

Characterization and Typology of Banana Producing farms in the District of Houeyogbe in Southern Benin

ABSTRACT

Background

Banana constitutes an important crop in the tropics and participates in food security in many countries of Africa. It is widely consumed fruit in Benin. Unfortunately, the trend in yields of this crop showed a year to year decrease since 2008 to 2019, leading the production to continue falling short of demand. However, there is a paucity of information on farming systems in Benin, an important step to tackle this issue. This study aims at characterizing the types of bananas farming production systems.

Methods: We conducted structured interviews with sixty-two (62) farmers in four villages of Houéyogbé District in southern Benin between November 2015 and February 2016. Farmers were selected randomly in each village from lists based on the recommendation of local authorities and extension services officers.

Results

The results reveal three classes of banana farms which operate differently and thus have different features. Group 1 is made up of small-scale farms with low-income farmers. These farmers, who did not hire labour, did not follow the agronomic production practices, and did not maintain their farms well. Such farms can be classed as “backyard crop garden”. Group 2 includes farms with average size and income in whose which farmers maintain their fields, conduct inter-cropping, did not use bought planting material but sold it. Exclusively headed by men, Group 3 includes large-size banana farms whose owners had with high income, who use fertilizer, and maintain their farms well. Areas planted, seed purchase, leaf removal and system of production significantly influence income at the 1%, 1%, 5% and 10% thresholds respectively. [unclear sentence]

Conclusion

Several constraints to banana production have been identified through this study. They, among which include pests and diseases, lack of clean-certified planting material, type of land, amount of fertilizer and maintenance inputs, and marketing. In addition, production is limited by there is a lack of knowledge on agronomic practices. Training on macro-propagation, agronomic practices, pests and diseases recognition with control strategy could help overcome these constraints and improve banana production in this district.

Keywords: Bananas and plantains, productivity, banana farming system, banana production constraints, banana farm typology

1. INTRODUCTION

Bananas is a widely consumed food in the world. It is consumed in various ways (boiled, fry, roasted) or processed as chips, flour, juice... (Dato et al., 2021). It is a staple food in some regions of Africa and can be produced all year round, providing food for households during the lean season (Sodédji et al., 2016). World production of bananas was estimated between 116,781,658 tons and 41,580,022 tons in 2019 respectively (FAOSTAT, 2021). [? something missing from the last sentence] Africa's production of bananas and plantains was estimated in 2019 at 21,481,876 tons and 26,705,333

tons representing 18.39% and 65.90% of the world production (FAOSTAT, 2021). In Central and West Africa, the production and [sale/marketing](#) of bananas and plantains plays an important role in achieving food and nutritional security while generating employment and contributing to poverty reduction (Kwa and Temple, 2019). In some sub-Saharan African countries, bananas feed more people per unit area than any other staple crop. Its production implies low production costs and is not subjected to shocks from changes in world prices, unlike crops such as rice, maize and wheat (Atkinson et al., 2015). In Benin, the production is estimated at 22284 tons for 4698 hectares of bananas (FAOSTAT, 2021). Unfortunately, since 2008, the statistics reveal a decline in yields of this crop. Banana yields decreased from 53,704 t/ha in 2008 to 47.433 t/ha in 2019 (FAOSTAT, 2021). Many factors such as edaphic, agronomic and organizational can explain this decrease (Sodédji et al., 2016). According to Ferraton and Touzard (2015), it is important to set up a mechanism to identify farmers' problems and find solutions for appropriate interventions based on prior knowledge on the farming system and their realities by considering the diversity of farms. This study was carried out in order to understand the constraints that farmers face in banana production in Houéyogbé Township and to find effective solutions to tackle them. It aimed at characterizing banana production systems in Houéyogbé in southern Benin and to identify the group of farms in order to make interventions to improve productivity of banana in this area.

2. MATERIAL AND METHODS

2.1 Study area

This study was carried out in 2018 in the District of Houéyogbé located in the department of Mono in southern Benin. Houéyogbé lies between 6°20' and 6°40' north latitude and 1°45' and 1°57' east longitude, and covers an area of 320 km², extending 16.25 km from north to south and 13.75 km from east to west (Nangbé and Guidigbi, 2006). The climate in Houéyogbé is sub-equatorial. Houéyogbé benefits from two rainy seasons and two alternating dry seasons. The average maximum and minimum temperatures are 33.03°C and 20.74°C respectively with an average rainfall of 936 mm. Houéyogbé has a ferrallitic soils, hydromorphic soils and a valley zone. These characteristics favour the development of agricultural production. Houéyogbé is characterized by 9689 agricultural households with a population of 50215 individuals (INSAE, 2016). Major agricultural products in Houéyogbé include cereals, palms, bananas and plantains. The choice of this municipality is linked to its high production of bananas and plantains (Lokossou & Achigan, 2000).

