Scientific Research Publishing

Journal of Agricultural Chemistry and Environment, 2023, 12, 275-295
https://www.scirp.org/journal/jacen
ISSN Online: 2325-744X
ISSN Print: 2325-7458

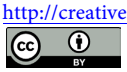
Farmers' Practices for the Orchard's Maintenance and Post-Harvest Treatment of Cocoa in Infiltrated Classified and Unclassified Zone of Méagui (South-West, Côte d'Ivoire)

Trazié Kevin Guessan-Bi[1], Kouadio Dagobert Kra[1], Koffi Éric Kwadjo[1], Konan Lucien Kouame[1], Mamadou Doumbia[1,2]

[1]Laboratory of Animal Biology and Cytology, Entomology Research Unit, UFR-SN, Nangui Abrogoua University, Abidjan, Côte d'Ivoire
[2]University Unit of Expertise and Advice for Agricultural Development, Abidjan, Côte d'Ivoire
Email: guessanbikevin@gmail.com

How to cite this paper: Guessan-Bi, T.K., Kra, K.D., Kwadjo, K.É., Kouame, K.L. and Doumbia, M. (2023) Farmers' Practices for the Orchard's Maintenance and Post-Harvest Treatment of Cocoa in Infiltrated Classified and Unclassified Zone of Méagui (South-West, Côte d'Ivoire). *Journal of Agricultural Chemistry and Environment*, **12**, 275-295.
https://doi.org/10.4236/jacen.2023.123021

Received: June 25, 2023
Accepted: August 18, 2023
Published: August 21, 2023



Abstract

An important part of Ivorian cocoa production comes from infiltrated classified forests. The objective of this study is to investigate orchard maintenance and post-harvest cocoa treatment practices used by cocoa farmers in infiltrated classified and unclassified areas of Méagui. To do this, 110 producers in two localities of the said zone were individually interviewed from February to April 2022, using a declarative questionnaire. It was found that cocoa orchards in the zone are aging. Nearly 68.55% of producers were heirs and 58.33% of those interviewed were under 46 years of age, with an average age of 43 years. Nearly 84.55% of the producers surveyed mainly use chemical insecticides to control the pests of greatest concern in these localities. Regarding the frequency of insecticide treatments, 11.82% of producers make 1 to 2 applications a year, 29.09% make 3 to 5 applications a year, and 43.64% make at least 6 applications a year. The active substances of the most used products belong to 99% of the Neonicotinoid and Pyrethroid families. Regarding cocoa harvesting and post-harvest operations, 93.64% of the producers carry out a single harvest/month; all do the shelling with mini machetes. Beans are fermented mainly in black plastic tarpaulins or in bags, for a period of 3 to 5 days (65.45%). Drying is done almost entirely (91.82%) on the black plastic tarp. This study shows that cocoa farmers in the areas surveyed do not respect the recommendations issued on phytosanitary practices and post-harvest treatment of cocoa. This non-compliance with the standards of good practices prescribed is particularly more accentuated in the locality located in infiltrated classified zone. It would, therefore, be judicious to revise or redefine the phyto-

sanitary recommendations and carry out sensitization and training-follow-up programs for producers in this important cocoa production area of Côte d'Ivoire.

Keywords

Cocoa, Farmers' Practices, Orchards Maintenance, Post-Harvest Treatment, Méagui

1. Introduction

Cocoa production in Côte d'Ivoire has developed over the years at the expense of forests including classified forests and protected areas [1] [2] [3] [4]. Higonnet *et al*. [2] and Koné [3] report that 40% of Ivorian cocoa production comes from infiltrated classified forests. Cocoa occupies a vital place in the socio-economic fabric of Côte d'Ivoire, the world leader in the production and export of marketable beans, with more than 42% of the international supply [5]-[10] and has done so for more than four decades [11] [12]. For the 2012 to 2017 crop years, the coffee and cocoa sector contributed 14% to the gross domestic product (GDP) and generated 38% of export revenue on average [13]. Cocoa farming has mobilized from about 600 farmers in the late 1970s to more than one million farmers in the 2000s [12]; millions of people in the secondary and tertiary sectors survive thanks to the cocoa sector [11] [14] [15] [16].

However, cocoa production is confronted with several difficulties, including the aging of orchards, poor agricultural practices, and the pressure of pests, which have a considerable negative influence on the productivity and quality of cocoa. Indeed, diseases and insect pests of the cocoa tree cause enormous damage in the producing regions with estimated production losses ranging from 10% to 100% depending on the type of pests and the production areas. Some of these pests can even cause the complete death of the plantation if adequate management is not provided [17]-[21]. Among the phytopathological pests, the fungal disease pod rot and the viral disease swollen shoot of cocoa are of greatest concern in Côte d'Ivoire. In addition, the most common insect pests considered to be of greatest concern in Ivorian cocoa farms are the two mirid species *Sahlbergella singularis* and *Distantiella theobromae* [22]-[27]. Furthermore, in the 2000s and 2010s, the quality of cocoa produced in Côte d'Ivoire was the subject of much depreciatory criticism partly due to poor post-harvest processing practices [28].

Thus, to control pests in plantations in an efficient and reasoned manner, on the one hand, and to produce good quality cocoa, on the other, standards of good agricultural practices are developed and recommended by scientists, professionals, and government bodies in the cocoa sector [29] [30] [31] [32]. However, it seems that these recommendations are not really followed by most cocoa farmers [33] [34], particularly those living in infiltrated classified areas and more

specifically in Méagui.

Work to characterize farmers' cultivation practices, with the aim of verifying their compliance with the recommended recommendations, does not yet seem to be carried out in this part of Côte d'Ivoire. It is, therefore, timely and necessary to evaluate the orchard maintenance and post-harvest cocoa treatment techniques practiced by cocoa farmers in Méagui, to initiate, if necessary, awareness and training-follow-up campaigns for producers in this cocoa-growing area of the country.

2. Study Area and Methods

2.1. Study Area

The study was carried out in the department of Méagui located between 5˚18' and 5˚26' North latitude, and 6˚31' and 6˚50' West longitude, in the southwest of Côte d'Ivoire. The climate is hot-humid subequatorial [35] and is characterized by four seasons, including two rainy seasons (March-June and September-November) and two dry seasons (December-March and July-August). Average precipitation ranges from 1300 to 1600 mm per year and average temperatures are generally between 25˚C and 28˚C. Average humidity ranges from 80-85% on average per year [36] [37]. The department's economy is primarily based on cocoa production, which is estimated to account for approximately 20% of national production [36]. Sérigbangan and Yaodankro are the sample areas. Yaodankro is in the classified area of Méagui and has cocoa farms bordering the northeast side of the Taï National Park (TNP) and seems to be one of the most important in terms of cocoa production in the department; whereas the locality of Sérigbangan is in the unclassified zone and is relatively further away from the TNP.

2.2. Methods

The survey was conducted from February 2022 to April 2022 in the localities of Sérigbangan and Yaodankro. A total of 110 cocoa farmers were interviewed individually using a declarative questionnaire. The survey focused on: 1) the profile of producers and cocoa orchards, 2) the types of diseases and insect pests observed in the plantations by the producers, 3) the cultural and phytosanitary practices used by the producers, 4) the way in which the producers carry out the harvesting and post-harvest operations of cocoa. The interview took place for some producers in their plantations and for others, at their homes. Using the statistical software RStudio 4.2.2, the chi-square test of independence was used to verify whether these different parameters (variables) studied are dependent on the "localities" variable.

