



## Human and Environmental Health Implications of Pesticide Utilization by Market Gardeners in the Western Highlands of Cameroon

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### Authors' contributions

This work was carried out in collaboration between both authors. Author DBNK designed the work, wrote the protocol, did the statistical analyses and wrote the manuscript. Author PNK conducted the survey in the field and contributed to literature searches. Both authors have read and approved the content of the final manuscript.

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### ABSTRACT

**Aims:** Assessment of human and environmental health implications of pesticide use by farmers in the western highlands of Cameroon, the case of Fotouni.

**Study design:** Descriptive Cross-Sectional

**Place and Duration of Study:** This work was done between November 2016 and March 2017 in Fotouni (West Region of Cameroon).

**Methodology:** A structured questionnaires randomly administered to 76 markets gardeners owning a farm and willing to take part in the survey.

**Results:** The survey revealed that secondary school was the highest level of education achieved by most of the respondents (68.4%). Farmers were aged between 19 and 63 years, the highest percentage (47.4%) being in the 31 to 40 years range. Five pesticide families were used in the study area with a predominance of insecticides. Thirty-one commercial names were recorded corresponding to 18 active ingredients. Chlorothalonil was the most used active ingredient.

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Beauchamp and Dimethoate were two illegally used compounds recorded. Most farmers (89%) mixed pesticide before application while others (31.6%) changed dosage per crop season. Furthermore, prescribed doses were not followed by 34.2% of respondents and 60.5% of farmers hadn't receive any training on pesticide application. Market gardeners chose pesticides to apply mainly from information on labels (71%). Farm water was used by 92.1% of respondents for domestic purposes; 28.9% of respondents testified active pesticide poisoning while 47.4% failed to use protective equipment during application. Seven post-application symptoms were recorded, the main one being impaired vision and nausea. The farm house was the main pesticide storage site (56%). Empty sachets were poorly managed as respondents burned (42%) or buried (10%). The Restricted Entry Interval was a mystery for the majority of respondents (70%) who declared they re-entered the farms less than 24h after application.

**Conclusion:** Farmers were highly exposed to pesticides due to ignorance and poor legislation.

*Keywords: Assessment; restricted entry interval; active ingredient.*

## 1. INTRODUCTION

Food shortage and poverty rank high among many challenges faced by the Cameroon population, subject to an exponential growth. Poverty is the main reason behind rural exodus leading to promiscuity and precocity in big cities. Ensuring food security in Cameroon is a key and difficult task for the government [1] despite the promotion of a second-generation agriculture in the country. Therefore, economic factors push more and more people into agriculture [2] which is the bedrock of the Cameroonian economy [1]. In order to clean farms, fight against pest and increase the yield, and while waiting for the setting up of resistant crop species, the use of pesticides is inevitable in agriculture. In the same line, a strong correlation between agriculture and the use of agricultural inputs was reported in a study carried out in Muea in the South-West Region of Cameroon [3]. Additionally pesticide use is integral to the livelihood of farmers and gardeners [4]. Unfortunately, in poor countries, pesticide use is equal to improper use [5].

Agricultural activities are among the main sources of environmental pollutants [6]. Pesticide use has many implications on human and environmental health. Pesticides have a very negative impact on male reproductive capacities [7], they may cause death of man and animal, bring about many post-application symptoms [8]; moreover, they are environmental risk factors for cancer [4]. Pesticides act as endocrine disruptors mimicking the action of hormones with many implications: new-born babies with low weight, growth retardation, behavioural changes in babies and reduction in sperm count [9]. The pesticides are very toxic to aquatic organisms [10]; insecticides in particular have been reported

to pose serious aquatic risk as compared to other pesticide families [11] especially organochlorines which have a very high lethal and sublethal toxicity [12]. In addition, organophosphorus and carbamates insecticides are extremely toxic to daphnids (zooplankton) while organochlorine insecticides and herbicides exhibit a high toxicity to fish [13]. Moreover, many organic molecules and heavy metals (found in some pesticides) are non-biodegradable [6], therefore, they last long in the environment and may pose risks to living things many years after they were last used as reported by the National Pesticide Information Center [14]. Agrochemicals in water cause a reduction in primary consumers, hypoxia and food shortage, hence a reduction in fish population [12]. The consumption of food that has been treated with pesticides is a possible exposure route even though an accurate estimation will be difficult and may require extensive collection of information [4].