2.2 Data collection

A total of 62 producers / farmers were randomly selected from four different villages namely: Doutou (11.29%), Houéyogbé (12.90%), Sê (35.48%) and Zoungbonou (40.32%). These villages were chosen based on the recommendation of local authorities according to their high production of bananas. Information on the socio-economic characteristics of producers, the farming systems and the constraints they faced ~~was~~ were collected using a structured questionnaire

2.3 Statistical processing and analysis

Data were analysed using descriptive statistics, to describe the socio-economic situation of the surveyed producers, the characteristics of their farms, and their cropping and production systems. A multiple correspondence analysis followed by the hierarchical ascending clustering coupled with "k-means" was carried out to refine this description by a typology of farms. Finally, multiple linear regression was used to identify factors influencing income distribution in production. Table 1 presents the variables included in the model. Different charts and tables were presented. All the analyses were performed using R v. 3.6.1 statistical software.

Table 1: Variables used in the linear model

Variables	Description of the variables
Gender	Dummy variable=1 si male, 0=female
Age	Age of farmer (Years)
Experience	Experience in banana production (years)
Surface area	Area used for production (m ²)
Purchase of seed	Dummy variable =1 if purchase, 0=otherwise
Thinning out the leaves	Dummy variable =1 if yes, 0= otherwise

Seed sale	Dummy variable =1 if yes, 0= otherwise
Farming system	Dummy variable =1 if yes, 0= otherwise
Income	Dependent variable (US\$)

3. RESULTS AND DISCUSSION

3.1. Socio-demographic characteristics of farmers

The banana and plantain farmers lived predominantly in monogamous households (56.45%), which are majoritively headed by men (77.42%). [In contrast to many parts of Africa, where women farmers are the majority, o](#)Only 22.58% of the producers surveyed are women, 6.45% of whom are widows (Table 2). The average age of the producers surveyed was 43.73 years (42 years old for men and 49 years old for women). Less than half (40.32%) of the producers were under 40 years old. The average number of individuals living in producers' households was seven. Fifty-five percent of producers had at least a primary education level. The most educated child in the household is a boy (61.00%) and has reached at least secondary school (61.29%), while less than 40% of girls in the household attend school. Most of the farmers surveyed were natives (74.19%) of their respective villages and had practically never left the community (69.00%). Considering the experience of producers in banana production, the average was 12.60 years (Table 2). The results also reveal that a significant part of producers (64.52%) is well experienced (more than 5 years of experience) in banana production.

[\[Why is there no number or percentage of "monogamous"?\]](#)

Table 2 : Socio-demographic characteristics of producers

Variables	Number	Percentage (%)	Means	Standard-deviation
Gender				
Male	48	77.42		
Female	14	22.58		
Marital status				
Married monogamous		56.45		
Married polygamist		29.03		
Single		6.45		
Widower		6.45		
Divorced		1.61		
Level of education				
Uneducated	22	35.48		
Literacy in local languages	6	9.68		
Primary school	15	24.19		
Secondary school	11	17.74		
Superior	8	12.91		
Age			43.73	14.13
[17-37[	17	54.84		
[37-57[	34	27.42		
[57-77[	11	17.74		
Experience			12.60	10.88
[0-6[	22	35.48		
[6-11[	16	25.81		
[11-16[	6	17.74		
[16-26[	11	11.29		
[26-46[	7	9.68		

3.2 Characteristics of the farms and constraints on production in Houéyogbé

3.2.1. Place of banana production in households

Bananas production ranks third among ~~other~~ cultivated food crops (Table 3). ~~It and~~ is considered ~~as~~ the most important crop and being ranked first by 24.19% of producers. The main reason why producers adopted this crop in Houéyogbé is because it is a cash crop. The majority of households ~~both~~ consume bananas and commercialise bananas their production ~~for foods and for their~~ financial needs. The second reason listed by farmers (35.48) was crop productivity, while the market availability came at the third position (29.03%). Family decision-making regarding banana farming in the households of the producers surveyed is led by the male for the majority of respondents (61.29%). Annual income from production varies from US\$ 17.94 (10,000 XOF) to US\$ 5383.00 (3,000,000 XOF) (Table 3) and less than a quarter of the producers (22.58%) had an income between US\$ 17.94 and US\$ 71.77. Only eight producers (12.90%) earned more than US\$ 897.17 (500,000 XOF). The average income earned by bananas producers in Houéyogbé was US\$ 534.39 (297,822.6 XOF) (Table 3).

