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Analysis of the Use of Phytosanitery Producsts in Vegetable Crops in the District of Abidjan, Côte d'Ivore

Anne-Edwige Coulibaly
Gilles Alex Pakora
Biology and Health Laboratory, UFR Biosciences, University of Félix Houphouët-Boigny d'Abidjan (UFHB),Abidjan, Ivory Coast
Ler-N'Ogn Dadé Georges Elisée Amari
Biotechnology Laboratory, Agriculture and Biological Resources Development, UFR Biosciences, University of Félix Houphouët-Boigny d'Abidjan (UFHB), Abidjan, Ivory Coast
Ako Aristide Berenger Ako
Department of Parasitology and Mycology, Institut Pasteur of Ivory Coast
Joseph Allico Djaman
Biology and Health Laboratory, UFR Biosciences, University of Félix Houphouët-Boigny d'Abidjan (UFHB), Abidjan, Ivory Coast

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Abstract

The development of vegetable crops contributes to the food security of populations while reducing the problems of unemployment. However, these crops are subject to many pests that cause quantitative and qualitative damage to crops. To improve their yield, most market gardeners resort to the use of phytosanitary products. In order to take stock of the use of these products in the fight against pathogens of vegetable crops in the district of Abidjan, Côte d'Ivoire, a survey was carried out from January to February 2018 among 33 producers in the communes of Cocody and Port-Bouët. Twenty-seven pesticide trade names divided into 8 different families were identified. The majority of pesticides used were insecticides (53%) followed by fungicides (25%). Seventy-five percent (75%) of market gardeners were aware of the risk of pesticide toxicity, however 53% of market gardeners did

not use any means of protection during pesticide spraying. These bad practices jeopardize their health, that of consumers and the environment. It is therefore important to train and educate market gardeners on phytosanitary products and to provide them with adequate protective equipment.

Keywords: Chemical pesticides, vegetable crops, phytosanitary practice

Introduction

Over the past two decades, following rapid urbanization and high economic concentration, agriculture has developed significantly in urban and peri-urban areas of West Africa (Koffi et al. 2012). This is the case of vegetable crops, which constitute one of the most dynamic agricultural sectors. Moreover, market gardening helps to reduce the problems of unemployment, particularly among women for whom this activity is a source of income.

Faced with the increased demand of populations in highly urbanized areas for fresh and good quality market gardening products, most market gardeners resort to the often abusive use of phytosanitary products in order to improve their yield and the marketability of the products (Soro et al. 2018). Indeed, these crops are subject to many pests which are the cause of quantitative damage, but also qualitative damage (alteration of the product). The immediate effectiveness of these synthetic pesticides makes producers neglect the health and environmental risks associated with their use (Yarou et al. 2017). Indeed, the use of pesticides is often massive, which generates widespread pollution of ecosystems. In addition, several pathologies are likely to be associated with pesticides in the long term (cancer, sterility, congenital malformations, mental deficiencies, neurological and reproductive disorders) **(**Multigner, 2005; Boithias et al. 2011; Diop**,** 2013). This study proposes to make an inventory of the use of phytosanitary products in the fight against pathogens of market gardening in Ivory Coast, in the district of Abidjan.

Methods

Study zone

This survey lasted one month (08 January 2018 to 10 February 2018). It was carried out in three (03) market gardening areas in the district of Abidjan, Ivory Coast. The sites were located in the communes of Cocody (2 sites: M'Badon and M'Pouto) and Port-Bouët (one site) (Figure 1).

Survey methodology

The study population consisted of market gardeners. A questionnaire was developed and divided into two sections: the first section concerned the

age, sex and level of education of market gardeners. The second section was related to the control practices by the chemical pesticides used, the frequencies, the doses of application and the protective measures used by the producers.

Data analysis

The survey data were entered into the Excel® 2016 software. A chi-square test of quality of adjustment was carried out to compare the distribution of men and women in market gardening in Abidjan and also compare the level of education of different market gardeners.

A chi-square test of independence was carried out to establish a relationship between the farming method and the sex of the market gardeners on the one hand and on the other hand between the knowledge of the risk linked to the use of pesticides and the means of protection market gardeners.