3. Results

3.1. Profile of Producers

Almost all (97.27%) of the plantation owners interviewed are men. Regarding

the mode of ownership of a cocoa farm ("owner-creator" or "owner-Heirs"), the majority (67.27%) of producers stated that they had inherited the plantation (Table 1). The average age of the producers interviewed was 43.58 ± 13.42 years with a minimum of 20 years and a maximum of 75 years. Overall, 31.82% of the respondents are between 20 and 35 years old; 23.64% are between 36 and 45 years old; 20% are between 46 and 55 years old; and 24.55% are over 55 years old (Table 2). The chi-square test of independence revealed that the mode of ownership of a cocoa farm was not dependent on locality ($p = 0.284$). Similarly, the age classes of producers were independent of locality ($p = 0.4935$), *i.e.* the proportions of age groups in Sérigbangan were like those in Yaodankro. In contrast, the age classes of producers and the mode of ownership of a cocoa farm are highly significantly dependent according to the chi-square test ($p = 6.824e{-}15$).

3.2. Profile of Cocoa Orchards

3.2.1. Area and Age of Cocoa Orchards

The declared areas of plantations range from about 1 ha to 12 ha, which was divided into three classes: [1 to 3 ha], [3 to 5 ha], and more than 5 ha. Overall, plantations with an area of [1 to 3 ha] represent 57.80% of the orchards. Plantations of [3 to 5 ha] and more than 5 ha, represent 22.02% and 20.18% respectively (Table 3). The average size of the orchards was 3.82 ha. The chi-square test showed no significant relationship ($p = 0.9664$) between the variable's locality and orchard size class.

The age of the cocoa farms surveyed ranged from 10 to over 40 years. Orchards older than 40 years are the most numerous (68.93%), followed by orchards between 30 and 40 years old (26.21%) and those between 10 and 20 years old

Table 1. Proportions of producers by mode of ownership of a cocoa farm.

Location	Proportions (%) of cocoa farmers surveyed	
	Owner-creators	Owner-heirs
Sérigbangan	25.58	74.42
Yaodankro	37.31	62.69
Global	32.73	67.27

Table 2. Proportions of age classes of producers by mode of ownership of a cocoa farm and by locality.

Mode of ownership and locations	Proportion (%) of age classes of cocoa farmers surveyed			
	[20 to 35 years old]	[36 to 45 years old]	[46 to 55 years old]	>55 years old
Creators	0.00	5.56	25.00	69.44
Heirs	47.30	32.43	17.57	2.70
Sérigbangan	30.23	30.23	20.93	18.60
Yaodankro	32.84	19.40	19.40	28.36
Global	31.82	23.64	20.00	24.55

Table 3. Proportions of area classes and age classes of cocoa farms surveyed.

Locations	% of orchard area classes (ha)			% of orchard age classes (years old)		
	[1 to 3]	[3 to 5]	>5	[10 to 20]	[30 to 40]	>40
Sérigbangan	22.02	8.26	8.26	0.00	7.77	31.07
Yaodankro	35.78	13.76	11.93	4.85	18.45	37.86
Global	57.80[a]	22.02	20.18	4.85	26.21	68.93

(4.85%). No orchards of this last age class were recorded in the locality of Sérigbangan where 80% of the cocoa farms are old orchards of more than 40 years. In Yaodankro, plantations between 30 and 40 years old and those older than 40 years recorded 30.16% and 61.90% of the local orchard respectively (Table 3).

3.2.2. Main Insect Pests and Diseases Present in Cocoa Orchards

The survey revealed that three morphotypes (or morpho species) of insects are the main insect pests that are currently of concern to producers in Sérigbangan and Yaodankro. These are the capsids *Sahlbergella singularis* and *Distantiella theobromae*, the cocoa mosquito *Helopeltis* sp., and the green bug *Bathycoelia thalassina* (Figures 1-3). Regarding capsids and their damage, 43.64% of the producers said that they noticed a significant presence of this pest in their plantations, while 56.36% said that they did not observe too much damage from these insects, although they were present in their fields.

As for cocoa mosquitoes and their damage, they were observed much more by 54.55% of producers and less observed by 39.09%; and 6.36% of respondents indicated that they did not observe them in their plantations. Some farmers indicated that the cocoa mosquito is more damaging to the youngest fruits (cherries) and has no real impact on pods of a certain size.

Regarding the green bug, 67.27% of the producers consider this insect as one of the most observed and dangerous in their plantations, while for 32.73% of the farmers, the insect is less present in their orchards (Table 4). Chi-square tests showed that the level of capsid infestation in orchards was not related ($p = 0.5968$) to the production locality. For the green bug and the cocoa mosquito, the level of their populations in orchards was very significantly dependent on locality ($p = 0.002$, $p = 3.826e{-}10$, respectively for the insect types). These two insects were significantly more observed in Yaodankro cocoa farms. In addition to these insects, farmers reported signs of stem and pod borers as well as termites, which do not seem to be a real concern for them. The pathological disease of current concern to producers in the area is Swollen Shoot of the cocoa tree, the presence and extent of which did not vary by locality according to the chi-square test ($p = 0.5792$). At least 82.73% of the producers interviewed reported the presence of this viral disease in their orchards. They attributed the death of many cocoa trees to the action of the swollen shoot virus. Only 3.64% reported that they had not yet found the disease in their plantations. The fungal disease pod rot, whose presence or severity of infection is very highly dependent

Figure 1. Adult and larvae of the capsid (*Sahlbergella singularis*) and their damage on pods.

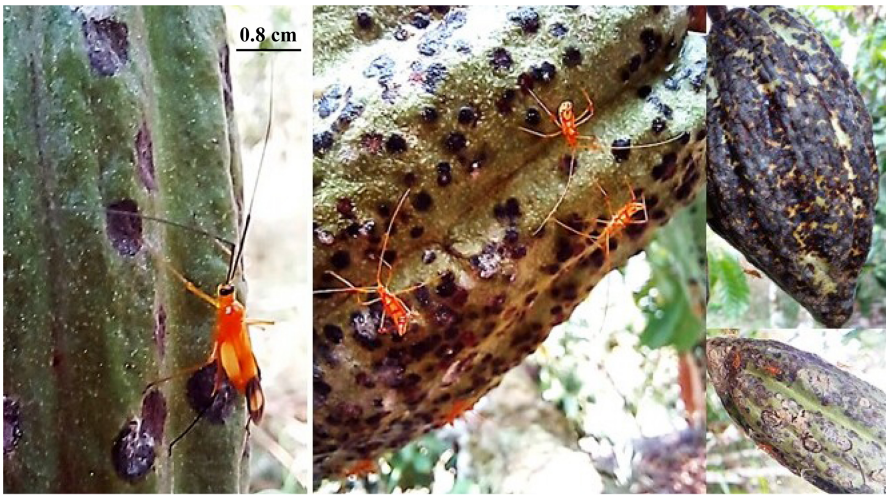


Figure 2. Adults and larvae of the cocoa mosquito (*Helopeltis* sp.) and their damage on pods.

