

## **GROWTH AND PRODUCTION OF CACAO**

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### **Summary**

*Theobroma cacao* is commonly characterized by three main cacao cultivars: *Criollo*, *Forastero* and *Trinitario*. It is one of the world's most valuable crops, cultivated worldwide on 8.2 million hectares, grown in 58 countries, and worth over US\$4 billion annually. Cacao is a well-adapted agro-forestry plantation crop grown in hot, rainy climates with cultivation concentrated in a band between 0 to 20 degrees north and south of the Equator, sometimes called the "Cacao Belt".

Economic cacao cultivars are grown for the production of dried beans, which are the source of cocoa liquor, cocoa butter, cocoa cake and cocoa powder. Cacao is a fast-growing tropical forest plant, capable of being cultivated in association with other trees, and providing additional goods like timber and firewood, fruits, construction materials, honey, resin, medicine and materials for ritual ceremonies.

The ecological impact of the different cacao cultivation systems is discussed. The focus is on practices that conserve biological hotspots, protect the environment, promote global carbon sequestration, cause no health problems and enhance the quality of life for farmers and society as a whole. These include the care of the different growth cycles in cacao plantations, realized according to the principles of Best Agricultural Practices for well-adopted sustainable ecological cacao growing systems. The cacao chain extends from the selection of cacao areas to post harvest management.

Traditional and modern methods of cacao harvest and post harvest treatments, roasting and chocolate preparation are analyzed. New trends, such as single-origin chocolate and recognition of the beneficial properties of the powerful antioxidants from cocoa phytochemicals are presented, as well as the wide diversity in preparation techniques for modern hot and cool cocoa drinks and culinary applications.

## 1. Introduction

*Theobroma cacao* belongs to the family of Malvaceae (alternatively Sterculiaceae), and is characterized by three main cultivar groups : *Criollo*, *Forastero* and *Trinitario*, which have recently been widespread in the (sub)humid tropics. All cultivated species originate from America. Cacao is one of the world's most valuable crops, cultivated worldwide on 8.2 million hectares, playing an important role in the social and economic life of more than 5 million households, and affecting 25 million people in poor rural areas. Ivory Coast, Ghana, Nigeria, Indonesia and Brazil are the most important cacao producers (Table 1). Cacao is grown in 58 countries and is worth in excess of US\$4 billion per annum to the world economy.

Cacao is a well-adapted agro-forestry plantation crop grown in hot, rainy climates. Its cultivation is concentrated between 0 and 20 degrees north and south of the Equator, sometimes called the "Cacao Belt". Although it is mainly known as principal ingredient of chocolate, there are actually other products derived from cacao beans: cocoa liquor, cocoa butter, cocoa cake and cocoa powder.

The cacao tree and its product cocoa have been harvested and used by indigenous people of Central and South America for thousands of years. Cocoa beans were introduced to Europe during the 16th century. The technology to separate cocoa butter

from dried beans was developed between 1825 and 1828, and this led to the manufacture of solid chocolate.

Cacao is a fast-growing tropical forest plant, cultivated in association with other trees and tall plants that provide shade. This allows for a diversified production including timber and firewood, fruits, construction materials, honey, resin, medicine and materials for ritual ceremonies. The cacao tree can be as tall as 8-12 m with tap-roots about 2 m deep. The main harvest usually begins at the end of the wet season and may extend for 3 months. The crop is mainly grown by smallholders located around central market units for uniform and standard industrial handling after harvesting.

Cacao cultivation is nowadays undertaken, either in agro-forestry systems in which some part of the natural forest is left in place, or in newly cleared or converted land. This involves that new land must be cleared under conditions which are ecologically not always satisfactory. Key points in this debate are:

- To what extent is cacao cultivation affecting the loss and / or degradation of natural forests, reforestation and restoration of degraded land?
- What needs to be done to guarantee a site-specific sustainable scientific and technical management of cacao agro-forestry systems?
- How are Best Agricultural Practices be achieved by participating farmers, professionals and scientists?
- How to assess and evaluate the combined effects of cacao plantations on landscape dynamics?

There exist strong public controversies over these key points and their impact on the environment. The focus is therefore to implement as much as possible the principles of Best Agricultural Practices (BAP) adapted to cacao for successful sustainable ecological cacao production while guaranteeing the highest possible cultivation standards in harmony with the existing economical, ecological and social site conditions.

## 2. Origins and Distribution

The genus *Theobroma* originated in the Amazon and Orinoco basins, and subsequently spread to Central America, particularly Mexico, where it was known and used by the local population. The Olmec and Mayas, and later the Toltecs and Aztecs considered it the “food of the gods”.

