# How to Grow
# Organic Cocoa

Naturland

*An illustrated handbook on organic principles of cocoa production*

# Index

## Introduction

Already known by the Aztec as "the beverage of Gods", cocoa is due to the fatcontent of its seeds a tasty product and rich in energy. Originally from the Amazonas forest and Central America the cocoa tree is nowadays planted in all humid tropical regions. Economically, *Theobroma cocoa L*. is the most important variety of the species *Theobroma*. In practice there are two subspecies called Criollo and Forastero, the latter being grown on over 80% of plantations worldwide. This manual provides information about the plant and how to cultivate it in an organic way.

## Botany

*Theobroma cacao* is a small to medium-sized tree of 8-10 m belonging to the family *Malvaceae*. Its blossoms appear from the wood of the leaf axil, on the trunk and the branches. Flowers appear throughout the year as long as no extreme drought or seasonal temperature fluctuations occur. The pods develop within 5-6 months from the flowers that are pollinated by insects, mainly midges of the genus *Forcipomyia* and *Lasiohelea*.

**Figure 1** Examples of the various shapes and colours of cocoa pods.

The cocoa fruit has a stunted cucumber-like shape, and is about 25 cm long, 8-10 cm thick and weighs 300-400 g, although they vary substantially between varieties (see Figure 1). The shell, which can be up to 20 mm thick surrounds the sugar-rich, bitter-sweet and acrid pulp. The fruit contains 25-50 almond-shaped and bitter tasting seeds which are arranged in 5-8 long rows. These are the valuable cocoa beans.

## Worldwide organically cocoa production

The first organically certified cocoa was produced in Bolivia during the 80's. More than 90% of worldwide cocoa is produced by small scale farmers that own 2-5 ha. Eight million hectares are estimated to be under cocoa cultivation. Of the global production, 71% comes from West Africa and the rest is equally shared between South America and Asia/Oceania (Südwind, 2013). Organic cocoa production is increasing rapidly. This is reflected in the growth from around 400 tonnes to 7000 tonnes of beans certified by Naturland in the years 2003 and 2010, respectively.

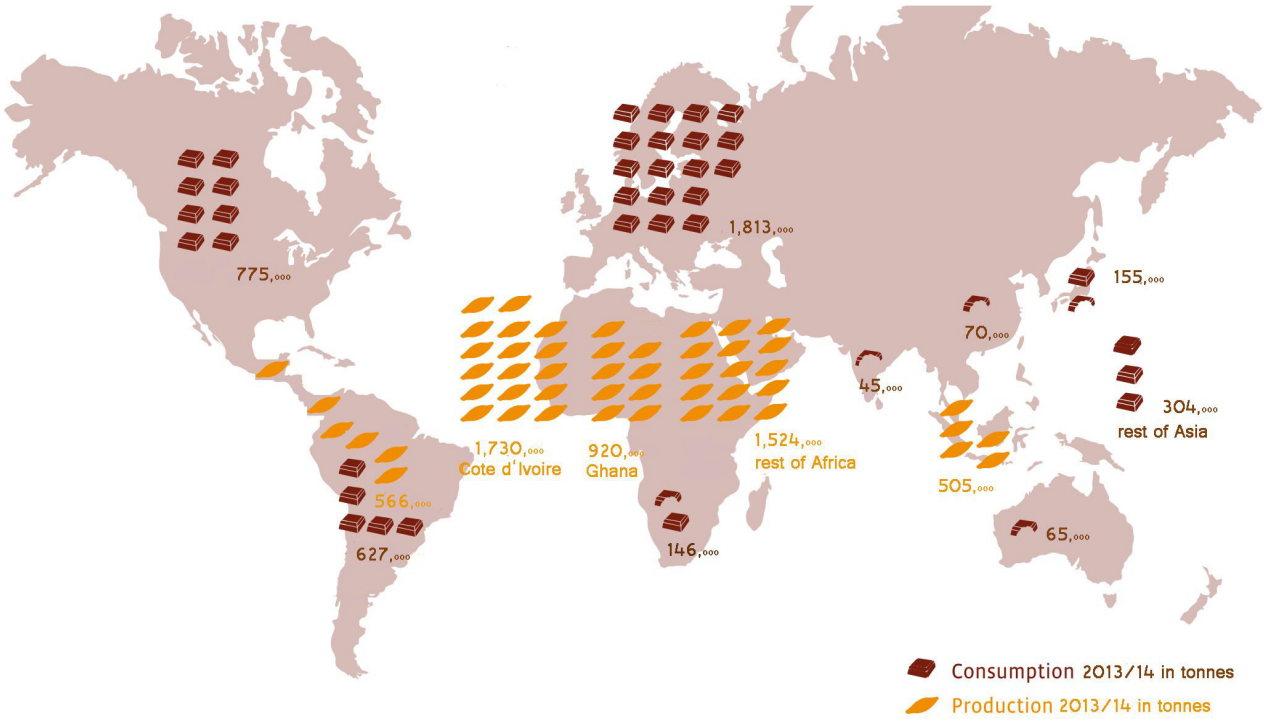


**Figure 2** Global production and consumption of cocoa beans with the most important producers and consumers (adapted but changed from Suedwind, 2012).

## Uses of cocoa

The seeds of the cocoa plant are mainly used to manufacture chocolate, cocoa-based drinks and other sweet products. On the international market raw, dried cocoa beans are the most common product; these need to be roasted before being processed into the various products. More and more cocoa-producing countries are now processing the raw cocoa in cocoa mills before export. This enables them to sell semi-manufactured goods such as cocoa butter, cocoa powder as well as cocoa blocks. Fresh cocoa fruit juice from the seed pulp, which is produced during the process, can be fermented into alcoholic beverages and vinegar, or made into fruit jellies.

## Principles of organic cocoa production

The aim of producing cocoa organically is to establish a production system that is socially, economically and environmentally sustainable in the long term, i.e. an agroforestry system. To achieve this, a few guiding principles have to be observed.

1. If a new cocoa plantation is established it is important that the existing forest be retained. Cocoa trees can be integrated into the existing forest structure. In this way the environmental impact is minimized and the multiple canopy storeys required for successful cocoa production are retained. Cocoa trees do best in **agroforestry systems** where they are grown in combination with taller shade and fertilizer trees. If no forest existed on the site, other trees should be planted to provide the agroforestry effect. The presence of other trees in the plantation helps regarding pest control, increased soil fertility, pollinator habitats, environmental and micro-climate buffering, diverse human food sources, improved cocoa yields and better income. By having more diverse food sources, farmers become food sovereign and can improve their income due to relying less on the cocoa market for their income. Having more food sources enables farmers to sell products on the local market and use it for self consumption.
2. When establishing a new plantation it is important to **incorporate crop successions**. This can be done by planting bananas, papaya and pineapples (for example) and reducing them as the cocoa trees develop. This improves soil fertility, cocoa tree growth, food availability and farm income.
3. **No chemical pest control** may be used. The conventional chemicals upset the systems balance by killing pest predators, being poisonous to animals and humans and causing damage further downstream in the ecosystem. Instead, biological or cultural methods should be used, for example removing and bury cocoa pods affected by black pod disease. Such methods do not kill pest predators, are non-toxic and cost less and are therefore better for farmers and their environment (Bateman, 2009).
4. **No chemical fertilizer** may be used. These disturb the balance of vital soil biota, cause eutrophication of waters (pollution by too many nutrients), are expensive and make farmers dependent on agro-chemical firms. Biological soil fertility improvements such as compost, vermicompost and fertilizer trees should be used instead; they avert all of these risks.
5. **Good care** must be taken of the plantation. This is done through careful pruning of cocoa and shade trees and maintaining phyto-hygiene to control pests and diseases.

These aspects are the main difference between conventional and organic cocoa production. Avoiding the use of chemical substances (including fumigation agents during storage), organic production calls for other solutions to soil fertility, pest management and quality assurance that are better for people and the environment.

It is important to note that organic production represents a general switch from external inputs to internal inputs and management. In the case of soil fertility management, for example, this is achieved by switching from chemical fertilizers brought onto the farm to compost and manure produced on the farm as well as a diversified agroforestry system. This strategy benefits farmers by:

- Lowering input costs
- Increasing their income
- Decreasing environmental and health risks
- Increasing the sovereignty of farmers

These four items will be explained in the chapter "Advantages of organic cocoa production".

