Sustainable cocoa management and production based on local knowledge in central Côte d'Ivoire

Abstract

Central Côte d'Ivoire is home to forest-savannah contact zones with conditions that are not very favourable for cocoa production. However, the existence of cocoa plantations in these areas has been observed and is attributed to the presence of various agroforestry systems in which local and exotic species are combined with cocoa trees to overcome the various environmental constraints. To provide information on the local knowledge and technologies underlying the viability and sustainability of these production systems, an ethnobotanical survey of 102 farmers in the Kokumbo sub-prefecture (central Côte d'Ivoire) was carried out. Floristic inventories were also carried out in the cocoa plantations of the producers interviewed. The data collected was analysed firstly to establish the history of the plantations and their management, and secondly to determine the quality of the woody flora preserved. These analyses show that the main knowledge that farmers have about cocoa growing comes from their parents and from sharing their experiences with other farmers. The average size of cocoa plantations is 2.53 hectares. The Forastero Upper-Amazonian variety is considered more productive by farmers, gradually replacing weak or dead plants. However, farmers use seeds from cocoa trees whose pods they visually appreciate. In addition to direct sowing and nurseries, farmers are using flattening techniques, which give better results. Lack of resources and awareness of the potential negative effects of herbicides mean that producers resort to manual weeding of their plantations. Trees remain an integral part of cocoa growing in the area. Indeed, the trees associated with cocoa trees provide essential goods and services to the local population, covering their needs for timber, firewood, food and medicinal plant remedies.

Key words: Agroforestry; Sustainable production; Farm management; Biodiversity; Côte d'Ivoire

Introduction

Cocoa production, a strategic crop for Côte d'Ivoire, faces numerous environmental, social and economic challenges. The country's status as the world's leading cocoa producer and exporter has been built on intensive farming practices (Assiri et al. 2009). These practices have often led to soil degradation, loss of biodiversity and economic inequalities (Climate Change, 2018; N'Guessan et al. 2020). To counter this exponential erosion of biodiversity in Côte d'Ivoire, the practice of sustainable agriculture has been recommended for the past few decades by both research bodies and the Ivorian government.

Cocoa growing in the country is characterised by small average areas farmed per producer (Assiri et al. 2009; Kouadio et al. 2021) and limited access to modern resources, such as quality agricultural inputs, technical support and funding mechanisms (Sanial 2015). This situation makes farmers vulnerable to climate change and soil degradation. However, cocoa farmers, particularly those in the central regions of Côte d'Ivoire, have ancestral knowledge of cocoa growing, which enables them to overcome often the unfavourable environmental conditions while preserving local ecosystems.

Agroforestry, which appears to be one of the best ways of dealing with this situation, has existed for several hundred or even thousands of years as a traditional land-use system for many populations around the world (Beer et al. 2003). Its presence has been demonstrated in several regions of Côte d'Ivoire (Cissé et al. 2016; Sanial 2018; Kpangui et al. 2015), including central Côte d'Ivoire. The special feature of this central area is that it is a forest-savannah transition zone characterised by a long dry season (more than three months), average annual rainfall of around 1,100 mm and an average annual temperature of 26.5°C (Kossonou 2020). In this region, cocoa farmers have been growing cocoa in various agroforestry systems for several generations, making it possible to overcome unfavourable environmental conditions while maintaining soil fertility, reducing erosion and preserving biodiversity (Kouadio et al. 2019).

Taking local knowledge into account in sustainable cocoa management and production strategies in Côte d'Ivoire implies a reconnection between indigenous knowledge and modern agricultural sciences. This integrated approach would make it possible to design farming systems that are both productive and environmentally friendly, while helping to improve the living conditions of cocoa farmers. It was with this in mind that the present study was conducted in the sub-prefecture of Kokumbo. Its aim was to provide information on the local knowledge and technologies that underpin the viability and sustainability of these production systems.

Materials and methods

Study area

This study was carried out in the localities of Niamkey-Konankro and Langossou in the sub-prefecture of Kokumbo (Fig. 1), which belongs to the Toumodi department and the Bélier region. It is located in the centre of Côte d'Ivoire and is characterised by mixed vegetation combining forest and savannah. The average annual temperature is 26.3°C, with an average annual rainfall of 1,075 mm (Climate-data.org).

