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

ABSTRACT

The Haut-Sassandra region (Côte d'Ivoire), experiencing climate change with its many consequences, continues to produce bananas even if the level has fallen in recent years. This work was 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, 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]. InCôte 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(Côte d'Ivoire). 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.

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(Côte d'Ivoire). 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.Distributionof banana plantationsof more than one hectare in the Haut-Sassandra region

Thecensus of banana plantations carried out in the Haut-Sassandra region allowed to identify 34 plantations of more than one hectareincludingthirteen (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, ZoukougbeuandIssia.However, in the department of Vavoua very few banana plantations metthis 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 inHaut-Sassandra

Plantain cultivation in Haut-Sassandra was mainly practiced by Ivorians. Most of the planters weremenover18 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%) practiced 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	11	32,40
	spper	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 was dominated by the cultural association (85%). Banana was 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 were favored by all farmers. The origin and quality of the seed (rejects) were not controlled. In fact, around 94% of rejects were acquired from a neighbor and 6% purchased on the market. These rejects (97.1%) came 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 farmersin the region maintain their plantationbyweeding andby spraying of fieldsfrom2 to 4 times a year.The majority of banana plantation managersi.e. 91.2%usedherbicides to combat weeds and only 8.8%used the manual method (daba, machete). As for the fight against diseases and pests, 85.3% of farmers practiced the natural method (traditional) and 14.7% used chemical products. The survey also indicated that only 14.7% of farmers fertilizedtheir fields. This fertilization was donethrough organic fertilizers (mixtureof bovine dung withwood chips, chicken droppings and compost from banana peel).The reliefswere flat in 58.8% of banana plantations andmoderately slopingin 41.2%(Table 3).

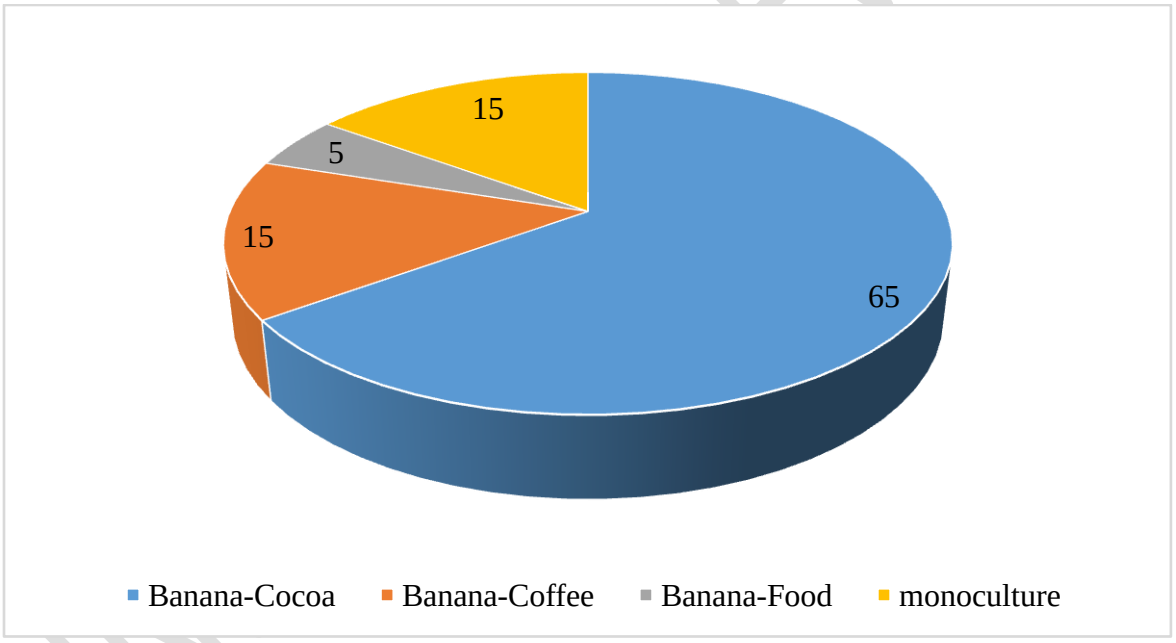

Figure 1: Percentage of plantain farming systems in Haut-Sassandra

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	32	94,1
	on the market	2	5,9
Type of releases	selected plants	1	2,9
	from old plantation	33	97,1
Estimated production	weak	12	35,3
	unsatisfactory	11	32,3
	satisfying	7	20,6
	high	4	11,8
Age of plantation (years)	from 2 to 5	30	88,2
	more than 5	4	11,8
Maintenance of the banana plantation	less than 2 years	2	5,9
	from 2 to 4 years	32	94,1
	Use of the same equipment for all plantations	34	100
Weed control methods	herbicides	31	91,2
	daba, machete (manual)	3	8,8
Methods for combating diseases and pests	chemical synthesis products	5	14,7
	biological control	29	85,3
Use of fertilizers		5	14,7
Type of fertilizers used	Chemical fertilizer	0	0,0
	organic fertilizer	5	14,7

	none	29	85,3
Relief of the plantation	flat	20	58,8
	moderately sloping	14	41,2

3.2.3. Impact of the cropping system on plantain production

Around 72% of banana plantationsin associationshowed good production over the last two years.The plantsof these farms wererobust withthemostly green foliage.As for monoculture banana plantations,80%presented poor production.These plantations were characterized bypuny 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. Constraintslinked toplantain cultivation in Haut-Sassandra