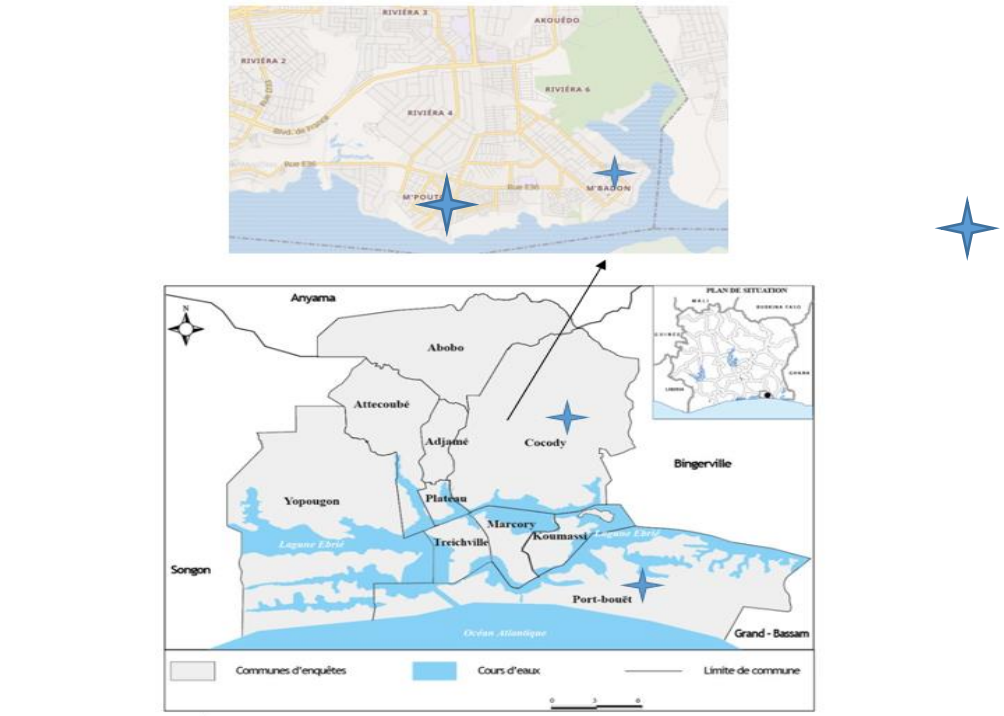

Figure 1: Location market gardening areas in the district of Abidjan, Ivory Coast

Results

Socio-demographic characteristics of market gardeners

A total of 39 market gardeners were surveyed in 2 communes in the district of Abidjan, namely the communes of Port-Bouët and Cocody

(M'Badon and M'Pouto). The proportion of respondents was 33% or 13 market gardeners per site.

About 74% of market gardeners were male. The frequency of observation (26%) of women was attributable to the M'Pouto site, which alone included 90% of the women questioned for all the sites.
These market gardeners were all of Burkinabe nationality (a country bordering Côte d'Ivoire) with a very low level of education, i.e., 74% of market gardeners with no schooling. Among those who attend school, 15% have completed primary school and only 10% have reached secondary school (Table 1).

The distribution of market gardeners according to age showed that the age group of market gardeners varied between 19 and 68 years. Among these producers, 62% were between 19 and 45 years old and 28% were over 45 years old (Table 2).

Vegetable crops practiced

The distribution of vegetables is presented in **Table 3** and **Table 4**. Eight cultivated species have been identified. These are leafy greens (lettuce, spinach, mint, and parsley), fruiting vegetables (okra, eggplant,) and bulb vegetables (onion and turnip).

Lettuce was the main vegetable grown on the M'Badon and M'Pouto sites, with 100% and 92% of vegetable production respectively. As for the Port-Bouët area, mint was the main crop observed with 69% of production, followed by lettuce with 38% of production. In terms of fruit vegetables, low production was noted, with respectively 10% and 9% production of eggplant and okra for all sites.