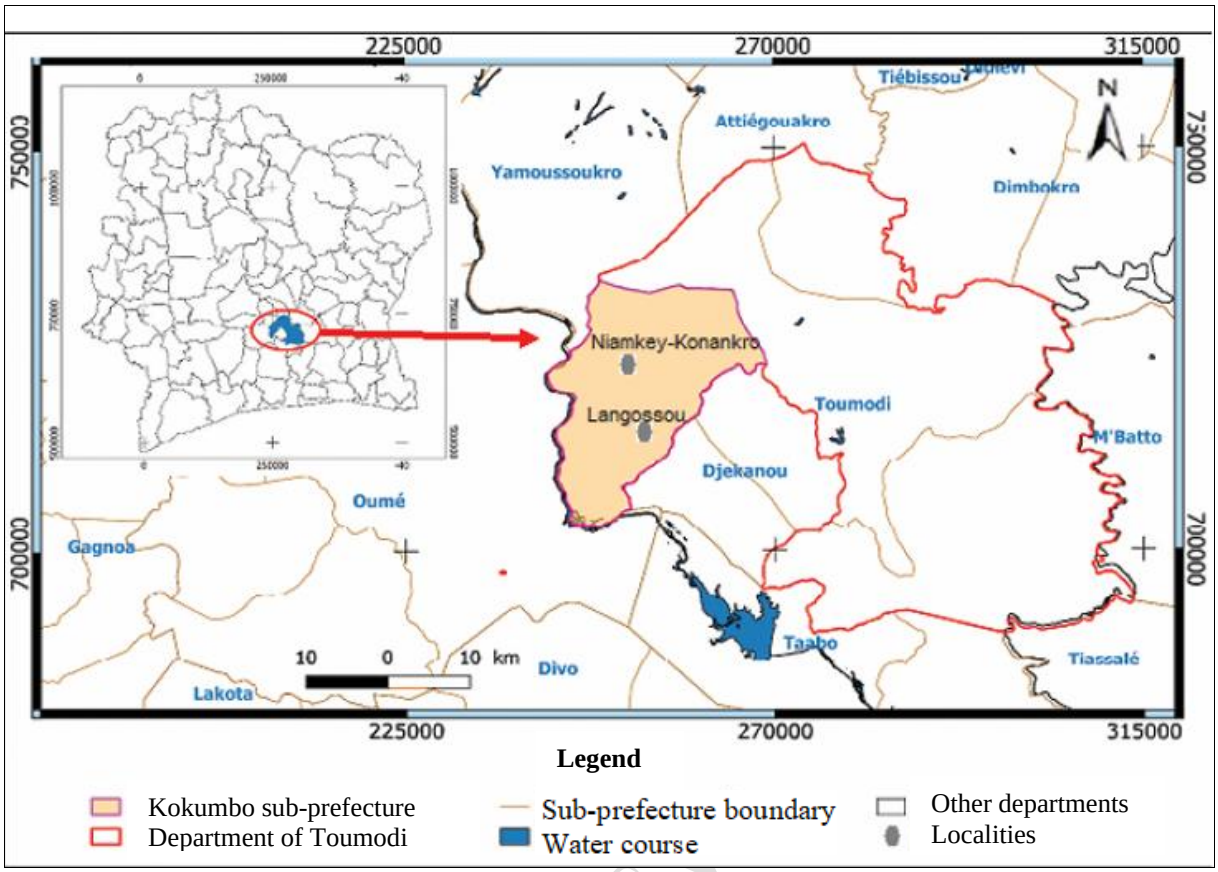

Fig. 1: Location of Kokumbo Sub-prefecture

Data collection

Sociological and ethnobotanical surveys were carried out among 102 cocoa farmers in the Kokumbo sub-prefecture, particularly in the localities of Langossou and Niamkey-Konankro. The sociological surveys were used to establish the profile of the farmers, looking at, among other things, their age, their level of education, the source of their knowledge of farm management, etc. The ethnobotanical surveys were used to characterise the plantations. The questions related to this aspect essentially concerned the size of the plantations, their age, their management methods and the resources employed, etc. In addition to these surveys, direct observations were made in the plantations in order to corroborate what the respondents had said. The aim was to visit different plantations belonging to the three main cocoa-based agroforestry systems (simple, mixed and complex) identified in the zone by Kpangui et al (2015) and Kouadio et al (2018) in order to obtain information on the practices used by farmers.