## Agroforestry

The word agroforestry describes crop production in a system that combines trees with shrubs and smaller crops. Basically, it is the combination of agriculture and forestry and it improves overall crop yields per hectare and provides a more diverse range of crops. Figure 3 shows an example of an agroforestry system as it could be established in West Africa. The various trees and shrubs interact to provide shade, nutrients, refuges to beneficial organisms (such as the midges that pollinate cocoa trees), pest control, micro-climate buffering, nutrient cycling, improved moisture availability and reduced weed competition. All components of the system benefit from this. Cocoa trees evolved in forests where

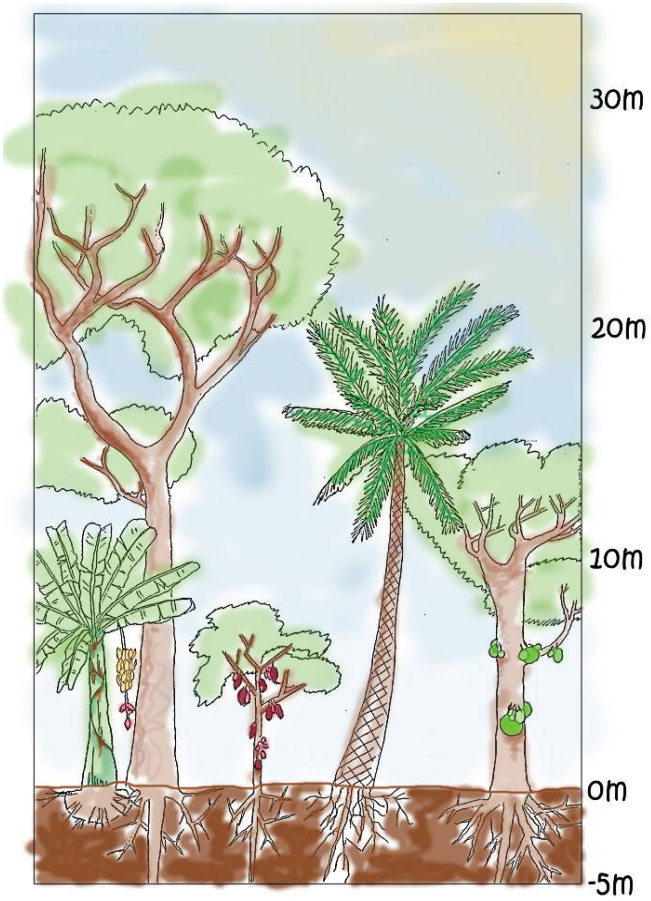


**Figure 3** An example of an agroforestry system as it could be established in West Africa. The trees are cocoas, banana, jackfruit, oil palm and Albizia zygia.

they were partially shaded from above. Therefore, an agroforestry system is the best way to cultivate cocoa so that the taller trees provide shade as well as nutrients to the cocoa trees. This in fact improves cocoa yields and the trees develop more biomass and are better at taking up nutrients (Isaac et al., 2007).

The idea of an agroforestry system for cocoa production is to create a number of canopy storeys or layers based on the different heights of trees. In Figure 4 the tall *Albizia zygia tree* forms the first canopy layer, the oil palm the second, jackfruit the third, and so on. The example has been adapted to a possible tree combination in West Africa, but the same principle can be replicated with different species in other cocoa growing regions. In Central and South America for example cocoa growers have long been using the leguminous tree *Gliricidia sepium*, which is also called 'madre de cacao' (mother of cocoa) because of its excellent use as a cocoa shade tree (Elevitch and Francis, 2006). This shade tree enjoys a good reputation due to its rapid growth, ability to fix atmospheric nitrogen, ease of establishment, ability to adapt too many different side conditions and capacity to grow back fast after pruning. Figure 5 and Figure 6 on the next page show the uses of the components of this agroforestry system. They divide the uses into two, Figure 5 shows the products the farmer can harvest and Figure 6, the ecosystem services provided by the different plants.

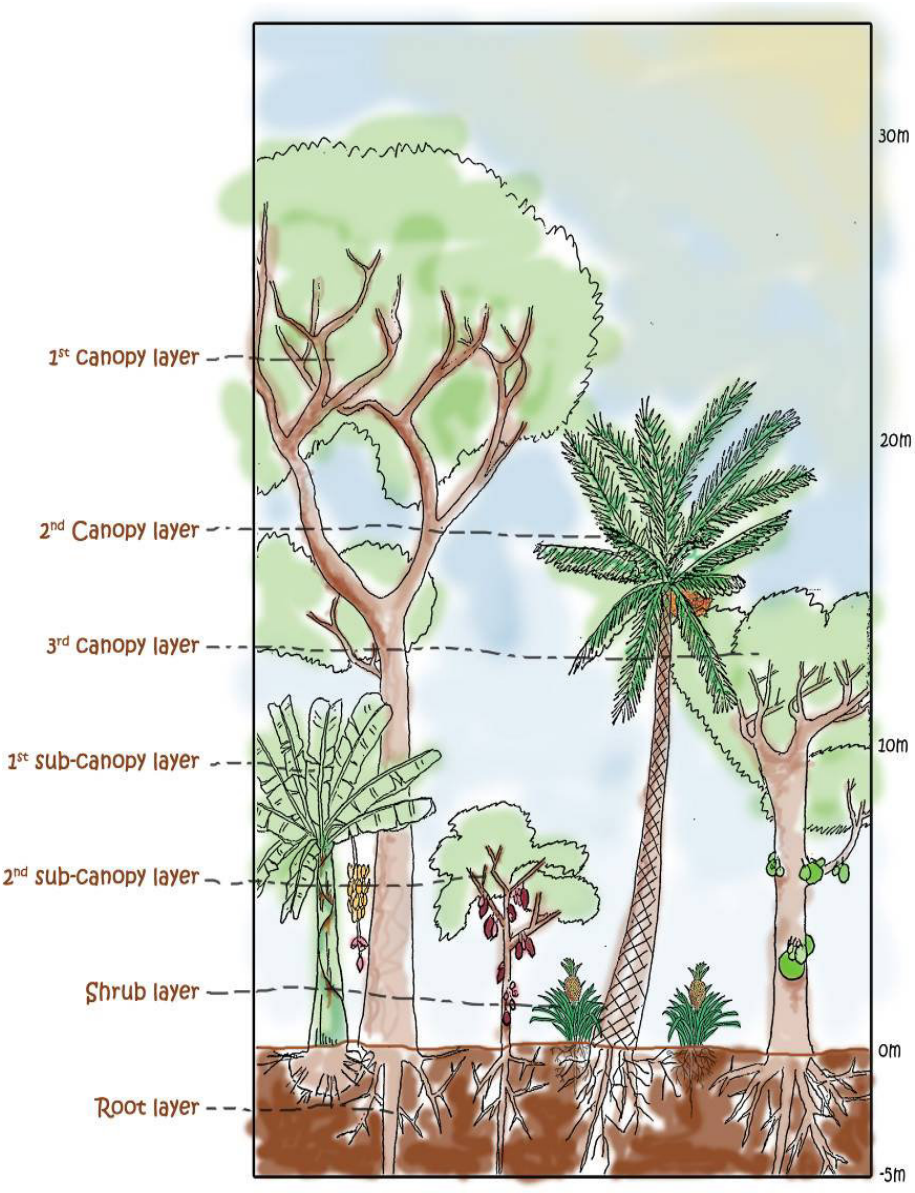


**Figure 4** The idea of an agroforestry system is to create a number of canopy layers, one above the other, as seen in this diagram.

It is important to note that this arrangement provides not only cocoa beans for sale and cash income but a number of other services and goods that directly or indirectly benefit the farmer. Especially the diversification of food sources helps farmers to become food sovereign by being more independent from cocoa prices.

