Available online at http://ajol.info/index.php/ijbcs

Int. J. Biol. Chem. Sci. 9(2): 723-736, April 2015

ISSN 1997-342X (Online), ISSN 1991-8631 (Print)

International Journal of Biological and Chemical Sciences

Original Paper http://indexmedicus.afro.who.int

Vegetable production in Togo and potential impact of pesticide use practices on the environment

Lakpo Koku AGBOYI[1,2*], Koffi Moïse DJADE[3], Koffi Mensah AHADJI-DABLA[2], Guillaume Koffivi KETOH[2], Yaovi NUTO[2] and Isabelle Adolé GLITHO[2]

[1]UR Défense des Cultures et Biotechnologie Végétale, Institut Togolais de Recherche Agronomique (ITRA), B.P 1163, Lomé, Togo.
[2]Laboratoire d'Entomologie Appliquée, Université de Lomé, 01 B.P 1515 Lomé 01, Togo.
[3]Ecole Supérieure d'Agronomie, Université de Lomé, 01 B.P 1515 Lomé 01, Togo.
[*]Corresponding author; E-mail: agboyikoku@yahoo.fr; BP: 1163, Lomé, Togo; Tel: +228 90 28 88 82, Fax: +228 22 25 15 59

ABSTRACT

In West Africa, market gardening is considered one of the sectors in agriculture that consumes lots of pesticides. In order to study (i) the principal protection practices of vegetables and (ii) the inherent environmental risks to pesticide use practices, a survey was carried in Togo from 2010 to 2011. A random selection of 161 farmers were interviewed on their farms, which are distributed over the most important vegetable production sites located in dry Savanna, forests and littoral zones of Togo. The results showed that 88% of farmers interviewed responded that, insects are the most important vegetable pests in Togo. Crop protection practices are primarily based on excessive use of synthetic pesticides which in most cases include organophosphates (27.3%) and pyrethroids (18.2%), known to be dangerous to human health and environment. Despite the excessive use of pesticides, farmers revealed that insect pests continue to cause serious damages, which is an indication that they have developed a resistance to pesticides. Moreover, about 80% of farmers did not have adequate materials for handling and application of pesticides and are thus exposed to pesticide poisoning. An integrated pest management programme based on crop rotation, biological control and biopesticides is discussed.

Keywords: Farmers, market gardening, crop protection, pests' resistance.

INTRODUCTION

Vegetables are important components of daily diets in Togo, and an important income-generating activity for smallholder farmers in urban centres and rural areas (Kanda et al., 2014). Unfortunately, farmers rely on a lot of inputs in West Africa, particularly pesticides for vegetable production in market gardening (Coulibaly et al., 2008). Several types of agricultural pesticides are being used by farmers in Togo to control several vegetable crop pests. However, farmers' practices in the use of these pesticides are not well known, as well as the impact of these pesticides on the environment. Synthetic pesticides are the most available pesticides on the markets in Togo and consequently, the most accessible to

DOI : http://dx.doi.org/10.4314/ijbcs.v9i2.13

farmers who in turn use them inadequately (Mondédji et al., 2014). In spite of the excessive amounts of pesticides used on vegetables, significant crop losses are often reported by farmers, which confirm a reduction of some vegetables pests' sensitivity. In Togo, the diamondback moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) can cause more than 50% of crop losses in cabbage farms treated with various groups of synthetic insecticides (Agboyi et al., 2013).

This study aims at (1) assessing various constraints to vegetable production according to farmers' perceptions, (2) presenting the vegetable protection practices of farmers against pests and diseases and (3) assessing the potential impact of the pesticides use on the environment and their implication in pests' resistance, especially for *P. xylostella*.

MATERIALS AND METHODS

Study sites

The survey was carried out during the period of 2010–2011 and the randomly selected farmers were drawn from the most significant vegetable production sites in three agro-ecological areas of Togo. The highest number of farmers interviewed was from the dry Savanna (n = 101) followed by the forests (n = 30) and the littoral (n = 30). The farmers interviewed were owners of market gardening farms.