Data analysis

The data collected were subjected to descriptive analyses (averages, sums, frequencies, percentages, etc.) and textual analyses. The textual analyses were applied to data relating to the history of the plantations, the quality of the woody flora preserved, and the means and techniques used to manage the cocoa trees. All these analyses were carried out using Excel spreadsheets.

Results

Profile of producers

A total of 102 producers were interviewed, including 56 in Langossou and 46 in Niamkey-Konankro. Men accounted for 83.30% and women for 16.70%. Their ages ranged from twenty-three (23) to sixty-four (64), with an average age of 44. Those aged over forty-five (45) were the most numerous, representing 50.54% of the farmers surveyed. Next come those aged between thirty (30) and forty-five (45) (38.71%). The fewest farmers were under thirty-five (35) (10.75%). Farmers' age does not influence their choice of system. Farmers aged between 45 and 55 are most represented in the simple cocoa-based agroforestry system (AFSc) (33%), the mixed AFSc (54%) and the complex AFSc (73%). Farmers aged over 55 are least represented in the simple AFSc (11%), the mixed AFSc (8%) and the complex AFSc (9%). Of all the producers interviewed, only 6% indicated that they had received training in cocoa production. The main sources of acquisition of knowledge and skills related to cocoa farming are learning from parents and exchanges of experience between producers.

When asked about their level of education, 49% of producers said they had attended school. Of these, 26% had secondary education. Among men, 56% (30% with primary education and 26% with secondary education) had attended school. As for the women, 35% of them (of whom 12% have primary education and 23% secondary education) have been to school.

Most farmers who adopted complex AFSc did not attend school (45%). As for mixed AFSc, the majority of farmers (46%) who adopted it had reached secondary school level. The trend observed among farmers who adopted simple AFSc is more or less balanced, with 28% having reached secondary school, 39% having reached primary school and 33% not attending school (Fig. 2). Furthermore, the type of AFSc adopted by these farmers is not linked to their level of education.

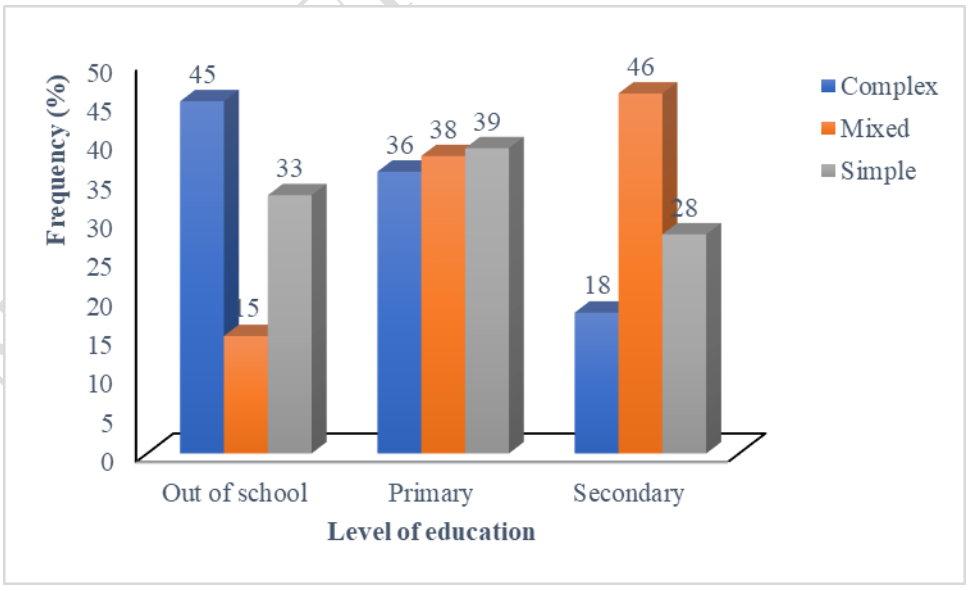

Fig. 2: Distribution of producers by level of education

Characteristics of cocoa plantations

Surveys show that the average plantation area is 2.53 hectares. Less than 2 hectares are farmed by 23% of producers. Those cultivating areas of between 2 and 4 hectares are the most represented, with a proportion of 68.18%. Farmers with holdings of more than 4 hectares represent only 7.96% of these farmers (Fig. 3).