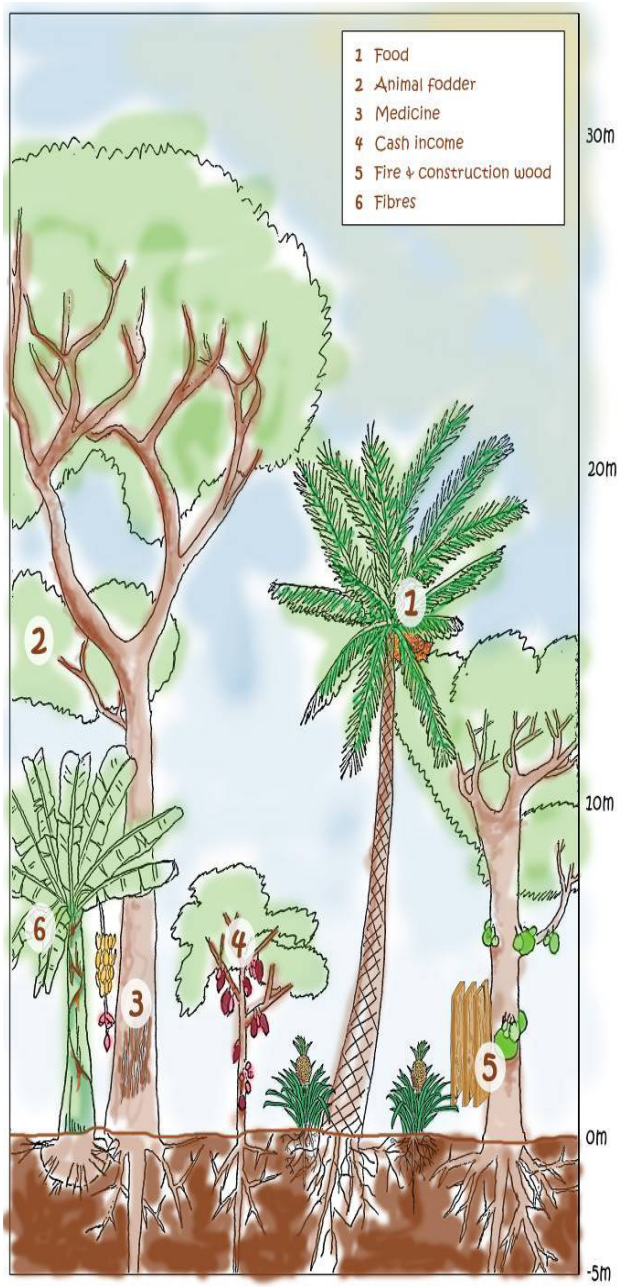


**Figure 5** Diagram showing the different products that can be derived from the components of the system, please note that any one tree may yield more than the one product indicated here, for simplification of the diagram they have not been included however.

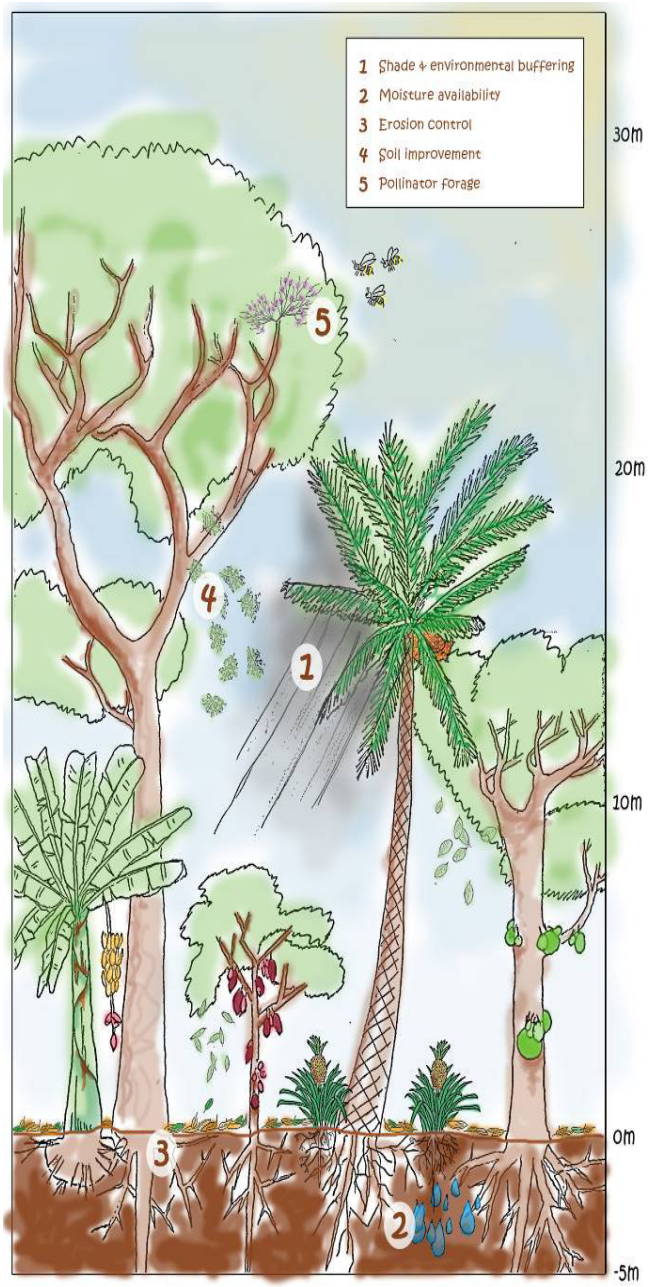


**Figure 6** Diagram showing the ecosystem services provided by the different trees. Again, please note that any one tree may yield more than the one service indicated here, for simplification of the diagram they have not been included however.

## Agroforestry vs. Mono-cropping

Every attempt to cultivate cocoa in mono-cropping systems or in systems with little ecological diversity has sooner or later encountered crises due to phytosanitary (plant health) problems or a loss of soil fertility. The problems could neither be solved by the selection of resistant plants, nor with chemical measures or supplying additional chemical fertilisers. A point in case is the previously largest area of cocoa production in the Brazilian state of Bahia. In the past 15 years, cocoa plantations there have been heavily reduced by the witches' broom disease (*Crinipellis perniciosa*), even though huge sums of money had been spent on scientific research. Attempts in Ecuador to counteract this disease by developing resistant clones have also failed. To avoid these problems, organic production therefore places great emphasis on establishing plantations based on agroforestry principles (see Figure 7).

