Mini Review

Cocoa production systems with emphasis on aspects that improve production in the state of Pará Brazil

André dos S. Melo1, Sara R. Batista1, Cristiano A. da Costa1, Joio J. Vilar1, Paloma França1, Sebastião G. Augusto1 and Daniel L. Pereira2

1 Faculty of Agronomy, Federal University of Pará, Altamira-PA, Brazil
2 Department of Agronomy, Rural Federal University of Pernambuco, Recife-PE, Brazil

Received: 17 June, 2017. Accepted: 16 November, 2017
First published on the web January, 2018
Doi: 10.26545/b00007x

Abstract

The production model developed by farmers in the Transamazon and Xingu Territory, in general throughout Amazonia, contributed over time to the increase the negative impact of agricultural activity on the forest. In the colonial times, the deregulated use of land compromised natural resources and biodiversity. This contribution aims to identify the systems of production adopted in cocoa cultivation in the Amazonian states (SAFs) and the Atlantic Forest (cabruca) states and the factors that directly affect production. Data from the Instituto Brasileiro de Geografia e Estatística (IBGE -2017) show that Brazilian estimated cacao production for the current year would be 236,441 tons, distributed in the producing states: Pará, Bahia, Espírito Santo, Rondônia, Amazonas, Mato Grosso, Minas Gerais and Roraima. The national cacauicultura follows new directions trying to rebound through verticalization of production, a world trend, which is an alternative to monoculture.

Key-words: Cacauicultura, Production, SAFs, Cabruca Systems

Introduction

By the time colonizers arrived in Brazil, cocoa (Theobroma cacao) production was already part of the indigenous culture, making up a portion of the vegetation cover of the forest. The indigenous used the pulp mainly for wine production. The first initiatives for the commercial use of the product in the Amazon Region only began to gain momentum during the colonial period (Martins, 2001).

The model of cocoa production developed in the Transamazon and Xingu Territory and, which is similar throughout Amazonia, had contributed to increase the negative impact of agricultural activity on the forest. During colonial time, promoting sustainable use of land and natural resources was not a concern (Junior, 2013). Nevertheless, by the 1930s cocoa had become the main export product of the Amazonian region.

From the 1960s, with the beginning of CEPLAC's activities in the Amazon Region and more precisely in 1976, with the advent of the National Cocoa Expansion Guidelines Plan, the activity received a remarkable boost, becoming recognized as an economic activity exploited under rational technical guidance in the Amazonian States (Martins, 2001).

The conservation form of cacao production has become an alternative for the sustainable economic use of the land in rural Pará, which could make up the legal reserve areas in the Amazonian rural properties. Traditionally, cacao cultivation is a good example for the agroforestry systems approach, as it can be cultivated in association with other species under thinned forest (Cabruca) (Müller; Rodrigues; Valle, 2007).

This work was based on a bibliographical review that aimed to identify the production systems adopted in the cocoa plantations in the Amazonian
states (SAFs) and in the Atlantic forest states (cabruca). The goal was to establish a gradation between the systems over the centuries, the factors that influenced production increase in the state of Pará and the decline of production in southeastern Bahia in recent years.

**SAFs production system**

Agroforestry systems (SAFs) can be defined as the combination of simultaneous cultures of forest trees with annual and / or perennial crops. As shown in figure 1, this system contributes to increase forest cover and is an option to increase the production of timber, firewood and food. Besides, it allows for a more efficient use of the natural resources, the diversification in production, the formation of food crops, the reduction of production risks and the diversification of producer’s income (Rodigheri and Graça, 1996).

![Fig. 1. Agroforestry systems (SAFs), Altamira-PA.](image)

There are two major cultivation systems that have been used for cocoa production: cocoa can be cultivated in a complete deforested area, in association with a legume plant to provide shade; alternatively, cocoa is also cultivated under thinned forest, which is commonly known as "cabruca" system. The first one is the most common in the Amazon Region and has been increasingly adopted in the state of Pará; the second one is mostly used in the Atlantic Forest region, particularly in the state of Bahia (Fontes, 2006).

