they are grown without shade.

5.2 Management of cocoa diseases

In Africa, the main cocoa diseases are the black pod and cocoa swollen shoot virus (CSSV).

a. Cocoa swollen shoot virus disease (CSSV)

The disease is caused by the swollen shoot virus and is a major problem in all cocoa growing regions. CSSV is transmitted by mealybugs such as *Planococcoides*. Symptoms include swelling of roots and stems, red vein-banding interveinal chlorosis of leaves, trees becoming yellow, and if there is a severe viral attack, infected trees die.

b. Black pod

This disease causes the most important yield losses in cocoa worldwide. It is caused by several species of the fungi *Phytophthora*. Two species—*P. megakarya* and *P. palmivora* – cause this most important yield-limiting disease in the African cocoa industry. Although *Phytophthora* species attack all parts of the cocoa tree, the major economic loss comes from infection of the pod. Pods can be infected at any stage of development.

Symptoms include the appearance of a small translucent spot. The spot turns into a chocolate brown colour, then darkens and expands until the whole pod turns black and mummifies. Infected pods also have white sporulation on their surface. This sporulation becomes denser as the disease progresses.





6. Postharvest handling of cocoa

Substantial quality characteristics of cocoa depend on correct processing, which starts already with the harvesting process and ends with the storing of the processed product.

6.1 Harvesting

Depending on the temperature, pod ripening can take between 4.5 to 7 months from flowering. Pods must be harvested when they are fully ripe with a visible orange or yellow shell. Beans from unripe pods produce low quality cocoa. Ripe pods should be removed as soon as possible in order to minimise attack by fungal diseases or animal pests. In addition, ripe beans can germinate inside the pod, which has a negative effect on the cocoa quality.

Recommendations for harvesting:

- > Harvesting should be carried out at regular intervals of 1.5 to 3 weeks.
- > Pods must be cut off the tree with knives without damaging the stem on which further fruits will form.
- > After harvesting, pods can be kept for a few days before opening. Such a delay has been found to be advantageous in improving the cocoa quality.
- > Pods then have to be opened for the removal of the beans. It is important to separate the beans from the placenta. Either the pods are opened in the field and only the beans moved for fermentation or the pods are transported and opened near the fermenting kegs. To reduce the risk of damaging the beans, the pods are to be cracked on a hard surface (stone or wood) or by hitting them with a piece of wood.

6.2 Fermentation

Beans must be fermented as soon as they are removed from the pod. Fermentation has four objectives:

- > Removes the mucilage (pulp) attached to the beans.
- > Kills the embryo so that the beans cannot germinate.



Discussion on post-harvest handling of cocoa

Inquire among the farmers, how they handle cocoa during and after harvesting and up to storage of dried beans. Identify any shortcomings in the methods and procedures that are locally used and advise accordingly on improvements needed in order to improve the quality of dried cocoa beans.



- › Encourages chemical changes within the bean, which produce the substances responsible for the chocolate aroma.
- › Reduces the moisture content of the beans.

Fermentation can be carried out in two ways:

Traditionally the beans are heaped or wrapped in banana leaves. Every second day the banana leaf packages are turned over to ensure even fermentation. The size of heaps is determined by the need for a sufficiently high temperature of 40 to 50 °C to permit liquid to drain out and air to circulate freely around the beans. Small quantities of less than about 70 kg will not reach the required temperature, while in heaps of more than 150 kg aeration becomes restricted. The end of the fermentation process is reached when most of the beans are brown. When 75 % of the beans have pale cotyledons in the centre with a brown ring, the fermentation process should be stopped. The process usually takes 6 to 8 days for Forastero and 3 to 5 days for Criollo cocoa.

A second way of fermenting the cocoa beans is by placing them in wooden tray stacked on top of each other and covered. This way saves on work for the farmer and ensures better fermentation. Waste water from the fermentation process should be properly disposed off, for example in other crop fields.

Germinated beans and beans from disease-infested pods should be fermented separately.

