Reflections on a Durable Cacao Production System: The Situation in the Ivory Coast, Africa

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Summary
Cacao tree cultivation plays an integral role among the Côte d'Ivoire's traditional activities. Farmers use an ambulatory method of exploitation, and the establishment of plantations has gone through three phases: cultivation of the Amelonado variety on the cleared forest floor, cultivation under forest regrowth, and cultivation of high-yield, Upper-Amazonian species in direct sunlight and in association with fruit trees and other food-producing plants.

Today, most plantations are products of the last phase which has resulted in considerable deforestation. The techniques recommended by research have shown varying levels of success among the farmers, and the exploitations with a satisfactory level of productivity are few. Phytosanitary treatments and fertilizers are applied only partially or not at all, which can result in the plantations' premature degradation.

In order to assure a long-lasting cacao production, the Côte d'Ivoire's plantations need to be rehabilitated through the use of pesticides and fertilizers, and an effective system of association needs to be developed between cacao trees and the shade trees that, while protecting the cacao, contributes to satisfying the producers' needs and protecting the environment during orchard renewal.

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1 - Introduction
The cultivation of cacao trees in the Côte d'Ivoire began with the introduction of cacao beans on the banks of the Cavally in 1892 (IFCC, 1979). It developed after the First World War, and production grew from 2,300 tons in 1922 to 55,000 tons in 1939. For the past twenty years, the Côte d'Ivoire has been the world's leading producer, with an annual rate of approximately 1 million tons, valued at nearly 450 billion francs CFA, or 750 million US dollars.

Cacao plantations currently cover 2 million hectares (almost 5 million acres), and have been the cause of 14% of the deforestation in the Côte d'Ivoire (Pallix et Comolet, 1996). Cacao trees are cultivated by approximately 500,000 farmers and their families, with an average of 4 hectares (10 acres) per farm.

The rapid growth in production is assured through the annual increase in cultivated land, claimed through deforestation. Cacao is grown by methods of extensive agriculture, and uses two main exploitation systems linked to researchers' recommendations and the farmers' know-how: the first system includes shade trees and the second cultivates the cacao plants without protection from the sun and entails the systematic clear-cutting of forest land. After an analysis of these two systems, we will discuss the prospects for a durable cacao production system in the Côte d'Ivoire.

2 - Methods of Cacao Tree Cultivation
2.1. - Cultivation under shade trees

The cacao tree has been described as an understory tree from the Amazon jungle. Thus, from its introduction in the Côte d'Ivoire, as in many other countries, temporary or permanent shade was necessary to its cultivation in order to limit the amount of sunlight that reached the plants. Several different methods of providing shade have been developed: cultivation on the cleared forest floor, cultivation in areas of natural forest regrowth, and cultivation under artificial shade.

The first two methods were recommended to farmers until the 1970's, while the artificial shade technique has not been sufficiently studied at our research sites.

2.1.1. - Cultivation on the cleared forest floor

This method involves first clearing all the undergrowth on the forest floor, and then eliminating certain species of trees that are harmful to cacao trees, either through their competition for water, especially in areas with low rainfall, their role as host to insects or diseases that threaten cacao trees, or because their foliage is too dense or too low (IFCC, 1964). The cacao saplings of Amelonado type are then planted and cultivated under the shade of the remaining trees. But, it is often difficult to attain a well-balanced shade coverage and to eliminate all of the harmful species.

In actuality, the farmers are unable to cut down certain species because of their domestic uses, because they lack the necessary equipment, or for socio-cultural reasons. These species include Piptadeniastrum africanum, Cola spp, Ceiba pentandra (Kapok tree), and Treculia africana (IFCC, 1964; Herzog, 1992).

In addition, the growth of both the shade and the cacao trees necessitates a regulation of the amount of shade through felling and poisoning that can cause great damage to the cacao trees (Besse, 1972).

2.1.2. - Cultivation in areas of natural regrowth

The introduction of high-yield, Upper-Amazonian hybrids (UPA), the effective struggle against insects and weeds thanks to phytosanitary treatments, and the unfavorable effects of certain shade trees have oriented cacao plantations toward areas of natural regrowth (Besse, 1972).

In contrast to the cleared forest floor method, cultivation in areas of natural regrowth entails clear-cutting forest land several months before planting, which consists in either opening 1 cm tracks on the young regrowth, or in using the same method as on the cleared forest floor in older regrowths.