Data collection

A total of one hundred and sixty one (161) farmers were interviewed on farms in various vegetable production sites, using a semi-structured questionnaire composed of 34 questions. Some questions were related to the answers that preceded them. Farmers interviewed were selected randomly on the study sites. The hazard level and the potential impact of pesticides used by vegetables growers were evaluated by using the World Health Organization (WHO) Hazard Class and a model called "Environmental Impact Quotient (EIQ)" respectively. The WHO Hazard Class used was lately established after the revision of the classification criteria in 2009. This new WHO Hazard Class was established in order to harmonize the system of classification and labelling of chemicals. The Globally Harmonized System (GHS) is largely used nowadays for the classification of the pesticides according to their level of danger worldwide (WHO, 2010). The pesticides classification criteria are primarily based on the acute dermal and oral toxicity of the compound; i.e. the dose able to kill 50% of a large population (LD_{50}) of rats (Table 1).

To evaluate the potential impacts of the pesticides identified during our investigations, we used the EIQ model, developed by Kovach et al. (1992) in the Integrated Pest Management (IPM) Program at Cornell University. The EIQ model has important characteristics which make it very adequate for the evaluation of the environmental impacts of agricultural pesticides and even for decision-making with regards to environmental protection (Nissen et al., 2001). It takes into account both the toxicity of the pesticides to farm workers, consumers, as well as an ecological component. The potential EIQ is predetermined for many agricultural pesticides starting from toxicological data obtained from several studies. The toxicity and indices of exposure are scored 1, 3 or 5 according to the importance of potential chronic toxicity, in order to make the parameters of toxicity comparable between them (Gallivan et al., 2001). Thus, the score allotted to the parameters varies according to the pesticides' danger. The EIQ is given starting from the sum of the effects on farm workers, consumers and ecological component, according to the formulas hereafter:

- Effects on farmworkers = Applicator + Picker

$$C\left((DT \times 5) + (DT \times P)\right)$$

- Effects on consumers = Food residue + Groundwater

$$C(\frac{S+P}{2}) \times SY + L$$

- Effects on ecological component = Fish + Bird + Bee + other Beneficial arthropods

$$(F \times R) + \left(D \times \frac{S+P}{2} \times 3\right) + (Z \times P \times 3) + (B \times P \times 5)$$

$$QIE = [C((DT \times 5) + (DT \times P)) + \left(\frac{C(S+P)}{2} \times SY + L\right) + \left((F \times R) + \left(\frac{D(S+P)}{2} \times 3\right) + (Z \times P \times 3) + (B \times P \times 5)\right)]/3$$

With
DT = dermal toxicity, C = chronic toxicity, SY = systemicity, F = fish toxicity, L = leaching potential, R = surface loss potential, D = bird toxicity, S = soil half-life, Z = bee toxicity, B = beneficial arthropod toxicity, P = plant surface half-life.

In this paper, the potential EIQ of pesticides used on vegetables were obtained from NYS IPM EIQ Database of 2012, developed by the Integrated Pest Management Program at Cornell University.

Data analysis

Data collected were encoded using Microsoft Excel 2010. The data were then analysed using the software SPSS 16.0 to calculate the proportion of various parameters. The levels of impact (LI) of pesticides were classified in (i) low LI ($0 \leq EIQ \leq 20$), (ii) medium LI ($21 \leq EIQ \leq 40$) and (iii) High LI ($EIQ \geq 41$), adapted from the classification of Mazlan and Mumford (2005).

RESULTS

Farmers' socio-economic background

The majority of farmers (92%) interviewed on the vegetable production sites were men (Table 2). Women owners of market gardening farms were thus very few. The majority of farmers (63%) were younger than 41 years old and the maximum age was 50 years. 76% of farmers were married and 24% were single. Moreover, the majority of farmers (71%) had received a school education and 56% among them have had a secondary level of education. Therefore, very few farmers (10%) had received formal training on growing vegetables (Table 2).