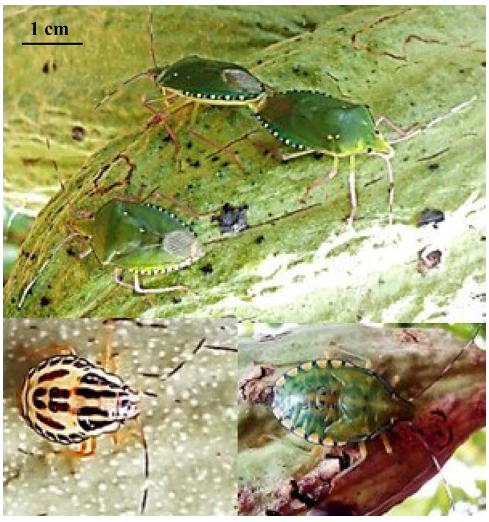


Figure 3. Adults and larvae of the green bug (*Bathycoelia thalassina*) on pods.

Table 4. Main insect and disease pests noted by producers in Méagui cocoa farms.

Major insects and diseases of concern	Presence and importance of populations	Proportion (%) of farmers surveyed		
		Global	Sérigbangan	Yaodankro
Capsids	Not presents	0.00	0.00	0.00
	Significant presence	43.64	48.84	40.30
	Low presence	56.36	51.16	59.70
Mosquito of cocoa tree	Not presents	6.36	16.28	0.00
	Significant presence	54.55	16.28	79.10
	Low presence	39.09	67.44	20.90
Green bug	Not presents	0.00	0.00	0.00
	Significant presence	67.27	48.84	79.10
	Low presence	32.73	51.16	20.90
Rotting of the pods	Not presents	35.45	76.74	8.96
	Significant presence	14.55	2.33	22.39
	Low presence	50.00	20.93	68.66
Swollen Shoot	Not presents	3.64	0.00	5.97
	Significant presence	82.73	79.07	85.07
	Low presence	13.64	20.93	8.96

on locality (p = 2.91e−12), seems to be no longer too much of a concern for most of the producers interviewed, especially those in Sérigbangan (Table 4).

3.3. Phytosanitary Practices of the Producers Interviewed

3.3.1. Weed Control

Two types of weeding are carried out in the cocoa farms by the farmers interviewed.

These are manual weeding using machetes, which is carried out once to three times a year, and herbicide treatment using chemical herbicides, which is applied once a year. Among the farmers interviewed, 84.26% reported using chemical herbicides in addition to machete weeding. Those who carry out two manual weeding operations are the most numerous, with a rate of 66.35%, of which 54.81% use chemical weeding as a supplement to manual weeding. The proportion of those who carry out a single weeding operation with a machete is 22.12%, and all of them carry out a second weeding operation using herbicide products. And the rate of producers who carry out three manual weeding plus an application of herbicide is 6.7%.

3.3.2. Pruning and Sanitary Harvesting

Overall, 48.57% of producers do not perform any maintenance pruning of their plantations. Of the 51.43% of farmers who stated that they do this operation, 21.90% spend time on it. The latter generally carry out this operation between January and April, mostly in February-March, and 29.53% carry it out either during weeding, at the time of the pod harvest, or at times when the producer considers the presence of twigs and/or branches to be too cumbersome on cer-

tain cocoa trees. In Sérigbangan, 80.95% of cocoa farmers no longer spend time pruning, and only 4.76% do this activity, mainly between January and April. In Yaodankro, 28.13% of producers do not perform maintenance pruning, and 32.81% perform the operation between January and April. Regarding sanitary harvesting, 52.83% of producers stated that they clear the cocoa trees of mummified dry fruit and fruit with rot, and this is done during the harvesting of ripe pods. The chi-square test, with p = 3.01e−07 for pruning and p = 5.17e−08 for sanitary harvesting, shows that the performance of these activities depends on the cocoa localities. As for the management of these embarrassing fruits, producers leave them in place after they have fallen from the trees.

3.3.3. Insecticide Treatments

1) Acquisition of products

The survey reveals that most of the producers (84.55%) use chemical insecticides to control insect pests, and 15.45% do not use them. Seventy-eight-point forty-nine percent (78.49%) of pesticide users indicated that they buy the products themselves from street vendors or local vendors. Of the remaining 21.51% who mentioned that they receive insecticides from their cooperatives, 15.05% indicated that they supplement it by buying other boxes (products) on the local market or from street vendors. Statistical analysis indicated that there is a very high significant relationship (p = 9.981e−08) between the variables "cocoa localities" and "use or not use of insecticides" against pests in the orchards. All the producers interviewed in Yaodankro use insecticides, while among those surveyed in Sérigbangan, 60.47% use them and 39.53% do not. It was noted that it is in the latter locality that producers are supplied with insecticides by cooperatives.

2) Insecticide products used

A total of 55 chemical insecticides with 11 active substances in 17 formulations, 03 fungicides (4 active substances in 03 formulations), and 01 bio stimulant were identified (quoted by the producers and/or empty containers found in the orchards). Of the insecticides identified, three do not appear on the list of pesticides registered in Côte d'Ivoire. These are CACAOEXTRA 36 SC, CAOBOSS SUPER 80 SC, and THODAN GRO 50 SC; all three of these products were found in Yaodankro. The active substance found in the most cited products, taken in isolation, is Bifenthrin (25.79%). It is followed by Imidacloprid (22.35%), Acetamiprid (15.47%), Lamb-da-cyhalothrin (13.18), and Thiamethoxam (12.61%) (**Figure 4(a)**). In the chemical formulation, 93.68% of the insecticides found are two active substances, 4.02% are three active substances, and 2.30% are single formulation insecticides (01 active substance). With a proportion of 36.21%, products combining Imidacloprid and Bifenthrin were the most cited. They are followed by insecticides based on Lamb-da-cyhalothrin + Thiamethoxam (16.67%), and Acetamiprid + Bifenthrin (11.49%) (**Figure 4(b)**). The active substances of the inventoried insecticides belong to 5 chemical families: Neonicotinoids, Pyrethroids, Avermectines, Pyriproxyfen, and Diamines. The