Cacao is a shade-tolerant plant species, where adequate shading leads to relatively high photosynthetic rates, growth and seed production. However, excessive shading reduces seed yield and increases incidence of disease (Almeida and Valle, 2007). In terms of productivity, full-sun or low-shade cocoa crops can be harvested earlier but are less sustainable, as they require more water, nutrients and insecticides (Arévalo et al., 2007). In a long run, however, full-sun cocoa-growing systems loose productivity as they deplete the soil and stress the plants (Ahenkorah et al., 1974).

The characteristic of shade tolerance makes cocoa one of the most interesting agricultural alternatives for rural sustainable development in the state of Pará. As a result, the inclusion of cocoa to compose the legal reserve of the Amazon agricultural land is currently on discussion (Mendes and Mota, 2015). Given the growing demand for new agricultural areas, SAFs are presented as an excellent alternative for increasing productivity and preserving biodiversity.

Agroforestry systems with cocoa have the characteristic of conserving organic carbon and soil nutrients, which can reach higher fertility levels than natural forests, if the right management strategy is adopted. Many aspects of nutrient cycling in cocoa systems are directly affected by the plant that is chosen for shading. Intercropping system with cocoa can be accomplished using several species for shading, such as banana (*Musa* spp) and rubber tree (*Hevea brasiliensis*). Smaller plants with shorter cycle, such as maize (*Zea mays*), beans (*Phaseolus vulgaris*) and black pepper (*Piper nigrum*) can also be adopted (Fontes, 2006).

In a study conducted at the Agricultural Colony of Tomé-Açu (PA), Stolberg-Wernigerode and Flohrschatz (1982) stated that among single crops, cocoa ranks first with 33% of crop area, usually combined with leguminous plants for shading. However, there are only a few studies with cocoa in the state of Pará. Thus, there are no records in the literature regarding cocoa cultivation with SAFs or other systems.

Cocoa agroforestry should not be considered as just an ordinary agricultural system, since its importance for environmental recovery and conservation is very relevant in the cacao region (Fontes, 2006). It must be treated in a particular and specific way for a given condition.

**Cutting and firing system**

The slash-and-burn system is known as any continuous agricultural system in which clearings are opened to be cultivated for shortest periods of time than those intended to the fallow (Júnior; Murrieta; Adams, 2008). It is known as a management tactic of the energetic and nutritive resources from the ecosystem soil-plant natural complex, mostly constituted as the only nutrient source to the farms
Cocoa production systems with emphasis on aspects that improve production in the state of Pará Brazil (Abreu de Sá et al., 2007). The slash-and-burn agriculture adapts efficiently to the conditions where the work, and not the soil is the more expressive limiting factor for the agricultural production.

The terms we can find in the literature to name it are different, as swidden (England), rai (Sweden), coivara, milpa, conuco, roza, chacra, chaco (South America), shmaba, chitemene (Africa), jhum (India), kaingin (Filipinas) ladang (Indonesia and Malasia), and many others. However, the popular terms we often find in literature are: slash-and-burn agriculture, shifting cultivation and, less often, swidden (Abreu de Sá et al., 2007).

Slash-and-burn agriculture is also the main factor responsible for the livelihoods of about 250-500 million people around the world, most of them in the tropics (Júnior; Murrieta; Adams, 2008), which use 240 million hectares of dense forests and 170 million hectares of open forest, comprising approximately 21 percent of the total rainforest area in the world (Júnior; Murrieta; Adams, 2008). Only in the Amazon, the traditional slash-and-burn system is responsible for feeding about 600 thousand families of small producers (Homma et al., 1998).

Figure 2 illustrates current fire outbreaks associated with agriculture in the Amazon. These outbreaks are mainly associated with family scale agriculture and livestock, resulting from the ancient practice of preparing the area for planting by family farmers in the Amazon and several tropical regions, which is known as shifting, migratory or slashand-burn agriculture.