Banana cultivation in the study area was 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

3.3. Agroecological practices observed in banana plantations

Only 5.9% of producers used hedges to combat violent winds. Live hedges were made up of either rubber plants (*Hevea brsiliensis*) 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 consisted mainly of legumes such as soybean (*Glycina 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 were 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[11] on the study of the plantain sector in Côte d'Ivoire. However, few plantations in the Vavoua department had more than one hectare. Indeed, the populations of this department were 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[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[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 had an average level of education and were male. Indeed, women are more interested in market gardening and commerceinHaut-Sassandra [14]. The majority of planters were 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 had 2 to 4 plantations and the harvests were intended for food and marketing [17; 18].

The establishment of plantations was 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[19]on farmers' perceptions of agroforestry on the mountain slopes in Man (Côte d'Ivoire).However, according to[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 were traditional varieties generally from an old plantation. The method of acquiring suckers clearly showed that farmers were faced with the problem of planting material. In fact,

more than 90% of releases were acquired from a neighbor. These results do not corroborate those of [10] which indicated that 80% of rejects wereacquired 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 were maintained 2 to 4 times a year. This could be the origin of the good production 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 was 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 used both chemicals and the manual method to control weeds [17]. Disease control was 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 used organic fertilizer (mixture of bovine dung with wood chips, chicken droppings and banana peel compost) for fertilization as indicated by[23] on the sustainability of the plantain sector in Benin.

Examination of the characteristics of the banana plantations investigated indicated that the plantations were mainly installed on flat land, which limits erosion phenomena. Plantain cultivation in Haut-Sassandrawas marked mainly by the cultural association. The same observations were made by[1] onthe annual replanting of plantain crops in Côte d'Ivoire. These authors stipulated 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 played a valuable shading

role for banana trees by mitigating the effects of sunlight and excessive heat. These observations are consistent with those of [24] who indicated 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 used cover crops to limit soil erosion and fight weeds. Indeed, these cover plants also play a valuable shading role in 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 used living hedges. Live hedges were made up of either rubber or teak plants. Similar observations were made by[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 used live hedges based on dead hedges, mixed hedges, *Anacardium occidentale* hedges or *Gmelina arborea* hedges to combat violent winds and leaching phenomena.

Thebanana cultivation in the study area was subject tovariousconstraintsnamely the pressures of biotic and abiotic diseases. Similar results were obtained by[28]on the innovation platforms of the plantain sector in Côte d'Ivoire.Indeed, all plantations investigated oftenpresented symptoms of illness. Thesesymptoms were manifested by fruit rot, leaf yellowing with the presence of black spots, leaf drying, root rot and fall of thepseudostem.About 53% of plantersattributed the effects of these diseases to drought and poor soil condition. However, this could also be linked to theeffectsof phytopathogens [29]. Indeed, the yellow coloring of the leavesand thestuntedbanana treesobserved in certain banana plantations could be linked to the presence of certain fungal and bacteriapathogens in these farms [29]. The black leaf spotsobserved in severalplantations investigated would be due to thepresence of micromycetes of the genus*Mycosphaerella*responsible for foliar diseases [30].

5. CONCLUSION

Thepresent study made it possible to identify the cultural modelsof plantainimplemented by the producers of Haut-Sassandra in the face of the phenomenon ofclimatic change.The results indicate that to mitigate the effects of climate change on plantain production, planters generallypracticecropassociation.This practicemadeit possible toreduce soilevapotranspiration, to limit wind erosion andtoprevent extreme temperatures. The majority

ofplantersuse suckers of different varietiesand frequently regenerate banana plantations to limit the effects of drought on production. Disease control and fertilization aremainly throughbiological control methods. Cover plantsare also usedincertain plantations for fertilization, to limit soil erosion and toreduceevapotranspiration. In addition, banana plantations areinstalled generallyon flat landto limit soil leaching. Live hedgeswereusedby aminorityof farmers to fight against violent winds. All these practicesobservedconstituteagroecological practices promoting sustainability and good productionof banana plantations.

6. REFERENCES

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