



# **Pesticides and Biopesticides Use in Market Gardening in Ouagadougou, Burkina Faso**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

This study aims to identify the pesticides and biopesticides used in market gardening in the outskirts of Ouagadougou in order to raise awareness among producers and populations. A semi-structured survey was conducted among 96 market gardeners on the use of pesticides and biopesticides in

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market garden production. Descriptive analysis was performed using GraphPad Prism 6 software. GC/MS analysis was performed to search for pesticide residues on the two most widely grown vegetables according to the survey results. The chemical compounds were studied using the WILLEY-CH 1992, NIST 2004 and PEST database libraries. According to this study, men represented 54.17% and women 45.83% of market gardening activity. The main crops encountered in the sites were lettuce (17%), cabbage (15%), eggplant (12%), onion (11%) and tomato (10%). Twenty-eight (28) pesticides were identified; two (2) were very dangerous, of which 18 were moderately dangerous, seven were less dangerous and one product was not classified according to the WHO classification. Nine (09) families of pesticides have been identified; the most important was pyrethroid (30%). More than half of market gardeners did not respect the dose prescribed (57%) on the labels. A large number of market gardeners (70%) respected the persistence time. The results also indicate eight biopesticide formulations and two complex formulations identified. No hazardous pesticides were detected in the two most widely grown vegetables, lettuce and cabbage. Market gardening on the outskirts of cities requires constant monitoring and supervision to reduce health and environmental risks.

*Keywords: Survey; market gardening; pesticides; biopesticides; GC-MS analysis; Burkina Faso.*

## 1. INTRODUCTION

Market gardening in Burkina Faso is increasingly important [1] and occupies men and women, especially in the outskirts of large cities. The vegetables produced are sources of income and food for producers [2, 3] and households in Burkina Faso [4]. The main crops grown are cabbage, eggplant, onion, lettuce, tomato, okra, carrot, cucumber, pepper, etc. These vegetables comprise short and long-cycle speculations and are rich in vitamins, proteins, mineral salts, and other constituents that contribute to nutritional balance and improved health. For example, vegetables like lettuce cure insomnia [5], and cabbage can help to reduce the risk of several diseases, such as cancer and degenerative diseases [6]. These vegetables offer a balanced diet and participate in the population's well-being and food security. Market gardening in the outskirts of large cities such as Ouagadougou is practiced on several plots throughout the year and concerns vulnerable groups in most cases.

Unfortunately, the majority of producers use synthetic pesticides [7] and sometimes complex mixtures of products to overcome pests, weeds, and vegetable diseases [8, 9]. Some work on pesticide use in market gardening revealed some unauthorized use of pesticides on vegetable crops [10] and drew attention to the risk of environmental contamination [7]. In addition, producers less aware of the use of these products—sometimes ignore or do not control the persistence time of the products used on vegetables, which could leave pesticide residues on the final product. In addition, we are witnessing the repeated treatment of crop

pesticides. From then on, we immediately understand the danger represented by repeated pesticide treatments and the use of these chemical substances that could influence the resistance of pests and negatively affect the health of farmers. However, in Burkina Faso, a law on quality control, use and compliance with labeling standards regulates the management of pesticides in agriculture [11]. But, the control measures on the sites of use (in the fields and the market gardening sites) are not put in place. This therefore leads growers to the use of pesticides according to their understanding. Moreover, today some producers are trying to integrate the use of biopesticides into their production to satisfy a certain number of more rigorous customers [12].

The objective of this study is to identify the pesticides and biopesticides used in market gardening in Ouagadougou's outskirts and their presence in post-harvest products. These findings will improve the knowledge of the gardening practices and the pesticides used in Burkina Faso.

## 2. MATERIALS AND METHODS

### 2.1 Field Investigation

This study was conducted from November 2021 to July 2022 in Ouagadougou outskirts (Kamboinsé and Boulmiougou) (Fig.1). Ninety-six (96) market gardeners were randomly selected across its two sites. The choice of market gardeners was made with the criteria of having a minimum of 500 m<sup>2</sup>, having at least five years of experience in the field, and consenting to the

questionnaires. Ninety-six (96) market gardeners were eligible for the survey. A sowing semi-directive questionnaire was used.

A descriptive analysis was carried out with the GraphPad Prism 6 software by calculating the means and frequencies and drawing the graphs.