Table 3 : Characteristics of the farms

Variables	Number	Percentage (%)	Means	Standard-deviation
Area planted (m²)			9046.61	18005.34
[0 -1000 [	30	48.39		
[1000 - 5000 [	12	19.35		
[5000 - 10000 [	9	14.52		
[10000 - 50000 [	7	11.29		
[50000 - 100000[	4	6.45		
Rank of bananas in agricultural production			2.94	1.49
1	15	24.19		
2	8	12.90		
3	17	27.42		
4	14	22.58		
5	5	8.06		
6	2	3.23		
7	1	1.61		
Cultivation system				
Banana-manioc association	7	11.29		
Banana and sugar cane association	18	29.03		
Banana-corn and pepper association	22	35.48		
Non-associated culture	15	24.20		
Labour force				
Family	11	17.74		
Employee	51	82.26		
Temporary	40	64.51		
Permanent	11	17.74		
Sources of seeds <u>[But bananas are not planted from seeds.]</u>				
Self-production of seeds	40	64.52		
Free supply of planting materials from neighbours	25	40.32		
Paying of planting materials from the neighbours	22	35.48		
Supply of planting materials on the village market	6	9.67		
Purchase of planting materials outside the village	8	12.90		
Incomes (US\$)			534.39	956.82
[17.94 - 71.77 [	14	22.58		
[71.77 - 179.43 [	19	30.65		
[179.43 - 897.17[	21	33.87		
[897.17 - 1794.33[	4	6.45		
[1794.33 - 5383.00[	4	6.45		

3.2.2. Land management

The banana production area [in question](#) was at least 100 m² (0.01 ha) and at most 80,000 m² (8 ha). Only 17.75% of the producers had an area of 10000 m² (1 ha) of banana plantation, and [these](#) were only men (Table 3). The maximum area held by women was 0.8 ha and mostly obtained via rental, purchase or inheritance. Purchasing is the second most common method of land acquisition (30.65%), and one farmer can hold up to four plots. [\[What?\]](#) Only 21.00% of them hold more than one plot, most of which are at various spots.

3.2.3. Banana growing system

Result revealed that most of the bananas producers adopt the system of inter-cropping on their farms (75.80%) (Table 3). This represents 79.16% of the men and 64.28% of women. Crops inter-cropped were maize and chilli (35.48%), sugar cane (29.03%) and cassava (11.29%). In that system, women gave priority to maize and chilli pepper, while men gave priority to maize, chilli pepper and sugar cane. This trend can be explained by the fact that maize and chilli are staple foods for the population in Benin, whereas sugar cane is a cash crop grown mainly for commercialization. The majority of producers (45.16%) grew plantain. The main reason for 77.42% of plantain production in this area was [the#](#) demand [for it](#). [Thus, t](#)The availability of the local and neighbouring markets is the main determinant in the choice of plantain production in this area. It is worth [to mentioning](#) some [of the](#) characteristics [that](#) influence the choice of varieties to be produced. These characteristics are taste (46.77%), high yield (22.58%), processing quality (20.97%), and short cycle (12.90%) (Fig. 1).

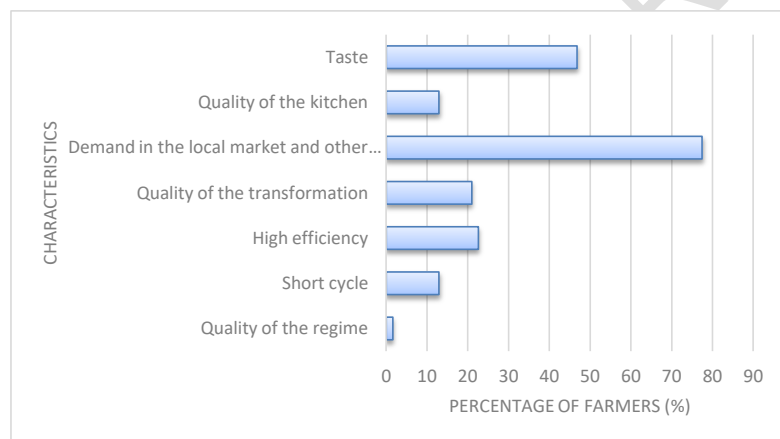


Figure 1: Characteristics sought on bananas

3.2.4. Labour for production

All farming activities are carried out by 17.74% of producers using family labour (Table 3). Men constitute the most used agricultural labor force for all types of activities. Women were most involved in activities such as fetching plant materials [for planting](#), harvesting, transporting for marketing and [stripping](#) off the [leaves](#). [\[Unclear.\]](#) In general, young boys were more involved in mulching, transporting suckers and fruits/bunch. As for girls, they were more involved in transporting food for consumption. [Hiring](#) labour was mainly used by 82.26% of producers for: soil preparation, planting, weeding, mulching and pesticide application when applicable. Producers often use casual [for](#) labourers (64.51%). [\[What do you mean by that?\]](#)

3.2.5. Sources of planting material and technical support

Planting material used for production comes from a various sources. ~~A~~The same producer may have multiple sources (Table 3). Most producers (64.51%) used planting materials from their own fields, some from their neighbours free of charge (40.32%) or with a lump sum (35.48%). Meanwhile, others collected material from local markets (9.67%) and/ or outside the village (12.90%). As far as technical assistance ~~is~~ concern, 92.00% of producers said they received no technical support on banana agronomic practices. Fortunately, some farmers revealed that there was knowledge exchange. ~~However, there are exchanges of knowledge~~ between themselves ~~and project~~ on diseases, symptoms and control measures.

