EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 10
Issue: 11
23-32
Year: 2023

ETHNOBOTANICAL STUDY OF TREES ASSOCIATED WITH COCOA TREES IN THE GOH REGION IN THE CENTER-WEST OF COTE D'IVOIRE

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Article Received on 15/09/2023 **Article Revised on 05/10/2023** **Article Accepted on 25/10/2023**

ABSTRACT
Cocoa-based agroforestry in the Gôh region appears to be an alternative for sustainable production. The main objective of this study was to determine the tree species compatible with cocoa trees. This will involve inventorying the species spared or introduced during the establishment of their plantation and evaluating the producers' perception of these trees through an ethnobotanical survey. To achieve this objective, ethnobotanical surveys were carried out among cocoa producers spread across nine localities. These interviews focused on the profile of the farmers, the previous cultivation of their farms, the variety of cocoa grown and the species of trees associated with the cocoa trees. The results obtained show that 59% of the 248 producers interviewed are indigenous, 32% are non-native and 9% are non-native. In total, 84 tree species divided into 69 genera and 32 families associated with cocoa trees were cited by producers and are subdivided into local species and introduced species. These tree species, in addition to ensuring food and health security for populations, also help fight climate change by absorbing greenhouse gases such as carbon dioxide (CO2).

KEYWORDS: agroforestry, associated trees, cocoa trees, ethnobotany, Gôh region.

INTRODUCTION
Ivory Coast is experiencing real success in terms of agricultural development thanks to cash crops such as cocoa. The current production of 41% of the world supply of cocoa beans maintains Côte d'Ivoire as the world's leading producer ICCO, (2016).[11] Cash crop agriculture is responsible for 40% of deforestation in tropical countries. In Africa, it is responsible for 35% of deforestation. The cultivation of cocoa trees (*Theobroma cacao* L) is, moreover, closely linked to deforestation : the first producing countries are those which have consented to the sacrifice of their forests. Based on the map of reduction in the area of forest areas in favor of crops, demonstrated that there are clear cause and effect links between the increase in agricultural activity due to cash crops and the reduction in rainfall in recent decades. Côte d'Ivoire has sadly succeeded in this substitution : it has lost 80% of its forest cover in the space of a century REDD, (2017).[27] While the international agenda is based on sustainable development as well as the fight against climate change and deforestation, cocoa farming is called upon to maintain itself in post-forestry conditions Sanial, (2019).[24] Beyond its impact on forest cover, this cash crop is one of the most important, due to its place in the global economy, but also, due to the diversity of services that rural populations benefit from ICCO, (2008).[10]

In order to sustainably reconcile forests and agriculture, the private forestry sector could contribute to the emergence of agricultural systems that make room for timber through agroforestry systems (Rivain et al., 2018).[28] However, all reforestation cannot succeed without involving local populations. In order to preserve the balance and biological diversity of ecosystems, sustainable development, which offers solutions integrating the ecological, economic and social aspects of any problem, seems to be one of the ways to deal with these problems. Although organic cocoa is booming, Africa is not driving this dynamic. The sustainability of Ivorian production is, however, threatened by numerous constraints Assiri, (2007).[4] The exhaustion of the country's forest reserves no longer ensures the continuity of the extensive system, which is one of the characteristics of Ivorian agriculture. Also, climate change (decrease in rainfall, long periods of drought) Brou et al., (2005)[7], has become another constraint on cocoa production, which mainly comes from farms run in full sun, it is that is, without shading.

MATERIAL AND METHOD

The investigation environment

This study concerns two departments, both belonging to the Gôh region, these are the departments of Gagnoa and Oumé.

The Gôh region is located in the center-west of Côte d'Ivoire between latitudes 5.679° and 6.649° N and longitudes 6.408° and 5.201° W. It belongs to the second cocoa loop and is limited by the regions of Marahoué and Haut-Sassandra in the North, Nawa in the West, Lôh-Djiboua in the South, Agnéby-Tiassa in the South-East, Bélier in the East, and the Yamoussoukro district in the North-west. This region is made up of two departments (Fig. 1): the Gagnoa department in the West and the Oumé department in the East.

