

TYPOLOGY OF BANANA PLANTATIONS IN A CONTEXT OF CLIMATE CHANGE IN THE AGROECOLOGICAL ZONE OF HAUT-SASSANDRA (CENTRAL-WEST, CÔTE D'IVOIRE)

ABSTRACT

Climate change in tropical Africa is partly the cause of drought, manifested by water scarcity. The banana tree, a very important crop for food and the economy of Côte d'Ivoire, is sensitive to low levels of rainfall. The Haut-Sassandra region, experiencing climate change with its many consequences, continues to produce bananas even if the level has fallen in recent years. So, what are the cultural models put in place by producers in the face of the phenomenon of climate change? This work is carried out to understand the adaptation strategies of plantain farmers facing the consequences of climate change. The methodological approach consisted of listing banana plantations of more than one hectare in Haut-Sassandra and carrying out a survey on plantain cultivation practices observed in this agroecological zone. The survey carried out made it possible to list 34 banana plantations with areas of between 1.5 and 5 hectares. For the establishment of banana plantations, slash-and-burn crops are the most favored (100%). The most used crop type is the crop association (85%) (cocoa (65%), coffee (15%) and food crops (5%)). Only 15% of banana plantations were monoculture. The fight against the wind is achieved by hedges made up of plots of rubber and teak surrounding the banana plantations. Symptoms of biotic and abiotic diseases were observed in all the banana plantations investigated. To maintain sustainability and better banana production, Haut-Sassandra planters combine several agroecological practices.

Keywords : Climate change, banana plantations, cultural practices, adaptation



1. INTRODUCTION

In Côte d'Ivoire, the plantain is a very important crop for food and the economy. It essentially contributes to food security, job creation, and income diversification in rural and urban areas [1]. The plantain sector also contributes between 5 and 8 % of the country's agricultural GDP and provides around 22,000 jobs [2; 3]. In Côte d'Ivoire, banana trees are generally grown in forest areas. These are humid climate plants, appreciating high humidity

and good sunshine, but fearing winds and sudden temperature variations [4]. Temperature and radiation are the essential factors influencing plant growth. They are involved in metabolism through the mechanism of transpiration and photosynthesis. The banana tree tolerates strong insolation if the water supply is sufficient [5]. However, the production conditions for this crop of interest are made increasingly difficult by climate change [6]. In tropical Africa and specifically in Côte d'Ivoire, this phenomenon is at the origin of unusual droughts materialized by a scarcity of rain. This water scarcity is caused by a change in the precipitation regime and a reduction in annual rainfall amounts [7; 8]. From an annual height of 1455.45 mm in 1983, the rainfall in the Haut-Sassandra region increased to 1063.46 mm of water in 2017 (data provided by SODEXAM: airport operating and development company, aeronautics and meteorology in Côte d'Ivoire). These rainfall anomalies have a negative impact on plantain production which is sensitive to low water levels [9]. The Haut-Sassandra region, once a major producer, continues to supply bananas even if the level of production has declined over the years. This work is carried out with the objective of describing the cultural models making it possible to support plantain production and to understand the adaptation strategies of plantain farmers in the agroecological zone of Haut-Sassandra facing the effects of climate change.

2. MATERIAL AND METHODS

2.1. Exploratory mission of the study area

Data collection took place in four departments of the Haut-Sassandra region. It began with an exploratory mission which was carried out from May to July 2022. This mission was marked by a census of banana plantations of more than one hectare in the Haut-Sassandra region. For its implementation, contacts were established with producers with banana plantations of more than one hectare.

Côte d'Ivoire

2.2. Conducting the survey

A survey was carried out during the month of July 2022 in all the identified banana plantations. Its objective was to identify the plantain cultivation practices observed in the agroecological zone of Haut-Sassandra. For its realization, interviews and direct observations in banana plantations were carried out. Each banana plantation manager was submitted to a questionnaire relating generally to the identification of farms, the different varieties of banana trees cultivated and the cultivation system. Direct observations focused on the morphological aspect of banana trees. This morphological aspect concerns the state of the different plants and banana leaves, the state of grass cover of banana plantations and the agroecological practices observed by producers in the plantations.