3.2.6. Analysis of constraints

According to some farmers (33.87%), the most important constraints are banana diseases and pests and the unavailability of clean seeds (17.74%) (Table 4). ~~[Bananas are not planted from seed though.]~~ In addition, lack of fertilizer inputs (12.90%), limited access to land (11.29%), unavailability of market ~~at all times~~ (8.06%), high cost of inputs when available (6.45%), slumps due to low farm-gate banana prices (3.22%) ~~proposed~~ by customers, ~~the~~ lack of credit (3.22%), ~~the~~ lack of technical support (1.61%) were also ~~identified as~~ constraints limiting ~~the~~ production. Fields observation revealed that 54.84% of the producers surveyed were confronted with Banana Bunch Top Disease (BBTD).

Table 4: Constraints related to banana production in Houéyogbé area

Constraints	Percentage (%)
Diseases and pests	33.87
Limited access to land	11.29
High input costs	6.45
Lack of input	12.90
Lack of clean seeds	17.74
Low field edge price	3.22
Market unavailability	8.06
Lack of funding	3.22
Pouring	1.61
Lack of technical support	1.61

3.3 Conventional and organic production systems and determinants of production income

Most banana producers in Houéyogbé (80.65%) were involved in organic farming (Table 5). Only 19.35% of the producers used NPK, chemical fertilizers in their production system, ~~and v-~~Very few producers (12.90%) use chemical pesticides ~~their~~ production systems. The average banana production per farm in Houéyogbé was estimated at 1,489.11 kg. The average yield is 8.79 t/ha, with a significant difference at the 1% threshold between the organic production system (5.81 t/ha) and the conventional production system (21.21 t/ha). The average annual income per hectare is US\$ 3154.37 (1,757,962 XOF). This is significantly higher at the 5% threshold for producers using a conventional production system US\$ 7,613.24 (4,242,933 XOF) compared to those not using chemical inputs US\$ 2084.24 (1,161,570 XOF). From all the initial explanatory variables, only area, seed purchase ~~[?]~~, leaf removal, and production system ~~[?]~~ significantly influence income at the 1%, 1%, 5% and 10% thresholds respectively (Table 6).

UNDER PEER REVIEW

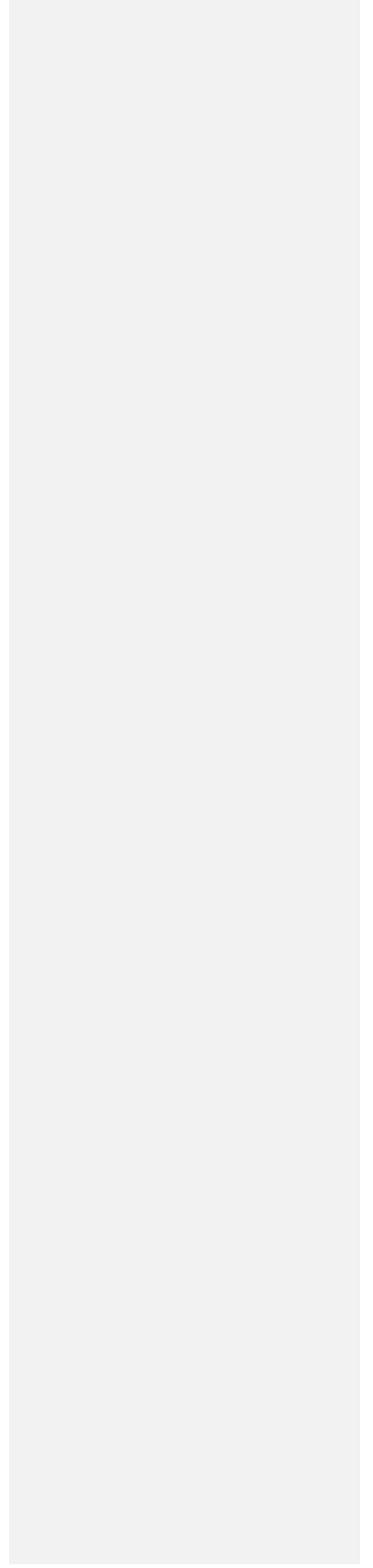


Table 5 : Conventional and organic production system and annual income per hectare

Variables		
Qualitative variables	Number	Percentage (%)
Use of chemical pesticides	8	12.90
Use of chemical fertilizers (NPK)	12	19.35
Farming Systems		
<i>Conventional</i>	12	19.35
<i>Organic</i>	50	80.65
Quantitative variables	Means	t-Statistic (p-value)
Average production (kg)		
<i>Conventional</i>	4650.00	
<i>Organic</i>	730.50	
All	1489.11	t=-5.59 (p=0.0000***)
Yield (t/ha)		
<i>Conventional</i>	21.21	
<i>Organic</i>	5.81	
All	8.79	t=-3.34 (p=0.0013***)
Income per hectare per production system (US\$/ha)		
<i>Conventional</i>	7613.24	
<i>Organic</i>	2084.24	
All	3154.37	t=-3.36 (p=0.0014***)