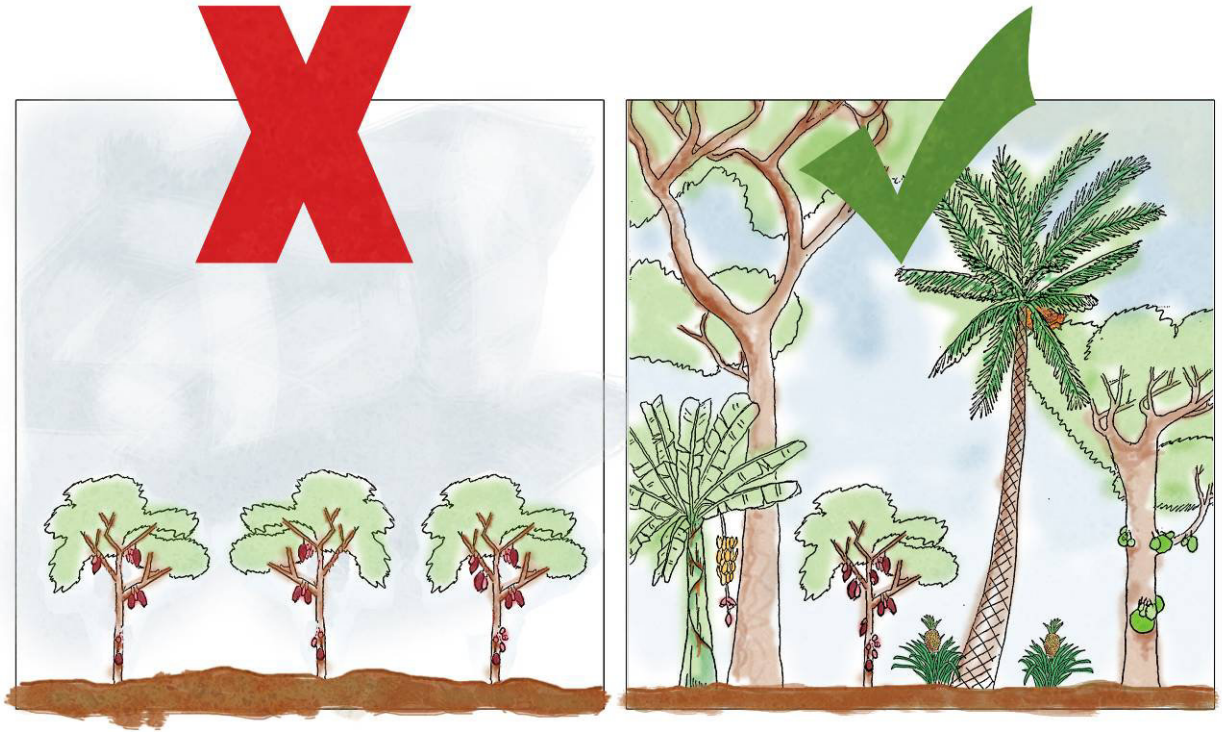

**Figure 7** Organic cocoa production emphasises the use of an agroforestry system instead of mono-cultures.

# Advantages of organic cocoa production

## Fewer inputs – reduced costs

Organic production virtually eliminates the use of expensive external inputs such as fertilizers and plant protection substances. By not using these, farmers can significantly reduce their operating costs. External inputs (that are usually bought from big agrochemical companies which contribute little to the local economy) are replaced with local inputs. For example, chemical fertilizers are replaced by compost and expensive hybrid seeds are replaced with locally kept seeds (e.g. when intercropping cocoa with papaya trees). This lowers costs and increases farmers' sovereignty by making them less dependent on big companies and money.

## Higher prices for organic cocoa

Organically produced cocoa beans also command a higher price in the international marketplace than conventional ones (ICCO, 2006). Therefore, the reduced input costs and the improved prize per ton of organic beans leads to a higher farm income, overall.

## Environmental and health benefits

Organic production is more environmentally sustainable than conventional production. This is achieved through avoidance of pollution and better production methods such as agroforestry. Additionally, by avoiding hazardous chemicals such as pesticides and insecticides, the health of cocoa farmers is also protected.

## Increasing the sovereignty of farmers and their income

Organic production encourages intercropping of the cocoa plantation with numerous other useful crops such as bananas, pineapples, shade trees, oil palms and jackfruit. Each of these provides the farmers with additional food and income sources, further helping farmers to become independent of having to buy food and improving their farm income. The farm income can also be increased by operating according to Naturland Fair Trade Standards.

### Advantages of Naturland Fair certification

Additional to organic certification, Naturland also offers its members to become certified according to the Naturland Fair Trade Standards. These are a set of Fair Trade rules for production and trade of cocoa. The benefits to farmers and farm workers are that preference has to be given to produce from small scale farmers' organisations, stable trade agreements with buyers and a better market price for cocoa beans (including a fixed minimum price guarantee). There is also the payment of a Fair Trade Premium to the community of cocoa producers. This Premium is then used to fund local social, educational, health-related or environmental measures and contributes to the well-being of the community and its farmers (Naturland Fair Trade Standards, 2012).

## The Naturland Standards

The rules governing what can be called organic production are laid down in the Naturland Standards (Naturland, 2014). These are a set of rules and principles that regulate which production methods are allowed and which are not. The standards were used to develop a checklist that is used to control each cocoa farmer to ensure they are producing organically. Therefore, to be able to market their cocoa with the Naturland logo, the following (among others) has to be observed during production:

- No chemical plant protection inputs are allowed (an exception can be made for the use of copper salts up to 3 kg/ha/year in emergencies.
- No synthetic chemical nitrogen fertilizers, chile saltpetre or urea are permitted (stone meals and raw phosphate may, however be used if composition hand heavy metal contents are known).
- No fumigation of cocoa beans in storage.

An agroforestry system is to be established. Depending on local agro-ecological conditions at least 40% all year coverage with shade trees is recommended with trees belonging to 12 or more species per hectare.

## Site requirements of cocoa

Cocoa originally grew in the so-called understory of primary forests and was associated with a variety of palm and tree species. These benefit the cocoa trees. For example, trees in the first canopy layer lose their foliage during months of shorter daylight hours. The resulting increase in light encourages the development of cocoa blossoms, and the falling leaves provide organic material to the soil.

Cocoa production needs an even spread of rainfall throughout the year (ca. 100 mm per month); the plantations being able to survive on 1250 mm per year. The average annual temperature should be around 25°C. In regions with extensive wet periods or large seasonal temperature fluctuations, the harvesting periods are reduced to only a few months per year. In regions with a balanced climate and only slight temperature and rainfall fluctuations, cocoa produces fruit throughout the year.

The soil on cocoa plantations should be deep, well-drained, and have sufficient water-retaining capacity. The pH-value should lie between 4.0 and 7.5, whereby care must be taken that sufficient organic material is available.

Cocoa trees can live for over one hundred years. Naturally occurring cocoa crops propagate themselves through lateral shoots, which can occur at any height on the trunk. Otherwise, the seeds are spread by small rodents and apes.

## Growing cocoa from seeds and seedlings

Many cocoa varieties are self-sterile, and need to be fertilised through allogamy, by relying on other varieties for fertilisation. These varieties belong mainly to the group of clones and hybrids of the group 'Trinitarios'. No general recommendations are available as to which seed and shoot material should be used, as this depends largely on the material which is locally available. So-called hybrid seeds can be used, as well as vegetatively developed material. Cocoa shoots are usually set out in plastic bags for 4-6 months, before being transplanted onto the site. In the vegetative method the shoots are sorted after 3-5 months, according to sturdiness of the rootstocks, after which the plants remain in the nursery for a further 4-6 months (see Figure 8).

**Figure 8** A nursery for the farm can be simple and built from locally available materials, this helps keep production costs low.

In regions with naturally occurring cocoa plants, or with self-fertilising varieties (see Table 1), the seeds can be sown directly, usually 3 seeds are sown per hole. In the course of the first 3-5 years, the plants are thinned to one or two per hole.

| Africa | Brazil | Ecuador | Mexico | Bolivia | Asia |
|---|---|---|---|---|---|
| Amelonado type | Cocoa común, Amelonado type | Cocoa nacional | Criollo (white seed superior cocoa) | Criollo (forastero amazónico) | No self-fertile varieties |

**Table 1** Self-fertilising cocoas varieties which are suitable for direct sowing.

## Starting a new plantation

When choosing the site for a new plantation, the natural requirements of cocoa should be respected. Ideal sites are those with well drained alluvial soils so as to prevent water-logging. Sites that are irrigated from wells are also favourable. Unsuitable sites are those with steep or convex slopes.

When creating a new plantation, care should be taken to reproduce as closely as possible the natural structure of forests (i.e. creating an agroforestry system). This means that all of the crops and trees that are to be cultivated along with cocoa in the agroforestry system should be planted at the same time (or even earlier) as the cocoa trees themselves. The best method is to leave an area free for natural growth, and to plant trees and crops which will rapidly provide shade, such as bananas and manioc, and to plant the cocoa in-between them at a later date. In this way, the biological activity of the soil is maintained, and the mycorrhiza of the cocoa can begin to develop immediately.

When establishing a new plantation maize may also be sown as a pioneer crop, simultaneously with new cocojam (*Xanthosoma sagittifolium*), bush peas (*Cajanus cajan*), and as ground coverage, Canavalia ensiformis. Along with standard commercial varieties of banana from the Cavendish group, other tall-growing local varieties which can tolerate shade should also be integrated into the plantation. The number of cocoa trees should lie between 600 and 1100 trees per ha.

The general idea is to mimic natural succession of an ecosystem. This means that the system will evolve from a pioneer stage (short lived shrubs and annuals dominate) to a climax stage (long lived trees dominate). In this way the farmer can harvest different crops from the first year onwards and the diversity of the evolving system gives it stability and improves cocoa yields. Figure 9 shows the principle of succession visually.