Previous studies on pesticides use patterns in Cameroon have been carried out [3,15-20]. These studies have greatly contributed to ecotoxicology but studies done in the West Region are very rare in literature apart from one study done in Galim [21] and Balessing [22]. This is a paradox because, the West Region of Cameroon has the highest number of pesticide sellers [23]. No study on pesticide uses patterns have been done in Fotouni (a locality crossed by two main rivers) known to be the main food supplier of the Upper-Nkam Division. This raises the necessity to carry knowledge to market gardeners on the implications of their practices, and consequently, improving conditions of the community. This study was then aimed at investigating on pesticide use by market

gardeners in the Western Highlands of Cameroon, the case of Fotouni.

Nkam Division as people live mainly from agriculture.

## 2. MATERIAL AND METHODS

### 2.2 Study Design

#### 2.1 Study Area

A structured questionnaire randomly administered to 76 market gardeners was used to carry out this descriptive cross-sectional study. Only those who agreed to take part in the survey were interviewed. The questionnaire was typed in French; the local language was used for respondents that were not fluent in French. Questionnaires have been a very useful tool to research in a wide range of topics [28].

The study was carried out between November 2016 and March 2017 in Fotouni. Fotouni is a locality of the Upper-Nkam Division, West Region of Cameroon, located at 1532m altitude, 28km from Bafang. Based on data from the Institute of Agricultural Research for Development (IRAD) and the “Programme National de Vulgarisation Agricole” (PNVA) of the Ministry of Agriculture and Rural Development, Fotouni receives about 1500mm rainfall per year and has a Cameroonian equatorial climate at altitude, with a very long rainy season (March to October) and a short dry season, November to February [24].

Each package of questionnaire had 32 main questions and six main sections: Section A was general information; Section B deal with pesticide used in farms; Section C was safety rules; Section D was concerned with sustainable pesticide use; Section E was on the use of aquatic resources and Section F deal with social feedback.

The locality has a dense hydrological network but there are two main rivers: Metchie and Ngnangnam (Fig. 1). The substrate is rocky and subject to constant erosion [24]; the topography shows evidence of a volcano-plutonic area with many hills [25].

The following information was collected: personal information of the farmer (age, level of education, crops cultivated), types of pesticides applied in the farm, application device, safety rules (protective clothing, recommended doses, REI, pesticide related accidents), use of aquatic resource (proximity with water bodies, use of water for domestic purposes) and legality of pesticide applied. Field observations were additional sources of information.

Fotouni had 7 430 inhabitants in 2005 [26], a number that is said to have increased to 20 000 inhabitants [27]. Located between 5°19'35" N and 10°13'34" E, Fotouni is known to be the main food products supplier of the Upper-

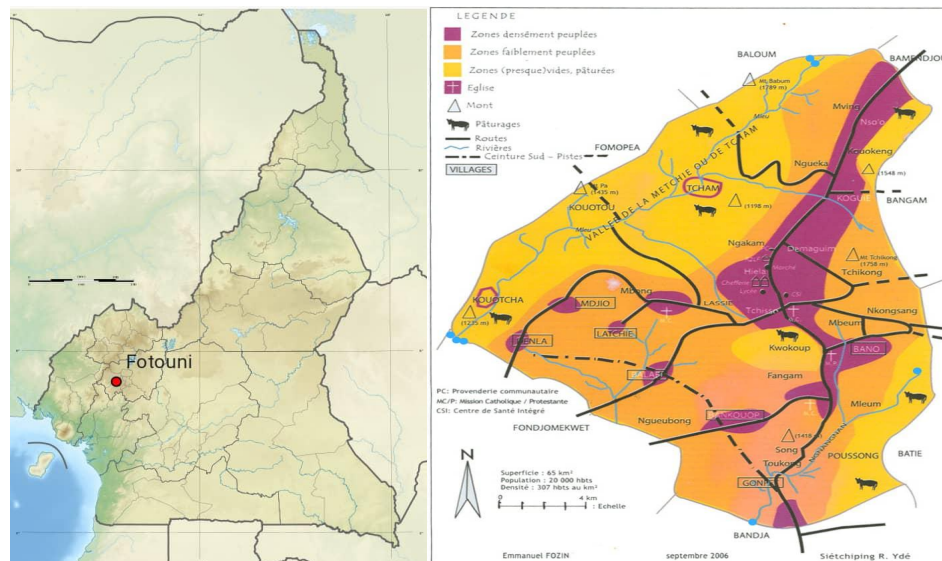


Fig. 1. Map of the study area showing the two main streams in agricultural valleys (Source: Emmanuel Fozing, 2006)

### 2.3. Data Processing and Analysis

Typing and drawing of graphs were done using Microsoft Excel 2016, and the tables were generated using SPSS version 21.