Table 6: Factors influencing income (logarithm of income) from banana production

Variables	Coefficients	Erreur-standard	T-Statistic	P-value
Intercept	10.07	0.39	25.705	2.0 E-16***
Farming system	0.77	0.40	1.94	0.057.
Area	2.69 E-5	9.07 E-6	2.969	0.00436**
Purchase of seeds	0.76	0.275	2.752	0.00793**
Stripping of leaves	1.074	0.407	2.635	0.01082*
Multiple R-squared	0.5138			
Adjusted R-squared	0.4797			
F-statistic	15.06			
Akaike Informative Criterion (AIC)	1.3217			
Shapiro-Wilk normality test				
W = 0,9583				0.03395*
Rainbow test				
Rain=1,1855				0.3314
Goldfeld-Quandt test				
GQ = 1,408				0.1943
Durbin-Watson test				
DW = 2,0346				0.5193

Variance Inflation Factors (VIF)	
VIF_Farming System	1.607
VIF_Area	1.723
VIF_Purchase of seed [?]	1.086
VIF_Stripping of leaves	1.092
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1	

3.4. Typology of banana-producing farms

After a multiple correspondence analysis (MCA) (Fig. 2) followed by a hierarchical clustering consolidated by the K-means method (Figure 3), three groups of banana farms were identified. The first group, on the left above axis 1 and comprising 11.29% of the farms (Fig. 2), is made up of farms with a small area, low income, not using hired laboreasual and not following the good agronomic practices (labour, soil preparation, plantingsewing, weeding and fertilization) in their farms (Fig. 2). All the individuals (100.00%) in class 1 have an area of less than 1000 m², do not carry out field fertilization, and rank bananas third among their crops. Three-quarters (75.00%) of these individuals have an income of less than US\$ 897.17 and half have an income of less than US\$ 71.77. Individual 9 represents the paragon of this class (individual in the centre of the class) and individual 51 is the most characteristic or representative of this class (Fig. 3).

The second group includes most (70.96%) of the farms. It includes farms using less than one hectare who practiced leaf stripping, mulching, soil preparation, weeding, seeding and intercropping. Most of farmers that had only one field did not buy seed [?] but do sell it (Fig. 2). Eighty seven point fifty percent (87.50%) of the farms with an income between US\$ 71.77 and US\$ 897.17 belong to this group as well, as 78.00% of thosethem that practiced weeding and soil preparation fall in belong to this class. The farms (100.00%) that had a size between 1000 and 10000 m² belong to this class. The majority (81.00%) of farmers in class 2 had an income between US\$ 71.77 and US\$ 897.17. All the farms in this group (100.00%) carried out soil preparation and weeding. Individual 5 represents the paragon of this class and individual 23 is the most characteristic of this class (Fig. 3).

The third group located on the right above axis 1 and comprising 17.14% of the farms, includes farms having of 3 to 4 plots with an area between 1 and 13 ha. Some of them did not practice stripping of leaf or mulching but did buy bought seed/planting material (Fig. 2). Their (100.00%) income lies between US\$ 1794.33 and US\$ 5383.00, and they are mostly represented by men. In this class, 83.00% of farm owned three plots. The mMajority of farmers (91.00%) used fertilizer, and other chemical inputs. At least 63.60% had an area between 1 and 5 ha. Individual 45 is the paragon of this class and individual 62 is the most characteristic of this class (Fig. 3). [This table's lettering is too small.]

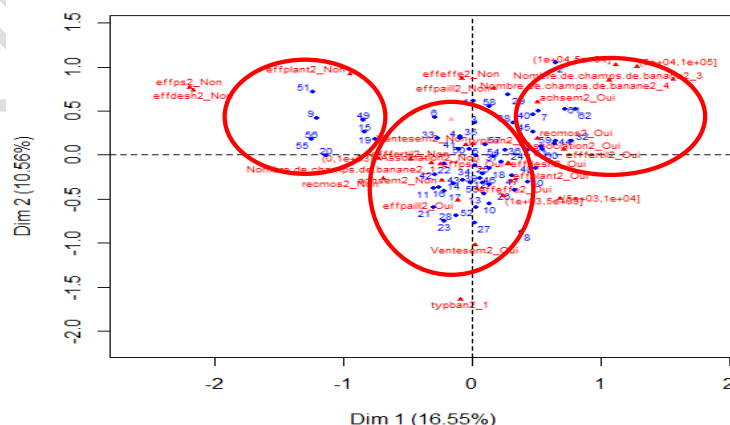


Figure 2: Representation of active modalities and farms on axes 1 and 2 using a factor map