Biological material

The biological material is composed of :

- samples of different tree organs (leaves, flowers, bark.) collected from the study sites; of the Herbarium of the National Floristic Center (CNF) of the Félix Houphouët Boigny University in Abidjan which served as a guide to the identification of samples of plants not determined in the field and of soil samples taken under the different species of trees in different plantations.

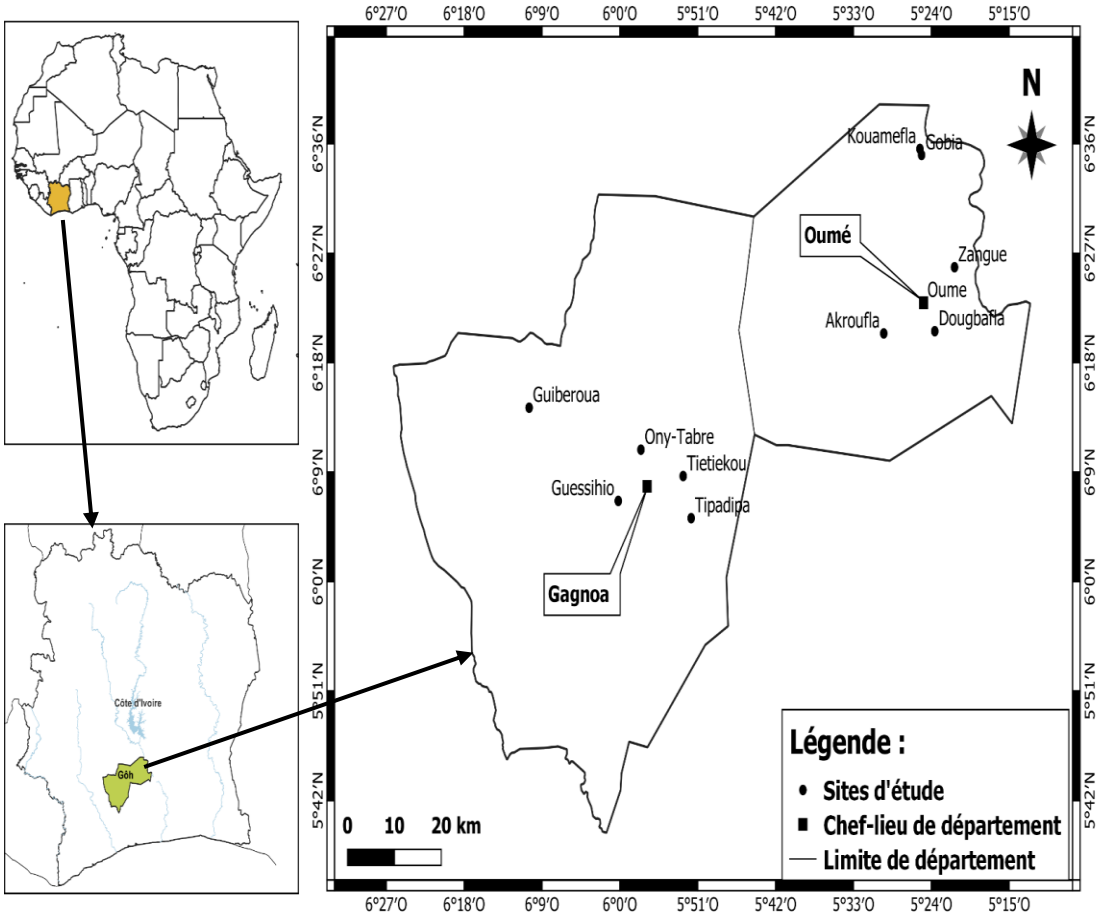

Fig. 1: Geographical location of the study area in western Côte d'Ivoire.