The highest observation frequency was at the Port-Bouët site with 23% eggplant production and 15% okra. On the M'Pouto site, none of these vegetables were observed. Bulb vegetables were only grown on the M'badon and Port-Bouët sites with a frequency of 46% for spring onions in Port-Bouët and 54% for turnips in M'badon. Sixty-four percent (64%) of market gardeners practiced at least two different crops on their plot (Figure 2). Among market gardeners, the combination of more than three crops on the same plot was higher on the M'Badon site with 56% of market gardeners against 33% and 11% of market gardeners respectively on the sites of Port-Bouët and M'Pouto (Table 5). Sixty-nine percent (69%) of market gardeners at the M'Pouto site practiced monoculture compared to 31% at the M'Badon and Port-Bouët sites.

Ultimately, market garden crops were diversely cultivated, with a predominance of leafy vegetables (lettuce 81%, spinach 36%, mint 33%).

Bulb vegetables were poorly cultivated with 11% and 8% respectively for eggplant and okra.

Note that for the M'Pouto site, only leafy vegetables were grown with a predominance of lettuce (92%).

Table 1. Distribution (%) of the characteristics of market gardeners in the peri-urban area in the district of Abidjan

Characteristics	Distribution			
	M'Badon	M'Pouto	Port-Bouët	All sites
Sex				
Man	12 (92%)	4 (31%)	13 (100%)	29 (74%) **a**
Women	01 (8%)	9 (69%)	00 (00%)	10 (26%) **b**
Age				
15 to 25	04 (31%)	00 (00%)	01 (8%)	05 (13%)
25 to 35	04 (31%)	02 (15%)	04 (31%)	10 (26%)
35 to 45	02 (15%)	04 (31%)	03 (23%)	09 (23%)
> 45	02 (15%)	05 (39%)	04 (31%)	11 (28%)
ND	01 (8%)	02 (15%)	01 (8%)	04 (10%)
Nationality				
aboriginal	00 (00%)	00 (00%)	00 (00%)	00 (00%)
Foreigner	13 (100%)	13 (100%)	13(100%)	39 (100%)
Education level				
Unschooled	11 (85%)	10 (77%)	08 (62%)	29 (74%) **a**
Primary	00 (00%)	03 (23%)	03 (23%)	06 (15%) **b**
Secondary	02 (15%)	00 (00%)	02 (15%)	04 (10%) **c**
Superior	00 (00%)	00 (00%)	00 (00%)	00 (00%) d

With $\alpha = 0.05$ and 1 degree of freedom; a read chi-square of 3.841 against a calculated chi-square of 9.256, the frequency of observation of men is statistically different from that of women.

With $\alpha = 0.05$ and 1 degree of freedom; a read chi-square of 3.841 against calculated chi-squares above 3.841, the observation frequencies of the different levels of study are statistically different.

Table 2. Distribution of market gardeners according to age

Age range	Age	Effective	Percentage
19 to 30 years	19 ;21 ; 23 ;24 ; 25 ;25 ; 28 ;30	08	21%
31 to 45 years	32 ;33 ;33 ;34 ;34 ; 35 ; 35 ; 35 ; 38 ; 38 ; 39 ; 39 ;40 ; 40 ; 40 ;45	16	41%
>45	47 ; 47 ; 48 ; 48 ;50 ; 55 ; 56 ; 57 ; 65 ; 68 ; 68	11	28%

ND	04	10%
Total	39	100%

Table 3. Main vegetable crops observed on the production sites investigated

Production Sites	Cultures encountered (frequency of observation)							
	Lettuce	**Spinach**	**Mint**	**Parsley**	**Eggplant**	**Okra**	**Chives**	**Turnip**
M'Badon	100% 13 /13	54% 7/13	15% 2/13	46% 6/13	7% 1/13	7% 1/13	15% 2/13	54% 7/13
M'Pouto	92% 12/13	23% 3/13	15% 2/13	7% 1/13	00% 00/13	00% 00/13	0% 0/13	00% 00/13
Port-Bouët	38% 6/13	23% 3/13	69% 9/13	00% 00/13	23% 3/13	15% 2/13	46% 5/13	00% 00/13
TOTAL	79% 31/39	33% 13/39	33% 13/39	18% 7/39	10% 4/39	8% 3/39	18% 7/39	18% 7/39