*Theobroma* has been divided into twenty-two species of which *Theobroma cacao* is the most widely known. The Maya provided tangible evidence of domesticated cacao. Archaeological evidence in Costa Rica indicates that cacao was drunk by Maya traders as early as 400 BC. The Aztec culture, dominant in Mesoamerica from the fourteenth century to the Conquest, placed much emphasis on the sanctity of cacao. Divina and Divina (2004) write:

*"Both the Maya and Aztec people prized cacao, using the beans not only for culinary purposes but also for trade and as money. Pre-Conquest chocolate was almost always a*

*drink, which had many forms and flavorings. The Aztec drink was called xocolatl which means warm liquid”.*

This chocolate drink today named *tejate* or *tiste* can have pounded maize added, but the highest aristocrats almost always took chocolate unadulterated, with a froth created by pouring the liquid from vessel to vessel. Chocolate also was of major ceremonial importance to the Maya and the Aztecs, served at lavish banquets, buried with the dead, and used to anoint newborn babies. However, chocolate history is probably much older than originally anticipated, as in pottery vessels from about 1100 BC in Puerto Escondido, Honduras, residues have been found of a chemical compound that could only have come from chocolate.

The first outsider to drink chocolate was Christopher Columbus, who reached Nicaragua in 1502 searching for a sea route to the spices of the East. Moctezuma II, the Aztec Emperor (1465-1520), greeted Hernando Cortés and his army in 1519 with a chocolate drink, most probably a gesture of friendship since cacao was a drink for nobles, warriors, and traders. According to Bernal Díaz the chocolate was served to Moctezuma in vessels of pure gold and eaten with a golden spoon. In the markets, there were sellers of fine chocolate drinks which were made with honey, flowers, vanilla, and even pepper. This chocolate was made from ground cacao seeds with added seasonings, and was a spicy, frothy, non-sweet form of what we call today simply chocolate.

Cortés sent beans to the Spanish King Charles V, saying that he found chocolate to be an energy source. The drink was initially received unenthusiastically. The Spanish refined the recipes adding sugar and heating the ingredients to improve the taste, and so it became a popular drink in the Spanish courts. The first shipment of chocolate was sent to Seville in 1585. The Catholic Church eyed the pep-giving bean with suspicion, and decreed that it could not be consumed during Lent or on any fast days. After the chocolate-loving Cardinal Brancatio declared chocolate to be essential, the Spanish drank their cacao with zeal, and it was their secret for almost 100 years.

Spanish Capuchin friars started to grow *Criollo* cacao in Ecuador by 1635. The rush by European mercantile nations to claim land to cultivate cacao began in the late seventeenth century. France introduced cacao to Martinique and St Lucia (1660), the Dominican Republic (1665), Brazil (1677), Guyana (1684) and Grenada (1714); England had cacao growing in Jamaica by 1670; and prior to this the Dutch had taken over plantations in Curaçao when they seized the island in 1620.

Later the explosion in demand required more cacao to be cultivated. *Amelonado* cacao from Brazil was planted in Principe in 1822, in Sao Tomé in 1830 and in Fernando Po in 1854, then in Nigeria in 1874 and Ghana in 1879. There was already a small plantation in Bonny, eastern Nigeria established by Chief Iboningi in 1847, as well as other plantations run by the Coker family established by the Christian missions. The seeds planted in Ghana were brought from Fernando Po by Tetteh Quarshie or his apprentice Adjah, after previous attempts by the Dutch (1815) and the Swiss (1843) to introduce cocoa in Ghana had failed.

*Trinitario* cacao was first planted in Ceylon in 1834, and then again tried in 1880. During that same period, it was transplanted to Fiji, Madagascar, Samoa, Singapore, and Tanzania. In Cameroon, cacao cropping was introduced during the colonial period between 1925 and 1939.

By 1828 van Houten invented a hydraulic press to reduce the cocoa butter content by nearly half, thereby creating a "cake" that could be pulverized into cocoa powder. The introduction of cocoa powder not only facilitated the creation of chocolate drinks, but made it also possible to combine chocolate with sugar and mix it with cocoa butter to produce solid chocolate. This permitted to make new chocolate products, starting mass production and consumption of chocolate or, as some call it, the "democratization" of chocolate.

The idea of mixing cacao powder with milk is credited to Sir Hans Sloane, physician to Queen Anne. He sold his secret recipe to a London apothecary who later sold it to the Cadbury brothers, still the name most associated with chocolate to the English. Franz Sacher, in 1832, introduced the dense chocolate cake with apricot jam in the middle and shreds of chocolate on the outside and it became an instant classic. In 1847 English chocolate maker Fry & Sons produced the first chocolate bar. Later developments were in Switzerland, where Daniel Peter introduced milk chocolate in 1875 and Rodolphe Lindt made chocolate more blend able by conching in 1879. In the United States, Milton Hershey introduced the original Hershey's milk chocolate bar, using more sugar than the European counterparts because it was less expensive than cocoa butter.