### 2.2 Sample Preparation and Residues Analysis

The leaf samples of the first two most cited vegetables in market gardening; lettuce and cabbage were collected for GC/MC analysis. In total 20 samples, including 10 cabbage plants and 10 lettuce plants were taken only in the market garden fields of Kamboinsé and Boulmiougou. The samples were prepared by the QuE Chers method for residue analysis using 5 g of sample from the mixture of each provenance and acetonitrile (10 mL), all mixed with the kit of chemical reagents composed of sulfate of magnesium anhydride sodium chloride, trisodium

citrate dihydrate and sodium citrate dibasic sesquihydrate for extraction. In addition, the purification phase used MgSO<sub>4</sub> from PSA (primary and secondary amine). 1 µL of the extract was injected at the level of the mass. Identification of chemical compounds was carried out using WILLEY-CH 1992, NIST 2004 and PEST database libraries.

## 3. RESULTS

### 3.1 Market Gardener's Socio-Demographic Characteristics

In this study men represented 54.17% and women 45.83% of the respondents (Table 1). The ages of the respondents ranged from 18 to 68 years old. People out of school represented 55.21%, while the rate of people in school was 44.79%. Market gardeners aged more or less than 10 years represented 50% of those questioned.

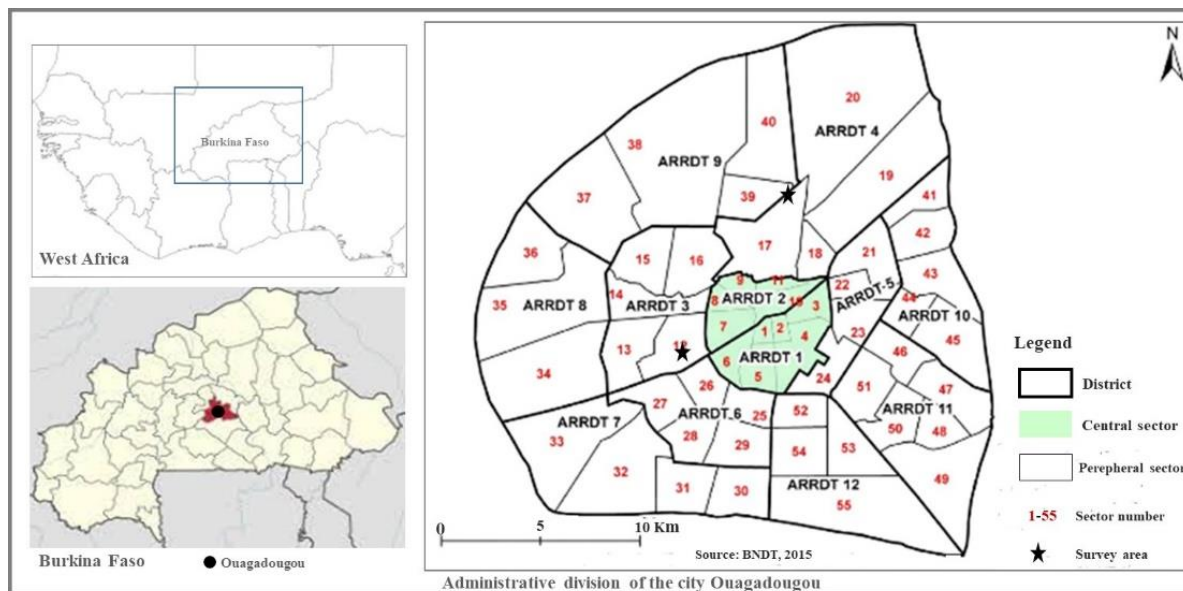


Fig. 1. Survey area

Table 1. Distribution of market gardeners by age, gender and educational status (n = 96)

Age	Women (%)	Male (%)	Educated (%)	Uneducated (%)	Number of years of experience	
					<10 years (%)	>10 years (%)
18-28	6.2	8.33	10.42	4.17	14.58	0
28-38	6.25	9.38	8.33	7.29	9.37	6.25
38-48	8.33	10.42	8.33	10.42	5.30	13.54
48-58	15.63	19.79	13.54	21.88	14.58	20.83
58-68	9.37	6.25	4.17	11.45	6.25	9.37
Total	45.83	54.17	44.79	55.21	50	50

### 3.2 Main Vegetable Crops Grown

In the urban and peri-urban areas of Ouagadougou several market garden crops were identified and these varied according to the seasons and market demand. However, at the time of our study, the main crops were lettuce (17%), cabbage (15%), eggplant (12%), onion (11%), and tomato (10%), etc. (Fig. 2a).

### 3.3 Pesticides Identified

The pesticides recorded during this study in the market garden perimeters are indicated in Table 1. Among the pesticides used in gardens, 4 (four) categories of pesticides have been identified according to the WHO classification [13]: 2 class I pesticides (very dangerous), 18 class II pesticides (moderately dangerous), 7 class III pesticides (less dangerous) and 1 unclassified product. Of the 28 products listed, 20 were approved by the Sahelian pesticide council [14, 15,16] while CSP did not approve 8.