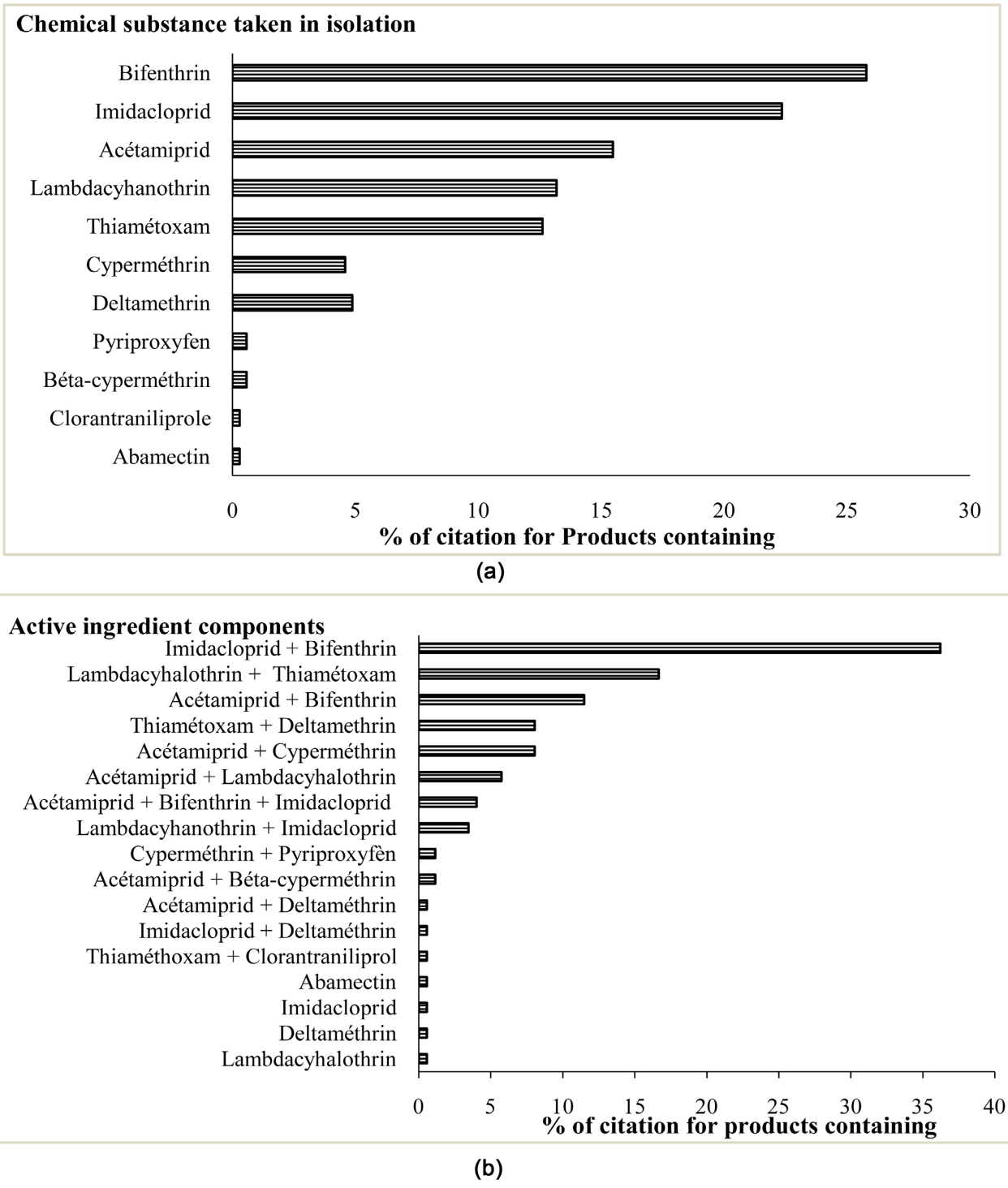


Figure 4. Proportion (%) of use of active ingredients of insecticides identified in Sérigbangan and Yaodankro.

first two families are widely used in the Méagui area. They are slightly (Class III) or moderately (Class II) dangerous products. Almost all (96.91%) of the producers interviewed indicated that they had never used a biopesticide. The 3.09% (in Yaodankro) who did use biopesticides indicated that they had used them only once on a trial basis. The names of the biopesticides used could not be provided

by users.

3) Application of insecticide products

Of the farmers who use insecticides, 68.89% indicated that they apply the treatments themselves. The remaining 31.11% reported using private individuals who are known to be experienced in the operation. The chi-square test (p = 1.615e−11) shows that using or not using an experienced applicator is dependent on locality. In Sérigbangan, 84.62% of producers use an applicator trained by the cooperative to which they belong.

Unlike those in Yaodankro, 90.63% of whom perform the operation themselves. The application device unanimously cited is the motorized backpack sprayer; the preparation of the product is done directly in the tank of the device. The survey also revealed that not all farmers wear full personal protective equipment (PPE) during treatments. However, 59.78% reported wearing a minimum of PPE, generally consisting of their usual field clothing, which consists of a long-sleeved shirt, pants, and a pair of boots, to which is sometimes added a cloth muffler and/or a hat for carrying out the activity. And the statistical test showed that the wearing or not of this minimum of PPE is done at significantly different proportions (p = 2.343e−05) from one locality to another. Approximately 96.15% of the applications in Sérigbangan versus 45.45% of those in Yaodankro were wearing PPE.

4) Frequency of insecticide treatments

The frequency of treatment of orchards varies from once a year to more than 6 times a year divided into three classes: [1 to 2 times], [3 to 5 times], and ≥6 times per year. The overall proportion of farmers who perform 1 - 2 treatments per year is 11.82%. That of those who make 3 - 5 applications per year is 29.09%, and 43.64% of respondents make 6 or more insecticide treatments during the year. Statistical analysis revealed that the frequency of insecticide application varied significantly (p = 4.899e−15) by locality. In Sérigbangan, the frequency of application was increased (30.23%) by the class of [1 to 2 times] and decreased (4.65%) by the class of 6 or more applications per year. On the other hand, in Yaodankro, 68.66% of cocoa farmers applied at least 6 times per year, and 31.34% applied between 3 and 5 times per year. The frequency of 1 to 2 applications per year was not mentioned by producers in the latter locality (Table 5). Growers applied an average of 1.06 ± 0.53 liters of insecticide product per hectare. Fungicide treatments for pod rot are used mainly in Yaodankro.

Table 5. Frequency of insecticide application by surveyed cocoa farmers.

Insecticide application	Frequency/year	Proportion (%) of surveyed cocoa farmers		
		Global	Sérigbangan	Yaodankro
YES	[1 to 2 times]	11.82	30.23	0.00
	[3 to 5 times]	29.09	25.58	31.34
	≥6 times	43.64	4.65	68.66
NO		15.45	39.53	0.00

5) Producers' level of knowledge on recommended timing and frequency of insecticide treatments

Of the producers surveyed, about 63% answered "NO" to the question of whether they had knowledge of recommended timing and frequency of insecticide treatments. Of the 37% who answered "YES" to the question by indicating 2 to 4 applications per year, 27% were able to mention at least one of the months corresponding to the periods during which treatments are recommended in Côte d'Ivoire, *i.e.* December-February and July-August. The chi-square test revealed that the level of education of producers on the recommended periods ($p = 0.5059$), as well as on the frequency ($p = 0.4654$) of treatments, is similar in the two study locations (Table 6).

6) Compliance with pre-harvest interval (PHI)

Regarding compliance with the PHI, 75.90% of respondents reported that they usually apply pesticides just after picking and shelling activities. The delay between the application of products and the harvesting of ripe pods can, therefore, extend over 2 to 3 weeks. On the other hand, 24.10% said they did not pay particular attention to the time between treatments and harvesting (Table 6). The attitude of producers concerning the respect of the PHI is not a function of locality according to the chi-2 test ($p = 0.3287$).

3.4. Harvest and Post-Harvest Operations

3.4.1. Harvesting

All the producers surveyed harvested the pods using machetes and pruners when they noticed that there was enough ripe fruit on the trees. Most (93.64%) cocoa farmers harvested only once a month, and only 6.36% reported harvesting twice a month. For some farmers, it was found that as they harvest, they or some of their family members put the pods in small piles, while for others, the pods are first picked from the whole field before being put in small piles. Subsequently, the pods are re-piled in three or four places in the plantation (depending on the area) for shelling. The time interval from the first day of harvest to the day of shelling varied from 3 days to more than 7 days with an overall average of 6.77 ±

Table 6. Proportions of cocoa farmers who are aware of the recommended timing and frequency of insecticide treatments for orchards and who respect the pre-harvest interval.