## 3. RESULTS AND DISCUSSION

### 3.1 Characteristics of the Study Population

Seventy-six (76) Fotouni market gardeners participated to the research. Secondary school was the highest level of education achieved by most of the respondents (52); just 2 reached the university level while 22 did not perform primary school. Market gardening in Fotouni seemed to be mainly for men as just 4 females were recorded during the study period (Table 1).

Respondents were aged between 19 and 63 years old with a mean of  $38.3 \pm 1.1$  years old. The age range 31 to 40 years old had the highest percentage (47.4%) followed by the range 41 to 50 years (21.1%). Very young and very old farmers were quite rare as the range 10 to 20 years and 61 to 70 years had 2.6% each (Fig. 2).

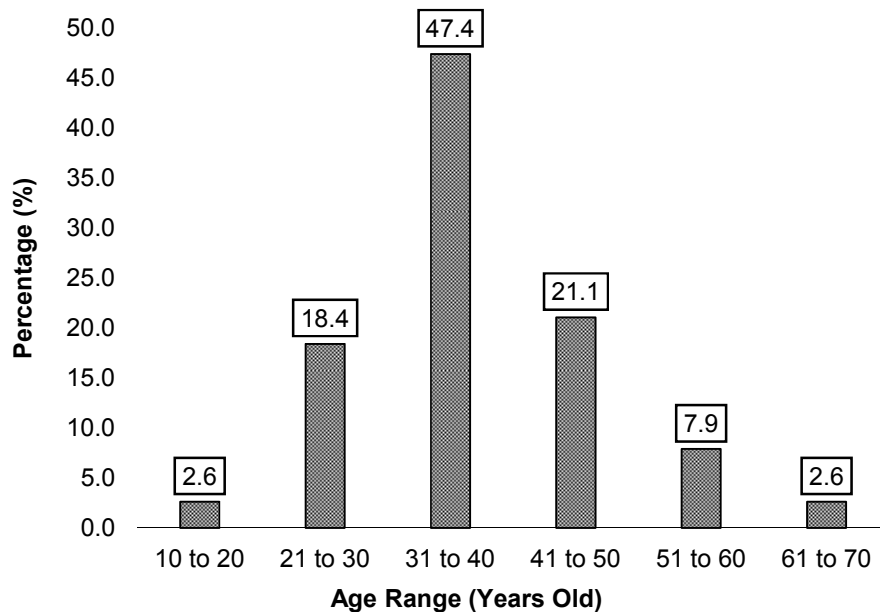
### 3.2 Pesticide Families

Thirty-one (31) pesticide commercial names were recorded in the study area (Table 2). Different commercial names sometimes had the same active ingredient and as such 18 active ingredients were recorded added to one unknown active ingredient sold under the commercial name (Beauchamp). These pesticides were applied on eleven crops varieties were recorded in the study area: banana, beans, plantains, cabbages, cocoa, coffee, Irish potatoes, maize, vegetables, pepper and tomato.

**Table 1. Level of education and gender of Fotouni market gardeners**

	Female	Male	Total
Primary School	2	20	22
Secondary School	2	50	52
University	0	2	2
Total	4	72	76

The 18 active ingredients included 7 insecticides (39%), 1 nematicide (5%), 3 herbicides (17%) and 7 fungicides (39%). This gives evidence of frequent use of insecticides and fungicides as compared to other pesticide families. Fig. 3 gives the proportion of each pesticide group in relation to all the active ingredients used in the area.