Survey methodologies

Farmers who own cocoa plots were identified to be interviewed individually on their plantation. The information provided was supplemented by direct observations on the plots. The survey lasted four months, from December 2021 to March 2022. Two methods were used to carry out this study : An ethnobotanical survey of planters, which focused mainly on the age group of planters, the level of education, the origin of the planters, the different types of activities they carry out, the age of the crop, the different varieties of cocoa planted, the method of acquiring the plot, the types of treatment (weeding and use of insecticides), the scientific and/or local name of the associated tree species (Fig. 2). This method was used by (Eponon et al., 2017).[8]

Fig. 2: Semi-structured interview with a cocoa producer on his plot in Dougbafla (Oumé).

Traveling floral inventory

Information on trees associated with cocoa trees (name, use, number) was obtained using the full-time inventory technique. It is also called a "roving inventory", a methodology similar to that deployed by Aké-Assi (2001).[2] This type of tree inventory is carried out over the entire extent of the chosen plot. This choice was motivated by the irregularity of the distribution of associated trees within the cocoa plantations. The name and presence of the species were noted in each plantation. The usefulness and origin (preserved or introduced) of the species were additionally collected from the owner of the plantation. The frequency of species recorded during the surveys was highlighted by calculating the "relative citation frequency" Malan and Tra Bi, (2007)[17], with the formula :

$$Fr = 100 \times (a / b)$$

Where "a" is the number of respondents who mentioned the plant and "b" the total number of respondents.

Floristic composition

Floristic composition refers to the number of species inventoried, the distribution by families, by genera, by biological, morphological and chorological types (Bakayoko, 2005).[5] It was used to characterize the floristic lists obtained and evaluate their richness.

Biological types

The biological type is a classification system initiated by Raunkiaer (1934)[26], in order to organize all plants according to the positioning of the plant's survival organs during the unfavorable period.

Chorological affinities

Chorology can be defined as the geographical distribution of species according to their ecological preference Kouamé, (1998).[16] The classification of the different species according to their chorology was made based on the work of (Aké-Assi, 2001).[2] The chorological types taken into account in this study are: the species of the dense humid forest of the Guinea-Congolese domain (GC); species belonging to the Sudano-Zambezian region (savannahs and light forests) (SZ); species common to the Guinea-Congolese region and the Sudano-Zambézian region (GC-SZ); introduced or cultivated species.

Statistical analyzes of data

The Chi-square test, (X^2), developed by Karl Pearson, is one of the most widely used statistical tests in scientific research. It is a non-parametric test which aims to compare the observed numbers to the expected theoretical numbers. It was used here to check relationships between different responses from respondents. It is based on two principles : which are the independence of the observations and the lower limit of the expected theoretical values which is 5. For theoretical numbers less than 5, the Fisher exact test was used. Note that this test is carried out using the XLSTAT software version 2014.5.03.

RESULT

Ethnobotanical survey

In the study area, 248 cocoa producers were surveyed in 9 villages including 4 villages in the Oumé department and 5 villages in the Gagnoa department. The 248 cocoa producers met are made up of 98% men and 2% women. The ages of these producers varied from 23 to over 65 years old. The most represented age group is 36 to 55 years old. From the point of view of origin, three groups are distinguished : indigenous people, non-native people and non-native people. The survey reveals a very high rate of the Indigenous community (59%), while the Non-Indigenous communities represent (32%) and (9%) respectively of all the people surveyed (Table 1).

Table 1: Origin and sex of those interviewed.

Features	Origin			Sex	
	Indigenous	Allogenes	Non-natives	Men	Women
Frequency (%)	59	32	9	98	2

Level of education of planters

Schooled people mainly characterized by the level of primary education occupy the highest proportion 47%. On average, 24% of the producers surveyed did not attend school. Only 19% reached secondary level. As for educated people, 8% have attended Koranic school

(Franco-Arab) and a very small proportion of those having reached the higher level 2%. Socio-professional activities of the producers surveyed The analysis of (Figure 3) shows that the people surveyed are mainly farmers (92%).