One of the main negative effects of burning the vegetation in the preparation of the agricultural land is undoubtedly represented by the nutrient losses accumulated in the vegetation biomass during the fallow phase between two growing seasons. These losses in this agricultural system are of 47% for phosphorus, 48% for potassium, 35% for calcium, 40% for magnesium and 76% of sulfur. Besides, there is a 98% loss of carbon, which is released to the atmosphere, according to studies carried out in the northeastern region of the state of Pará (Denich et al., 2005).

Table 1 shows some of the major advantages and disadvantages of this method, which has its use reduced each year in the cocoa farming, as it presents little advantage over more current methods.

Table 1. Adapted from Bonazzi and Hiroo (2014).

| Method and its variations | Performed procedures | Advantages | Disadvantages |
|---------------------------|---------------------|------------|--------------|
| Slash and burn            | Cut of all native vegetation followed by burning. Cocoa seeds were planted directly in the field under the shade of temporary crops such as cassava and corn. After harvesting, the cocoa plants were kept without shading until spontaneous trees appeared in the area. | High productivity in the early years. | Destruction of soil humic substances; stress of young cacao plants without shading; vigorous emergence of spontaneous plants; rapid aging of the plantation. |
| Slash without burning     | The same procedures of the slash and burn method were carried out, except for the burning of the felled vegetation. | Conservation of soil humic substances. | The vegetation left in the ground disturbed the movement of the workers. |

Cabruca production system

The Atlantic Forest has as its main characteristic the great variety of faunal and floristic species, as well as an expressive ecological complexity and degree of threat and endemism, making it a Hotspot for biodiversity conservation. In southern Bahia, specifically in the cocoa region, much of the Atlantic forest was replaced by cocoa plantations (Theobroma cacao L.). In some areas, the Cabruca agroforestry
system (Fig. 3) was implemented, in which the forest is thinned and cocoa is planted under the shade of large trees (Sambuichi, 2003).

Cacau-cabra is a regional term to designate cocoa tree cultivated by the cabruca method. The word cabruca is derived from the verb to drill, which means “brocar” in Portuguese and it is used to characterize the system implemented in the southeastern region of Bahia by the colonizers to cultivate cacao. The agrosilvicultural production system has many agroecological and environmental benefits. These benefits are highly valued in sustainable agriculture and can be considered the best model of tropical agriculture ever practiced in the humid tropics. In fact, many studies had pointed out that it should be mentioned as an example of an agroforestry system that is economically, socially and environmentally efficient (Lobão et al., 1997; Lobão et al., 2009).

Cocoa culture, more specifically cocoa-cabra, is perhaps the precursor of all agroforestry systems. The first cocoa farmers arrived in the southern region of Bahia more than 200 years ago, facing great challenges to produce cocoa in the sub-forest of the primary forest. These were migrants and immigrants from the arid regions of the Northeast and the desert of Arabia (Lobão et al., 1997; Tavares, 1979).

In southern Bahia, about 20 to 35 native tree species per hectare are left to shade the cocoa plants, which dominate the understorey with 891 trees per hectare. About 650,000 hectares of cocoa are grown in Bahia, 70% of which are under the cabruca system. Although significantly altered, the cabruca supports a wide variety of native plants and animals and contributes to connect conservation units, such as the Una Biological Reserve and the Nova Esperança Ecological Station. (CEPF, 2001).

We can classify a plantation on the Cabruca method according to the density of trees that were left to serve as shading: low density, when shading presents between 25 and 50 ind ha-1; medium density, between 50 and 85 ind ha-1; and high density, greater than 85 ind ha-1. Areas with a shading density of less than 20 ind ha-1, even with native tree, should not be considered cabruca and may be densified (recabruca).

According to data from the Instituto Brasileiro de Geografia e Estatística (IBGE), the estimated Brazilian cocoa production for 2017 would be 236,441 tons, distributed in the producing states: Pará 117,365t, Bahia 105,022t, Espírito Santo 6,727t, Rondônia 5,291t, Amazonas 1,304t, Mato Grosso 562t, Minas Gerais 0.162t, Roraima 0.8t. The State of Pará has currently the largest cocoa production with a planted area of 175,328 ha.