This method requires a considerable amount of time preparing the plot. It can involve 500-700 days of labor per hectare, while the cleared forest floor method involves 200-300 days. In return, it gives the farmer the possibility of choosing a better selection of useful shade trees species: Trema guineensis, Chlorophora excelsa, Ficus spp, Pycnanthus angolensis, Terminalia spp..... The majority of these species are in the Euphorbiaceae family.

2.1.3. - Cultivation under artificial shade

This method consists of planting shade trees according to a specific plan involving the clear-cutting of forest land, therefore eliminating all harmful species and introducing new local or exotic ones, especially: Manihot glazivii, Manihot utilissima, Gliricidia spp, Albizia spp, Alstonia boonéi, Antrocaryon micraster, Pycnanthus angolensis, and Terminalia spp (Besse, 1973). Unfortunately, no research has been conducted on this subject.
However, over the last few years, the lack of remaining forest land has forced farmers into making use of their last alternative: cultivating cacao trees in former orchards or on land left fallow after the cultivation of *Chromolaena odorata*, which blocks or greatly inhibits forest regeneration. In response to these limitations, researchers have initiated a program to plant rapid-growth ligneous species (*Acacia mangium* and *auriculiformis*) in land left fallow in order to create forest surroundings and conditions that favor the restoration of soil fertility (Konan et al, 1995).

The direct association of Acacia trees spaced at 6 x 5 m and 3 x 2.5 m with cacao trees provoked a mortality rate of over 60% among the cacao saplings after a lengthy dry season of 4 months, from November to March. At the same time, when the Acacia trees were planted as a windbreak, the mortality rate dropped to 20%, approaching the 15% attained with banana trees. In light of these results, current research is orienting toward a 3 year soil enrichment period before planting the cacao trees. Given these considerations, how then should the cacao saplings be replanted: in direct sunlight with banana trees, or under ligneous species that have a lower density? Research is still underway.

2.1.4 - The effects of shading techniques

Observations at research sites show an increase in the insect population in the cacao trees planted in areas of natural regrowth when compared to those planted on the cleared forest floor. The insects concerned are Earias, (*E. biphaga* and *E. insulana*), *Tragocephala nobilis* in cacao saplings, and mirids and leafhoppers in adult trees (Besse, 1972). Shade trees therefore decrease insect attacks and the amount of money spent on phytosanitary treatments.

But, studies comparing the productivity of trees grown with and without shade show that flowering and the weight of the beans in each pod tend to be lower in the trees grown under shade (Table 1). Also, the number of pods lost to withering or the effects of phytophthora are greater for these trees (Lachenaud, 1985). Since the shade trees reduce the amount of sunlight and photosynthetic activity, they also reduce productivity. They may also compete with the cacao trees for water and other nutritional elements in the soil, making them less vigorous, but this last aspect has yet to be studied.

Table 1: Productivity factors influenced by the presence of shade trees

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Shade</th>
<th>Sunlight and Fertilizer</th>
<th>Sunlight without Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average intensity of flowering/month</td>
<td>504.8</td>
<td>1,346.1</td>
<td>1,103.1</td>
</tr>
<tr>
<td>Nb of pods/tree</td>
<td>25.09</td>
<td>69.60</td>
<td>62.21</td>
</tr>
<tr>
<td>Weight of fresh beans per pod</td>
<td>87.97</td>
<td>116.21</td>
<td>112.55</td>
</tr>
</tbody>
</table>


Though research has been centered on the needs of the cacao trees in order to create the optimal conditions for growth and productivity, the local farmers have kept the shade trees because of their other specific functions: therapeutic, domestic, as a source of food, or other (De Row, 1987; Moassa, 1991; Herzog et al, 1992).
The surveys conducted in the central, west central, and western Côte d'Ivoire reveal the place and role of shade trees in the cacao plantations. The kola trees, whose nut plays a simultaneously social, religious and economic role in African society, are preciously maintained among the cacao trees. These two trees are part of the same family (*Sterculiaceae*), and the kola trees are host to a large number of insects that are harmful to the cacao trees.

The density of trees per hectare observed in the agricultural exploitations varies greatly, especially according to the age of the plot. (K. N'goran, 1985). The older the plantation, the more forest elements it contains in proportion to the number of species planted or kept for their products. This is also an indication of the evolution in cultivation techniques. The newer plantations contain fewer trees, thus showing that farmers are turning toward methods of cultivation in direct sunlight (Table 2). The same observations were made by Herzog et al, (1992) in the V-Baoulé at Zougoussi and Bringakro.