Crop cultivation systems on the market gardening sites in Togo

The main crop cultivation systems on the market gardening sites were polycropping (100%) and crop rotation (100%) (Table 3). None of the farmers adopted monoculture practices. The farming system choice was especially influenced by the market. 76% of farmers chose their cropping system according to the market. A considerable proportion of farmers (26%) also used the cropping system as a technique to control pests' resistance, but very few of them (4%) used it for improving the fertility of their soil (Table 3).

Species of vegetable crops grown

The survey revealed that nineteen vegetable species were being cultivated on the market gardening sites under polycropping practice (Table 4). This practice was dominated by some crop species like cabbage (*Brassica oleracea*, 67%), lettuce (*Lactuca sp.*, 40%), pepper (*Capsicum spp*, 37%), tomato (*Solanum lycopersicum*, 35%) and carrot (*Daucus carota*, 30%) (Table 4). The importance of the area occupied by each species was variable. Other crop species such as the French bean (*Phaseolus vulgaris*, 17%), gboma (*Solanum macrocarpon*, 16%), eggplant (*Solanum esculentum*, 13%), onion (*Allium cepa*, 12%), beet (*Beta vulgaris*, 9%), okra (*Abelmoschus esculentus*, 7%), sorrel of Guinea (*Hibiscus sabdariffa*, 7%) and cucumber (*Cucumis sativus*, 6%) were moderately represented with area varying from extremely to slightly significant (Table

4). The crop species slightly represented in the market gardens visited were zucchini (*Cucurbita pepo*, 4%), amaranth (*Amaranthus spp*, 3%), adémè (*Amaranthus spp*, 2%), manioc (*Manihot esculenta*, 2%), cowpea (*Vigna unguiculata*, 2%) and melon (*Cucumis melo*, 1%).

Cabbage cultivation: constraints and protection practices of farmers

Insect pests, particularly *P. xylostella* and several Aphis species, represented the major constraint (67%) of cabbage cultivation reported by farmers (Table 5). The attack of cabbages by phytopathology agents were evoked by only 6% of farmers. Other constraints, such as difficulties of access to inputs and water, soil degradation, drop in sales and attacks of molluscs, were revealed by 16% of farmers. Faced by these constraints, most of the farmers (72%) adopted the use of synthetic pesticides (Table 5). A considerable proportion of farmers (21%) used cultural control by adopting crop rotation. Very few farmers (4%) used botanical pesticides to control cabbage pests. A proportion of 3% of farmers used mechanical control against cabbage pests (Table 5).

Pesticides used in market gardening in Togo and targeted pests

All the farmers (100%) have used at least one synthetic pesticide against vegetable pests and there are some who used mixed them (Figure 1 A). A proportion of 45% of farmers mixed two pesticides to control pests and 22% used three pesticides. Less than 10% of farmers mixed 4 or 5 pesticides against their crops pests. Overall, during the surveys, 23 pesticides' active ingredients were identified, based on their labels (Table 6). Among the active ingredients identified, there were 65% insecticides, 22% fungicides, 9% insecticides-nématicides and 4% insecticide-acaricides.

In sum, insects, phytopathology agents, nematodes and molluscs were the categories of pests against which farmers used pesticides (Figure 1 B). However, 88% of farmers revealed that insect pests were the principal constraints of vegetable cultivation. The problems of diseases caused by phytopathology agents and nematodes were reported by 14 and 12% of farmers respectively. Damages due to molluscs were reported by only 1% of farmers interviewed.