However, there are minor activities such as commerce present at 4% and others which represent activities such as (mason, tailor, breeding etc.).

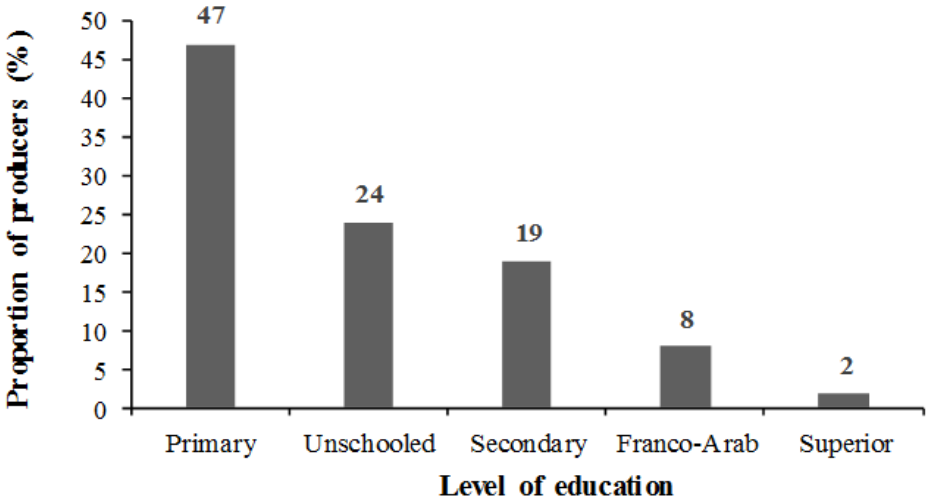

Fig. 3: Distribution of producers according to level of education.

Parcel information

Age of culture

Surveys carried out among cocoa tree owners made it possible to establish a classification of the latter by age class. The most represented age group is that of 20 years and over, called Mature or 33%, it is followed by that between 15 and 20 years or 32%, age groups between 10 and 15 represents 25%, while a small proportion is made up of plantations less than 10 years old, called immature (Fig. 4).

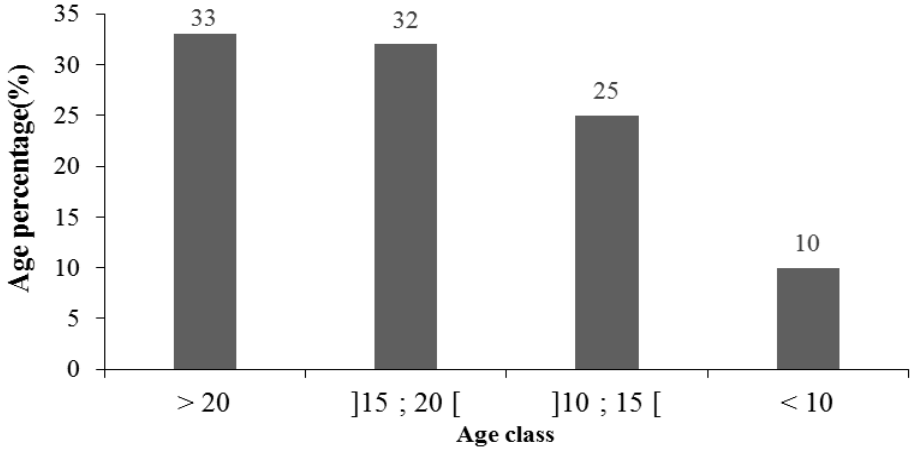

Fig. 4: Distribution of age classes of cocoa trees.