Location	Proportion (%) of cocoa farmers on recommended insecticide use					
	Known period		Known treatment frequency		Compliance with the PHI	
	NO	YES	NO	YES	Not Att	YES
Sérigbangan	58.14	41.86	58.14	41.86	15.38	84.62
Yaodankro	66.67	33.33	67.24	32.76	28.07	71.93
Global	63.00	37.00	63.37	36.63	24.10	75.90

PHI: pre-harvest interval; Not Att: producer not paying attention to the PHI after insecticide application.

2.24 days. About 32.73% of the producers reported that they perform harvest to shelling activities generally within 3 - 5 days, 40% perform them within 6 - 7 days, and 27.27% go beyond 7 days before shelling. The chi-square test of independence ($p = 0.042$) shows that this time frame varies from one locality to another (Table 7).

3.4.2. Shelling

A mini machete called a "shelling knife" is unanimously mentioned by the producers as the equipment used to open the pods. During the interview, they stated that they never use any other tool than the shelling knife to perform this operation. The producers do not detach the beans from the placentas during shelling. Regarding the separation of healthy pods from those in poor condition (fresh pods blackened or in a state of blackening and/or pods broken during harvesting), the farmers said that shelling is done without distinguishing the condition of the piled pods. However, they specify that during the operation, if the contents of a pod are not at all good (the case of mummified pods, beans that have germinated too much, or pods that have been badly attacked by insects causing total or almost total abortion of the beans), then the latter is thrown away with its contents. In Sérigbangan, during the operation, the beans are first placed in small baskets and then spilled onto a black plastic tarp after these containers are filled. In contrast, in Yaodankro, almost all producers use empty fertilizer bags (50 kg) as containers for the beans during shelling and for fermentation of the beans (Figure 5).

Table 7. Timing of harvesting-shelling activities of surveyed producers.

Harvest time to shelling	Proportion (%) of surveyed producers		
	Global	Sérigbangan	Yaodankro
[3 to 5 days]	32.73	39.53	28.36
[6 to 7 days]	40.00	46.51	35.82
>7 days	27.27	13.95	35.82

Figure 5. Fermenting cocoa beans in bags at Yaodankro (Méagui).

3.4.3. Fermentation

Four techniques for fermenting the beans are overall applied by the cocoa farmers in the localities surveyed. These are fermentation on a bed of banana leaves, used by only 6.36% of producers; fermentation on a bed of black plastic tarp, used by 32.72% of respondents; fermentation in bags only, used by 19.09% of producers; and fermentation in bags and then on a bed of black plastic sheeting. Regarding this last method of fermentation, 41.82% of farmers interviewed said that after shelling, the beans remain in bags, and the day before or two days before they are put in the sun, they are tipped in a heap on the tarp and covered by it. Only in Yaodankro was fermentation in the bags noted, and the use of banana leaves was noted only in Sérigbangan (Table 8). For the duration of fermentation, 65.45% of the producers let 3 to 5 days pass before putting the beans in the sun. Twenty-four-point fifty-five percent (24.55%) reported 5 to 6 days of fermentation, and 10% reported 2 to 3 days of fermentation. The statistical test revealed that this fermentation time depends significantly ($p = 0.0003091$) on the locations (Table 9). No stirring is done by producers when the beans are fermenting, and prior removal of placentas is not done before fermentation but rather on the first and/or second day of drying.

3.4.4. Drying

The only drying method used by producers is sun drying, which varies from 4 days to more than 7 days depending on the time of year. Nearly half (50.91%) of the respondents stated that they usually dry cocoa for 5 to 6 days; 21.82% do so for 4 to 5 days and 27.27% indicated that they do 6 to 7 days of drying. However, farmers indicated that during periods of low sunlight, cocoa is exposed to the sun for more than 7 days. The chi-square test indicated that the proportion of

Table 8. Cocoa fermentation techniques used by the producers surveyed.

Fermentation support	Proportion (%) of producers interviewed		
	Global	Sérigbangan	Yaodankro
Black tarp	32.73	83.72	0.00
Banana leaves	6.36	16.28	0.00
Empty fertilizer bags	19.09	0.00	31.34
Bags then black tarp	41.82	0.00	68.66

Table 9. Fermentation and drying time for cocoa applied by the producers surveyed.

Location	Proportion (%) of producers interviewed					
	Days (d) of fermentation			Days (d) of drying		
	2 to 3 d	3 to 5 d	5 to 6 d	4 to 5 d	5 to 6 d	6 to 7 d
Sérigbangan	4.65	51.16	44.19	9.30	74.42	16.28
Yaodankro	13.43	74.63	11.94	29.85	35.82	34.33
Global	10.00	65.45	24.55	21.82	50.91	27.27

Figure 6. Cocoa beans p spread out in the sun on the black plastic tarps on the ground.

farmers observing these times varied significantly (p = 0.0003595) across localities (**Table 9**). As a drying medium, almost all (91.82%) of the producers interviewed dry cocoa on black plastic tarps installed on the ground (**Figure 6**); 3.64% do so on cemented areas and 4.55% use trailer tarps. At sunset (and in case of rain) during the drying days, the beans are piled up and covered with black tarps.

3.4.5. Storage

On the last day of drying, the dried beans are put in bags and transferred to the store by the tracker or stored for a few days at the producer's place waiting for the arrival of the buyer (tracker or cooperative).

4. Discussion

Most current cocoa farmers in the Méagui area have inherited their plantations. Many are young people between the ages of 20 and 35 years old and adults between 36 and 45 years old. However, most plantations are old orchards that are 30 to 40 years old. This means that there is likely to be a turnover in the age class of producers without significant renewal of cocoa farms, which would have taken off in the 1970s to 1980s [4]. The decrease in the labor force or the death of the first plantation owners could explain the succession of the latter by the current plantation owners [15] [38]. In the locality of Sérigbangan (in the unclassified zone), most cocoa plantations are old orchards over 40 years old, and no plantations under 30 years old were recorded, while in Yaodankro (in the infiltrated classified zone), old (over 40 years old) and young (10 to 20 years old) orchards were recorded. This implies that the so-called classified area has not only been infiltrated for several decades but also that the remaining portions of the forests probably continue to be subject to conversion to cocoa farms. According to Koné [3], the current pockets of deforestation in Côte d'Ivoire, largely due to agriculture (led by cocoa farming), are in the classified forests, where the annual rate of deforestation was 3% over the period 1990-2000 and 4.2% over the period 2000-2015. Koné [3] and Higonnet *et al.* [2] report that 40% of Côte d'Ivoire's cocoa production would come from protected areas. This reinforces

the idea that the continued performance of Ivorian cocoa production is primarily linked to the advance of pioneer fronts at the expense of the last classified forests in the west of the country [1] [4].

Two types of weeding (manual and herbicide) are carried out by cocoa farmers in Méagui, the vast majority of whom alternate these two maintenance operations, which is in line with the recommendation made by the state regulatory body for the coffee and cocoa sector in Côte d'Ivoire [31]. As for the frequency of this weeding operation, while three to four passes are recommended annually [30] [31], it should be noted that not all the producers interviewed follow, this last recommendation. Those who do not manage to properly weed their plantation justified it mainly by the lack of financial means and the decrease in family labor. Another reason given by these farmers is that they are involved in other field activities in addition to cocoa production during the year, in particular subsistence crops such as rice and yams. These different field activities were indeed noted in 2010 by Tano [39].