Seven (7) methods of accessing land were identified, the main ones being inheritance (81%), gift (6%) and management for the family (5%). The other methods of accessing land were receipt by acknowledgement, a fixed-term contract and being a landowner.

Analysis of data on the age of plantations shows that the average age of plantations is estimated at 19 years. Producers with plantations between five (5) and fifteen (15) years old are the most represented (43.75%). Farmers with plantations between fifteen (15) and thirty (30) years old represent 32.29% of the total. Farmers with plantations less than 5 years old are the least numerous, with a proportion of 7.29%.

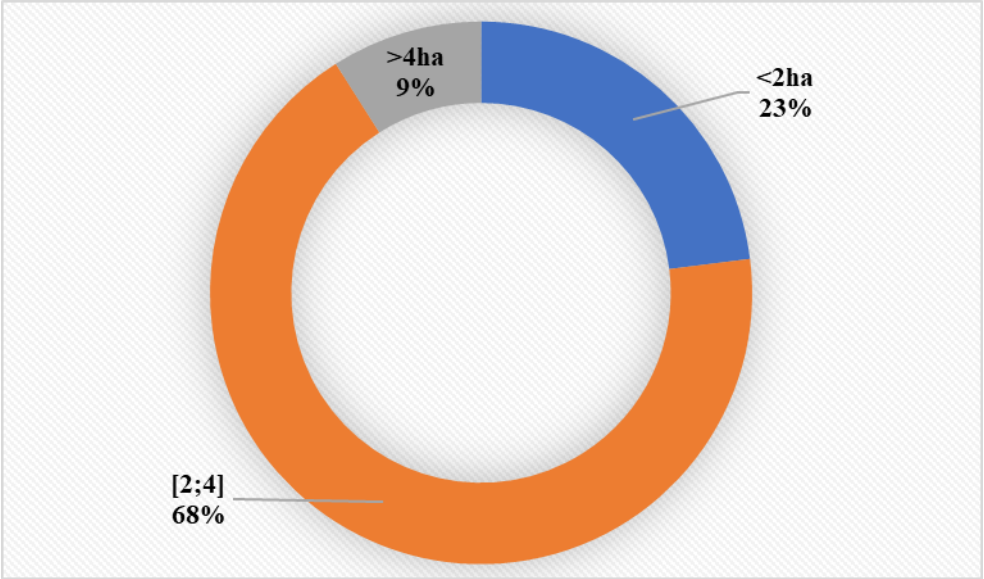

Fig. 3: Distribution of producers according to the size of their plantations

Overall, the 'Ghana' variety (Forastero Haut-Amazonienne) is the most widely used by farmers, with a frequency of 68.47%. Next comes the 'French' variety (Amelonado) with a frequency of 23.42%. The hybrid variety commonly known as Mercédès cocoa is the least used by farmers (8.11%). This variety and the 'Ghana' variety are grown in the simple AFSc. In the mixed and complex AFSc, the 'Ghana' and 'French' varieties are grown.

For the establishment or renewal of the plantation, farmers (82.40%) take their seeds from other plantations. Only 29% of all farmers interviewed use seed from their own plantation. Those who bought their seeds and those to whom they were offered (either by the CNRA or ANADER or by third parties) represent only 10.8% (Fig. 4).

Farmers prefer to use nurseries to sow cocoa trees. This method is used by 80.4% of the producers interviewed. This is followed by direct sowing of cocoa beans in the soil, cited by

55% of farmers. A third technique, not widely used, known as the flat technique (dry nursery on the ground), is used by 4.9% of farmers.