Concerning insecticides, 27.3% of the active ingredients identified belong to the class of organophosphates and 18.2% to pyrethroids (Table 6). A small proportion of insecticide compounds were classified among organochlorines (9.1%), neonicotinoids (4.5%) and Phenylpyrazoles (4.5%). The class of carbamates was represented by carbofuran, an active ingredient belonging to the type of insecticide-nematicide and accounted for only 4.5% of common pesticides classes. Another insecticide-nematicide named fenamiphos belongs to organophosphate and accounted also for 4.5% of pesticides used by farmers. The class of avermectins (4.5%) was represented by abamectin which is a biopesticide belonging to insecticide-acaricide. Only 8% of farmers used botanical insecticides resulting from ashes of plants, neem seeds or leaves extracts and tobacco leaves extract. However, the number and the amount of active ingredient in these compounds were not evaluated. Therefore, their WHO Hazard Class and EIQ were not indicated. For fungicides, the class of alkylen-bis (dithiocarbamate) represented 10% of the pesticides used (Table 6). Those of Phenylamides (acylamines) and Benzimidazoles accounted for only 5% each one.

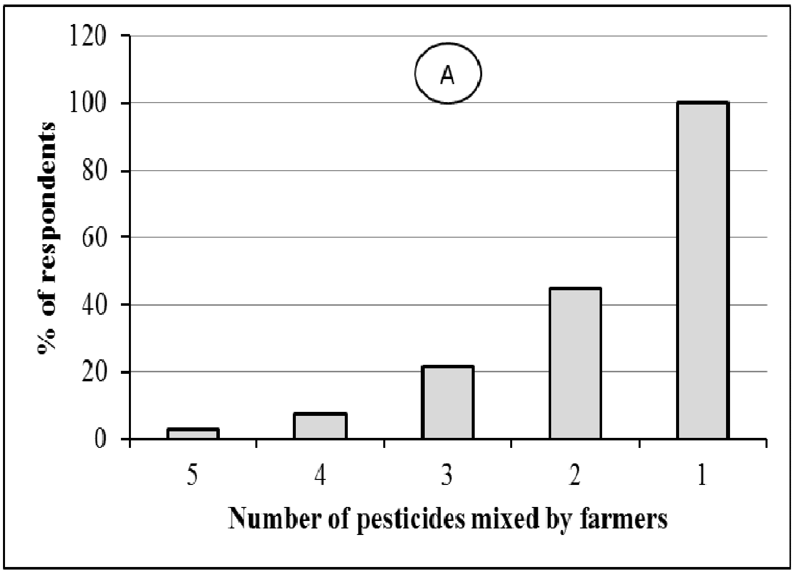
Generally, the most frequent active ingredients in the pesticides used by farmers were Lambda-cyhalothrin (19%), Deltamethrin (17%), Cypermethrin (14%), Acetamipride (11%), Abamectin (11%) and Mancozeb (10%) (Table 6). The others active ingredients were used by a very few farmers (1-6%). It is worth mentioning that 41% of farmers used non identified pesticides and 8%, botanical pesticides respectively.

According to WHO Hazard classification, the majority of pesticides, especially insecticides are highly or moderately hazardous (Table 7). However, some pesticides belong to fungicides such as Maneb, Mancozeb and Thiophanate-methyl are unlikely to present acute hazard. Other insecticides such as Malathion and Endrin were slightly hazardous and obsolete respectively.

Concerning the potential environmental impacts of the pesticides, all the active ingredients used by farmers has an EIQ higher than the threshold of the low level of impact (EIQ = 20). Only the fungicide Metalaxyl-M present a potential EIQ lower than 20.

Personal protective equipment used by farmers during pesticides handling and application

A proportion of 76% of the market gardeners declared that they have personal protective equipment against pesticides exposure (Figure 2). However, further investigation about the materials necessary to constitute normal protective equipment against pesticides exposure revealed that about 80% of these farmers did not have latex gloves, rubber boots and long sleeved shirt for pesticides handling and application (Figure 2). Moreover, 73% of the farmers did not have a respirator and only 51% had protective eyewear. Nevertheless, a high proportion (73%) of market gardeners had long pants kept for pesticides handling and application. A small proportion of farmers (32%) used sprayers (Figure 3). The others who applied the pesticides on their crops with inadequate tools such as watering-cans, brushes and tuft of grass represented 68% of farmers interviewed.