Note that all crops are planted simultaneously and as time goes by the shorter lived ones will disappear while the longer lived ones mature and start to bear fruit and pods. An important effect of this approach is that the soil is covered at all times and therefore soil quality is maintained or improved, which is very important to good cocoa yields.

Choosing the trees that are to be included in the agroforestry system depends on which species are available in the region and their uses to the farmer and the system as a whole. For example, it is always a good idea to incorporate a number of trees that provide human and animal food, medicine, shade, soil fertilisation, construction and fire wood and protection from soil erosion.

Apart from the possible combination given in the example for West Africa (Figure 3), an endless amount of combinations are possible. An already existing monoculture plantation can be improved by planting new trees in between the old ones. The best method is to re-forest in between existing trees and to fill up spaces that open up after unproductive cocoa trees have been removed.

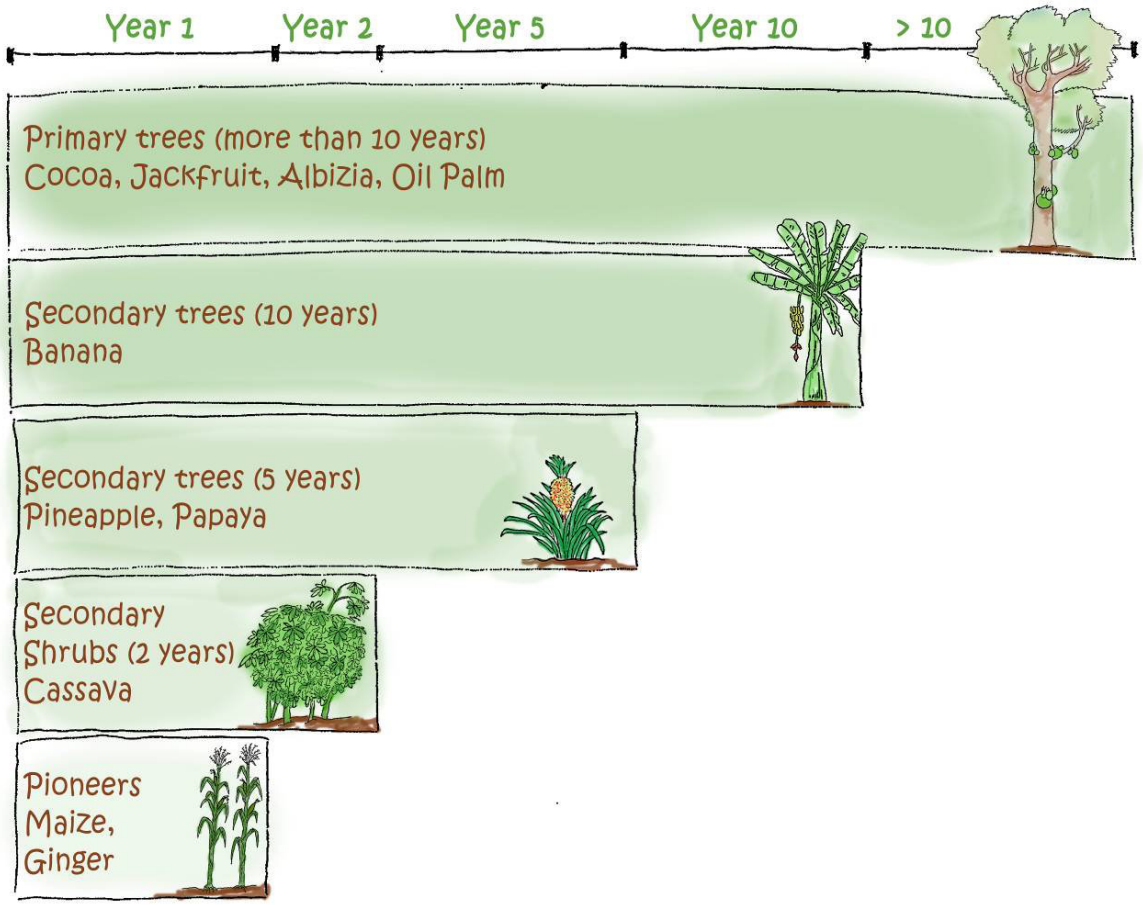


**Figure 9** Diagram showing the concept of succession in an agroforestry system.

## Nutrient cycling on the plantation

Since organic cocoa production focuses on internal cycling of nutrients it is not advisable to use fertiliser that has not originated from the site. This also helps to keep input costs to a minimum. The creation of organic material through mulching and pruning activities is sufficient for an economically viable production – provided a stratified (numerous canopies), diverse and densely planted agroforestry system is in place.

Any cocoa shells that remain after harvest must remain on the plantation. This means that the fruits should be broken open on site, and the resulting shell material spread as evenly as possible. The cocoa fruits harvested on a plot are first piled into a heap and then broken open to provide around 50 kg of fresh cocoa. The cocoa fruits should then be piled onto a different heap during the next harvest stage, and broken open there. This is a simple method of ensuring that the remaining pod shells are spread evenly throughout the plantation.

Many varieties of palms are capable of actively breaking down phosphorous through symbiosis with mycorrhiza, as well as binding heavy metals in the soil. This means that incorporating palms into the plantation will help provide the cocoa trees with phosphorus (an essential nutrient for a good harvest and plant health) and lower the heavy metal content of the beans. This is crucial because Naturland certification calls for a minimum heavy metal content of the beans. It is therefore strongly recommended to integrate suitable palm varieties into the plantation.

Another important tree type to add to the agroforestry system is a leguminous or Nitrogen fixing tree. In the example for West Africa, *Albizia zygia* is such a tree. Leguminous trees are able to fix Nitrogen from the air and make it available to the plants growing around them, including the cocoa trees. Nitrogen is an essential nutrient for the health and productivity of cocoa and therefore it is important to include at least one species of leguminous plant in the plantation.

## Biological methods of plant protection

A very important aspect of organic cocoa production is the management of pests and diseases. Because chemical inputs are not an option, the diversity of the agroforestry system and other biological control methods should be used to fight these problems. The approach encouraged by Naturland makes use of a variety of methods such as crop diversity, biological pest control agents (such as herbal extracts and beneficial fungi and bacteria species) and pruning to control pests and diseases.

## Diseases

Severe diseases which can lead to high yield losses of cocoa worldwide are among others the following: The worldwide occurring "Black Pod" which is caused by several species of the fungi Phytophthora makes the pods turn black and mummify. The "Cocoa Swollen Shoot Virus Disease" (short CSSV) in Africa is transmitted by mealybugs and affects roots, stems, leaves and may lead to a die-off of the whole cocoa tree. Especially in Latin America the "Witches' Broom Disease" (*Crinipellis perniciosa*) and the "Monilia Pod Rot", caused by species of the fungus Miniliophtera (*Moniliophtera (crinipellis) perniciosa* and *Moniliophtera roreri*), are to be taken seriously.

Most of these diseases are caused by the following:

- Cultivation in mono-cropping systems with insufficient diversity and amount of shade and crop trees
- Bad maintenance, no regular pruning
- Too little space between trees of the same species due to a failure to thin out the agroforestry system
- Degraded or poor soils which exhibit a lack of organic material, wrong weed control
- Unsuitable site (water-logged, too dry or not enough soil depth for proper root development)

Besides making sure that these problematic general issues in the cocoa cultivation are eliminated, there are several types of direct remedies to these diseases: Using tolerant or resistant varieties, removing diseased pods regularly, pruning in order to let light in and air circulate, weeding in order to reduce humidity in the season of heavy rainfall. These methods destroy the favourable environment in which the mentioned diseases spread easily.

Effective measures are often only possible in the form of improvements to the whole system. One possibility lies in radically cutting back the trees and subsequently replacing them with more suitable ones. Another is a complete renewal of the system by cutting down all trees to about 40 cm above ground level. Between one and three of the resulting shoots which sprout from the stumps are left to develop. Opening up the plantation in this way allows many new tree species to be included as it is similar to establishing a new plantation.

In the case of infestation with *Phytophtora palmivora*, removing infected pods regularly and burring in a deep hole. In case of intolerable infestation harvest losses can be alleviated by application of permitted copper preparation but not more than 3 kg per ha and year.