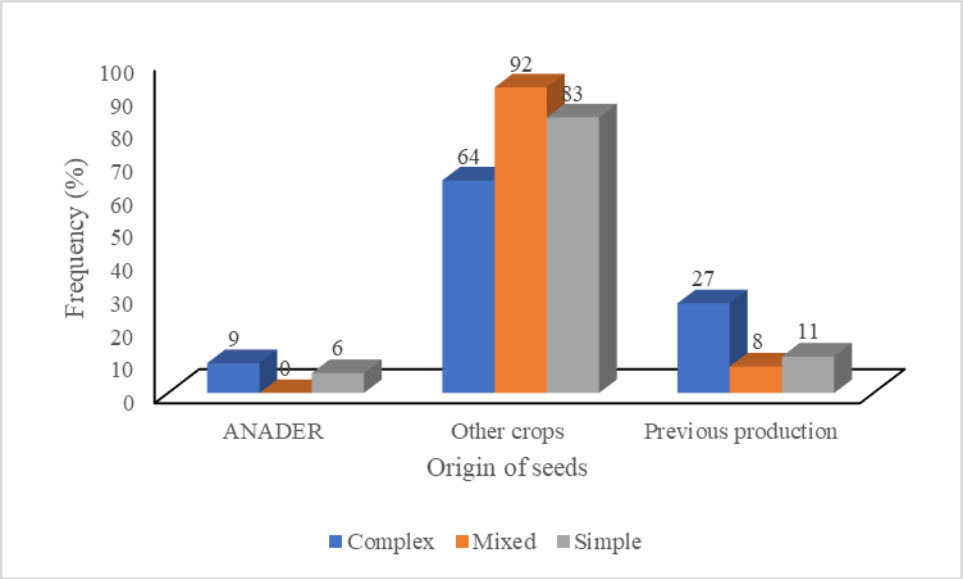

Fig. 4: Histogram of the distribution of farmers by type of AFSc according to seed origin

Regardless of the type of AFSc, the type of labour used to maintain the plantation does not change. Family members are the most frequently used labour force for watering nurseries, with 93% of farmers citing them. Only 4.5% of these producers said they used labourers and 2% day labourers for this activity.

Manual weeding is generally carried out three (3) times a year. The first weeding operation generally takes place between June and July. The second is carried out between September and October. The third and final weeding takes place between November and December. It should be noted that some farmers who have adopted complex AFSc carry out a single annual weeding operation, while in the group of farmers who have adopted simple AFSc, some carry out more than six weeding operations (Fig. 5).

During the pre-harvest period, some farmers use herbicides and chemical inputs to fertilise the soil and control cocoa tree pests. This use of inputs is aimed at reducing the work effort and maximising the productivity of the cocoa trees on their plantation. The type of input and frequency of use of these chemical inputs do not vary according to the type of AFSc adopted. Generally speaking, 52% of farmers claim to use fertiliser to increase their production, insecticides and/or fungicides to treat cocoa trees and their pods. This category is followed by producers who apply neither fungicides nor insecticides to their cocoa trees. The use of herbicides is the least cited, with 7% of producers. In the complex AFSc, 61% of farmers use insecticides and/or fungicides to maintain their cocoa trees. Only 28% use fertiliser. Those who use neither fertiliser nor insecticides and/or fungicides represent only 11%. The simple AFSc follows the same trend, but this time only 7% of farmers use chemical weedkillers. In the mixed AFSc, on the other hand, 55% of farmers used neither fertiliser, insecticide and/or fungicide, nor herbicide (Fig. 6). Insecticides and/or fungicides are generally applied twice (2) a year. The first application is made during the months of July and August. The second application is made between August and September or in December.