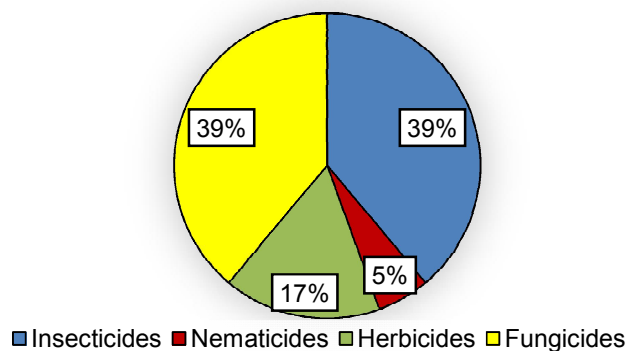


**Fig. 2. Distribution of Fotouni markets gardeners in terms of age groups**

**Table 2. Pesticide active ingredients and commercial names used by market gardeners in Fotouni**

Active Ingredients	Commercial names	Frequency	Family
Chlorothalonil 500g/L + Carbendazim 100g/L	Banko plus	34	
Chlorothalonil 720g/L	Balear 720, Bravo 720SL	42	
Copper Hydroxide	Kocide 2000	2	
Copper Oxide 86%	Nordox 75WG	2	
Mancozeb 80g/kg	Ivory 80WP	18	Fungicide
Mancozeb 750g/kg	Penncozeb 75DG	2	de
Maneb 800g/kg	Trimaneb	30	
Metalaxyl 80g/kg + Mancozeb 640g/kg	Fongistar 72WP, Mancozan Super	4	
2,4-D Amine	Amistar 720SL	2	
Glyphosate	Kalach 360SL, Cleanfarm 360SL, Herbistar 360SL, Glyphader	16	
Paraquat	Almoxon, Supraxone, Gramoxone	8	Herbicide
Cadusafos	Rugby	2	
Cypermethrin 12g/L	Cigogne 12EC, Cypercal 12EC	20	
Cypermethrin 360g/L	Cigogne 360EC	6	
Cypermethrin 50g/L	Cypercal 50EC	2	
Deltamethrin 25g/L	Decis 25EC	2	
Dimethoate*	Dimex*	12	
Imidacloprid	Iron	2	
Imidacloprid 20g/l + Lambda-cyhalothrin 20g/l	Parastar 40EC	8	Insecticide
Imidacloprid 30g/L + Lambda-cyhalothrin 60g/L	Lamida Gold 90EC	12	
Lambda-cyhalothrin + Acatamiprid	K-Optimal	2	
Ethoprophos	Mocap	6	Nematicide
x	Beauchamp**	12	x

\*Completely banned in Cameroon [29]  
 \*\*Not registered in Cameroon [29]



**Fig. 3. Percentage of pesticide families used by Fotouni market gardeners**

**3.3 Pesticide Application Scheme**

All the respondents used a Side Lever Knapsack Sprayer (SLKS) to apply pesticides. A large

percentage of market gardeners (68; 89%) applied pesticide in combination (Fig. 4). Twenty-four (31.6%) replied they changed application dosage as compared to previous crop season;

20 (26.3%) increased while 4 (5.3%) decreased. Changing application dosage is synonymous to non-respect of prescribed doses. Fifty (65.8%) respondents had no knowledge on legislation on pesticides while 24 (31.6%) said they didn't know whether pesticide they used were legal or not.

Fifty respondents (65.8%) followed recommended doses while 26 (34.2%) failed to follow prescribed doses. The majority of respondents (46; 60.5%) hadn't received any training on pesticide application.

### 3.4 Decision on Pesticide to Use

In order to choose which pesticide to apply, farmers replied they mainly relied on information

on labels (71%). They sometimes used past experiences (16%); a few chose pesticide to apply based on advice from sellers (5%) or from fellow farmers (8%) as shown on Fig. 5.

### 3.5 Human and Environmental Health Implications

Seventy (i.e., 92.1%) respondents replied they used farm water for domestic purposes; 22 (28.9%) have suffered from active pesticide poisoning; 24 (31.6%) witnessed post pesticide application health disorders while 36 (47.4%) failed to use protective equipment during application (Fig. 6).