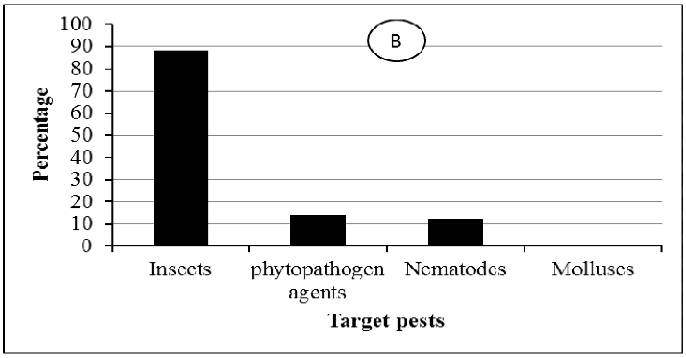


Figure 1: Percentage of farmers using single or mixed pesticides for pests' control in Togo (A) and proportion of target pests (B).

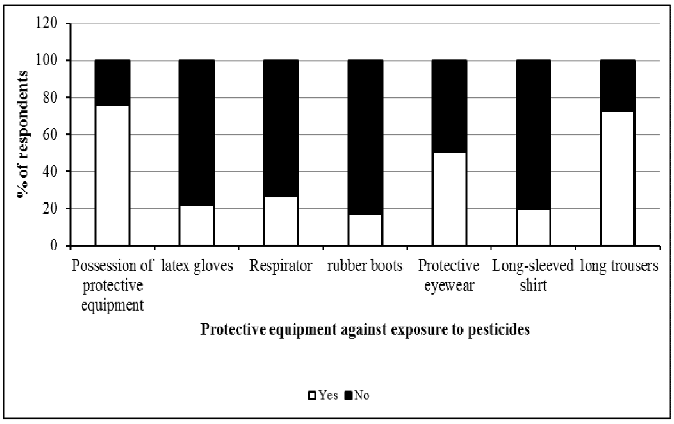


Figure 2: Proportion of farmers having personal protective equipment against exposure to pesticides.

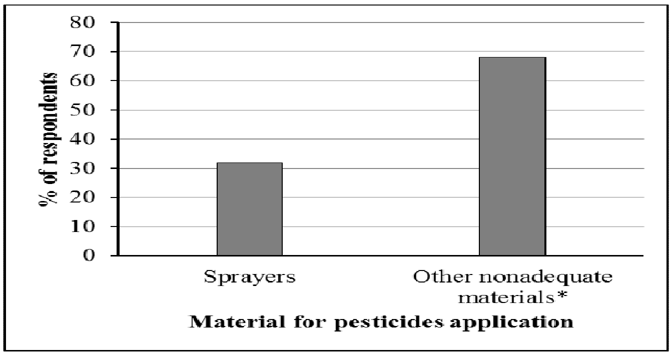


Figure 3: Proportion of farmers using handling and pesticides application materials. * Watering-cans, brushes, tuft of grass.

Table 1: Pesticides Classification according to WHO Hazard Class 2009.

WHO Class		LD_{50} for the rat (mg/kg body weight)	
		Oral	**Dermal**
Ia	Extremely hazardous	< 5	< 50
Ib	Highly hazardous	5 – 50	50 - 200
II	Moderately hazardous	50 – 2000	200 – 2000
III	Slightly hazardous	Over 2000	Over 2000
U	Unlikely to present acute hazard	5000 or higher	

LD_{50}: lethal dose of the compound able to cause 50% mortality. Source: WHO (2010).

Table 2: Socio-economic background of vegetable farmers interviewed.

Farmers' background		Proportion (%)
Gender	Females	8
(n = 161)	Males	92
Age category[a]	20-40 ans	63
(n = 41)	41-50 ans	37
Matrimonial statut[a]	Maried	76
(n = 41)	Single	24
	Divorced	0
	Widower	0
Education level[a]	Graduate	12
(n = 41)	Secondary education	56
	Primary education	3
	Reading and writing taught	7
	Training in vegetable growing	10
	None	12

n: number of farmers interviewed; a: characteristic of some farmers interviewed in the dry Savanna.