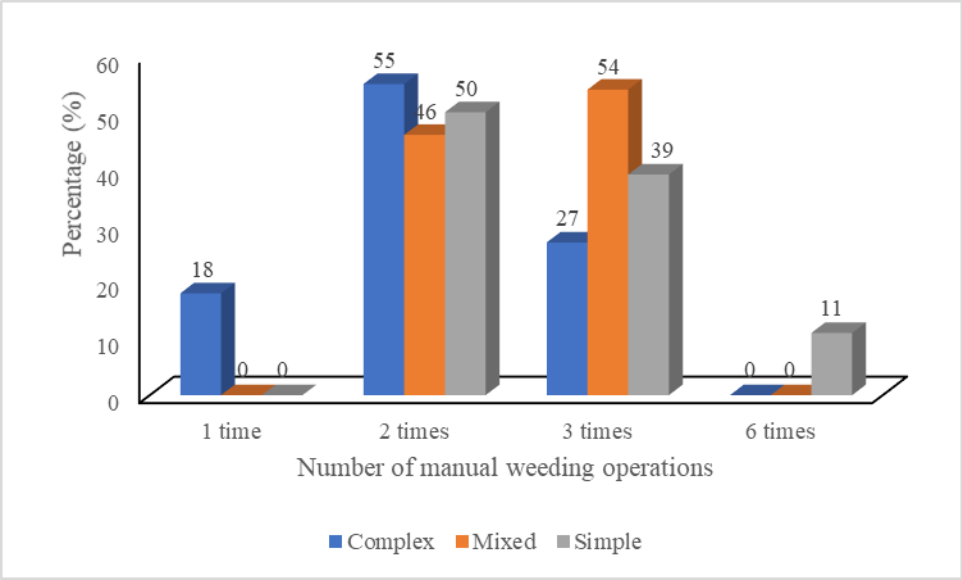

Fig. 5: Histogram of the distribution of plantations by type of AFSc according to the number of manual weeding operations.

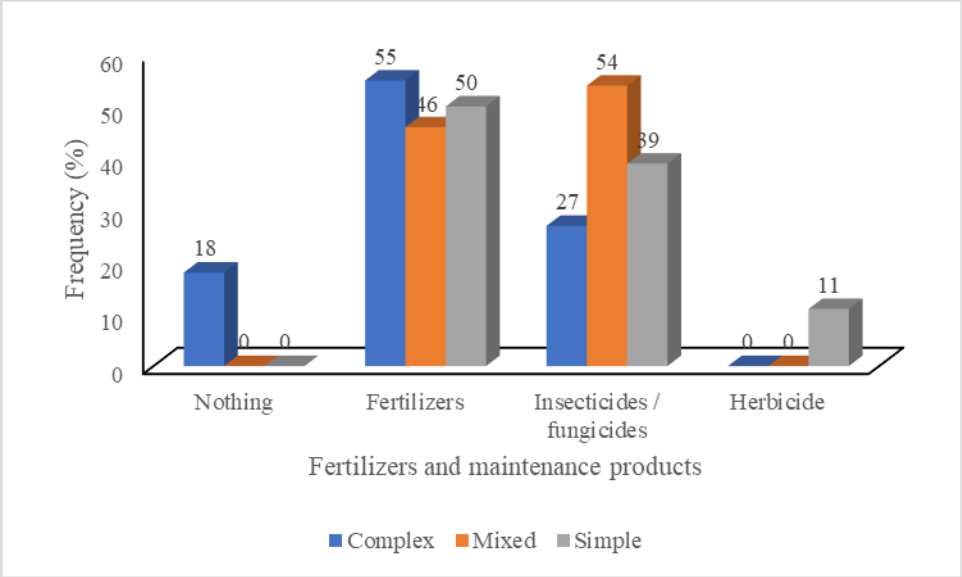

Fig. 6: Histogram of the distribution of plantations by type of AFSc according to the use of chemical inputs

Discussion

Farmers' know-how in the spatial and temporal management of cocoa plantations

The results of this study show that farmers (men and women) grow cocoa. They are on average 44 years old and farm small areas (2.53 ha). The small size of cocoa plantations is similar to that recorded by Assiri et al (2009) in Issia and Bongouanou (2 to 3 hectares per farmer). The small size of the plantations could be explained by the fact that farming is not mechanised and by land tenure constraints, which have led farmers to adopt small family

farms. The work of Boni (1985) and Assiri et al (2009) has shown that cocoa farming in Côte d'Ivoire is dominated by smallholders. The small areas cultivated are also similar to those recorded by Konan et al (2015) at national level (2 to 3 ha). However, Assiri et al (2009) recorded an average area of 6.3 ha per farmer considering the main cocoa production areas at national level. These large cocoa farm areas are due to extensive cocoa farming, which has increased following the shift of the cocoa loop from east to west.