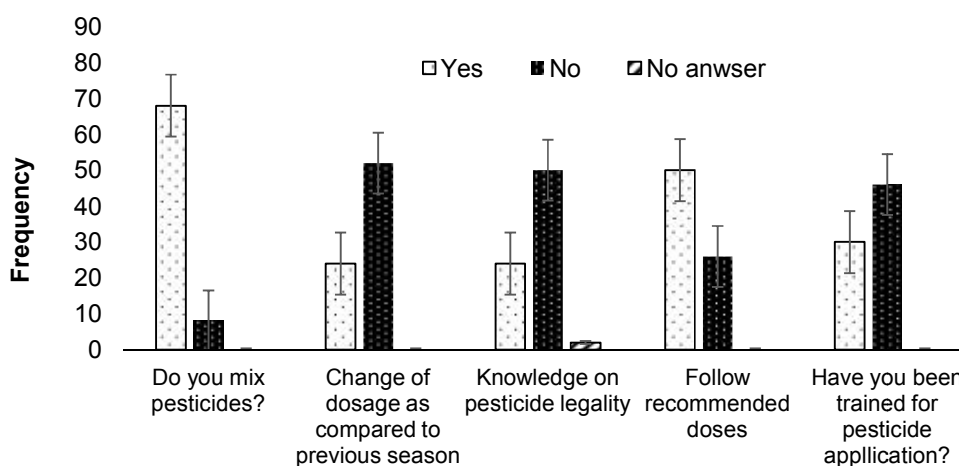


Fig. 4. Pesticide application scheme practiced by Fotouni farmers

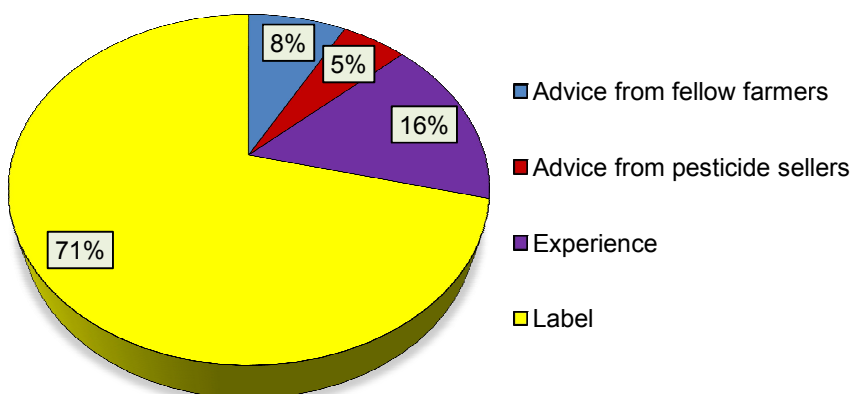


Fig. 5. Market gardener's decision on pesticides to use

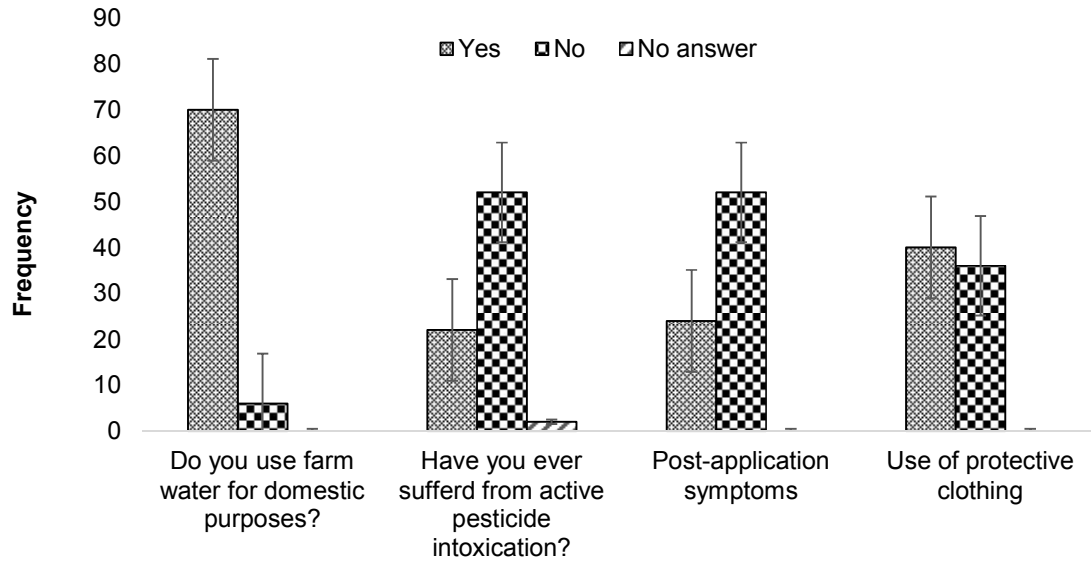


Fig. 6. Human health implication of pesticide used by Fotouni markets gardeners

Table 3. Post application symptoms

Frequency of post-application symptoms	Frequency	Percentage (%)
Fatigue	4	5.3
Fatigue + Dizziness	2	2.6
Headache	2	2.6
Impaired vision	6	7.9
Impaired vision + Itches	2	2.6
Impaired vision + Nausea	4	5.3
Impaired vision + Itches + Cough	2	2.6
Respiratory disorders	2	2.6
No specific symptoms	52	68.4
Total	76	100

### 3.6 Frequency of Post-application Health Disorders

Respondents complained about seven (07) post application symptoms: fatigue, dizziness, headache, impaired vision, itches, nausea and cough. Sometimes, there was a combination of symptoms felt by a single respondent following pesticide application. Nevertheless, the majority of respondents (68.4%) did not mention any post application symptoms (Table 3).