2.3. Data analysis

The data collected during the survey was entered using the Excel 2013 spreadsheet and analyzed by the sphinx lexica software.

3. RESULTS

3.1. Distribution of banana plantations of more than one hectare in the Haut-Sassandra region

The census of banana plantations carried out in the Haut-Sassandra region allowed to identify 34 plantations of more than one hectare including thirteen (13) in the department of Daloa, four (4) in the department of Vavoua, ten (10) in the department of Zoukougbeu and seven (7) in the department of Issia. The majority of these banana plantations have been listed in the departments of Daloa, Zoukougbeu and Issia. However, in the department of Vavoua very few banana plantations meet this selection criterion (Table 1).

Table 1 : Lists of banana plantations in Haut-Sassandra

Departments	Daloa	Vavoua	Zoukougbeu	Issia
Number of banana plantations	13	4	10	7

3.2. Cultural aspects of the plantain in Haut-Sassandra

3.2.1. Sociological profiles of plantain producers in Haut-Sassandra

Plantain cultivation in Haut-Sassandra is mainly practiced by Ivorians. Most of the planters are men over 18 years old. Only 35 % of plantain producers have never been to school. More than 55 % of farmers have 2 to 4 plantations and use the same maintenance equipment for all of their banana plantations. All farmers (100 %) practice plantain cultivation both for family food and for profit (Table 2).

Table 2 : Profile of banana plantation managers

Producer profile		Number of banana plantations	Frequency (%)
Nationality	Ivorian	30	88,20
	others	4	11,80
Sex	man	30	88,20
	Woman	4	11,80
Age (years)	under 18	0	0,00
	from 18 to 45	24	70,60
	over 45	10	29,40
Level of study	None	12	35,30
	Primary	10	29,40
	Secondary upper	11	32,40
		1	2,90
Type of activity	primary	27	79,4
	secondary	7	20,6
Number of banana plantations per planter	less than 2	15	44,1
	from 2 to 4	19	55,9
Purpose of production	for profit and family	34	100

3.2.2. Cultural practices observed in banana plantations

Plantain cultivation in Haut-Sassandra is dominated by the cultural association (85%). Banana is grown in association with cocoa in 65 % of cases, coffee in 15 % and food crops in 5 % (Figure 1). For the establishment of plantations, slash-and-burn crops are favored by all farmers. The origin and quality of the seed (rejects) are not controlled. In fact, around 94 % of rejects are acquired from a neighbor and 6 % purchased on the market. These rejects (97.1 %) come from an old plantation. According to producers, 32.4 % of banana plantations showed good production over the last two years, including 20.6 % with satisfactory production and 11.8 % with very satisfactory production. The majority of banana plantations, 88.2 %, had a duration varying from 2 to 5 years and only 11.8 % had been in existence for more than 5 years.

The survey carried out revealed also that 94.1% of farmers in the region maintain their plantation by weeding and by spraying of fields from 2 to 4 times a year. The majority of banana plantation managers i.e. 91.2 % use herbicides to combat weeds and only 8.8 % use the manual method (daba, machete). As for the fight against diseases and pests, 85.3 % of farmers practice the natural method (traditional) and 14.7 % use chemical products. The survey also indicated that only 14.7 % of farmers fertilize their fields. This fertilization is done through organic fertilizers (mixture of bovine dung with wood chips, chicken droppings and compost from banana peel). The reliefs are flat in 58.8 % of banana plantations and moderately sloping in 41.2 % (Table 3).