Table 3: Cropping systems used by vegetable growers in Togo.

Parameters	Proportion (%)
Cropping systems (n = 161)	
Polycropping	100
Monocultures	0
Crop rotation	100
Reason of the choice (n = 161)	
Manage pest resistance	26
Favourable market	76
Improve soil fertility	4

n: number of farmers interviewed.

Table 4: Proportion of farmers growing each crop and the importance of crops' area on the farms.

Crop[a]		Proportion of farmers by the importance of the area occupied by the crops on farm (n = 161)					
Common name	**Scientific name**	**Extremely important (%)**	**Very important (%)**	**Important (%)**	**Moderately important (%)**	**Slightly important (%)**	**Total proportion**
Amaranth	*Amaranthus spp*	0	1	1	1	0	3
Eggplant	*Solanum esculentum*	5	3	4	1	0	13
Beet	*Beta vulgaris*	1	4	2	1	1	9
Carrot	*Daucus carota*	12	7	9	1	1	30
Cabbage	*Brassica oleracea*	33	21	8	3	2	67
Cocumber	*Cucumis sativus*	1	2	1	1	1	6
Adémè	*Corchorus olitorius*	0	0	1	1	0	2
Zucchini	*Cucurbita pepo*	0	1	2	1	0	4
Gboma	*Solanum macrocarpon*	2	5	3	3	3	16
Okra	*Abelmoschus esculentus*	2	1	2	1	1	7
French bean	*Phaseolus vulgaris*	3	6	4	3	1	17
Lettuce	*Lactuca sp.*	8	16	9	6	1	40
Manioc	*Manihot esculenta*	1	1	0	0	0	2
Melon	*Cucumis melo*	1	0	0	0	0	1
Cowpea	*Vigna unguiculata*	0	1	1	0	0	2
Onion	*Allium cepa*	3	6	2	0	1	12
Sorrel of Guinea	*Hibiscus sabdariffa*	1	1	2	2	1	7
Pepper	*Capsicum spp*	9	12	9	6	1	37
Tomato	*Solanum lycopersicum*	17	5	9	2	2	35

n: number of farmers interviewed; a: The crops in this table were those really present on the market gardening sites at the time of the survey.

Table 5: Cabbage cultivation constraints and protection practices used by farmers in Togo.

Parameters	Proportion (%)
Cabbage cultivation problems (n = 161)	
- Damages caused by insect pest[a]	67
- Diseases	6
- Others[b]	16
Solutions adopted by farmers (n = 161)	
- Use of synthetic pesticides	72
- Use of biopesticides[c]	4
- Mechanical control	3
- Cultural control (crop rotation)	21

n: number of farmers interviewed; a: The most devastating insect pests accused were *Plutella xylostella* and Aphids; b: Difficulties to gain access to water and other inputs, soil degradation, drop in sales, attack of mollusc; c: Botanical pesticides: neem and tobacco extracts, ashes resulting from various plants.

Table 6: Pesticides used by famers in Togo and their hazard level and potential impact on the environment.

Pesticide			Proportion of farmers (%)	WHO Hazard Class	Potential environmental impact Quotient (EIQ)	
Type	Class	Active ingredient			Value of EIQ	Level of impact (LI)
Insecticide (65%)	Organochlorines (9,1%)	DDT	4	II	-	-
		Endrin	2	O	-	-
	Pyrethroïds (18,2%)	Cypermethrin	14	II	36,35	Medium[c]
		Lambda-cyhalothrin	19	II	44,17	High[d]
		Deltamethrin	17	II	28,38	Medium
		Fenpropathrin	2	II	25,33	Medium
	Organophosphates (27,3%)	Dimethoate	6	II	33,49	Medium
		Profenofos	1	II	59,53	High
		Malathion	1	III	23,83	Medium
		Chlorpyrifos-ethyl	1	II	26,85	Medium
		Acephate	1	II	24,88	Medium
		Cadusafos	1	Ib	-	-
	Neonicotinoides (4,5%)	Acetamiprid	11	-	28,73	Medium
	Phenylpyrazoles (4,5%)	Fipronil	1	II	88,25	High
	Botanicals	Insecticides derived from plants[a]	8	-	-	-