Table 2: Density of shade trees in rural cacao exploitations

<table>
<thead>
<tr>
<th>Community</th>
<th>Number of Cacao trees/ha</th>
<th>Number of trees/ha</th>
<th>Palm, Avocado, Orange, and Kola trees/ha</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Daloa (*)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Sipo</td>
<td>1,152</td>
<td>4</td>
<td>12</td>
<td>13 years</td>
</tr>
<tr>
<td>- Belleville</td>
<td>1,212</td>
<td>12</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Gagnoa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Ouragahio</td>
<td>1,028</td>
<td>36</td>
<td>20</td>
<td>23 years</td>
</tr>
<tr>
<td>- Bayota</td>
<td>1,124</td>
<td>28</td>
<td>24</td>
<td>18 years</td>
</tr>
</tbody>
</table>

(*) 48 parcels per community

2.2. - Cultivation without shade

Beginning in the 1970s, the performance of Upper-Amazonian hybrids cultivated in direct sunlight was confirmed. Also, the government encouraged the population to cultivate cacao trees by setting up culture blocks, distributing subsidies for cacao planting, and buying cacao at advantageous, guaranteed prices that went from 85 francs CFA in 1972, to 175 F in 1974, then to 250 F in 1977 and to 300 F in 1979. The current price is 455 F, after a drastic fall from 400 F to 200 F in 1989.

Another factor to rapid growth in national production has been easy access to inexpensive land, which includes plots that were previously protected forest. As a result, cacao tree cultivation represents a high profitability that demands little capital or immediate investment. Thus, during the 1970's, the first migrants who arrived in the southwest easily obtained forest lots of 20 to 50 ha (Ruf, 1995). The ease with which these migrants obtained land attracted inhabitants from central and northern Côte d'Ivoire and those of neighboring countries, especially Burkina Faso and Mali.

Various new associations are being tried in these experimental zones. Cacao saplings are planted along with food-producing species in systems that are more or less intensive in labor and capital
The forest is almost completely clear-cut to assure that the food-producing cultures have direct sunlight. These cultures consist mainly of plantains, yams, taros, and vegetables (tomatoes, peppers, okra ...). The disastrous effects of the cassava on cacao trees is well known to the farmers.

These food-producing species assume a triple function: they provide shade for the cacao saplings, food for the farmer and his family, and are a significant source of income. Today, we can see that the plantain production zone moves in conjunction with that of cacao, an observation already made by Tano Kouadio in 1979.

At research sites, the study of the layout of exploitations that associate plantains and cacao trees confirmed the relevance of this traditional practice. The density of one plantain for every cacao tree, planted the same year between the rows, gives the best results and is the recommended method (Lachenaud, 1987).

But the farmers don't follow these recommendations (Table 3). The observable densities are based on the farmers' logic and know-how, his habitual diet, and the limited availability of land. In the young cacao plantations in the west central area, we can see an average of 870 plantain/ha, 3,600 taro/ha, 7,000 yam mounds/ha to 2,400 cacao trees obtained through planting directly at the foot of the yam mounds (K. N'goran et al, 1984).

Table 3 : Average density of food-producing cultures associated with cacao saplings (1 to 2 years) in the west central area (1983-84)

<table>
<thead>
<tr>
<th>Community</th>
<th>Cacao trees per ha</th>
<th>Yam mounds per ha</th>
<th>Taro plants per ha</th>
<th>Plantains per ha</th>
<th>Okra plants per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daloa</td>
<td>2010</td>
<td>6150</td>
<td>1338</td>
<td>665</td>
<td>1732</td>
</tr>
<tr>
<td>Issia</td>
<td>2934</td>
<td>6711</td>
<td>4975</td>
<td>720</td>
<td>3380</td>
</tr>
<tr>
<td>Gagnoa</td>
<td>2698</td>
<td>6728</td>
<td>3190</td>
<td>981</td>
<td>3597</td>
</tr>
<tr>
<td>Oumé</td>
<td>1967</td>
<td>8145</td>
<td>4910</td>
<td>1120</td>
<td>4243</td>
</tr>
<tr>
<td>Average</td>
<td>2402</td>
<td>6934</td>
<td>3603</td>
<td>872</td>
<td>3238</td>
</tr>
</tbody>
</table>