Concerning the *Moniliophtera* ('Monili') diseases (Figure 10), there are practical recommendations which can be useful:

**Figure 10** Cocoa tree infected by Monilia.

Removing infected pods regularly – and especially the cutting off before spores are produced can avoid the spreading of the disease. In that stage they can either be removed very carefully or left on the ground – the organisms in the soil will soon decompose pod and fungus. It is especially recommended to not move the pods that have already produced spores from the place they have fallen down to. If they haven't fallen, they should be cut off the tree and put onto the ground. They should also be covered with leaves and soil. At the beginning this can cause quite a bit of work, but if done regularly the infected pods are reduced to a minimum. Ensuring that water can drain off well and doesn't form any puddles is important to not favour the disease.

A carefully repeated application of copper and the usage of resistant cocoa varieties may help to limit the disease, too.

Besides the preventive measurements mentioned above, air and light circulation as well as a good water balance should be assured by regular pruning (twice a year: May and October) so that there's no more than 30% of shade. An eye should be kept on weeds.

## Pests

An infestation with pests in a cocoa plantation generally has similar causes as diseases (see above). The losses caused by pests world-wide are enormous. They result from the cocoa fruits being sucked dry in all stages of growth, after which the plant can die off if the damage has been severe. Pests which often turn up in cocoa cultivation areas are insects, such as Mirids (*capsidis*), causing damage to young shoots and pods and make the tree susceptible to infection. Also other insects and vertebrates can lead to damages on cocoa plants. Without losing sight of the need to combat the root causes, a solution which can be immediately utilised to save a harvest is the application of a 3% alkaline soap solution (potassium soap[1]).

[1] 100 g edible oil are mixed with 70g fuel or high percentage alcohol. 20g pure of potassium hydroxide (highly caustic!) are then dissolved in 33g of luke warm water (caution, strong build-up of heat!), and added to the oil and alcohol mixture, then thoroughly stirred or shaken. The soap is ready after ca. 5 min., and can be tested to see whether a small amount mixed in water remains transparent or not.

This has proven itself in regulating different bug varieties in Bolivia. In addition, other preparations being permitted on organic farms can also be used.

## Plantation maintenance

During the first three years, the cultivation measures consist almost entirely of selective regulation of weed growth. The grasses and flowering weeds are cut down and used as mulching material, which improves soil quality and nutrient availability. Trees which do not lose their leaves need to be radically trimmed during the blossoming period of the cocoa trees (ca. 6 months before the main harvest begins). This is necessary because cocoa blossom tends to take place due to a higher availability of light. The resulting organic material should be chopped and spread out over the soil as green mulch. Diseased plant parts and fruits should be removed and buried. The cocoa trees should also be lightly trimmed and diseased or poorly developed trees removed during these shading regulation tasks. Regular trimming and pruning will help greatly in improving plant hygiene (phytosanitation) and thereby reduce the incidence of pests and diseases (see Figure 11).

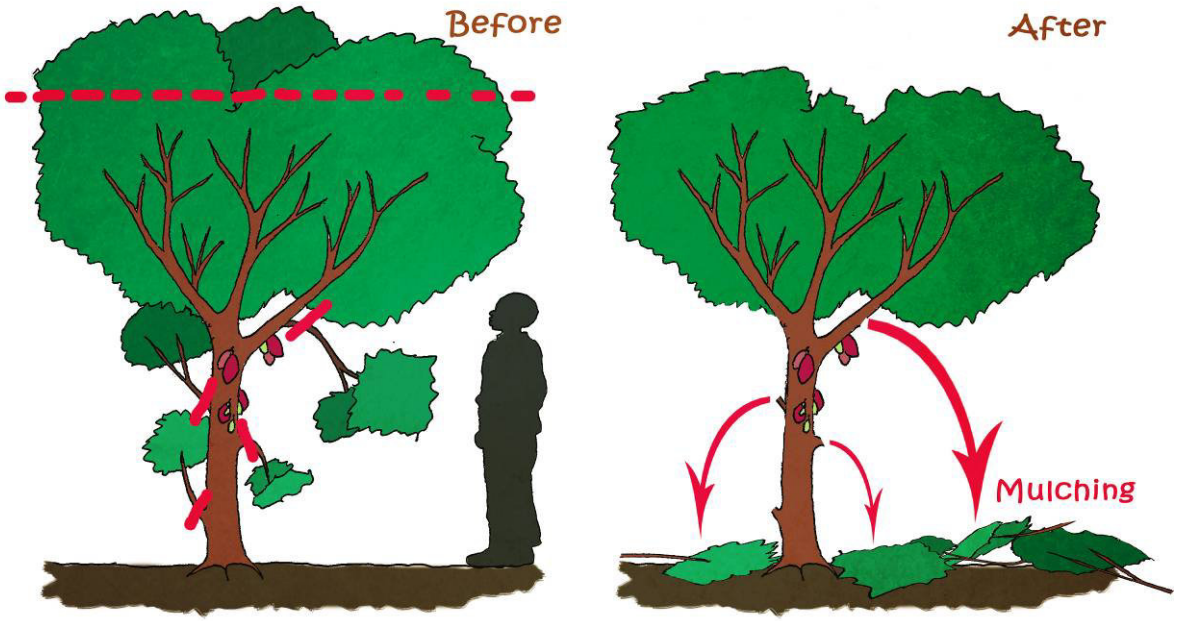


**Figure 11** Cocoa trees (as well as the other trees) need to be pruned regularly to maintain plant health. The pruned material should be spread on the ground as mulch, this improves soil fertility.

## Harvest and post harvest steps

The quality of cocoa beans determines the price. It is therefore important to ensure the highest possible quality of the beans. To do this, all steps of treatment of the beans need to be handled with care, starting at harvest an ending at storage (Figure 13). Harvest begins when the fruits are completely ripe. In many Trinitario types, with their red and dark violet fruits, this can be recognised by an orange discolouring of the shell.

Yet other varieties take on a yellow colouration when ripe. Depending on the region and weather conditions, there are usually one or two harvesting phases, which are spread out over several months.

**Figure 12 Splitting** of cocoa beans.

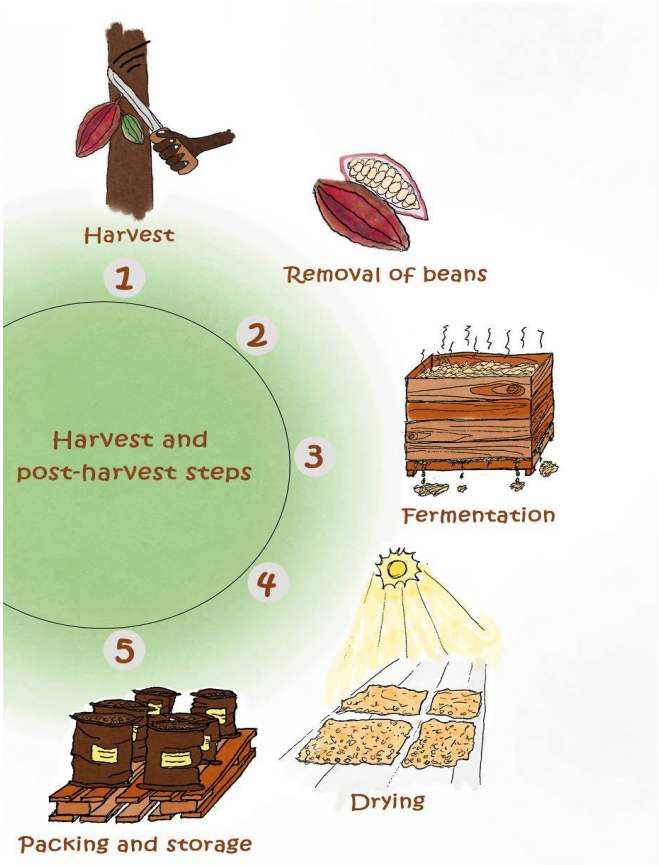


**Figure 13** The five steps from harvest to packing of cocoa beans.

In order to achieve a uniform ripeness of the fruits harvested, it is wise to harvest all of the ripened fruits every 2-3 weeks. Make sure to harvest only those pods that are fully ripe. The best way to avoid harming the bark is to cut off the fruits at the base of the blossom with a sharp knife, secateurs or other suitable instrument. Cocoa seeds have no lull in germination. If the fruits are harvested when overripe, then germination can already have begun in the shell. A large number of already germinated cocoa seeds will not pass a quality control.