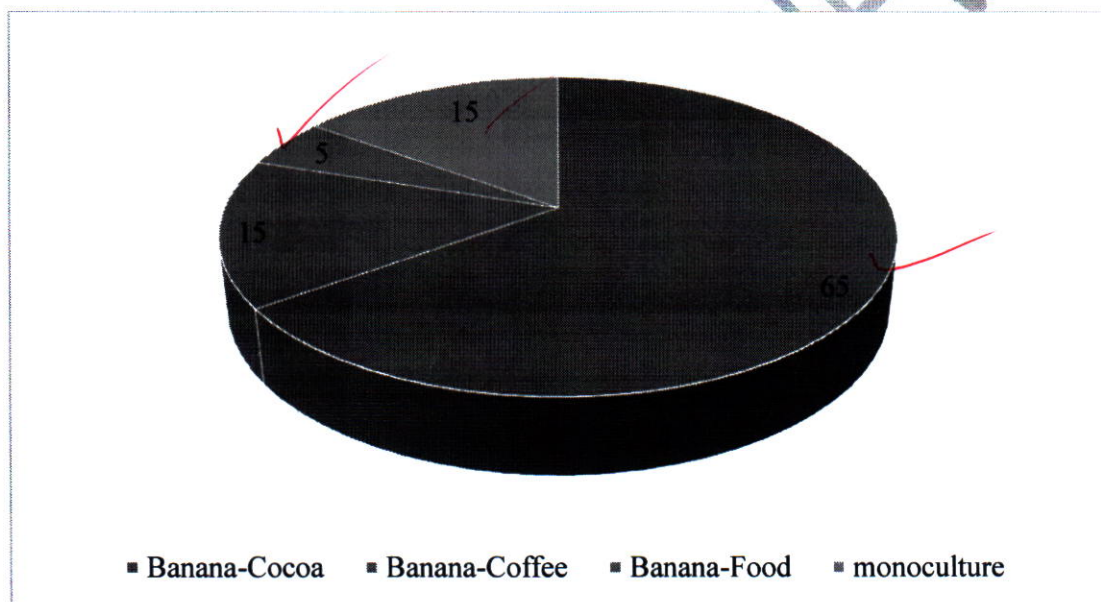


Figure 1: Percentage of plantain farming systems in Haut-Sassandra

Table 3: Some characteristics of the banana plantations investigated

Settings	Number of banana plantations	Frequency (%)
Slash-and-burn cultivation	34	100
Acquisition of rejects	with a neighbor	94,1
	on the market	5,9
Type of releases	selected plants	2,9
	from old plantation	97,1
Estimated production	weak	35,3
	unsatisfactory	32,3
	satisfying	20,6
	high	11,8
Age of plantation (years)	from 2 to 5	88,2
	more than 5	11,8
Maintenance of the banana plantation	less than 2 years	5,9
	from 2 to 4 years	94,1
	Use of the same equipment for all plantations	100
Weed control methods	herbicides	91,2
	daba, machete (manual)	8,8
Methods for combating diseases and pests	chemical synthesis products	14,7
	biological control	85,3
Use of fertilizers	5	14,7
Type of fertilizers used	Chemical fertilizer	0,0
	organic fertilizer	14,7
	none	85,3
Relief of the plantation	flat	58,8
	moderately sloping	41,2

3.2.3. Impact of the cropping system on plantain production

Around 72 % of banana plantations in association showed good production over the last two years. The plants of these farms were robust with the mostly green foliage. As for monoculture banana plantations, 80 % presented poor production. These plantations were characterized by puny plants with predominantly yellow leaf surfaces.

Table 4: Comparison between monoculture and crop association of plantain in Haut-Sassandra

Settings		Number of banana plantations	Frequency (%)
Banana plantation yield	association	21 banana plantations (72.4 %) with satisfactory production.	
	monoculture	1 banana plantations (20 %) with satisfactory production.	
Morphological aspects of banana trees	association	21 banana plantations (72.4 %) presenting robust plants with predominantly green leaves.	
	monoculture	4 banana plantations (80%) presenting stunted plants with predominantly yellow leaf surfaces.	

3.2.4. Constraints linked to plantain cultivation in Haut-Sassandra

Banana cultivation in the study area is subject to various constraints, namely the effects of biotic and abiotic diseases. Indeed, according to banana plantation managers, all the plantations investigated often showed symptoms of disease. These diseases caused fruit rot in 29.4 % of banana plantations, leaf drying, root rot and pseudostem fall in 70.6 %. Farmers attributed the cause of these diseases to drought, poor soil condition and animal attacks.