3 - Prospects for a sustainable cacao production system

3.1. - Actual situation

The different cultivation methods described above indicate that the cacao plantation has undergone several modifications in keeping with the introduction of new plant species and changes in the social and economic environment: the race for land, government aid, and the profitability of cacao production. We have gone from the cultivation of Amelonado on the cleared forest floor to that of Upper-Amazonian hybrids in direct sunlight after clear-cutting forest plots.
There has been a considerable amount of deforestation over the last thirty years and as a result this phase of pioneering and plantation expansion is nearing its end. The predominate landscapes are now the fallow fields once cultivated with *Chromolaena odorata*, (which slows down the ligneous regrowth and therefore the restoration of the forest), a few secondary forests, and coffee and cacao orchards of various ages.

On the plantations where cacao trees are associated with various food-producing species, the use of certain techniques recommended by researchers has had varying success. The phytosanitary treatments necessary to the protection of foliage and to the maintenance of production are rarely used. In the same way, the need to rapidly expand the area of cacao exploitation does not always allow for the selection of good soil. In the majority of regions, there is still no use of mineral fertilizers, and certain plantations are experiencing premature degradation, resulting in problems with the rehabilitation and regeneration of the orchard.

It is easy to imagine that soil fertility would be less affected with the recycling of leaves and small branches that fall from the cacao trees which can improve the chemical characteristics of the soil and the weak production levels by around 500kg/ha in rural areas. In fact, it has been shown on research sites that the total amount of dry material produced in a cacao orchard is approximately 3 tons/ha and per year, and that this figure is identical in fertilized and non-fertilized areas. The use of fertilizer raises the level of P, Ca, and Mg in the leaves (IDEFOR-DCC 1992).

At the same time, the climate is getting worse each year; we can note a perturbation in rainfall distribution and an increase in the hydric deficit.

An analysis of the dry periods, when the rainfall level did not reach 5 mm, during the long dry season, from December to February at the Abengourou site from 1955 to 1990, indicates that the severe dry seasons started in 1978, and that these seasons last over three consecutive months.

These perturbations observed at Abengourou confirm the results of the analysis of the average hydric isodeficit curves from 1950 to 1986 established by Quencez (1989) in the Côte d'Ivoire's southern forest. From 1977 to 1986, we can see a north-south corridor with a 500 mm deficit, which can accelerate the degradation of cacao trees that receive no fertilizers. In light of this information, what measures need to be taken in order to establish a sustainable cacao production system?

### 3.2. - Propositions

First, it is important to specify what we mean by a "sustainable production system". Here, we are using the definition offered by Wessel et al (1993), of a durable cacao production system as an economically viable system in which the level of soil nutrients is maintained, and that of disease and insects remains within acceptable limits. The question that haunts the mind is that of the desired life span of cacao trees: 30, 40, or 50 years? Genetic progress should dispel this question. On the basis of this definition, cacao can be produced in a durable fashion using shade trees and small amounts of fertilizers and pesticides, or in a system of direct sunlight using large amounts of fertilizers and pesticides. It is then a question of adapting one or the other system to the surroundings. In the Côte d'Ivoire, the two systems can exist simultaneously:
i) The rehabilitation of existing cacao orchards, cultivated in direct sunlight, through the use of pesticides and fertilizers, according to the hypothesis that the world market will remain favorable. Research has acquired an important amount of information in this area.

ii) The development of a system of cultivation using shade trees. This would require the selection of hybrid species less susceptible to phytophthora, the selection of shade trees according to the financial resources they can provide as fuelwood or timber, for their effect on soil fertility, and their pharmacopoeic or other diverse uses for producers. It is also necessary to perfect the system of association between cacao plants and trees which reduces spending on pesticides and fertilizers, and especially the techniques for replanting former orchards and fallow land with cacao saplings during plantation renewal. The shade trees need to contribute to the protection of the forest environment. Because of the decrease in rainfall, the accent must also be put on the competition between the trees and cacao plants for water, a relationship that we still know little about.

4 - Conclusion
The understanding of the constraints and economic environment of the current cacao production system in each region remains a prerequisite to the elaboration of long-lasting cacao production techniques. These techniques, whether they deal with rehabilitation or with the association of cacao/shade trees, must be reproducible and present solutions to the specific problems of the agro-ecological areas in each region.

BIBLIOGRAPHY