### 3.7 Storage Sites

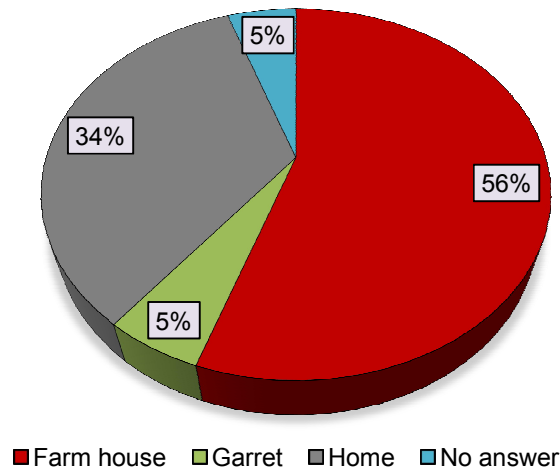
In the study area, pesticides were mainly kept in the farm house (56%). Nevertheless, some respondents said they kept pesticide at home (34%) or in the garret (5%) as shown on Fig. 7.

### 3.8 Management of Empty Sachets or Containers

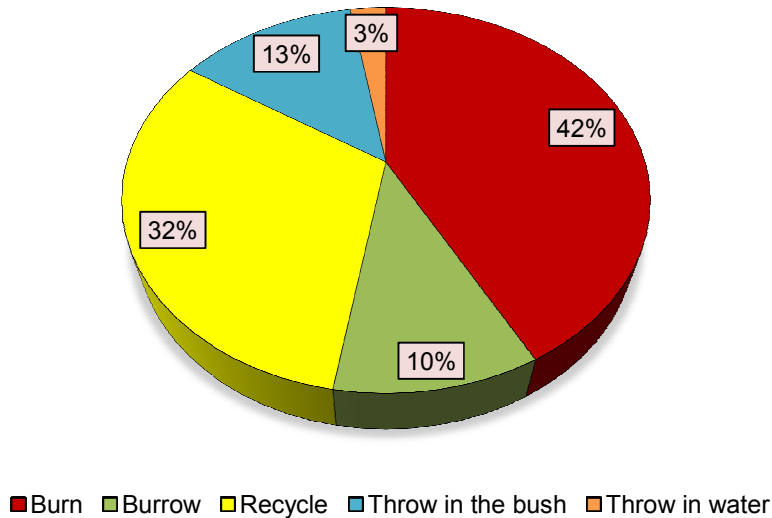
The majority of respondents (42%) replied they burnt empty pesticide sachets. Some respondents recycled them (32%) especially when they are plastic containers from 0.5L upwards; others buried in the ground (10%), threw in water (3%) or threw in the bush (13%) as shown on Fig. 8.

### 3.9 Restricted Entry Interval (REI)

The majority of Fotouni market gardeners (70%) entered the farms less than 24h after pesticide application (Fig. 9). The most dangerous case if those entering the farms less than 1h following pesticide application (11%). Above all, Fotouni farmers were not very knowledgeable about the REI.