Three morphotypes of insect pests, namely the capsids *Sahlbergella singularis* and *Distantiella theobromae*, the cocoa mosquito *Helopeltis* sp., and the green stink bug *Bathycoelia thalassina*, are named by producers as the most damaging insects in their plantations. The last two pests are observed much more by cocoa farmers in Yaodankro. The observations of farmers in the area are consistent with those of Guessan-Bi *et al*. [40] who found a significant and continuous abundance of these three types of pests in the same localities. These authors, building on previous work by other researchers, largely explained that local environmental and trophic factors favorable to the development and maintenance of these species would be the cause of their permanent and abundant presence in the said localities. The explanation given by producers, especially those in Yaodankro, is their proximity to the forest (Taï National Park), which is a reservoir for these insects. Some of the Yaodankro respondents also believe that the use of chicken droppings as fertilizer in their fields is also the reason for the high presence of insect pests. They believe that the application of chicken droppings (as organic fertilizer) in cocoa orchards is a factor that attracts insects to the plantations. They are not the first and only ones to make this assertion because, in other cocoa localities where chicken droppings are used to fertilize cocoa trees, producers have reported this [41].

With regard to pathological diseases of the cocoa tree, the presence of swollen shoot disease is much more frequently mentioned than pod rot in the localities surveyed. This is contrary to the observations of Koua *et al*. [15] who noted the greater presence of pod rot symptoms than swollen shoot in the departments of Abengourou, Divo, and Soubré. Cocoa farmers in the Méagui localities surveyed expressed concern about the degradation and progressive destruction of their orchards. They attributed this in part to the swollen shoot virus disease of the cocoa tree, in addition to the hypothesis of the aging of the orchards and other factors such as the state of the soil, the increase in temperature, and the intensi-

fication of the dry seasons. This state of degradation of the orchards and the lack of suppression of the pod rot dis-ease no doubt explains why most producers in the localities surveyed do not/no longer carry out maintenance pruning of their plantations.

This study also reveals that chemical insecticides are used by a very large number of cocoa farmers in the Méagui localities where the survey was conducted. This result agrees with the results of Siapo *et al*. [38] and Ano *et al*. [42] who noted in some localities of Daloa and Abengourou, high proportions of cocoa farmers who use chemical pest control in cocoa farms. This does not seem to be the case in other localities of Abengourou, Divo, and Soubré where Koua *et al*. [15] noted a low proportion of cocoa farmers who treat their plantations with insecticides. The annual frequency of insecticide treatments prescribed as "the norm" is two to four applications [31]. In the localities surveyed, this norm is not respected by most cocoa farmers. The majority would carry out more than six insecticide treatments annually, with an average dose of 1.06 liters of product per hectare. This dose is practically double that generally prescribed on the labels of cocoa insecticides authorized in Côte d'Ivoire. Most of the insecticides identified during the survey consist of two active ingredients. The intensive use of these agrochemicals was justified by growers by the continuous and intensive presence of insect pests, notably cocoa mosquitoes, and green bugs, on their plantations. Some growers felt that the action/effect of the insecticides they used would be short-lived (low remanence) and that they would have to make repeated treatments to hope for a good cocoa harvest. In view of the above, could we not also put forward the hypothesis that the target pests would develop resistance mechanisms [43] [44] to avoid frequent treatment of orchards in this area? It is possible that due to the repeated use of insecticides over several years, some insects have become resistant to the frequently used chemicals. Insects are indeed known to easily develop resistance to insecticides when exposed to a specific chemical for long periods of time or if the pest can multiply rapidly [43]. It should be noted, however, that while not following the recommendations on insecticide use, the farmers surveyed still observe the pre-harvest interval (PHI) of products, which is generally two weeks for insecticides recommended for cocoa farming.

Cocoa farmers in the surveyed area harvest cocoa once a month, as opposed to the two monthly harvests that are generally recommended in the guides to good harvesting practices and post-harvest cocoa operations [31] [45] [46] [47]. Ruf *et al*. [33] estimate that it is impossible for a plantation of more than one hectare to carry out two harvests per month, given that for one hectare, the operations from harvesting to the sale of dried beans require 17 to 18 days. The duration (three to seven days) of work from harvesting to shelling observed by most cocoa farmers in Méagui is in line with the recommended timeframe. However, instead of the club being recommended as a shelling tool, all producers in the zone use mini machetes (shelling knives) to carry out this activity. They do not

detach the beans from the placentas, but everything remains in the bean pile until the end of fermentation, which is not in accordance with the recommendation. Some producers explained that, if the separation of beans from placentas during shelling was possible in the past, it was because the shellers were accompanied by their wives and/or one of their young children. It was, therefore, the latter who took charge of this action while the men were content to open and extract the contents of the pods in blocs.

Fermentation in black plastic tarps (in Sérigbangan) and in empty bags of fertilizer (in Yaodankro) is carried out by the producers. Producers justified their practice by the difficulty of currently having banana leaves, one of the recommended fermentation materials [31] [45] [46] [47]. The use of black plastic tarps by producers to ferment beans was also revealed by OIT [30] who also provided the same justification. In addition, the fermentation time observed by producers varies from two to six days, while six full days are recommended for good fermentation of cocoa in Côte d'Ivoire. According to OIT [30], producers who do not ferment cocoa or who do so within a period (one to two days) are those who, for financial reasons, wish to sell their cocoa quickly.

The non-compliance of the conditions of use of pesticides in plantations and post-harvest cocoa operations with the prescribed standard norms is more remarkable in Yaodankro, a locality located in the classified area of Méagui. Several reasons, including ignorance of these standards and the absence/lack of motivation on the part of producers to apply these standards, could explain this fact. In fact, according to their testimony, some producers indicated that they did not benefit from monitoring, or the premiums provided for cocoa farmers because of the "classified zone" label attributed to their geographic location. This would demotivate producers in terms of applying the rules of "good agricultural practice" [4] [41].

It is reported that 40% of Ivorian cocoa production comes from infiltrated classified forests. Given the importance of insect pests as well as the phytosanitary and post-harvest practices of cocoa producers in Yaodankro, one might wonder whether the observations made in this locality are an isolated case, or whether this locality is like other cocoa-producing localities that have been clandestinely established in classified forests and protected areas in the country.