Table 5: Some constraints linked to banana cultivation in the Haut-Sassandra Region

Settings		Number of banana plantations	Frequency (%)
Attack of the plantation by diseases		34	100,0
Damage caused by these diseases	fruit rots	10	29,4
	leaf drying, root rot and pseudostem shedding	24	70,6
Disease symptoms	biotic	16	47,1

abiotic (drought, soil poverty)	18	52,9
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3.3. Agroecological practices observed in banana plantations

Only 5.9 % of producers use hedges to combat violent winds. Live hedges are made up of either rubber plants (*Hevea brasiliensis*) or teak (*Tectona grandis*) (table 6 and figure 2). Some ecological practices were observed in certain plantations, notably with the addition of manure in 2.9 % of banana plantations and the use of cover plants in 5.9 % of plantations. Cover crops consist mainly of legumes such as soybean (*Glycine max*) and cowpea (*Vigna unguiculata*) (Table 6 and Figure 2).

Table 6: Some agroforestry and ecological practices observed in banana plantations

Settings	Number of banana plantations	Frequency (%)
Use of live hedges to combat the wind	2	5,9
Manure input	1	2,9
Use of cover plants	2	5,9



Rubber hedge



Cover plants in a banana plantation

Figure 2: Photograph of some agroforestry and ecological practices observed in banana plantations

4. DISCUSSION

This study was carried out to understand the adaptation strategies of plantain farmers in the Haut-Sassandra agroecological zone to the effects of climate change. In the Haut-Sassandra region, there are large plantations of more than one hectare distributed according to the

departments while the average surface area of plantain plantations in Côte d'Ivoire is one hectare [10]. The Haut-Sassandra region is therefore one of the areas of high plantain production as indicated by Audrey [11] on the study of the plantain sector in Côte d'Ivoire. However, few plantations in the Vavoua department have more than one hectare. Indeed, the populations of this department are more interested in cashew cultivation; thus, making plantain cultivation a secondary crop [12]. This department located 54 km north of Haut-Sassandra is currently better suited to crops in the savannah zone which are more resistant to drought. The same observation was made by François *et al.* [13] on the cashew boom in Côte d'Ivoire.

In the Haut-Sassandra region, plantain cultivation is dominated by Ivorians. This could be linked to the fact that the majority of cultivated land is family property and bananas are part of the eating habits of these populations. Similar observations were highlighted by Traoré *et al.* [10] on the plantain cultivation system in a peasant environment in the departments of Aboisso, Agboville, Bouaflé, Gagnoa and San-Pedro (Côte d'Ivoire). Most of the planters have an average level of education and are male. Indeed, women are more interested in market gardening and commerce in Haut-Sassandra [14]. The majority of planters are young because the establishment and maintenance of banana plantations requires weeding and digging, requiring a fair amount of physical strength. This work is therefore very difficult for women and the elderly [15; 16]. Planters generally have 2 to 4 plantations and the harvests are intended for food and marketing [17; 18].

The establishment of plantations is done by slash-and-burn crops. According to the planters, this practice requires little work, the ash fertilizes the earth and the fire destroys pathogenic organisms and harmful insects. This observation had already been described by Lassailly-Jacob [19] on the logic of itinerant and cyclical agriculture in Africa. However, according to Ducourteux [20], slash-and-burn cultivation leads to deforestation, a decline in soil fertility, an increase in erosion and a drying out of the climate. The varieties cultivated are traditional varieties generally from an old plantation. The method of acquiring suckers clearly shows that farmers are faced with the problem of planting material. In fact, more than 90% of releases are acquired from a neighbor. These results do not corroborate those of Traoré *et al.* [10] which indicate that 80 % of rejects are acquired on the market in the departments of Agboville and Aboisso. However, using suckers of different varieties could be a way to mitigate the effects of drought because all these varieties do not have the same sensitivity to lack of water. Some could be more resistant and provide satisfactory production even with low water levels. Almost all plantations are maintained 2 to 4 times a year. This could be the origin of the good production

→ of references denoted by number such as [18], [19] etc. Then both [19] and author's name together is necessary?

observed in 32.4% of banana plantations over the last two years. The majority of banana plantations (88.2%) were young (2 to 5 years old). This could partly explain the good production in certain plantations. However, in these banana plantations, the same maintenance equipment is used for all the plantations available to the same planter. This could lead to the transmission of phytopathogenic diseases from one plantation to another. ✓