Table 4. Nature of the vegetables grown on the production sites investigated

	Vegetables grown		
Production sites	**Leafy greens**	**Fruiting vegetables**	**Bulb vegetables**
M'Badon	Abundant dominated by lettuce	Low : eggplant, okra	Not abundant dominated by turnip
M'Pouto	Abundant dominated by lettuce	Absence	Low : chives
Port-Bouët	Abundant dominated by mint	Not abundant: eggplant, okra	Not abundant: chives, turnip

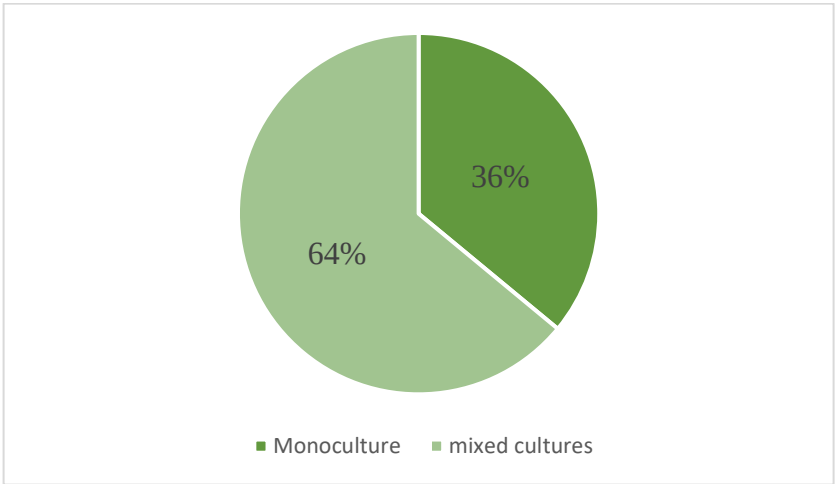

Figure 2. Distribution (%) of the farming method of market gardening on the sites studied

Table 5. Distribution (%) of the farming method according to the sites

Cultivation mode	Distribution							
	M'badon		M'pouto		Port-Bouët		Total	
	n	%	n	%	n	%	n	%
Monoculture	2	15	9	69	2	15	13	36
Association of 2 cultures	2	15	2	15	3	23	7	17
Association of 3 cultures	4	31	1	8	5	39	10	25
Association of more than 3 cultures	5	39	1	8	3	23	9	22
Total	13	100	13	100	13	100	39	100

Relationship between cropping method and gender of market gardeners

The results of the analyzes of the chi-square test of independence showed that the variables "cultivation mode" and "gender of market gardeners" were not related. The chi-square value with $\alpha = 0.05$ and one degree of freedom is 3.841, the calculated chi-square value is 3.03.

Use of pesticides in market gardening in Abidjan

The surveys identified 27 trade names of pesticides divided into 8 different families (Table 6). Carbamates are the most used (43.1%) followed by pyrethroids (32.6%), avermectin had an observation frequency of 10.5%. The organochlorine and organophosphate family was also observed (9.5%) (Figure 3).

The majority of pesticides used were insecticides (53%) followed by fungicides (25%). Insecticide-acaricide type formulations were also used (18%) (Figure 4).

Six of the pesticides listed were not approved for vegetable crops but for the most part approved for cotton crops. They were used by 13 market gardeners, including 7 market gardeners on the Port-Bouët site, 4 market gardeners on the M'Badon site and 2 market gardeners on the M'Pouto site. Apart from Stomp 455CS which is a herbicide from the Dinitroanilides family, the other pesticides were insecticides and belonged to the family of Organophosphates (Polytrine, Pyrical, Pyriforce 480), Organochlorines (Endocotton 375 EC) and Dinitroanilides (Duel CP 186).

In the different study areas, all market gardeners use backpack sprayers to spread phytosanitary products. These sprayers have a capacity of 15 liters. Application frequencies varied from one grower to another, but in the majority of cases, they are once a week.

Twelve market gardeners apply phytosanitary products twice a week compared to two market gardeners who use them in the event of disease (Figure 5).

The supply of phytosanitary products was done in 3 ways: direct supply on the production sites by itinerant merchants (44% of market gardeners), purchase in the various relay sales points (focal points of Callivoire, approved structure for marketing phytosanitary products) (47% of market gardeners) and purchasing from Callivoire (17% of market gardeners) (Figure 6).