Varieties of cocoa grown and reasons for choosing these varieties

In the two departments surveyed, the Amelonado cultivar commonly called "Ghana" cocoa is the cultivar most used by all cocoa producers, i.e. 69.52% in Oumé and 30.07% in Gagnoa, followed by "all-purpose" mixture with 30.48% in Oumé and 23.08 in Gagnoa. As for the mix of Ghana-French people, we observe 20% in Oumé and 13.29% in Gagnoa. The cultivar "Mercedes" is an improved variety which was developed by the National Agronomic Research Center (CNRA), it is cultivated in association with other cultivars such as Ghana, i.e. 16.19% in Oumé and 6.99% in Gagnoa (Table 2). The chi-square statistical text reveals that there is no significant difference between the cultivated varieties and also between the two departments. The Forastero variety, also called "French" cocoa, was less observed in older plantations. The focus groups carried out with

producers confirm that there is a real propensity among producers in general to use improved cocoa seeds. However, many producers still use "all-purpose" plants because of the difficulties they experience in sourcing selected cocoa seeds. Cooperative societies are not supplied in time to allow their cooperators to plant according to the growing calendar of their zones. In this case, producers resort to "all-purpose" plants. The Ghana variety is the most used by producers because according to their perception, it is a variety that produces a lot and at any time of the year.

Table 2: Varieties of cocoa trees planted (% of areas) according to departments.

Cultivated cocoa varieties	GAGNOA	OUME
Ghana-Mercedes	11,89[a]	9,52[a]
Ghana-Français	14,69[a]	18,10[ab]
All comers	22,38[a]	31,43[bc]
Ghana	51,05[b]	40,95[c]
Chi-square statistical parameters		
dl	3	3
χ^2	73,50	32,65
P	> 0,001	> 0,001

Means followed by the same letters in a column are not significantly different at the 5% level.

The results of Table IV show that in the sub-prefecture of Oumé the rate of cocoa tree varieties grown by producers therefore the age class is between [18-35], [36-55] and [56-65] differs significantly from the others (X^2 = 59.49, df = 3, p < 0.001). Only the percentages of producers whose age is greater than 65 (> 65) do not vary significantly from one variety to another (X^2 = 10.17, df = 3, p = 0.156).

Methods of acquiring cultivable plots

The entry into activity of the populations surveyed takes place through land. The surveys revealed that planters have three modes of integration. In both departments, the most common mode of acquisition is acquisition by inheritance with 70.63% in Gagnoa and 78.09% in Oumé (Table 3). Purchasing and sharecropping were cited respectively as 20.28% in Gagnoa and 19.08% in Oumé, sharecropping recorded a low proportion, i.e. 9.09% in Gagnoa and 2.86% in Oumé. The Chi square test indicates a highly significant difference between the three methods of plot acquisition.

The most common method of acquiring plots among non-natives and non-natives is purchase and sharecropping (shared work) with a slight dominance of purchase, then followed by inheritance. On the other hand, among the natives, the vast majority of producers acquire their plot of land through inheritance. Analysis of the Chi square test indicates a highly significant difference in purchasing and sharecropping among the indigenous community (X^2 = 148.2, df = 2, p = 0.001).

Table 3: Reparation for producers depending on the mode of access to the plot.

Acquisition mode	GAGNOA	OUME
Legacy	70,63[a]	78,09[a]
Achat	20,28[b]	19,08[b]
Sharecropping	9,09[c]	2,86[c]
Chi-square statistical parameters		
dl	2	2
χ^2	148,20	138,30
P	> 0,001	> 0,001

Means followed by the same letters in a column are not significantly different at the 5% level.

Crop precedents of cocoa trees

Cocoa plantations are established on three main types of cultural precedents. The previous "Fields of food crops and fallows" represents 51% of the orchard, compared to 37 to 12% on average for the other previous crops which are the "forests" former cocoa and coffee plantations.

Ethnobotanical study

Floristic characteristics and specific richness

In all the cocoa plantations studied, the traveling floristic inventory made it possible to identify a total of 84 species belonging to 32 families and 69 genera. The families most represented in the different cocoa tree fields in terms of species in order of importance, Malvaceae (10 species or 12%), Fabaceae (9 species or 11%), Moraceae (7 species or 8%), Meliaceae (5 species

or 6%) (Fig. 5). The other less important families are only represented by one species. The traveling floristic inventory also made it possible to identify a total of 64 preserved species which are distributed among 29 families, while 20 species are introduced and distributed among 12 families. In terms of introduced species, *Persea americana* is the most predominant in terms of individuals while *Elaeis guineensis* Jacq is the most common preserved species.