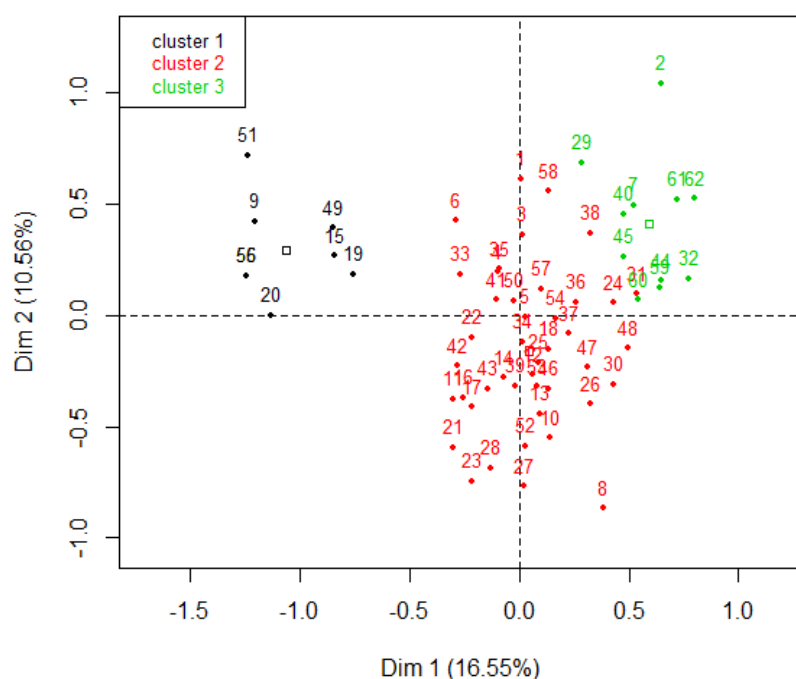


Figure 3: Representation of the farm groups on axes 1 and 2 using a factor map

4. Discussion [This discussion is not well-organized. I suggest that it be reorganized and each paragraph be made more clear about which category of farm is being dealt with.]

The characterization of banana and plantain production farms in the commune of Houéyogbé reveals that men are dominant (77.42). The high percentage of men involved in this activity is explained by the fact that bananas production requires several farming steps and significant muscular efforts. Men are considered as heads of households and are the decision-makers, therefore capable of meeting all the requirements involved in this activity. Although different generations of producers are engaged, youth are more involved in the production. The rate of young people under 37 years is higher than that found by Mialoundama Bakouétla et al. (2016) in Mouyondzi district in Congo and Adigbonon et Allagba (2015) in Akpro-Missérété and Adognon et Medenou (2015) in Adjara in Benin. This might be explained by the fact

that most people engaged in the production are native from the communes and ~~that there is not~~ much smuggling in fuel ~~business~~ as ~~it happened~~ in Adjara. The survey showed also that most of youth who travelled out usually returned to their respective villages to capitalize experiences gained elsewhere. More than 50% of those farmers are educated, ~~a~~ ~~This~~ number ~~is~~ less than those reported in Congo by Mialoundama Bakouétla et al. (2016). Education being an important pillar ~~of improved farming~~, it could be critical in production improvement and adoption of technological innovations ~~of other farmers~~. Banana production is ranked first by 24% of them. This proportion is generally low compared to other locations (Mialoundama Bakouétla et al., 2016). Indeed, Congo as well as Cameroon are Central African countries, an area reputed to be a major producer of banana and plantain compared to Houéyogbé where production has just started to emerge. Bananas ~~in Central Africa~~ are in most cases associated with food crops ~~not cash crops~~ (Temple et al., 1993; Mialoundama Bakouétla et al., 2016). ~~[Is that what you mean?]~~ This is understandable as land availability is recognized to be a limiting factor in some areas, and farmers driving force include opportunity cost. ~~[Something wrong with that sentence.]~~ Looking at banana production cycles, they prefer ~~totaking cultivatein account~~ other crops ~~forte get~~ income, and cover the family needs before the harvesting time of the fruits. ~~[What?]~~

Again, diseases and pests are the primary factors limiting banana production ~~in Central Africa~~ [?]. ~~Pouring~~ ~~[You need another word there.]~~ observed among bananas farms in Houéyogbé, could be a consequence of climatic changes. With the impact of climate ~~change~~, many diseases emerged ~~or there is an outbreak of known diseases and pests~~. The ~~m~~Majority of producers in this ~~[Which area are you talking about?]~~ area obtain their planting material from their own farms or neighbors. As the distribution system of planting material is ~~even at~~ the heart of any production system, there should be a ~~better~~ way to improve the ~~seed flow~~ system. ~~Perhaps and discourage~~ farmers ~~should be discouraged~~ from this tradition ~~of sharing planting material locally, given that it knowing that this tradition~~ can explain why disease spread (FAO, 1989). It is easy in this situation to justify the high prevalence of diseases and pests, more specifically the BBTD responsible for production losses in that commune and in other communities where losses up to 100% were recorded (Sodédji et al. (2016)) ~~making households vulnerable~~. This disease has been observed in more than 50% of the producers surveyed, who have little knowledge of its symptoms, means of transmission and control methods. The lack of technical assistance can justify why farmers have no knowledge about the diseases. It is worth to mention that bananas ~~s~~ were one of the 'motherless' fruits ~~although its uses~~ in Benin. ~~[What do you mean by that?]~~