In the present study, the plantations were generally established in place of pre-existing forests or from the rehabilitation of former cocoa plantations. The young age of the plantations run by women shows that they are increasingly interested in cocoa farming, which has long been characterised as a 'man's crop'. Women generally become involved after the death of their spouse or when they are not living as a couple. They generally inherit the land they farm. In the study area, parents generally bequeath their plantations to their descendants (Kpangui 2015). In the first case, the heirs are young people who have been by their side throughout the creation and management of these plantations. They mentioned the forest and sometimes a former cocoa plantation as their cultural precedent. In the second case, the heirs are people who did not take part in the creation of the plantation from which they benefit. This category mentioned old cocoa plantations as the previous crop. The age and sex of these beneficiaries of bequeathed plantations do not influence the type of AFSc they adopt. When a woman inherits part or all of the plantation, she entrusts it to her husband, who is responsible for management. The size of the family (10 people on average) requires at least one other plantation to be maintained, in addition to the cocoa plantation that the farmer has. These are either perennial crop plantations (cocoa, rubber, teak) and/or food crops (yams, manioc, etc.). The food crops meet the family's food needs and the surplus is sold on the market in the said locality or on the market in the nearest town (Kossonou et al. 2018). This practice is adopted by farmers in the localities of Niamkey-Konankro and Langossou, regardless of the system they have adopted. Farmers prefer seeds from cocoa trees of the 'Ghana' variety and its hybrids. In the locality of Lakota in central-western Côte d'Ivoire, Cissé et al (2016) made the same observation. These seeds generally come from pods seen, appreciated and harvested during a visit to the plantation of a relative or friend in the village. In complex and mixed AFSc, farmers combine the 'French' and 'Ghana' varieties, with a preference for the 'Ghana' variety. Following the example of farmers in the Department of Lakota, farmers in the Kokumbo sub-prefecture combine these two varieties as part of the rehabilitation and rejuvenation of their old cocoa plantations (Cissé et al. 2016).

Indeed, plants of the 'Ghana' variety, considered more productive by the farmers, replace those that have failed or died. The 'Mercédès' variety is found in a few plantations with the configuration of a simple AFSc. Despite genetic aptitudes that enable it to grow without shade and to produce early (after 18 months), farmers in the Kokumbo sub-prefecture are reluctant to use this variety. Indeed, the use of this variety by some farmers to create nurseries or for direct seeding has resulted in several failures. These failures have led most farmers to take a negative view of the variety. Added to this is the fact that young plants of this variety find it difficult, if not impossible, to withstand the dry season in this area. Furthermore, the failures recorded during the establishment of nurseries, whether for the 'Ghana', 'Français' or 'Mercedes' varieties, can be attributed to the methods used by the farmers. To achieve better results, Kébé et al (2009) proposed a methodology for setting up nurseries. These authors, working on behalf of the Centre National de Recherche Agronomique (CNRA), suggest that nurseries should last an average of 6 to 8 months, with regular chemical treatment against

defoliator caterpillars, psyllids and twig borer. However, the techniques and means used by the majority of farmers in the study area do not differ whatever the AFSc adopted. These techniques do not enable them to achieve the results predicted by these authors. Indeed, they do not have the necessary means to acquire the chemical products recommended by the CNRA. Added to this is the low level of education among farmers, which makes it difficult for them to adopt the techniques proposed by the CNRA. Financial constraints on the purchase of plastic bags and the technical rigour required to create nurseries mean that farmers alternate between planting by direct sowing and planting by nursery. In addition to these two main planting methods, the 'flat' technique is occasionally used. Flat planting is used instead of nurseries. It corresponds to nurseries on the ground. Fresh beans are placed in ploughed soil. Sometime later, the resulting seedlings are removed and transplanted into the plantation. According to the farmers, this technique has a high success rate, especially as the transplanted plant is young. In fact, this technique has the advantage of better simulating the conditions under which the plants are actually grown. As a result, they reduce the time spent in the nursery to an average of 4 months. Transplantation of seedlings from the nursery, from the 'flat' or direct sowing is generally done without staking. As a result, the seedlings are not aligned and there are too many of them on the farm (Kouassi 2010), particularly in mixed and simple AFSc. This overcrowding, which is generally deliberate, is intended to reduce the impact of the dry season on young seedlings. In fact, large enough spaces between young plants would cause them to dry out in the dry season. The farmer gradually eliminates certain plants as the plantation develops.