Relationship between knowledge of the risk associated with the use of pesticides and the use of means of protection for market gardeners

The results of the analyzes of the chi-square test of independence showed that the variables "knowledge of the risk" and "use of means of protection" were not related.

The chi-square value with $\alpha = 0.05$ and one degree of freedom is 3.841, the calculated chi-square value is 2.68.

Table 6. List of phytosanitary products identified in market gardening in Abidjan

Trade names	Family	Nature	Number of times cited	Field of use
ALMANEB	Carbamate	Fungicide	2	Vegetable and food crops
BANCO PLUS	Organochloré-Carbamate	Fungicide	1	Vegetable crops
BOMEC 18 EC	Avermectine	Insecticide-acaricide	2	Vegetable crops
CALLIFERT	×	Foliar fertilizer	2	Vegetable crops
CALLIMAN	Carbamate	Insecticide	3	Vegetable crops
COTZEB 80 %	Carbamate	Fungicide	2	Tomato crops
CYPALM 50 EC	Pyréthrinoïde	Insecticide	1	Vegetable and food crops
CYPER MAX	Pyréthrinoïde	Insecticide	1	Vegetable and food crops
CYPERCAL 50 EC	Pyréthrinoïde	Insecticide	5	Tomato crops
DECIS 12 EC	Pyréthrinoïde	Insecticide	3	Tomato, green bean and okra crops
DUEL CP 186 EC	Dinitroanilide	Insecticide-acaricide	3	Cotton crops
ENDOCOTTON 375 EC	Organochloré	Insecticide-acaricide	2	Cotton crops
FURADENT	Carbamate	Insecticide-nématicides	1	Tomato crops

IVORY 80 WP	Carbamate	Fungicide	6	Tomato crops
KART 500 SP	Carbamate	Insecticide	14	Cabbage crops
K-OPTIMAL	Pyrétrinoïde +Néonicotinoïde	Insecticide	8	Tomato and cabbage crops
LAMBAD 2.5 EC	Pyréthrinoïde	Insecticide	7	Vegetable crops
LAMBDA POWER	Pyréthrinoïde	Insecticide	3	Vegetable and food crops
MANCOMAX 80 WP	Carbamate	Fungicide	5	Vegetable crops
MANCOZAN 80 WP	Carbamate	Fungicide	8	Vegetable crops
MPK-MIRACLE	×	Foliar fertilizer	1	Vegetable crops
POLYTRINE	Organophosphoré	Insecticide-acaricide	3	Cotton crops
PYRICAL	Organophosphoré	Insecticide	1	Wood
PYRIFORCE 480	Organophosphoré	Insecticide	2	Mango and pineapple crops
STOMP 455CS	Dinitroanilide	Herbicide	2	Rice and cotton crops
THRIMAX 35 EC	Pyréthrinoïde	Insecticide	3	Vegetable fruit and food crops
VERTIMEC 18 EC	Avermectine	Insecticide-acaricide	8	Fruit and vegetable crops (cabbage and tomato)