~~Knowing that k~~ knowledge on disease diagnosis and management is a very important parameter for effective disease and pest control (Abiola et al., 2019; Blomme et al., 2014; Zandjanakou et al., 2009), ~~so it is urgent that~~ there should be an ~~urgent~~ program of training ~~forte~~ these farmers. Moreover, according to Atkinson et al. (2015), the effectiveness of support to agricultural innovations necessarily depends on the recognition of farmers' needs, ~~such as~~ widely available and affordable planting materials, the dissemination of knowledge for their effective use, and ~~the~~ access to markets. Although banana and plantain production were considered as backyard crops in Benin, ~~theyit~~ contributes significantly to household food security (Sodédji et al., 2016). Bananas are highly valued by consumers and are subject to diverse market transformations. ~~[What do you mean by that?]~~

The analysis of ~~typology in the~~ banana production systems in the commune of Houéyogbé has shown that there is a diversity of banana production systems. They are distinguished by the banana cultivated area, income, use of casual ~~labor~~, field fertilization, field maintenance, cropping system and agronomic practices. The first category is made up of farms practicing traditional banana production, without maintenance and without sowing ~~[Not clear what you mean by sowing.]~~, using suckers from the mother plants suckers from the plant. Banana production in Benin is for the most part traditional and is carried out on very small areas (Adigbonon and Allagba, 2015). These are the ~~hut-house gardens~~ ~~rewards~~ (CTA, 2012). For these farms, the banana plants are often in tufts, ~~[You need to explain that technique. I think you mean the plain is done in groups of suckers.]~~ a technique that is used in Cameroon according to Temple et al (1993) to increase the resistance of the mother plant to the ~~phenomenon of lodgingfalling phenomenon~~ and to spread production over the year, providing them with a ~~more~~ regular ~~productionincome~~. These types of farms that use so-called "food-producing" strategies ~~are~~ described as "~~house gardenhut plantation~~" ~~havewith~~ characteristics similar to those of the commune of Houéyogbé. Their cropping system is described as "extensive monoculture" where the farmer does not use ~~fertilizer~~ inputs, an irrigation system, ~~orand~~ selected varieties (Mialoundama Bakouetila, 2016). According to the same author, producers use this ~~traditional~~ cropping system in order to sustainably manage their farms

and maintain their livelihoods. In Benin, this system of production was common as the fruit were not so valuable. [\[What?\]](#) An improved form of "~~househut~~ ~~gardenerchards~~", but still traditional characterizing the farms in the second group [of the Benin study](#) are in an intermediate situation compared to those in classes 1 and 3, particularly in terms of area cultivated and income from the sale of bananas. However, its characteristics are closer to those in group 3. In contrast to group 1, they ~~useare into~~ intercropping and follow agronomic practices. They [still](#) use subsistence-~~type~~ strategies ~~by whichwhere~~ the producer gives priority to food self-consumption.

The surplus is then marketed, providing them with permanent income, enabling them to meet the family's needs (Mialoundama Bakouetila, 2016). Moreover, the production is in ~~spatially separated~~~~sparse~~ clumps ~~associated~~ with a few ~~other~~ food crops including macabos [\[What is that crop?\]](#) in Cameroon (Temple et al., 1993). This ~~contrasts is in contradiction~~ with the plantations in Cameroon that use same strategy ~~but~~ have a larger surface area of 1 to 4 ha, unlike those in the commune of Houéyogbé, where they have less than 1 ha and more than 1000 m²

The surplus is then marketed, providing them with permanent income, enabling them to meet the family's needs (Mialoundama Bakouetila, 2016). Moreover, the production is in sparse clumps associated with a few food crops including macabo (Temple et al., 1993). This is in contradiction with the plantations in Cameroon that use same strategy, but have larger farm size The farmers in this group seem to be better off as far as engagement is concerned. [\[This paragraph seems to repeat. Also, what you mean by engagement is unclear.\]](#)

Generally larger, and more engaged in banana production as their main activity, the farms in the group 3 are characterized by a large production area and ~~higher~~ income in comparison to others. The size of the farm, the [higher](#) income, as well as the agronomic practices carried out show the beginning of ~~intensification~~~~specialization~~ in banana production by this category. [\[No paragraph needed here.\]](#)

~~MM~~Most of them use chemical fertilizer that lead to high yields (21,21 t/ha in average) compared to the two others clusters. However, these yields are lower than those recorded in Ivory Coast by N'Guetta et al. (2015) that achieve 38.1 t/ha. The characteristics of these farms are similar to those of plantain producers in Cameroon who implement the business strategy [\[What business strategy?\]](#) and who own an area of more than 4 hectares of banana ~~plantstrees~~ (Temple et al., 1993). The yield could increase if technical assistance is given. Most producers do not use chemical (chemical fertilizers and chemical pesticides) in production. This is an environmental advantage at the community level but that does not allow them to be competitive compared to those who use chemical inputs in production. They obtain an average yield of 5.81 tonnes per hectare while those using chemical inputs have an average yield of 21.21 t/ha. The yields obtained in so called 'organic banana production' in Houéyogbé are comparable to those reported by Nkapnang Djossi (2011) and those of Nkendah and Akeyeampong (2003) on banana production in tropical Africa. [\[Well, are you suggesting using environmentally unsustainable production methods just to compete?\]](#)