Therefore, overripe and diseased fruits should not be mixed with healthy cocoa fruits. Process them separately. Ripe cocoa fruits are split open (either in the field or near the fermenting kegs) with a large splitting knife or iron bar or piece of wood or cracked on a hard surface (stone or wood), taking care not to harm the seeds.

# Processing of the beans

## Fermentation

The aim of fermentation is to remove the fruit pulp residues that remain, to kill off the seed, and to commence the development of aroma, taste and colour in the beans.

**Figure 14** Fermentation carried out in banana leaves.

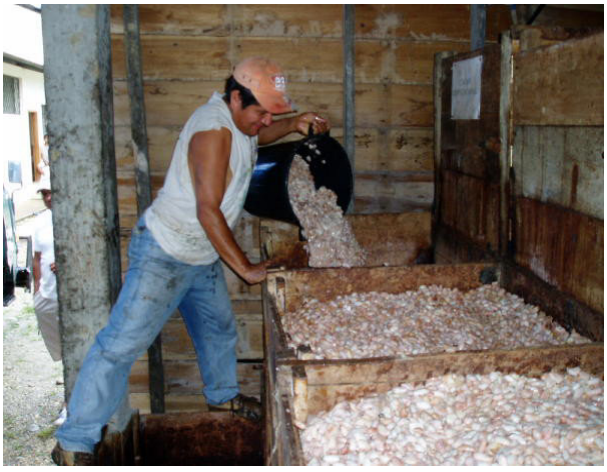

**Figure 15** Fermentation in wooden boxes. (Source:http://timbergrowers.com/Kallari)

## Fermentation tanks

Fermentation of the cocoa seeds can be carried out in two ways: Beans heaped or wrapped in banana leaves (Figure 14) need a sufficiently high temperature (40-50°C). This 'packages' should be turned over every other day in order to ensure an even fermentation. The fermentation process depends on the variety and can take 3-8 days until most of the beans are brown.

The second way of fermenting is in wooden trays stacked on top of each other, wooden boxes, woven baskets, and in other suitable containers made of natural materials (Figure 15).

Care should be taken to provide them with insulation, and protect them against the weather, in order to prevent the fermenting cocoa from losing too much heat. The containers should not exceed a capacity required for 1 t of fresh cocoa, or a height of 0.75 m, because otherwise, the fermentation process cannot be carried out uniformly. Small amounts of cocoa also only ferment insufficiently, because the ratio of surface to volume is too large for the heating process to continue. Therefore, a minimum amount of 50 kg fresh cocoa is needed for fermentation.

During the entire fermentation process the fruit pulp plays an important role, as it attracts a lot of microorganisms such as fungi. Yeast fungi dominate the process producing alcohol:

The fruit pulp disintegrates and flows away. The fermentation tanks therefore need to be constructed and set up so that the fruit pulp juices can drain away. Large harvests also produce large quantities of juice, which is not allowed then to flow directly into the environment. It must either be processed, or disposed of in a soakage or sewage pit.

Figure 16 gives an overview of the fermenting process.

| Aeration ⇩ | Aeration ⇩ | |
|---|---|---|
| 1. day | 3.-4. day | 5.-7. day |
| Fruit pulp strongly acidic (ph 3.5)<br>Contents white in colour<br>pH 6.5 in seed interior<br>violet colour of seed interior<br>no development of heat<br>Smell sweet-sour.<br>aromatic | Contents acidic (ph 4.5)<br>Contents light brown in colour<br>pH 4.5 in seed interior<br>violet colour of seed interior.<br>Edges brown<br>Temperature increase of contents to 45-50°C<br>Strong smell of acetic acid | Contents slightly acidic (pH 5.5)<br>Contents brown in colour<br>pH 5.5 in seed interior<br>Brown colour of seed interior<br>Temperature decrease of contents to 40°C Smell of acetic acid somewhat weakened |

**Figure 16** Overview of the fermentation process.

## Drying

After the fermentation process is finished, any unripe or damaged beans are sorted out and the rest dried in order to develop the typical chocolate aroma. The starting level of water content is around 55%, which must be reduced to around 6-7% before the beans are stored.

It is important to dry the cocoa beans carefully, in order to maintain a certain stability and storability. The beans are dried on equipment especially created for this purpose; such as, e.g. reed mats, or wooden, plastic or metal racks, which then need to be placed high enough above the ground to prevent them becoming dirtied by animals or dust. Sunlight will increase the browning process and also the development of aroma. Slow, careful drying in the sun can take up to 7 days. It is important to turn the cocoa beans by often raking them through with a large rake – this will ensure that the beans are dried uniformly and carefully. Drying apparatus that utilise warm air are recommended for use in those regions where it is often cloudy during the harvest season. Yet it is important to note that the cocoa should not come into contact with the fumes from the fuel – as this would adversely affect their taste and smell, and therefore, their quality and price.

**Figure 17** The cocoa beans should be dryed carefully in the sun for several days as shown here on an ecological farm in Africa.

**Figure 18** Raking the cocoa beans with a large rake ensures an uniformly drying. The photo was taken on an ecological farm in Ecuador.

## Storage

Cocoa can be stored for years in temperate climates without problems. In the moist tropics on the other hand, the high temperatures and humidity cause a rapid infestation of storage with pests and mould fungi. Because cocoa is strongly hygroscopic, even a product that has been well dried can rise in moisture content up to 10% in regions with 80-90% humidity, and thereby lose its capacity to be stored, the critical value for which is 8%.

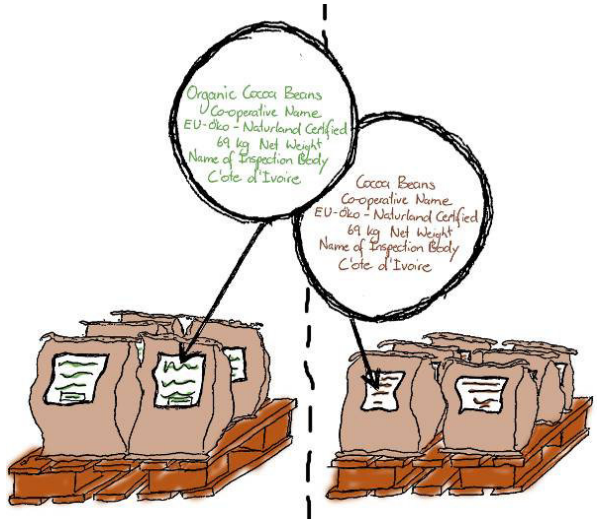


**Figure 19** Organic cocoa beans have to be labelled clearly and stored separately from conventional ones.

The cocoa should be stored in air-permeable sacks in a dark, dry and well-ventilated room on the production site for only a short time. Best would be 16°C and a relative humidity of 55% for short-term and 11°C and a relative humidity of 55% for long-term storage. The sacks should be stacked on wooden planks or boards.

Sacks made from organic fibres (e.g. jute, sisal) are recommended, but not if they have been treated with pesticides. The cocoa butter part in the cocoa shell is an excellent solvent for chlorinated hydrocarbons. These diffuse into the cocoa seed through the outer shell when they come into contact with it. In such cases, tests have shown limits for certain agricultural poisons being exceeded – although no pesticides had ever been used on the site.

On conventional warehouses, it is quite usual to gas the cocoa with methyl bromide in order to protect them against storage pests. In addition, tetraline soap, hydrogen phosphide and prussic acid are also used. On organic cocoa plantations, it is not permitted to use either insecticides against storage pests, or to gas the beans.

Should the organic cocoa beans be stored alongside conventional ones it is important to avoid mixing these two. This is best achieved by training and informing the warehouse personnel, having explicit signs in the warehouse (silos, pallets, tanks etc.), establishing colour differentiation (e.g. green for the organic product) and documenting incoming/dispatched goods separately by keeping a warehouse logbook.

Wherever possible, storing both organic and conventional products in the same warehouse should be avoided.