Today chocolate history has a new chapter. The United States has become the leading consumer of cacao. The Swiss, Germans and the British eat the most chocolate. The Norwegians and Austrians consume the most chocolate drinks. The Belgians eat and produce the world famous chocolates named "pralines".

### 3. Botany

The genus *Theobroma*, of the family Malvaceae, includes 22 species. The cacao tree (*Theobroma cacao* L.,  $2n = 20$ ) is the dominant cropped species. Other local species of importance are *T. bicolor* (patate), *T. angustifolium* (cacao de mono) and *T. grandiflorum* (cupuassu). The cola nut (*Cola acuminata*) is a related species.

#### 3.1. Cultivars and Classification

All cultivated cacao is classified into a single species *T. cacao* and subdivided into three well-defined groups (forms, types or cultivars) of cacao: *Forastero*, *Criollo*, and *Trinitario* which is a hybrid of *Forastero* and *Criollo*.

Since the 1980s cocoa genetic improvement programs have been initiated to create and select bi-parental crosses (hybrid varieties) with variable yields. It was found that cacao is characterized by a high rate of redundancy and this not only hinders the efficient conservation of international collections but also hampers the effectiveness of germplasm evaluation and utilization. From 1990 onward, a reciprocal recurrent selection program has been set up with the purpose of improving simultaneously the

characteristics of the two main genetic groups in Ivory Coast, *Upper Amazon Forastero* (UA) and a mixture of *Lower Amazon Forastero* (LA) and *Trinitario* (T) (Pokou *et al.*, 2009).

Zhang *et al.* (2009) classified cacao into 12 groups based on their geographical origin, including Brazil, Central America, Colombia, Ecuador, Mexico, Peru, Trinidad, and French Guiana. The *Trinitario* hybrids from Costa Rica, PMCT, CC, UF, and ARF, were each treated as an independent group in order to illustrate the interrelationship among these groups. Obviously, large efforts are undertaken in cacao germplasm collections to identify redundant accessions using morphological data.

***Forastero*** – This group now forms the greater part of all cacaos grown. It is a hardy and vigorous tree, producing beans with a strong flavor. *Amelonado*, with a smooth yellow pod and with more pale to deep purple beans, is the *Forastero* variety most widely grown in West Africa and Brazil. Today, *Forastero* mainly refers to cacao that has its ancestry from the upper Amazon basin. Through trade, this cacao has been spread throughout much of the cacao-growing world, including Africa.

Today, the largest producers of these cacao beans are Ivory Coast and Ghana, where *Forastero* was established very early in the cacao trade. Because of this and the disease resistance of this variety, the top producing countries grow primarily *Forastero*. Most of the chocolate produced in the world today is made from *Forastero* beans.

The hull of the *Forastero* pod, rather than being deeply furrowed with a knobby skin and pointed pod, as the *Criollo* pods are, is relatively smooth, with more of a bulbous pod shape. In addition, the hull is also woodier than the *Criollo*, and thus the pods are harder to open. The pods may also be red or yellow, as well as orange or purple. The beans themselves are very dark purple and are relatively flat compared to those of the *Criollo*.

The *Forastero* does not have the complex flavor of the *Criollo*, nor does it have the spicy and fruity notes that one may find in the *Criollo*. Instead, the *Forastero* has a much richer "chocolate" flavor. Hence, *Forastero* beans are usually considered "bulk beans," while *Criollo* beans are considered "flavor beans." Chocolate makers will typically use primarily the *Forastero* for their chocolate blends to create a rich, chocolate flavor background, and then add a variety of flavor beans to make the final chocolate more complex and tasty.

While cacao from Ecuador is fine in flavor, it is generally considered to be a *Forastero* by popular classification. The flavor is very similar to that of other *Forasteros*, with the addition of fruity overtones not present in other *Forasteros*. This cacao is native to Ecuador, and thus it is a *Criollo* (native) as far as Ecuador is concerned. As may be imagined, this could have caused plenty of confusion except that the native cacao variety has been named National, thus preventing further confusion of the *Criollo* name than already exists.

Unlike the *Criollo*, the *Forastero* varieties are much more hardy and disease-resistant and, therefore, they are preferred by farmers as they guarantee a more saleable crop, despite they do not give them a high a price.

***Criollo*** - *Criollo* trees are not as hardy, and they produce softer pods, containing 20-30 ivory or very pale purple beans. *Criollo* cacao typically has red or yellow pods, some being green or white. The pods have a bumpy or warty skin with pointed tips. The beans, on the other hand, vary from light purple to white in color, and they are plump and full (Photo 1). In general, the beans from *Criollo* cacao are considered to have a finer flavor than of other cacao varieties.

*Criollo* trees are not very disease-resistant and, hence, are hard for farmers to grow and keep them healthy. Typically, when chocolate is made from *Criollo* beans, the chocolate is not overly rich, though the resulting chocolate will have a complex flavor that is often reminiscent of various fruits and spices. *Criollo* beans are therefore considered to be "flavor beans".