Banana plantation managers frequently use both chemicals and the manual method to control weeds [17]. Disease control is generally done using the empirical method, i.e. destroying the banana tree showing a wide range of disease symptoms, using the ash to control root-eating ants and laying beef dung on the fruits to prevent their destruction by pests. ✓ Generally, chemical synthesis products are rarely used against plantain diseases in Africa [21]. Producers justify it by lack of resources [22]. However, these empirical control methods are similar to biological methods. They are efficient and would be at the origin of the sustainability of production. Also, approximately 15 % of producers use organic fertilizer (mixture of bovine dung with wood chips, chicken droppings and banana peel compost) for fertilization as indicated by Hedegla [23] on the sustainability of the plantain sector in Benin. ✓

Examination of the characteristics of the banana plantations investigated indicates that the plantations are mainly installed on flat land, which limits erosion phenomena. Plantain cultivation in Haut-Sassandra is marked mainly by the cultural association. The same observations were made by Mengué *et al.* [12] on the participatory selection of plantains in Cameroon. These authors stipulate that the banana tree is generally grown in association with food crops, cash crops or fruit crops in the forest zone. Around 72% of banana association plantations showed good production over the last two years. The plants from these farms were robust with mostly green foliage. As for monoculture banana plantations, 80% showed poor production. These plantations were characterized by stunted plants with predominantly yellow leaf surfaces. The positive effects observed in most banana plantations in association would be linked to the fact that the plants associated with banana trees play a valuable shading role for banana trees by mitigating the effects of sunlight and excessive heat. These observations are consistent with those of Souza *et al.* [24] who indicate that in a crop association system some plants behave like shade trees for others. Indeed, according to these authors, shade trees regulate the microclimate, thus helping to reduce soil evapotranspiration, limit wind erosion and prevent extreme temperatures. This creates a more favorable environment for plants by allowing healthier growth and reducing water stress. The mitigation of thermal stress allows the plant to maintain its transpiration at an optimal level [25]. Some planters use cover crops to limit soil erosion and fight weeds. Indeed, these cover plants also play a valuable shading role in

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plantations and allow the increase in soil fertility by providing organic matter, fixing nitrogen, increasing biodiversity and reducing the risk of nitrogen leaching [26].

To combat violent winds, 5.9 % of planters use living hedges. Live hedges are made up of either rubber or teak plants. Similar observations were made by Kouamé *et al.* [27] on peasant strategies and practices for sustainable management of soil fertility in the Korhogo department in the north of Côte d'Ivoire. Indeed, according to these authors, farmers in the Korhogo department use live hedges based on dead hedges, mixed hedges, *Anacardium occidentale* hedges or *Gmelina arborea* hedges to combat violent winds and leaching phenomena.

The banana cultivation in the study area is subject to various constraints namely the pressures of biotic and abiotic diseases. Similar results were obtained by Kouakou *et al.* [28] on the innovation platforms of the plantain sector in Côte d'Ivoire. Indeed, all plantations investigated often presented symptoms of illness. These symptoms were manifested by fruit rot, leaf yellowing with the presence of black spots, leaf drying, root rot and fall of the pseudostem. About 53% of planters attributed the effects of these diseases to drought and poor soil condition. However, this could also be linked to the effects of phytopathogens [29]. Indeed, the yellow coloring of the leaves and the stunted banana trees observed in certain banana plantations could be linked to the presence of certain fungal and bacteria pathogens in these farms [29]. The black leaf spots observed in several plantations investigated would be due to the presence of micromycetes of the genus *Mycosphaerella* responsible for foliar diseases [30].

5. CONCLUSION

The present study made it possible to identify the cultural models of plantain implemented by the producers of Haut-Sassandra in the face of the phenomenon of climatic change. The results indicate that to mitigate the effects of climate change on plantain production, planters generally practice crop association. This practice makes it possible to reduce soil evapotranspiration, to limit wind erosion and to prevent extreme temperatures. The majority of planters use suckers of different varieties and frequently regenerate banana plantations to limit the effects of drought on production. Disease control and fertilization are mainly through biological control methods. Cover plants are also used in certain plantations for fertilization, to limit soil erosion and to reduce evapotranspiration. In addition, banana plantations are installed generally on flat land to limit soil leaching. Live hedges are used by a minority of farmers to fight against violent winds. All these practices observed constitute agroecological practices promoting sustainability and good production of banana plantations.

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