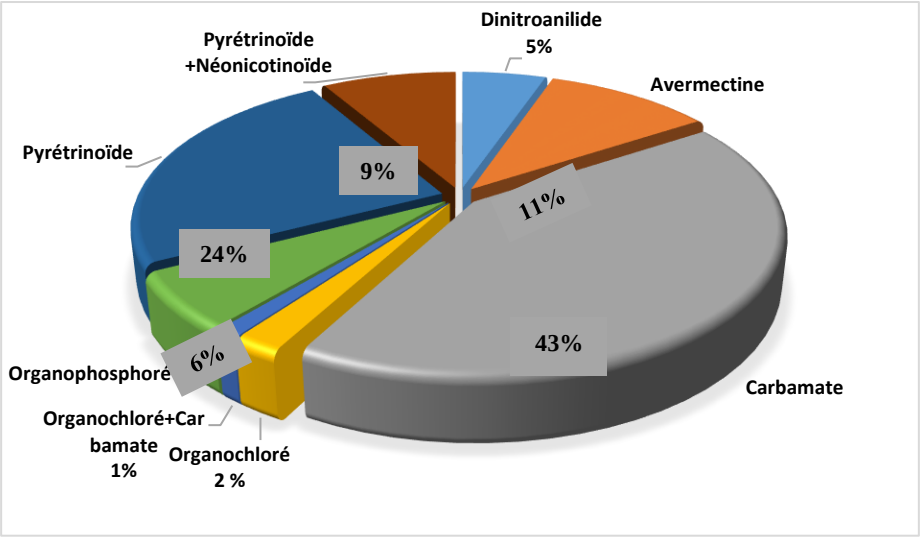

Figure 3. Family of pesticides used in market gardening in Abidjan

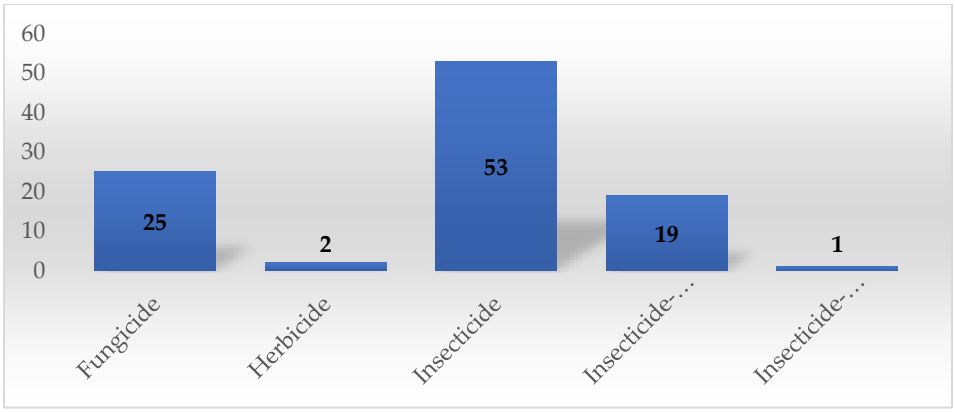

Figure 4. Nature of pesticides used in market gardening in Abidjan

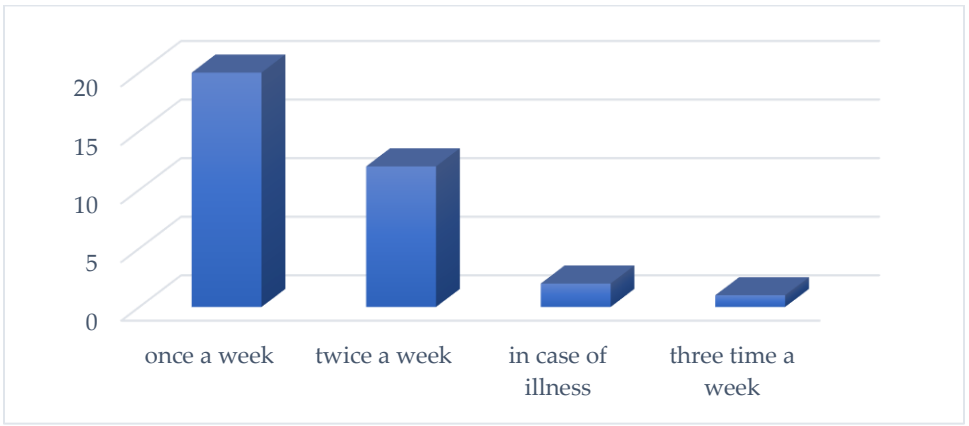

Figure 5. Frequency of pesticide use in market gardening in Abidjan

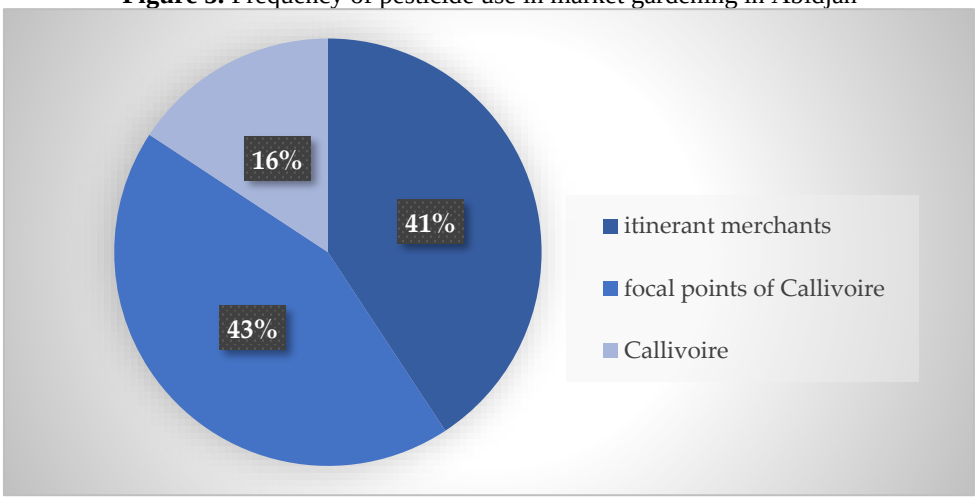

Figure 6. Mode of supply of phytosanitary products used in market gardening in Abidjan

Discussion

The socio-demographic survey carried out among market gardeners in the city of Abidjan reported a high percentage of male market gardeners for all the sites visited. This high proportion of men in market gardening could be explained by the fact that market gardening work requires a lot of physical effort that men have been empowered to deploy (Mondedji et al. 2015). Indeed, vegetable production requires a heavy irrigation practice dominated by manual work (Wognin et al. 2013). These results agree with those of Koffi et al. (2012) who observed a frequency of more than 80% of men in market gardening in Abidjan. In CI, this observation is not limited only to Abidjan, Fondio et al. (2011) and Son et al. (2017) have also observed it respectively in Bouaké and Burkina Faso.

The low representation of women in vegetable production can be explained by the fact that women were busy harvesting or collecting vegetables from production sites for sale in the various markets (Kpan et al. 2019).

The survey shows a low level of education among market gardeners in Abidjan. This observation was also made by Akesse et al. (2018) among pepper producers in Port-Bouët. This could be due to the fact that market gardening is an activity that does not require any particular skills (Wognin et al. 2013). Moreover, with an age between 19 and 68, this low schooling rate for market gardeners could be attributed to the fact that school was not compulsory in its time. The job search becoming more and more difficult, non-graduates are forced to opt