Venezuelan *Criollo* cacao is found throughout the entire Central American region, including Mexico. It is most notably present in the states of Tabasco and Oaxaca. Even so, these regions still have their own "native" (or *Criollo*) varieties.



Photo 1. Cacao *Criollo* in Chiapas, Mexico.

***Trinitario*** – This is a cultivated hybrid of the other two types. *Trinitario* cacao trees are grown mainly in Colombia and Central America, but also in Cameroon and Papua New Guinea. The hard pods contain 30 or more beans of variable color; white beans are rare. As the name implies, *Trinitario* originates from the island nation of Trinidad.

Today, *Trinitario* along with *Criollo* provides the basis for "flavor beans," used to enhance the flavor of today's chocolate. *Trinitario* pods are typically not pointed, and their skin is relatively smooth, compared to *Criollo* pods; beans are flat and purple when cut in half. *Trinitario*, like *Forastero*, has spread throughout the world as a major cacao crop.

### 3.2. Structure

**Plant and Tree** - The cacao tree can be as tall as 8-12 meters, and its fruits (pods) are 15-40 cm long. The stem is straight, the wood light and white and the bark is thin, somewhat smooth and brownish. Cacao trees have a well-defined tap root, with lateral swirls at intervals. The root system is influenced by soil texture, depth and structure, and permeability. After 10-18 months of growth the orthotropic stem, usually 100-150cm high, ceases its vertical growth and forms a whorl, named jorquette, of 3-5 plagiotropic branches (fan) and one or more orthotropic suckers. The sucker or chupon initiates the next step of vertical growth.

Pods are produced throughout the year, but the main harvest usually begins at the end of the wet season and may extend for 3 months. A kilo of dry beans is produced by 14 to 28 pods.

**Inflorescence** - Cacao flowers arise in groups directly from old wood of the main orthotropic stem (cauliflory) or older plagiotropic branches at points (ramiflory), which were originally leaf axils. Each flower has five prominent pink sepals, five smaller yellowish petals, each of which forms a pouch, an outer whorl of five staminodes, and an inner whorl of five double stamens, each stamen bearing up to four anthers. The staminodes are about as tall to twice as tall as the upright style and form a "fence" around the style. The stamens are curled so that the anthers develop inside the petal pouches. The ovary consists of five united carpels each having 4 to 12 lobules and one style that has several linear stigmatic lobes. The flowers secrete nectar, which has an odor that attracts male mosquitoes and some other local insects.

The flower opens about dawn, and the anthers dehisce just before sunrise. The stigma is usually pollinated 2 to 3 hours later but is receptive from sunrise to sunset of the day of opening. The stigma is receptive to pollen along its whole length, and not merely at the apex as in most flowers. If the flower is not pollinated, it usually sheds the following day. Pollination before noon is best.

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### Biographical Sketches

**Hermann Alfred Jürgen Pohlen** is an International Consultant for more than 15 years, and a former Professor in Tropical Agriculture, University of Bonn, Germany. He holds a Diplomagraringenieur (1972), a PhD. in citrus growing (1976) and a Post-Doctoral Degree in Sustainable Tropical Cropping Systems (1983). He is Professor emeritus of the UNA Managua, Nicaragua (2009). He worked in more than 20 tropical countries in four continents on sustainable development aspects of agro-ecosystems with coffee, cocoa and other perennial tropical crops.

He was a technical and scientific advisor in more than 40 development projects for international and national agencies, companies and NGOs active in inter-tropical regions. He organized several training courses in the fields of coffee and cocoa, and horticulture. His special interests include the conversion of traditional coffee and cocoa growing areas with high value crops, the development of agro-ecosystems with energy crops, and intensification of organic farming systems. He is the author or co-author of more than 60 peer-reviewed and 130 congress papers, published in national and international journals, and author or editor of 15 books or proceedings and 37 chapters in books.

**Valentin Diaz** is an international consultant and technical advisor, with over 20 years' experience, in rural development, agro-industrial food processing, and tropical crops, especially cocoa and tropical fruits. He holds degrees in Industrial Engineering, Business Administration, Agribusiness, Rural Development, Environment and Rural Policy Making. He is a candidate in Economic, Agro-Alimentary and Rural Development.

Dr. Diaz has been active for more than ten years, both in the academic world and in research in rural development, international marketing, industrialization of tropical fruits, and alternatives to illegal crops, especially in developing countries. During the past years his work was oriented to improve the socioeconomic conditions of people in rural areas in Latin America. He is author or co-author of more than 20 papers and chapters in specialized books, and of more than 50 manuals for specific products like cocoa crops maintenance, fruit juices, sanitary and phytosanitary rules.