**Fig. 7. Pesticide storage sites as practised by Fotouni market gardeners**



**Fig. 8. Pesticide empty sachets or containers management schemes**

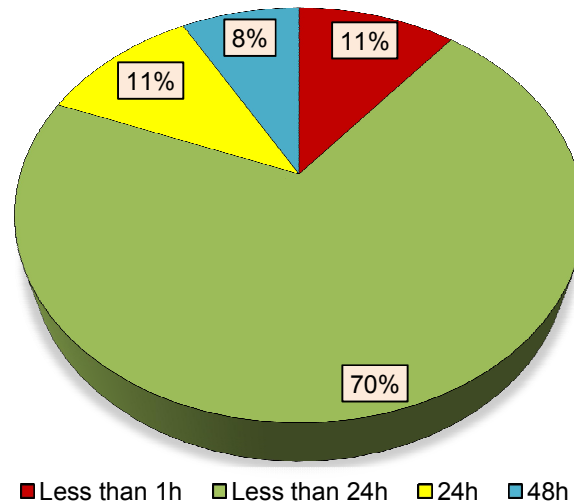
#### 4. DISCUSSION

This study aimed at investigating on pesticide use patterns in Fotouni, a locality of the Upper-Nkam Division, West Cameroon. The survey revealed that Fotouni market gardeners were mostly illiterate; in the same line, it was reported that most of the farmers in Galim (West Cameroon) were illiterate [21]. Moreover, people involved in farming generally had a low level of education even though this may not imply their inability to master agricultural techniques [3]. Having many illiterates in farming may be related to poverty forcing people to abandon school to look for means of survival. Food provision for household and looking for a source of income,

were the two main reasons for involvement in crop production enterprise [1]. The lack of formal education has greatly contributed to the misuse of pesticides [30].

Fungicides and insecticides were the most used pesticides probably because of the proliferation of fungal diseases and insect pests. Insecticides and fungicides were earlier reported to be two groups of pesticides that make up the bulk of agricultural inputs used in Cameroon [31]. In the same line, farmers in the Fako Division, South West Cameroon, mostly used fungicides [8]. Elsewhere, insecticides were the most used chemicals followed by herbicides and fungicides [30].





**Fig. 9. Restricted Entry Interval (REI) practiced by Fotouni market gardeners**

Two illegal pesticides were recorded: one pesticide not registered in Cameroon was found under the commercial name Beauchamp (unknown active ingredient); another compound known as Dimex (Dimethoate) used in the area is completely banned in Cameroon [29]. In the same line, Cameroon cocoa farmers used eight banned pesticides [32]. The use of banned compounds may be related to ignorance and lack of regulation. The absence of pesticide sellers in a locality and the proximity with neighbouring countries as it is the case in the northern regions of Cameroon, may be responsible for the use of fake and unknown pesticides [23]. This confirms that legislation on pesticide use in Cameroon is still in the draft stage [31]. Twenty-two years later, pesticide importation and distribution in Cameroon was still done under conditions that were far from ideal [7]. A situation that has remained unchanged as farmers in Cameroon claimed they knew of use of expired, banned, fake and adulterated pesticides [15]. Cameroonian cocoa farmers used pesticides of unknown origin and unknown manufacturer [32]. Moreover, Lindane [banned in Cameroon) was used by gardeners of the Yaoundé VII municipality [17]. In the same line, the use of three illegal pesticide was reported in the South West region of Cameroon [8] idem in Balessing (West Region, Cameroon) where market gardeners used even banned pesticides on their crops [22]. The liberalisation of the Cameroon crop sector in the early 1990s due to the 1989 financial crisis accounts for the use of banned pesticides. The lack of technical assistance to

farmers is responsible for poor pesticide application safety rules [32], hence a negative impact on human and environmental health.

Most farmers applied pesticides in combination; this practice can be risky. Reasons behind this practice may be efficiency or more pest incidence. Farmers mixed different brands of pesticides to combat resistant pests [30]. Some pesticide formulations occur in combination, so further mixtures done by pesticide users bring about complex mixtures with many possible mechanisms: synergy, addition, potentialization and antagonism. Interactions between pesticides is complex as it involves a network of targets and mechanisms [33].

Changing application dosage as reported by some respondents implies, they didn't follow prescribed doses. Fake farmers (South West Cameroon) were also reported to change (increase or decrease) pesticide application dosage from one crop season to the next [8]. The severity of the pest attack may sometimes push farmers to increase application dose and frequency; sometimes, farmers have no knowledge on recommended doses [32]. Changing application dosage may increase health risks and even reduce crop yield. Random variation of application dosage may influence pesticide persistence into the environment. Pesticide persistence in the environment depends on the application interval and the amount of pesticide applied [13].

Having received training on pesticide application was not on the agenda of many farmers (60.5%), implying that some may rely on trial-and-error learning. In the same line, some (34.2%) replied they don't follow prescribed doses, a practice earlier reported in the South-West Region of Cameroon [8]. The fact is that most of the farmers in the village are illiterates because after primary school, they abandoned school, got married and started farming; even those who went to towns after primary school and fail, come back to the village to get married and start agriculture (the main activity) with inadequate training in the domain. Farmers decided on pesticide to use mainly based on labels; since many have not been trained, some information on labels may be misunderstood.