for an occupation that does not require them to have a diploma. Thus, urban market gardening, which is part of the activities of the informal sector, constitutes a point of departure for these unskilled job seekers (Kpan et al. 2019). However, this illiteracy of market gardeners would contribute to increasing the risk of poisoning and environmental pollution. Indeed, not knowing how to read or write, most producers cannot understand the labels written in French, nor respect the instructions for use or even interpret the safety pictograms (Son et al. 2017). The speculations cultivated by market gardeners in Abidjan are diversified with an abundance of leafy vegetables. The predominance of leafy vegetables could be explained by the fact that most crops complete two to three cycles per year. Thus, farmers focus on the production of those that have a short rotation period (example, lettuce), they flow quite easily and are much appreciated by the population (Wognin et al. 2013**)**. This abundance of leafy vegetables is also found by Kanda et al. (2009) in Togo, with 53% of crops and by Loudit et al. (2017) in Gabon, with 62% of cultivated species.
The fact that market gardening is dominated by the cultivation of lettuce could be partly explained by the fact that the climate of Abidjan is favorable to the cultivation requirements of this leafy vegetable (Kouakou, 2009).

The association of crops combining a main vegetable crop and a secondary crop is a widespread practice among the vast majority of market gardeners. This situation is similar to those observed in central Côte d'Ivoire, particularly in Yamoussoukro and Bouaké and in northern Côte d'Ivoire in Korhogo (Soro et al. 2018; Fondio et al. 2011; Tano et al. 2011). Dugué et al. (2016) in Senegal have made the same observations and justify the choice of market gardeners by the scarcity of irrigable land due to the increase in the number of producers and the high cost of fertilizers, the prices of which are regularly increasing.