Insecticide-Nematicide (9%)	Organophosphates (4,5%)	Fenamiphos	2	Ib	71,33	High
	Carbamates (4,5%)	Carbofuran	4	Ib	50,67	High
Insecticide-Acaricide (4%)	Avermectins (4,5%)	Abamectin	11	-	34,68	Medium
Fongicides (22%)	Alkylen-bis (dithiocarbamate) (9,1%)	Maneb	1	U	21,43	Medium
		Mancozeb	10	U	25,72	Medium
	Phenylamide (acylamine) (4,5%)	Metalaxyl-M	1	II	19,07	Low[b]
	Phénylamide (acylamine) (4,5%)	Cuprous oxide	1	II	-	-
	Benzimidazoles (4,5%)	Thiophanate-methyl	1	U	23,82	Medium
-	-	non identified active ingredients	41	-	-	-

For the class of the pesticides, the percentages were calculated starting from the sum of the identified active ingredients (i.e., 22 active ingredients); the percentages of the types of pesticides were calculated starting from the sum of all the active ingredients except the non-identified ones (i.e. 23 active ingredients).

-: Data non available; a: Extracted from seeds and sheet of neem, Extracted from sheets of tobacco, Ashes resulting from plants; b: $0 \leq EIQ \leq 20$; c: $21 \leq EIQ \leq 40$; d: $EIQ \geq 41$; Ia: Extremely dangerous; Ib: Highly dangerous; II: Moderately dangerous; III: slightly dangerous; U: Unlikely to present acute hazard; O: Obsolete pesticide, not classified.

DISCUSSION

The market gardening farms in Togo are mainly owned by men. However, even though men are the main owners, women make a very important contribution in these farms. In fact, not only the tradition in sub-Saharan Africa, especially in Togo is unfavourable for women's access to agricultural lands but, it does not exclude their participation in the agricultural activities. A study carried out in five areas of Ghana by Duncan (2004) showed that from 1970 to 1984, the number of women farmers increased by 102%, although they were not the majority owners of farms. This inequality of access to the basic agricultural productive resources particularly lands was also reported by FAO (2011) which estimates that only 15% women farmers are owners of farm in Sub-Saharan Africa.

Besides, the activities in market gardening farms are often carried out by young people who are mostly married, confirming the crucial contribution of market gardening into social stability. The majority of these young farmers had a secondary level of education and are thus, potentially able to easily adopt new technologies with respect to good agricultural practices. However, very few among them had received training on sustainable cultivation practices of vegetables. Consequently, the non-observance of good plant production practices, especially the inadequate and abusive use of agricultural inputs such as pesticides are frequently observed on farms. Under these conditions, there are risks of environmental pollution related to current farmers' practices. These bad agricultural practices observed in Togo are also reported in other countries of West Africa (Obeng-Ofori and Ankrah, 2002; Avicor et al., 2011).

The predominated cropping systems are crop rotation and polycropping. Some farmers know that they can use them, especially for crop rotation, like preventive measures for crop protection against pests. Indeed, according to James et al. (2010), crop rotation can be used as an effective control technique against pests but, this require good knowledge of farmers on plants' sensitivity to the pests. Obopile et al. (2008) found also in Botswana that crop rotation is the principal farming technique of crops protection adopted by the farmers against vegetable pests in their market garden.

In Togo, according to our results, there is a great diversity of crops grown on the market gardening sites, making it possible to establish beneficial crop rotation systems against pests.