Workforce involved in farm management

Family labor is used most frequently on the farms to carry out all the activities involved in plot maintenance, harvesting and shelling. Family labor helps reduce plantation maintenance costs, and is a means of training young people to run a plantation. Family workers are the only ones involved in planting and watering the seedlings. Weeding the plantation involves both family labor and paid outside labor. This external workforce is made up of laborers, daily contract workers (tréclé) or young people from the village organized into work groups known as "societies" (Kouassi 2014). Laborers and contract workers are employed by farmers who have adopted a simple or mixed AFSc. Unlike complex AFSc, such systems require much more time for maintenance. These results are also justified by the low proportion of farmers employing groups of people associated in "companies" for weeding in the complex AFSc, compared with the other systems. These data clearly illustrate the reduction in labour effort in cropping systems that associate more trees. Plantation maintenance Plantations are weeded either manually or using phytosanitary products to control pests and diseases. Contrary to the proposals made by Kébé et al (2009) and Konan et al (2015) concerning the alternating use of manual and chemical weeding, farmers in the localities of Niamkey-Konankro and Langossou generally content themselves with manual weeding. Manual weeding is carried out three times a year, regardless of the type of AFSc, and is the most "time-consuming" activity (Carrière 2003). Lack of means for some, and a poor perception of chemicals for others, are the main reasons behind the very low use of chemicals for weeding (Koua et al. 2018). Indeed, farmers have not failed to point out that the effect of these herbicides does not distinguish between certain non-woody food species (*Xanthosoma maffafa*, *Musa* spp. seedling) that they associate with cocoa trees and weeds. In addition, they are increasingly aware of the negative impact these chemicals could have on their health and the health of consumers. Contrary to the findings of Geilfus (1994) and Boulay (1998), who concluded that the presence of trees

increases labor and labor costs, the present work showed a reduction in labor in complex and mixed AFSc, but equivalent costs for the maintenance of the different AFSc. The reduction in labor in the complex and mixed AFSc is due to the fact that the presence of shade and litter made up of dead leaves reduce the development of weeds in the undergrowth (Dufumier 2016). During manual weeding, the farmer clears the undergrowth to prevent the cocoa trees from competing with other plants (Carrière 2003; Tondo et al. 2015). He also takes the opportunity to prune the gourmands growing along the main cocoa stem. He also eliminates branches attacked by insects or harboring parasitic plants. Chemical control of the insects and fungi that attack cocoa trees is carried out twice on average. It comes after manual weeding, which explains why it is applied by farmers in July and August. This low number of applications, compared with the minimum of 4 recommended by Kébé et al (2009), is observed in the various agroforestry systems observed. This can be explained by the high cost of inputs. Added to this is the lack of means to acquire an atomizer. Some cooperatives provide their members with chemicals and an applicator. Sometimes, however, cooperatives only make insecticides and/or pesticides available to farmers, who do not use them for lack of a sprayer. This lack, or even absence, of pesticide application was observed by Sonwa et al (2008) in Cameroon. Another practice observed in the two localities visited is the borrowing of a sprayer from one of the few farmers who own one, and the solicitation of a person to act as applicator. Ripe pods are harvested in such a way as to reduce labor time. It is done periodically, at regular intervals, according to the farmer's availability, and does not depend on the cropping system. A farmer may harvest every two, three, four or even five weeks. However, the trend observed in the field is towards a monthly harvest. In most cases, the farmer is responsible for harvesting the pods and then shelling them. He gets help from his children, his wife or some friends. During this task, the woman's contribution is in transporting and stacking the pods, in transporting the beans and occasionally in preparing meals for the "workers".

All these practices have contributed to the maintenance and sustainability of cocoa cultivation in the central region of Côte d'Ivoire. Local knowledge forms a solid basis on which any scientific contribution to sustainable cocoa production in the region can be built. Indeed, several recent initiatives, such as certification programs and sustainable agriculture projects funded by international organizations, have highlighted the importance of this knowledge in the transition to more sustainable agriculture (International Cocoa Initiative 2021).

Conclusion

Sustainable agriculture is at the heart of today's global challenges, particularly when it comes to the production of essential raw materials such as cocoa. In Côte d'Ivoire, one of the world's leading cocoa producers, sustainable management and production of this resource are crucial, not only for the country's economy, but also for preserving the environment and improving the living conditions of local communities. In this context, the ancestral knowledge of Ivorian farmers plays a vital role. This traditional knowledge, handed down from generation to generation, enables the adoption of environmentally-friendly farming practices, while guaranteeing efficient, sustainable production. Integrating this local knowledge into modern cocoa management strategies thus offers an innovative model for combining economic profitability, biodiversity preservation and producer well-being. Traditional knowledge plays

a key role in the sustainable management of natural resources, as it is often based on intimate knowledge of local ecosystems and how they function, developed over centuries.

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