5. Conclusion

This study shows that cocoa orchards in the Méagui zone are quite aging, and their owners are mostly young and young-adult heirs. The pests of greatest concern in this area are the cocoa swollen shoot virus disease and the insects *Bathycoelia thalassina*, the cocoa mosquito *Helopeltis* sp., and the capsids *Sahlbergella singularis* and *Distantiella theobromae*. The control of these insects is done mainly by the intensive use of chemical insecticides by most producers. The manner in which these pesticides are used does not conform to recommended norms of phytosanitary practice in cocoa farming. Furthermore, the practices of producers, re-

lating to cocoa harvesting and post-harvest treatment operations for the most part, are not in line with those recommended. These practices (phytosanitary and post-harvest) of farmers who do not respect the prescribed norms are particularly accentuated in the locality of Yaodankro, a cocoa-growing locality that has been established illegally in a classified forest area of the country.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Ruf, F. and Kiendré, J. (2016) L'innovation "fiente de poulet" dans les cacaoyères: Réseaux familiaux et migratoires en Côte d'Ivoire. Inter-Réseaux, 14 p. https://www.researchgate.net/publication/296331081_L'innovation_fiente_de_poulet_dans_les_cacaoyeres_1_Reseaux_familiaux_et_migratoires_en_Cote_d'Ivoire

[2] Higonnet, E., Bellantonio, M. and Hurowitz, G. (2017) Chocolate's Dark Secret. How the Cocoa Industry Destroys National Parks. 24 p. http://www.mightyearth.org/wp-content/uploads/2017/09/chocolates_dark_secret_english_web.pdf

[3] Koné, A. (2018) Les émissions liées à l'UTCATF et la disparition des forêts: Une situation toujours aussi dramatique. 13 p. https://www.climate-chance.org/wp-content/uploads/2018/12/fp17-utcatf-cote-divoire_def.pdf

[4] Ruf, F., Uribe-Leitz, E., Gboko, C., Kla, A.G. and Konan, A. (2018) L'innovation "coopératives cacao" en Côte d'Ivoire: Entre mythes et dynamiques. 15 p. https://agritrop.cirad.fr/591043/

[5] ICCO (2018) Quarterly Bulletin of Cocoa Statistics, Vol. XLIV, No. 4, Cocoa Year 2017/18. https://www.icco.org/app/statistics/

[6] ICCO (2019) Quarterly Bulletin of Cocoa Statistics, Vol. XLV, No. 4, Cocoa Year 2018/19. https://www.icco.org/app/statistics/

[7] ICCO (2020) Quarterly Bulletin of Cocoa Statistics, Vol. XLV, No. 4, Cocoa Year 2019/20. https://www.icco.org/app/statistics/

[8] ICCO (2021) Quarterly Bulletin of Cocoa Statistics, Vol. XLV, No. 4, Cocoa Year 2020/21. https://www.icco.org/app/statistics/

[9] ICCO (2022) Quarterly Bulletin of Cocoa Statistics, Vol. XLV, No. 4, Cocoa Year 2021/22. https://www.icco.org/app/statistics/

[10] ICCO (2023) Quarterly Bulletin of Cocoa Statistics, Vol. XLIX, No.2, Cocoa Year 2022/23. https://www.icco.org/app/statistics/

[11] BASIC (2016) La face cachée du chocolat: Une comparaison des goûts sociaux et environnementaux des filières conventionnelles, durables et équitables du cacao. 110 p.

[12] Vroh, B.T.A., Abrou, N.E.J., Gone Bi, Z.B. and Adou Yao, C.Y. (2019) Système agroforestier à cacaoyers en Côte d'Ivoire: Connaissances existantes et besoins de recherche pour une production durable. *Revue Marocaine des Sciences Agronomique et Vétérinaires*, **7**, 99-109.

[13] Conseil du Café-Cacao (2017) Evolution de la filière café-cacao de 2012 à 2017. 4ème Edition des Journées Nationales du Cacao et du Chocolat (JNCC), Abidjan, 60 p.

https://fr.readkong.com/page/volution-de-la-fili-re-caf-cacao-de-2012-2017-5212084?p=3

[14] Tahi, G.M., Aka, A.R., N'Guessan, W.P., N'Guessan, K.F., Kouakou, K., Assiri, A.A. and Tahouo, O. (2017) Le point sur la lutte contre la maladie du swollen shoot du cacaoyer en Côte d'Ivoire. Centre National de Recherche Agronomique, Le CNRA, Abidjan, 7 p.

[15] Koua, S.H., Coulibaly, N.A.M.-D. and Alloueboraud, W.A.M. (2018) Caractérisation vergers et des maladies de cacao de la Côte d'Ivoire: Cas des départements d'Abengourou, Divo et Soubré. *Journal of Animal & Plant Sciences*, **35**, 5706-5714.

[16] Banque Mondale (2019) Situation économique en côte d'ivoire, au pays du cacao: Comment transformer la côte d'ivoire. 61 p. https://documents1.worldbank.org/curated/en/277191561741906355/pdf/Cote-dIvoire-Economic-Update.pdf

[17] Adu-Acheampong, R., Jiggins, J., Huis, A.V., Cudjoe, A.R., Johnson, V., Sakyi-Dawson, O., *et al*. (2014) The *Cocoa mirid* (Hemiptera: Miridae) Problem: Evidence to Support New Recommendations on the Timing of Insecticide Application on Cocoa in Ghana. *International Journal of Tropical Insect Science*, **34**, 58-71. https://doi.org/10.1017/S1742758413000441

[18] N'Guessan, A.H., N'Guessan, K.F., Kouamé, N.N., Kouassi, K.P. and N'Guessan, W.P. (2016) Distribution géographique et importance des dégâts de foreurs des tiges dans le verger de cacaoyers de Côte d'Ivoire. *Journal of Animal &Plant Sciences*, **27**, 4282-4292.

[19] Mahob, R.J., Etam, P.B.N., Dibog, L., Babin, R., Voula, A.V., Begoude, D., *et al*. (2018) Assessment of the Effect of Cocoa Mosquito Mirid True Bug, *Helopeltis* sp. (Hemiptera: Miridae) on the Cocoa (*Theobroma cacao* L.) Production in Cameroon (Central Africa). *International Journal of Biological and Chemical Sciences*, **12**, 1865-1875. https://doi.org/10.4314/ijbcs.v12i4.27

[20] Ndoungue, M.M.D. (2020) Origine et modes de dispersion des épidémies dues à *Phytophthora megakarya* dans les systèmes de cacaoculture innovants au Cameroun. Ph.D. Thesis, Université de Montpellier SupAgro, Montpellier, 192 p. https://theses.hal.science/tel-04075964v1/document

[21] Ouattara, A. (2020) Isolement et sélection de bactéries endophytes natives du cacaoyer (*Theobroma cacao* L.) efficientes dans le biocontrôle de *Phytophthora* spp., agent causal de la pourriture brune des cabosses. Ph.D. Thesis, Université Jean Lorougnon Guede, Daloa, 232 p. https://hdl.handle.net/20.500.12177/4012

[22] Kouakou, K., Kébé, B.I., Kouassi, N., Anno, A.P., Aké, S. and Muller, E. (2011) Impact de la maladie virale du swollen shoot du cacaoyer sur la production de cacao en milieu paysan à Bazré (Côte d'Ivoire). *Journal of Applied Biosciences*, **43**, 2947-2957.

[23] Kouakou, K., Kébé, B.I., Kouassi, N., Aké, S., Cilas, C. and Muller, E. (2012) Geographical Distribution of *Cacao swollen shoot virus* Molecular Variability in Côte d'Ivoire. *Plant Disease*, **96**, 1445-1450. https://doi.org/10.1094/PDIS-09-11-0749-RE

[24] Tra Bi, C.S. (2013) Diversité spécifique et dégâts des termites dans les cacaoyères (*Theobroma cacao* L., 1753) de la région d'Oumé en Côte d'Ivoire. Ph.D. Thesis, Université Félix Houphouët-Boigny, Abidjan, 287 p.