Cacao cultivation in Pará is mainly exploited by small farmers located in medium to high fertility soils. Concentrating 77% of state production (Mendes, 2015), the Transamazônica region has a high average productivity (850 kg ha$^{-1}$) and a low production cost of the crop (US$ 800,00-1). These characteristics make this region one of the most competitive in the world in the production of cocoa.

The analysis of the historical series of cocoa production in Bahia shows that the peak of production occurred in the year of 1980, with approximately 328 thousand tons (Fig. 4). Subsequently, there was a fall in production due to the economic situation, difficulty of access funds, low prices and the establishment of the witches’ broom disease, Moniliophthora perniciosa. The fall in productivity reached its lowest level in 1999/2000, with only 96 thousand tons of cocoa produced (IBGE, 2017). It is important to note that the cultivated area did not show a significant decrease over the years (Fig. 4).

The state of Pará has a cultivated area of approximately 175,146 ha of cocoa, which is four times smaller than the cultivated area in the state of Bahia, with 560,050 ha (Fig. 5). However, the average yield of cocoa almond in Pará is 859 kg ha-1.
Cocoa production systems with emphasis on aspects that improve production in the state of Pará Brazil

while that of Bahia is 298 kg ha^{-1} (IBGE, 2017), showing that Pará has an average yield 2.88 times greater than Bahia.

The largest world cocoa producers are Ivory Cost and Ghana. For some years Brazil has been importing cocoa from Ghana, which is the second largest producer and exporter. According to the AIPC (National Association of Cocoa Processing Industries), farmers are worried that those imports would result in the introduction of pests and diseases. However, Brazilian sanitary regulation requires that the newly arrived products undergo careful examination (Revista Globo Rural, 2017).

Brazil, which was once one of the largest producers and exporters of cocoa in the world, now occupies the fifth place, having to import the fruit to supply the national chocolate production. In order to increase productivity, research has been carried out to improve seed quality (Assad, 2017). Table 2 provides a comparison among the largest cocoa producers (states) of the country, showing the cultivated area, the harvested area and the production, per year, of cacao.

For many years, the state of Bahia has been the largest cocoa producer in the country, but this scenario has been changing. In 2016, the state suffered a great drought and there was a sharp drop in the estimated harvest. As a result, Pará is now the biggest producer in Brazil. Important partnerships have been established between the State Government and government, private and third sector entities to provide technical assistance to the producers. In addition, the protagonism of the network of small producers, which is the great force of Para's production, the good experiences of cocoa in agroforestry models of planting and the geographical, soil and climate conditions of the Amazon are today the great trump of the turn of cacao from Cacao (Mercado do cacau, 2016).

Cacao News
As seen in Table 2, the state of Pará, even with a smaller planting area, had a higher cocoa production, as opposed to Bahia, due to the circumstances already mentioned.

Among these products, the almond is the one that stands out in the market, as it constitutes the primary item for making the famous chocolate, also very important for the national economy. Unfortunately, Brazil still imports cocoa, since domestic production is not able to supply the needs of the industry. The by-products and derivatives of the almond are described in Table 3 as alternatives in periods of low market price of the seed.

Table 3. Subproducts and derivates.

| SUBPRODUCTION OF COCOA | COCOA RESIDUES | DERIVATIVES OF ALMOND |
|-------------------------|----------------|----------------------|
| Cocoa pulp              | Fruit peel     | liqueurs             |
| Cocoa honey             | Almond tegumen | Cocoa paste          |
| Cocoa jelly             | -              | Cocoa butter         |
| Peduncle or Sibyl       | -              | Cocoa powder         |
| Almond                  | -              | Chocolate            |

Conflict of interest: All authors declare no conflict of interest.

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Cocoa production systems with emphasis on aspects that improve production in the state of Pará Brazil

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Cite this article as:
Dos Santos Melo, A.; Batista, S.R.; Da Costa, C.A.; Vilar, J.J.; França, P.; Augusto, S.G.; Pereira, D.L. 2017. Cocoa production systems with emphasis on aspects that improve production in the state of Pará Brazil. Amaz. Jour. of Plant Resear 1(2): 69-75.
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