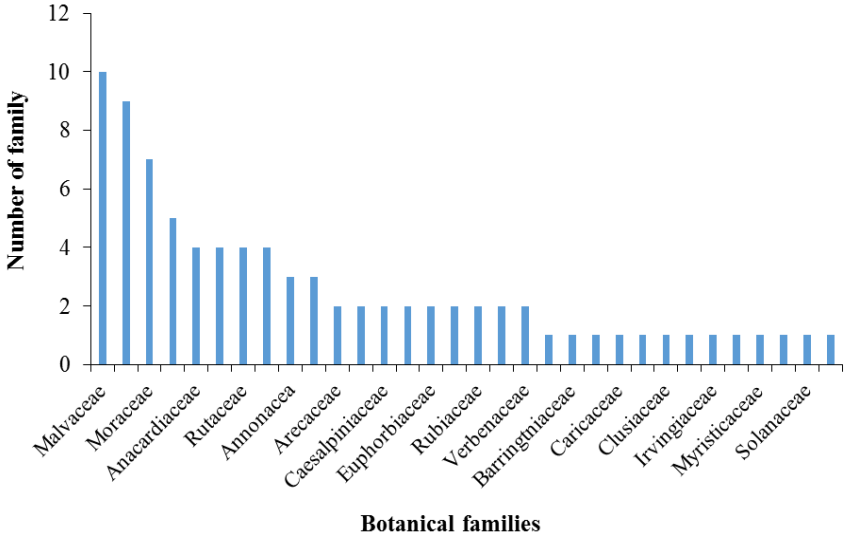

Fig. 5: Proportion of species families encountered.

Typology of services provided by trees associated with cocoa trees

The spectrum of biological types of all the cocoa trees sampled in the departments of Gagnoa and Oumé indicates four (4) main biological types throughout the study area. These are microphanerophytes (mp) with 36% of individuals followed by mesophanerophytes (mP) and megaphanerophytes (MP) with 33% and 30% respectively, nanophanerophytes (np) are the least represented with only 1% of the species inventoried (Fig. 6).

Chorological affinity of the inventoried species

The different species inventoried in the cocoa plantations were distributed according to the following chorological affinities : the Guinea-Congolese region (GC) with 51%. These taxa are followed by introduced species and species common to the two Guinean-Congolese and Sudano-Congolese transition regions. Zambezian (GC-SZ) with respectively 24% and 23% of transitional taxon species (GC-SZ) with 33% while introduced species and those from the Sudano-Zambezian zones are minimal with only 2% of species (Fig. 7).

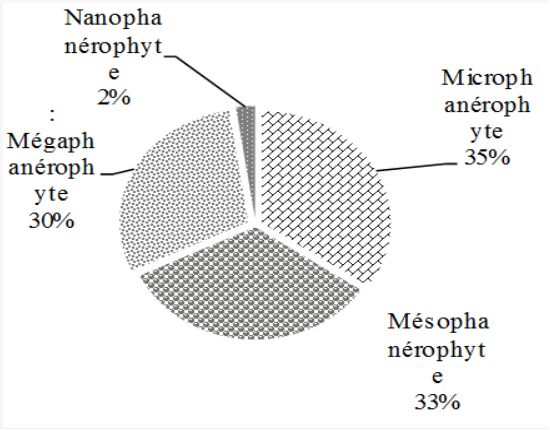

Fig. 6: Percentage of species according to biological type.