The pesticides listed during this survey belonged to 8 different families, of which carbamates and pyrethroids were the most widely used. These pesticide families, which are not very persistent in the environment, do not tend to bioaccumulate in the food chain. Moreover, with low toxicity, these families are increasingly recommended instead of organochlorines and organophosphates (Samuel et al. 2007). These results agree with those of Soro et al. (2018), Son et al. (2017) and Kpan et al. (2019) who also found that the active substances of this chemical family were the most used by market gardeners. It should be noted that some market gardeners use very toxic and very persistent products of the organophosphate and organochlorine family intended for the cultivation of cotton and other crops. They are poorly biodegradable and persistent in water, soil, and plants, hence a risk of environmental pollution (Viala, 1998); Benecke et al. 2004). This could constitute a danger for the applicators and the consumers since, unlike cotton, the majority of the crops encountered are consumed raw. The informal nature, the high level of illiteracy and the absence of training programs on good practices in urban farming could justify this use of unregistered pesticides in vegetable crops (Wognin et al. 2013**)**. Indeed, the use of pesticides requires a minimum of theoretical and practical knowledge to rule out any risk to human health and the environment (Kanda et al. 2013). In addition, for some market gardeners, organophosphates and organochlorines are more effective than those recommended for market gardening (Akesse et al. 2018).

The majority of pesticides used were insecticides (53%). This is probably due to the fact that vegetable crops are most often subject to attacks by insect pests (Soro et al. 2018). Our results confirm those of Son et al. (2017); Kpan et al. (2019), Loudit et al. (2017) and Tchamadeu et al. (2017) who studied the cultivation practices of market gardeners. These authors showed the highest level of insecticide use in Burkina Faso (73%), Abidjan (65.35%), Gabon (53%) and Cameroon (50%).

Seventy-five percent (75%) of market gardeners were aware of the risk of pesticide toxicity. This finding was observed by Mondedji et al. **(**2015**)** in Togo where 98.16% of market gardeners were aware of the

toxicity of synthetic pesticides. Despite their knowledge of the risk of synthetic pesticides, only 47% of market gardeners surveyed used at least one means of protection when spraying pesticides. As the main protective measure, 100% of producers consider the direction of the wind. To avoid receiving pesticide droplets in the face, producers position themselves in the direction of the wind. When the wind blows from east to west, they face east. We should also point out the non-compliance with international standards of the means of protection used by market gardeners. In fact, the latex gloves and mufflers used are not specially designed for phytosanitary treatment operations. As a result, farmers are not protected (Schiffers and Mar, 2011). The low purchasing power of market gardeners in their great majority could play a big role in the non-respect of good agricultural practice. Indeed, market gardeners who, despite their low level of education were aware of the long-term effects of agrochemicals, admitted that they did not have the financial means to acquire adequate protective equipment (Kpan et al. 2019). In addition to the high cost of protective equipment, some market gardeners claim that it is hot in the suits. In addition, wearing equipment wastes their time before applying chemical pesticides Akesse et al. (2018).

Conclusion

It appears from this study that market gardening in the district of Abidjan is dominated by men. In addition, market gardeners had a low level of education. The main crops encountered were lettuce and mint. The phytosanitary products used by market gardeners consist of insecticides and fungicides belonging to the family of carbamates and pyrethroids. These families of pesticides are not very toxic. However, some market gardeners use very toxic and very persistent products of the organophosphate and organochlorine family intended for crops other than market gardening. Market gardeners use phytosanitary products without adequate protection. This study reveals the need to train and educate market gardeners in the use of phytosanitary products. These poor practices jeopardize their health, that of consumers and the environment. It is therefore important to train market gardeners and make them aware of phytosanitary products and to provide them with adequate protective equipment. It would also be important to promote organic farming which requires a small amount of chemical inputs.

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Conflicts of Interests: The authors declare no conflict of interest.

Author contributions

This research was undertaken as part of Anne-Edwige Coulibaly's Doctor of Molecular and Functional Biology thesis. Joseph Allico Djaman is the promoter of this thesis. Anne-Edwige COULIBALY; Gilles Alex PAKORA, Georges Elisée AMARI; Aristide Berenger AKO and Joseph Allico DJAMAN conceived and designed the study plan. Edwige COULIBALY conducted sampling, analyzed the data, and wrote the initial manuscript. Joseph Allico DJAMAN and Gilles Alex PAKORA guided this study and provided revisions on the manuscript. Finally, all the authors have read and approved the final manuscript.

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