Cabbage, lettuce, pepper, tomato and carrot were the most significant plants species according to the area occupied on the farms and the proportion of farmer who cultivate them throughout the country.

The major constraint of vegetables production revealed by the majority of farmers is the attacks of insect pests. This result is similar to those of the surveys on vegetable production sites carried out by Avicor et al. (2011) in Ghana and Mondédji et al. (2014) in Togo. For cabbage production in particular, in spite of the great dependence of farmers to chemical control, it was revealed that the major pest *P. xylostella* continues to cause serious damage. Indeed, the excessive use of synthetic insecticides on cabbage by farmers, would involve a rapid reduction of the susceptibility of in the targeted insects to the compound used against them, because of the development of resistance mechanisms. It is well known that when a population of insects is continuously exposed to insecticides, its sensitivity to the toxic molecules decreases, because of the selection of resistant individuals (Shono and Scott, 2003). It is the case of *P. xylostella* which is largely known for its great capacity to develop resistance to several classes of insecticides (Tsukahara et al., 2003; Nakasuji et al., 2006).

The majority of pesticides used by farmers were insecticides, confirming their efforts to fight against insect pests which represent the major constraint of vegetable crops. The insecticides used belong to various classes of which the most significant are organophosphates and synthetic pyrethroids. The class of pyrethroides was also identified in West Africa, precisely in Ghana like the most insecticide class used by farmers (Obeng-Ofori and Ankrah, 2002). Insecticides belonging to the class of organochlorines are still being used on vegetable crops by the farmers, although they are obsolete. These are probably from old and not destroyed stocks which continue to circulate illegally in West African countries.

Moreover, the majority of pesticides used by farmer are highly or moderately hazardous according to the WHO Hazard Class, and their potential EIQ are high or medium. Farmers' crop protection practices based on the intensive use of hazardous pesticides throughout most of vegetable farms in West Africa (PAN UK, 2007; Coulibaly et al., 2008) especially in Togo would constitute a factor worsening not only the farmers and consumers intoxication but also the environmental pollution. This agricultural practice is also at the origin of the qualitative and quantitative modifications of the ecosystems (FAO, 2007), through the pollution of the environment, the elimination of the useful insects and the selection of resistant pests.

The use of incomplete personal protective equipment during pesticides handling and applications and the inadequacy of materials used for spraying pesticides can be considered as the factors which would facilitate famers poisoning in Togo. According to PAN UK (2007), the lack of protective equipment against the pesticides constitutes a serious source of poisoning to farmers in Africa. Williamson (2008) estimated that the indirect cost related to misuse of agricultural pesticides constitutes a great expense supported by rural communities in Africa. According to this author, the expenses are made up by: (i) the health damage of farmers and consumers, (ii) the pesticides resistance development in crop pests, (iii) the negative impacts on beneficial organisms and (iv) the loss of livestock and biodiversity.

Conclusion

The present study shows that in Togo, the market gardening farms are mostly owned by men. The ignorance of good crop protection practices due to the insufficiency of training for the majority of farmers on vegetable protection, in spite of their good level of education, lead to the excessive use of several pesticides which are very hazardous to human and environmental health. Organophosphates and pyrethroids are the classes of pesticides mostly used by farmers in Togo. The use of inadequate materials for pesticides application, likewise the excessive use of pesticides having various modes of action contribute to the development of the resistance revealed by some pests, especially *P. xylostella*. The recourse to alternative control methods such as crop rotation, biological control and insecticides of natural origins, in an Integrated Pest Management (IPM) approach would contribute to a better insecticides resistance management and reduce the agricultural impacts on the environment. Therefore, the effectiveness of these alternative methods and their impact on beneficial arthropods is discussed.

ACKNOWLEDGMENTS

We thank Anna Yuwen and Francis Mwambo both of the Center for Development Research (ZEF) University of Bonn for making valuable comments on the manuscript of this paper. We are also grateful to the farmers for granting us access to their farms and for the data collection without which this study would not have been possible.

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