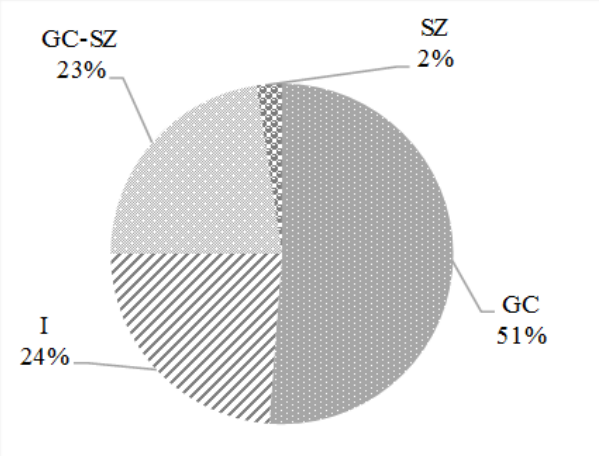

Fig. 7: Proportion of species according to their chorological affinities.

Species with special status

In this study no species endemic to the Ivorian forest was inventoried. On the other hand, 21 inventoried plant species are included on the red list of the International Union for Conservation of Nature. Among these, 11 species are considered Vulnerable (VU). In the category of species of least concern (LC), 10 species were counted and we note the presence of one (01) species of insufficient data (LR/NT), this is *Irvingia gabonensis.* Among which, we can *cite Albizia adianthifolia, Anthocleista djalonensis, Alstonia boonei* and *Baphia nitida*.

Uses of species associated with cocoa trees

The species preserved or introduced into cocoa trees are important not only for their uses by populations, but also for their ecological role in the agricultural system. The survey carried out among producers showed that most of the associated species are used for several purposes in the plantation. The priority uses of the species mentioned by the farmers interviewed are : provision of shade, marketing, food use, medical use and others. The surveys made it possible to identify 06 uses including an ecological role of species associated with cocoa trees. These are food use (*Elaeis guinensis, Mangifera indica, Myrianthus aboreus*), commercial use *(Persea americana, Irvingia gabonensis, Ricinodendron heudelotii*), medicinal use (*Alstonia boonei, Morinda lucida, Pycnantus angolesus*), timber species (*Triplochiton scleroxilon, Terminalia superba, Ceïba pentandra*). The other uses are : (soil fertility, crafts, firewood, fodder and protection of the plantation) According to the respondents, the species having an ecological role, that is to say the shade species are the most predominant and represent 32 % (Fig. 8).

Fig. 8: Distribution of species associated with cocoa trees according to their uses.

DISCUSSION

In the areas surveyed, cocoa farming is generally practiced by men. The latter represent 98% while women occupy only 2% of cocoa farmers. This dominance by men could be explained by the fact that, in cocoa farming in Côte d'Ivoire and also in African culture, women are generally relegated to the background. In cocoa-producing areas of Africa, women were generally not allowed to establish their own plantations Mikell, (1989).[18] The results of the survey revealed a higher proportion (around 59%) of indigenous producers than

non-natives and non-natives in the production areas of the Center-West.

Regarding the trees associated with cocoa trees in the two departments visited (Gagnoa and Oumé), 84 tree species were identified. The families Malvaceae, Fabaceae, Moraceae and Meliaceae are the most represented with rates respectively of 10 species or 12%, 9 species or 11%, 7 species or 8% and 5 species or 6%. The majority of Ivorian forests are dominated by the same procession of families Adou Yao., (2005).[1] The high proportion of Fabaceae can be explained by the fact that the species of this family have a very high possibility of tillering and a greater speed of regrowth after weeding of plantations Adou Yao., (2005).[1]