## Packaging for transport

The transport packaging should display details of the following:

- Name and address of the manufacturer/packer and country of origin
- Description of the product and its quality class (organic or intransition)
- Year harvested
- Net weight
- Batch number
- Destination, with the trader's/importer's address
- Visible indication of the organic source of the product
- Organic Standard (e.g. EC834/2007, Naturland), inspection body code

## Pollutants of cocoa beans

### Heavy metals

Cocoa plants extract naturally occurring heavy metals from the soil and store them in the fat of the seeds. Depending on the country of origin, this leads to varying concentrations of heavy metals in the cocoa fat. Planting palms in between the cocoa trees will help reduce the amount of heavy metals accumulating in the beans and is thus an important step to improving their quality.

## Insecticides

In Germany the BNN- Association of Organic Processors, Wholesalers and Retailers- adopted an orientation value for pesticides. Due to environmental pollution of previous land use or spillover from conventional farms products cultivated according to the standards of organic farming are not always free of non-permitted substances. According to this value the sum of pesticide residues is not allowed to exceed 0.01 mg/kg.

In many cocoa plantations regions during the 60's and 70's, insecticides, such as DDT, were used to deal with pests. This has resulted in several of the active substances still being discovered in cocoa samples from plantations where DDT has not been sprayed for years or even decades. Also, up until a few years ago DDT was used in many countries to combat malaria, meaning that the substances can be found in concentrations which still cause problems. The health personnel responsible for residual sprayings of DDT pay no heed to foodstuffs and storage depots. In these cases, organic producers need to be especially careful, and, if necessary, store their produce away from living areas – because in many regions, denying access for spraying is a criminal offence.

## Micro-organisms

Certain special measures need to be adhered to during the processing of cocoa products in order to prevent contamination by micro-organisms. According to the regulations from 26.06.1995 (Switzerland) regarding hygienic-microbiological requirements for foodstuffs, instruments, rooms, equipment and personnel, the tolerance levels for chocolate without fillings, chocolate powder and cocoa powder are:

| | |
|---|---|
| Aerobic mesophile germs | 100,000/g |
| Enterobacteriaceae | 100/g |
| Staphylococcus aureus | 100/g |
| Yeasts | 1,000/g |
| Mould | 100/g |

Ensuring a minimum of pollution with micro-organisms can be achieved through clean and hygienic storage and processing facilities.

## Examples in growing organic cocoa

### El Ceibo Bolivia

El Ceibo is a small farmer's cooperative, which unites more than 1,200 small farmers, in the Amazon region of Bolivia. In order to improve their own economic and social development, the farmers founded the umbrella organization El Ceibo in 1977, which consists today of 50 cooperative. In 1987 the production system was changed into organic farming and since 1993 the farmers have been operating according to Naturland standards.

**Cultivation**

Farmers are cultivating their crops in the agroforestry system, combining cocoa plants with a variety of native trees and shrubs. This system offers many benefits, such as improved plant health and better soil fertility, and it also helps to mitigate effects of climate change. Moreover, the mixed culture system improves the livelihood of small farmers, by generating additional income from selling other fruits and crops on local markets or by using them for own consumption

Seedlings and plants for the agroforestry system are provided by the own research center, PIAF El Ceibo foundation (PIAF- Programa de Implementación Agroecológica). The research center studies tropical production systems and has a strong focus on various trees species and also on plants for medicinal and ornamental purposes. The research center distributes a series of inexpensive seedlings among members of the cooperative and also other farmers, in order to diversify their agroforestry system. Farmers can also rely on the advisory service and even training by the research center, which offers help with respect to organic farming practices, the improvement of production and quality but also topics not directly related to farming such as health care in the community.

**Processing**

The processing of cocoa is also done collectively. About 90 % of the whole production is fermented and dried on the farm. The remaining 10 % are sent to El Alto - a processing company run by small farmers – in La Paz. El Alto processes cocoa beans into cocoa butter, -powder and chocolate for the national and international market.

Uniting tree nursery, growing, harvesting, processing, marketing and advisory service in one organization, El Ceibo realizes most of the value adding along the chain, benefiting its own members.

Further development of the value chain and continuous improvement of the quality system, are important factors for being successful in the future, just as well as the democratic, social and ecological principles on which the organization has been founded.

**Organic and Fair**

El Ceibo is a paradigm for the successful combination of organic farming and fair trade. Combining both systems, the living conditions of the cooperative members and their families have improved significantly regarding income security and planning reliability. The fair trade premium is used for the education of adolescents and adults, for health care, and a smaller part is spent on the pension of elderly members of the cooperatives. A share of the total profit of El Ceibo is dedicated to the PIAF El Ceibo foundation which offers technical support to the members. Additionally the cooperative promotes the cultural activities in the community as for example by the celebration of the cocoa day.

## Cooproagro Dominican Republic

„Together we can do it"...according to this motto several cocoa farmers of the Dominican Republic joined in the 1980s together to found the cooperative Cooproagro. Tired of being controlled by middlemen, the cooperative allows their farmers now to market their cacao on their own. Later on some farmers changed their producing system into organic farming and ensured fair traded cocoa. In 2007 the fair trade cooperative Cooproagro – Cooperativa de Productores Agropecuarios- was established, which is now responsible for around 460 tonnes of organic cocoa annually. Today the cooperative counts 1.800 farmers and 210 of them are operating to the strict Naturland standards.

**Cultivation and maintenance**

The cocoa is planted on 0,4 to 40 hectare large fincas in mixed culture with shade trees including timber and fruit-trees. Such an agroforestry system provides the cocoa with the necessary shade, stabilize the water balance und protects against erosion. Furthermore, by selling the fruits of the other cultures such as citrus fruits, bananas, avocados, sapotes and coconuts the farmers can tap an additional source of income or use the fruits for themselves.

The shade management contributes also to plant health. High-growing plants are offering the required shade for the cocoa and their foliage serves together with harvest residues of the cocoa plant as a fertilizer and protection against erosion. In addition, by controlling the shade the spread of the Phytophtora fungus can be suppressed.

Pruning the trees in the right way increases the solar radiation and this withdraws the moisture-loving fungus its living conditions. Collecting the fungus infected fruits can also halt the spread of the pathogen. Regarding the harmful Rosellinia fungus the removal of infected plants and part of the plants helps to curb the spread as well as the application of slaked lime.

**Processing**

The harvest of cocoa, including the varieties Hispaniola and Sanchez, occurs twice a year. There is one between October and January and a main harvest from April to July with a harvest quantity of around 490 kg per hectare. The farmers verify that the fruits are undamaged and sort them according to their quality. The processing is done on the farm or, depending on the infrastructure, locally in cooperation. After sorting the beans the farmers split the fruits open and take out the beans together with the pulp. This mass needs to be fermented for six days while it's turned over regularly. After the fermentation process is finished the beans have to be dried. This takes around five to seven days until the water content is 7 %. Finally the beans are stored in sacks which are labeled according to the quality class of the beans and get ready for export. Some cocoa also is sold as cocoa liquor,-butter and powder on the national market.

**Figure 20 The o**rganic cocoa beans are stored in sacks and labeled as shown here in Cooproagro.

**United it is working better**

The cooperation not only supports the farmers how to cultivate, prepare, transport and market the cocoa but takes also responsibility for the social life. The profit of selling the cocoa and the fair trade premium were for example used to expand the road network, supply the villages with electricity and to build a community centre as well as a school canteen. In addition, the farmers benefit from an improved access to loan, credits, saving programs and help for dependants of deceased members. A major concern of the cooperation is also the promotion of women. The production of cocoa jam, cocoa wine and chocolate generate additional income sources.

## Ecotop Consult

Ecotop S.R.L. is a consultancy firm in La Paz/ Bolivia (http://www.ecotop-consult.de/), which mainly focuses on the improvement of cocoa production systems in Latin America, Asia and Africa. It offers services in the area of rural development, particularly focusing on sustainable agriculture based on the natural dynamic of ecosystems.

Ecotop's objective is to promote agriculture and agro-forestry as a central axis for sustainable development in tropical regions, considering food security, biodiversity and resilience of impacts of climate change.

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