Using farm water for drinking, washing and irrigation as reported by 92.1% of respondents may be risky (dietary exposure) since the largest part of pesticide applied get into water via diffuse or point sources [34]. In addition, the possibility always exists that pesticide application will contaminate the environment and cause hazards to living organisms [13].

The use of protective equipment was a mystery for many respondents who pointed poverty and routine as main reasons. Similar studies found that respondents failed to use, or used incomplete and inappropriate personal protection equipment [23,30].

Cases of active poisoning (31.6%) and post-application symptoms (47.4%) were recorded. In the same line, 60% of farmers in Galim had been victims of pesticide related accidents [21]. Dizziness, fatigue and headache found in this study may be signs of central nervous system involvement. Pesticides have neurotoxic and cancerogenic effects [9]. Respiratory disorders and nausea may indicate inhalation, impaired vision may be due to volatilization while itches may be related to skin contact because of no or inappropriate body cover. Skin irritation is mostly due to pesticides containing chlorine [9]. These common symptoms were reported in a pilot study carried out in Cameroon [23]; stressing the need to educate farmers on the use of protective equipment. Poverty, discomfort and lack of regulation are the main factors governing inadequate protective clothing during pesticide application in poor countries. Low government intervention is the main reason behind poor pesticide use [32]; hence the necessity for the Ministry of Agriculture and Rural Development

(MINADER) to play a leading role in raising pesticide users' awareness. In Cameroon, the most recent list of banned agrochemicals was published in 2013 by the National Registration Commission of Phytosanitary Products and Certification of Sprayers of the Ministry of Agriculture and Rural Development.

Despite the fact that pesticides were mainly kept in farm houses, some farmers still kept them at home which may be very risky for children (accidental poisoning) or even adults (suicide attempts or criminals). In Galim (West Cameroon), farmers mainly stored pesticides in living rooms [21]. In another study done in Cameroon, 78% of pesticide poisoning were accidental, 12% were suicide attempts while 4% were criminal [23]; so, storing pesticide in safe places may reduce these risks.

Large plastic empty pesticide containers were recycled by some users. Previous studies reported that large plastic containers were washed and used for the storage of grain, kerosene and palm oil by farmers in Cameroon [8,18,20]. Pesticide users also sell empty containers to pesticides sellers for unclear reasons [30].

Empty pesticide sachets were poorly handled by pesticide users (burning, throwing into water or bush). Generally, farmers exhibit poor pesticide disposal [35]. Moreover, market gardeners in Galim abandoned empty pesticide containers in bush, buried or burned [21]. Burning pesticide residues that remain in containers may release poisonous fumes or contaminate the environment. Throwing empty containers in the bush or water will cause pesticide residues to accumulate in the environment. Persistent pesticides may travel long distances in the air or water, or even in living organisms such as migratory birds [14]. Pesticides residues released in the aquatic milieu may be ingested by organism through food (bioaccumulation) or via gills and epithelial tissues (bioconcentration) leading to several ecological perturbations [12]. The use of pesticides under prevailing conditions in Cameroon constituted a danger to the entire ecological chain [31]. This danger is potentialized with environmental factors as pesticide toxicity is temperature-dependent: high temperatures make pesticides more toxic [13].

Fotouni market gardeners had no knowledge on the Restricted Entry Interval (REI). Re-entering the farms immediately after pesticide application

is very risky for human health. according to the Canadian Centre for Occupational Health and Safety (CCOHS), for a slightly toxic pesticide, the REI is at least 24h while it is at least 48 h for moderately to very toxic pesticides [36]. Farmers in the Fako Division (South West, Cameroon) failed to respect the REI [8]. This is an evidence that farmers are completely ignorant of the risks associated with exposure to pesticides. This ignorance is added to pesticide regulation in Cameroon which is still in the draft stage. The poor regulation on pesticide has many implications; illegal pesticide supply chain to cocoa farmers caused a loss of Value Added Tax of about 550,000.00 to 2.4 million Euros per year for the Cameroonian government [32], added to human and environmental health related issues.

## 5. CONCLUSION

In summary, pesticide use by Fotouni markets gardeners was widespread. Fotouni market gardeners were highly exposed to pesticides because of ignorance and poor legislation on pesticides. Sensitization and re-enforcement of regulation should be implemented. Further studies on pesticide risk assessment, microcosms, biomonitoring, bioaccumulation should be carried out to put more light on the impact of pollutants on living organisms.

## CONSENT

As per international standard or university standard, participants' written consent has been collected and preserved by the author(s).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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