According to Nkapnang Djossi (2011), banana yields are 5.4 t/ha, 7.6 t/ha, 5.1 t/ha, 2.9 t/ha, 4.4 t/ha, 11 t/ha and 6 t/ha for Cameroon, Republic of Congo, Equatorial Guinea, Central African Republic, Democratic Republic of Congo, Ghana and Nigeria respectively. Yields estimated by Nkendah and Akeyeampong (2003) were 7.0 t/ha, 16.6 t/ha, 4.6 t/ha and 8.1 t/ha respectively for Ghana, Cameroon, Gabon and Côte d'Ivoire. Knowing that banana production in tropical Africa is generally carried out in a traditional way with an extensive system, which does not allow yields in the order of 30-40 t/ha compared to research stations and agro-industries data (Kwa et al., 2005; Nkapnang Djossi, 2011; N'Guetta et al., 2015). It is worth ~~te~~-mentioning that intensification of production is necessary to achieve higher yields. However, it is important to provide guidance to producers on the use of inputs in order to not damage ecosystems following this intensive use of chemical pesticides and fertilizers.

[\[You need to move this next section explaining what leaf stripping is to the first time you mention leaf stripping.\]](#) Leaf stripping is a practice that positively influences the yield and income of banana producers in Houéyogbé. Leave stripping is a technique that removes leaves with necrosis and significantly reduces the amount of inoculum and control spp. (Dural and Fouré, 2011) In case of disease control such as Sigatoka disease, farmers use mechanical control that is not effective when used in a random way. [\[These sections are not clear in what you mean. Also, for each disease mentioned in this article, you need to include a brief summary of what each is and its effects.\]](#)] Another control strategy consists in using herbicide. Gomez Balbin and Castano Zapata (2001) after their work on integrated pest management (IPM) of cercosporiosis in bananas report that IPM including leaf stripping provides effective control of the

disease. Leaf stripping outside the control of cercosporiosis results in photosynthetic efficacy on the rest of the leaves present on the banana tree (Blomme et al., 2001). [The next sentence is a conclusory one. It is not effective organization of an article to tack it onto a detailed discussion of disease control methods.] The results of the present study indicate that banana and plantain in Houéyogbé are not efficient and not competitive. There is a need to support producers by providing them with new techniques and tools to improve their productivity and income. [Since organic bananas yield premium prices in informed markets, organic producers elsewhere in the world do not mind lower production levels that you get when avoiding chemical fertilizers and pesticides. It seems to me you should make suggestions that make more sense than just intensifying in ways well known to be problematic.]

5. CONCLUSION

This temporal evolution of study of cultivation practices in the banana sector in a locality in Benin has led to the identification of three types of banana-producing farms there. They are distinguished by the practice of cultivation activities, the use of inputs, the use of paid labour, the area sown, the cropping system, and the income. Some are purely traditional (hut house gardensorchards), others are intermediate and some are tending to modern (more market-oriented). These characteristics and specific operations to each group do not spare them from constraints that hinder the development of this sector. They constraints are essentially related to diseases and pests, particularly Banana bunchy top disease (BBTD), which causes significant economic losses and threatens household food security. The non-availability of healthy plant materials, which implies the use of seeds from dubious sources, is a means of spreading diseases. [You, actually, have not demonstrated that local sucker sources are necessarily more contaminated than outside ones.] However, in this Township, there is no technical assistance on banana production, on diseases recognition and their management although this knowledge was very important parameters for good production. Moreover, there was a lack of use control of agronomic practices for banana production. It is urgent at the level of agricultural policy to encourage initiatives to promote the expansion of its production. [You have not discussed what should be the goal of improvement. You seem to be assuming that merely increasing production is the goal. I think you need to have a more sophisticated and nuanced set of possible goals, each of which may have different rationales.] Thus, training on macro propagation to obtain healthy plant materials, on banana agronomics practices, on recognition and control of diseases and pests could improve the production in the area. Also, training specific to each category of farm could help them maximize their productivity.

[I think you should consider that there is not one agronomic goal to be promoted. Maybe low-income farmers should focus on improvements that support their food needs. Furthermore, as you must know, intensification has many bad sides to it, as is shown by the widespread pollution of water and soil in the US corn belt. Agronomic practices that involve organic methods can benefit cash farmers because the products demand much higher prices and do not result in the problems caused by the industrial farming that oyu seem to be promoting here. You need to pay attention to the fact that intensive industrial farming is often associated with increased pest problems, not decreased. If you are going to recommend policy affecting these farmers and those like them, you need to consider different options because the practices you seem to espouse create larger problems than those you have identified here.]

Otherwise, I suggest you discuss for the traditional farmers the traditional methods that are benficial, whichthey are likely using. Aren't they using mulching? And if these are house gardens, aren:t they using household waste for fertilizer? "Modern" farming is not necessarily better than traditional.]

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