However, the numbers of tree species in the cocoa plantations of the Gôh region (84 species) remain lower than the majority of the wealth obtained in tropical agroforestry systems based on cocoa. In Nigeria, for example, Bobo et al. (2006)[6] recorded 206 species and Zapfack et al., (2002)[34], 116 tree species. The same is true in the cocoa agroforests of eastern Ghana; 116 species recorded by Osei-Bonsu et al., (2003).[22] On the other hand, the cocoa trees of the Gôh region have richness similar to the results of studies carried out in Nigeria by Oke and Olatiilu, (2011)[21] with a richness of 76 species in the cocoa trees of the Ogbese forest reserve. All these variations in the richness of companion species of the cocoa tree in the plantations could be explained by the importance of the choices or preferences of producers during the establishment of the crop and during the production phase Vroh et al. (2015).[32] Indeed, for producers, the choice of a companion species in cocoa farming, whether native or exotic, responds to the dual concerns of finding an appropriate balance of shade and identifying trees compatible with cocoa trees, so as to optimize bean yield Sonwa et al., (2007).[25] Fruit species are most often planted by human hands from seeds or wildlings collected near the farm. This addition of exotic species serves to replace the forest species eliminated during the creation of farms Koko et al., (2013).[13] The fruit trees are introduced into the cocoa plantations for food purposes and also intended to diversify income from the plantations. While the forest trees served as shade for the young cocoa plants.

It appears from this study that the level of education is low among the majority of respondents; strategies are needed to reverse the trend because in fact, sustainable management of natural resources requires a minimum level of education in order to accommodate or contribute to education relating to the sustainable management of these FAO, (2019).[9] In addition, the level of education has a very remarkable impact in the adoption of innovations and/or in the transfer of knowledge and technologies with a view to increasing productivity in all sectors of activity and in decision-making. Tingu et al., (2019).[30]

The majority of species recorded in cocoa plantations in the study area belong to the Guineo-Congolese (GC) phytogeographic zone with 51% of the species. The strong presence of species from the Guineo-Congolese zone in the floristic procession of an area is proof that it does indeed belong to the Guineo-Congolese region of White N'Dja., (2006).[19] This same result was obtained by Koffi (2016)[12] who states that the high proportions of species from the Guineo-Congolese region in an environment could be a sign of a fairly good reconstitution of the vegetation. The survey carried out among farmers showed that most of the associated tree species are multi-use, meaning that they are used for several purposes in the plantation. The uses most mentioned by respondents are : the provision of shade, the marketing of the fruits of its associated species as well as. Food use. These results are corroborated with those of Saj et al., (2017)[23] and Temgoua et al. (2018).[29] Plants for food use rank third among species used by populations in the study area.

Plants for food use rank third among species used by populations in the study area. The food plants listed during the surveys concern both species whose fruits or parts are consumed directly or are used in the preparation of various meals. Indeed, for these species, fruits, seeds, sap, nuts and leaves are used in food, as shown by Kouakou et al. (2017).[15] The abundance of food species is due to the fact that they constitute an additional source of income, particularly for women and children who can sell them in local markets Zanh et al., (2016).[33] Associations of trees with perennial crops, in particular cocoa trees, contribute to the protection of species with special status because a significant number of species belonging to the IUCN red list have been identified there. Indeed, 12 species inventoried in cocoa-based agrosystems in the Gôh region are vulnerable.

CONCLUSION

The inventories carried out during this study made it possible to identify 84 plant species divided into 69 genera and 32 families. These species are left on plantations by producers for several reasons. Producers have created agrosystems through the introduction or conservation of exotic or local woody species. The species associated with cocoa trees provide production services such as medicinal plants with a proportion of (4%), commercial (27%), food (21%), timber (3%), as well as ecological services such as shading (32%) and others (13%). Thus, they make it possible to ensure food and health security for the populations living near these localities and to increase the productivity of agrosystems. Thanks to these cultural practices (associations of trees and perennial crops), species useful to populations (health, food, income from sales) are available. Which contributes to the fight against climate change by absorbing greenhouse gases such as carbon dioxide (CO2). In view of these results, we recommend that farmers' support structures encourage them to associate more plant species with their agrosystems in order to

restore the land for sustainable and profitable production in the Center-West of Côte d'Ivoire.

ACKNOWLEDGEMENTS

This work was carried out as part of our Doctoral research work which took place in the Gôh region. We deeply thank the administrative authorities, traditional leaders and cocoa producers of the localities visited. Many thanks to all those who enabled the collection and analysis of the data used in this study.

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