[25] Kouamé, N.N., N'Guessan, F.K., N'Guessan, H.A., N'Guessan, P.W. and Tano, Y. (2014) Variations saisonnières des populations de mirides du cacaoyer dans la région de l'Indénié-Djuablin en Côte d'Ivoire. *Journal of Applied Biosciences*, **83**, 7595-7605. https://doi.org/10.4314/jab.v83i1.2

[26] Kouamé, N.N., N'Guessan, F.K., N'Guessan, H.A., N'Guessan, P.W. and Tano, Y. (2015) Variations saisonnières des populations de mirides du cacaoyer dans la région du Haut-Sassandra en Côte d'Ivoire. *Journal of Animal & Plant Sciences*, **25**, 3787-3798.

[27] Aka, R.A., Coulibaly, K., N'guessan, W.P., Kouakou, K., Tahi, G.M., N'guessan, K.F., *et al*. (2020) Cocoa Swollen Shoot Disease in Côte Ivoire: History of Expansion from 2008 to 2016. *International Journal of Sciences*, **9**, 52-60. https://doi.org/10.18483/ijSci.2203

[28] Abouo, N.V. (2016) Étude comparative de deux techniques de séchage: Solaire et Micro-onde des fèves fermentées de cacao (*Theobroma cacao* L.). Ph.D. Thesis, Université Nangui Abrogoua, Abidjan, 126 p.

[29] Barel, M. (2013) Qualité du cacao: L'Impact du traitement post-récolte. Edition Quae, Versailles, 107 p.

[30] OIT (2013) Manuel du producteur relais sur les techniques d'accroissement de la productivité du cacao. Organisation Internationale du Travail (OIT), Genève, 110 p. https://www.ilo.org/ipecinfo/product/download.do?type=document&id=26155

[31] Konan, A., Yaméogo, I., Assiri, A.A., Ehougban, V., Pokou, Y., Kouamé, J. and Tanoé, R. (2015) Manuel technique de cacaoculture durable: A l'attention du technicien. 165 p. http://www.conseilcafecacao.ci/docs/2016/MANUEL_CACAOCULTURE_040415.pdf

[32] N'Guessan, W.P., N'Guessan, K.F., Aka, A.R., Assiri, A.A., Kébé, B.I. and Tahi, G.M. (2016) Bien lutter contre les insectes nuisibles du cacaoyer en Côte d'Ivoire. 4 p. https://cnra.ci/download/bien-lutter-contre-les-insectes-nuisibles-du-cacaoyer-en-cote-divoire/

[33] Ruf, F., N'Dao, Y. and Lemeilleur, S. (2013) Certification du cacao, stratégie à hauts risques. Inter-Réseaux Développement Rural, 7 p. https://www.inter-reseaux.org/wp-content/uploads/Certification_du_cacao_Ruf_juin2013.pdf

[34] Dufumier, M. (2016) L'adaptation de la cacao-culture ivoirienne au dérèglement climatique: L'agroécologie pourrait-elle être une solution? Plate-Forme pour le Commerce Equitable. Rapport de Mission, 16 p.

[35] Ouattara, A.A., Krouba, G.I.D., Kouakou, A.C.A., Adopo, A.A.I.R., Fauret, P., Coulibaly, B., *et al*. (2018) Pression anthropique et dynamique paysagère en zone de forêt ivoirienne dans la région de Méagui. *Tropiculturea*, **36**, 183-194.

[36] Danho, M., Bini, K.N.K., Adja, N.A., Gnago, A.J. and Akamou, F. (2014) Efficacité des néonicotinoïdes et des pyréthrinoïdes utilisés contre le foreur des tiges du cacaoyer (*Eulophonotus myrmeleon* Felder: Lepidoptera, Cossidae). Implications dans la stratégie de protection de la cacaoculture en Côte d'Ivoire. *International Journal of Biological and Chemical Sciences*, **8**, 459-467. https://doi.org/10.4314/ijbcs.v8i2.6

[37] Conseil Régional de la NAWA (2019) La NAWA: Le guide des potentiels à découvrir. 48 p. https://pdfslide.net/documents/le-guide-des-potentiels-la-nawa.html?page=1

[38] Siapo, Y.M., Tahiri, A., Ano, E.J. and Diby, Y.K.S. (2018) Évaluation Des Pratiques Phytosanitaires Paysannes Dans Les Vergers De Cacao Dans Le Departement De Daloa, Côte d'Ivoire. *European Scientific Journal*, **14**, 267-208. https://doi.org/10.19044/esj.2018.v14n33p267

[39] Tano, A.M. (2012) Crise cacaoyère et stratégies des producteurs de la sous-préfecture de Meadji au sud-ouest ivoirien. Ph.D. Thesis, Université Toulouse le Mirail-Toulouse

II, Toulouse, 261 p.

[40] Guessan-Bi, T.K., Kouamé, K.L., Kwadjo, K.É., Kra, K.D. and Doumbia, M. (2022) Abundance and Dynamics of the Main Heteroptera Pests of Cocoa Tree in the Orchards of the Department of Méagui (South-West, Côte d'Ivoire). *Journal of Agricultural Science*, **14**, 40-49. https://doi.org/10.5539/jas.v14n8p40

[41] Ruf, F., Kla, A.G., Dja, K. and Kiendré, J. (2015) Chicken Manure in the Cocoa Plantations of Côte d'Ivoire. An Agroecological and Social Revolution, a 'Frugal' Village Innovation. 23 p. https://www.researchgate.net/publication/285055054_Chicken_manure_in_the_cocoa_plantations_of_Cote_d'Ivoire_An_agro-ecological_and_social_revolution_a_'frugal'_village_innovation

[42] Ano, E.J., Tahiri, A., Diby, Y.K.S. and Siapo, Y.M. (2018) Évaluation des pratiques phytosanitaires paysannes dans les cacaoyères: Cas du département d'Abengourou (Est, Côte d'Ivoire). *Journal of Animal & Plant Sciences*, **38**, 6159-6174.

[43] FAO (2012) Code international de conduite pour la distribution et l'utilisation des pesticides: Directives pour la prévention et la gestion de la résistance aux pesticides. Food and Agriculture Organization, Rome, 68 p.

[44] CSAN Niger (2017) Classification des pesticides et des acaricides selon le mode d'action. IPMnote, Vol. 1, 8 p. https://www.csan-niger.com/wp-content/uploads/2017/08/Pesticides-Mode-of-Action-Scheme.pdf

[45] Amani, C. (2014) Cacao: Obtenir des fèves de qualité. Agroivoire, 23 p. https://agroivoire.files.wordpress.com/2014/09/cacaoobtenir-des-https://agroivoire.files.wordpress.com/2014/09/cacaoobtenir-des-fc3a8ves-de-qualitc3a9s.pdf-de-qualitc3a9s.pdf

[46] Initiative Cacao et Forêts (2018) Initiative Cacao et Forêt. Plan de mise en œuvre des activités du cadre d'action commune 2018-2020, République de Côte d'Ivoire. Initiative Cacao et Forêts, Abidjan, 24 p.

[47] N'guessan Kouassi, G. (2020) Manuels de bonnes pratiques applicables aux filières du cacao, de l'anacarde et du coton: Exigences liées aux mesures sanitaires et phytosanitaires à l'exportation. CUTS International, Geneva, 145 p.