6.3 Proper drying

Fermented beans must be dried to prevent deterioration. This is mainly done by spreading them out in the sun on concrete floors or raised mats. The beans need to be covered overnight and in rain. Sun drying alone will take at least a week. Foreign matter should be picked out from the beans while they are spread out. Sun drying can be supplemented with hot air in specially-designed drying chambers. Well-dried beans should have a moisture content of about 6 to 7 %. Beans with a moisture content of more than 8 % become mouldy, while beans with moisture below 5 % become brittle. Before packing dried beans into air permeable bags, all flat, broken and poorly fermented beans should be removed.



6.4 Proper storage

Due to the high temperature and humidity in the tropics, stored cocoa rapidly gets attacked by storage pests and moulds, because dried cocoa easily absorbs water. In locations with 80 to 90 % humidity, the moisture content of cocoa often increases to more than 10 %. As a result, cocoa loses its storage capacity.

Therefore, for proper storage good ventilation should be ensured. The bags should be stack off the ground, preferably on wooden pallets, and off the wall.

Organic production does neither allow the treatment with methyl bromide nor the application of synthetic storage insecticides. The jute bags used for packing should also not have been treated with pesticides.

7. Marketing and organic certification of organic cocoa

Sustainable production of cocoa has become an increasingly important driver for the development of the cocoa sector in Africa. Driven by consumer demand, new initiatives have emerged, including commitments by cocoa importers and chocolate manufacturers to purchase sustainably certified cocoa and to provide services to producers. Because of these developments there is a growing market for sustainably produced and certified organic cocoa in Europe and the US. This trend provides an opportunity for cocoa producers to improve their livelihoods, and for the cocoa sector to make its sustainability efforts more visible. To realize this opportunity, producers need support to access these emerging markets.

There are different sustainability initiatives to certify cocoa, which include organic production, and others like 'Rain Forest Alliance', 'Fairtrade' and UTZ Certified which are mainly social standards, but also require 'good practices in cocoa production'.

Organic certification of cocoa should only be done as a market requirement. Generally organic production of cocoa will have the following requirements:

- > Implementation of organic approaches to soil fertility, pest and disease management. Organic production does not allow the use of synthetic pesticides and fertilisers as well as other unnatural postharvest treatments for cocoa beans, packaging materials and stores.



Discussion on marketing and organic certification of cocoa

Analyse the cocoa marketing situation in the area by asking the following questions:

- > Where do you commonly sell your cocoa products?
- > Are those markets interested in organic cocoa?
- > Is there a common understanding among cocoa farmers in the area, which would allow collaboration for certification and marketing?
- > Are there opportunities to obtain support during conversion to organic, either from the existing customers or any other support organisation?

Propose ways to access the necessary market information.



- > Proper separation of organic cocoa and conventional cocoa during production and postharvest handling
- > Implementing a good traceability system, based on clear labelling and record keeping in order to minimise contamination.
- > In order to reduce organic certification cost for the individual farmer, small-holder farmers should look for group certification.

Specific national or international organic standards may define additional requirements. Therefore, interested cocoa farmers should consult the national organic movement or organic certification body operating within the region or country for further guidance.

Recommended further reading

- > FAO. Organic Cocoa Production: A guide for Farmer Field Schools in Sierra Leone. 2007. www.fao.org/fileadmin/templates/organicexports/docs/OrganicCocoa_FFS_Guide.pdf
- > SIPPO, FiBL, Naturland. Market Overview on Coffee, Cocoa and Tea. 2002. www.sippo.ch > Publications > Food > Organic Food Products
- > Naturland. Organic Farming in the Tropics and Subtropics: Cocoa. 2000. www.naturland.de/fileadmin/MDb/documents/Publication/English/cocoa.pdf
- > Asare, Richard. Cocoa agroforests in West Africa. A look at activities on preferred trees in the farming systems. 2005. Forest and Landscape Denmark. Working Papers No. 6-2005. www.SL.kvl.dk
- > EPOPA. The Organic Cocoa Market in Europe. Summary of a market study. 2003. www.epopa.info