The most cited pesticides were Emacot 050 WG (57.29%), followed by Lambda super 2.5 EC (52.06%), and Emir Fort 104 EC (41.66%), etc.

There were 10 chemical products (Attackan C 344 SE, Caïman B19, Capt 88 Ec, Emacot 050 WG, Emaron, Emir Fort 104 EC, Hitcel 440 EC, Ibis A 52 Ec; Pichen 440 EC ; Thalys A56 EC ) intended solely for the cotton plant which is used to treat vegetable pests.

Nine families of pesticides have been recorded (Fig. 2b), the most important of which are those of Pyrethroid (30%) followed by Neonicotinoid (19%), avermectin (14%), and organophosphate (14%).

### 3.4 Complex Formulation

Complex formulations have been recorded, and this concerned 1.04% of the surveyed population who used these complex mixtures to treat fungi and other pests that attacked the leaf and fruit of okra (Table 2).

### 3.5 Formulation of Natural Biopesticides

Biopesticide formulations were developed by market gardeners to sometimes treat certain vegetables attacked by pests (Table 4). This investigation identified 8 formulations composed of a mixture of 5 local plants. These were

*Azadirachta indica* A.Juss., *Allium cepa* L., *Carica papaya* L., *Allium sativum* L., and *Capsicum annuum* L. The most cited formulation was the mixture of *Azadirachta indica* and ash (7%).

Four (4) plant organs including leaves, fruits, seeds and bulbs were used to prepare pesticide mixtures (Table 5). Leaves comprised 31% of recipes and bulbs and fruits shared 25% while seeds comprised 19% (Fig. 2d). The main ingredients consisted of Neem organs and *C. papaya* leaves.

Ingredients such as ash and soap were also involved in formulating biopesticides. Thus, ash was cited 1 time in the listed formulations, while soap was cited 7 times.

The biopesticide preparations were made by maceration and left to rest for 24 hours or often 2 weeks. The obtained mixture was used by spreading.

### 3.6 Analysis of Phytosanitary Practices

The analysis of phytosanitary practices showed that more than half of the respondents (57%) did not respect the doses prescribed on the labels (Fig. 2c). Almost all of the market gardeners interviewed (95%) did not wear overalls when using pesticides. Most market gardeners (75%) respected the perseverance time. Pesticides were used on the sites by sprinkling or manual spraying. Most respondents used both types of methods. Watering was done using a bucket of pesticide mixture in which tree branches, brooms and brushes were dipped to spray the plants. For powders, use was done by hand without protective equipment. Manual spraying was carried out using the bottle lids as a measuring tool. The dosage was done approximately without respecting the standards indicated on the bottle label. After using the products, the packaging was left on the cultivation sites.

### 3.7 GC/MS Screening

The results of research on pesticides for the most cultivated vegetables are mentioned in chromatograms 1 and 2 (Figs. 3 and 4). Indeed, the search for chemical compounds in lettuce indicated 100 compound peaks, among which 21 compounds were identified (Table 6). GC/MS screening of cabbage showed 92 peaks, among which the most abundantly identified were 19 (Table 7).

**Table 2. Other formulations in garden market practice**

Mixture	Vegetable treated	Parasites	Frequency of citation (%)
1. Lambda super 2.5 EC + macerated Neem seeds	<i>Abelmoschus esculentus</i> (L.) Moench (Okra)	Parasite (fungus)	1.04
2. Karaté + Soap	<i>Abelmoschus esculentus</i> (L.) Moench (Okra)	Parasite (fungus)	1.04

**Table 3. Pesticides identified in market gardening sites in Ouagadougou and surroundings**

Commercial specialties	Principle active	Chemical family	Recommended areas of use	Type	Citation frequency (%)	Approval by CSP	WHO class
1. Attackan C 344 SE	Imidacloprid, cypermethrins	Neonicotinoid + Pyrethroid	Cotton	Insecticides	10.41	Yes	II
2. Attack 5%WDG	Emamectin Benzoate (5%)	Avermectin	market gardening	Insecticide	10.41	No	II
3. Biok 16	Bacillus thuringiensis 16 000 UI/mg	Bacillus thuringiensis bacteria and their insecticidal proteins	market gardening	Insecticide	1.04	Yes	U
4. BOMEK 18 EC	Abamectin 18 g / L	Avermectins	market gardening	Insecticides, Acaricide	5.21	Yes	II
5. Caïman B19	Emamectin benzoate (19,2 g/l)	Abamectin	Cotton	Insecticide	31.25	Yes	II
6. Capt 88 EC	Acetamiprid 16g +cypermethrin72gg/L	Neonicotinoid + Pyrethroid	Cotton	insecticide	20.83	Yes	II
7. Cypercal 50 EC	Cypermethrin	Pyrethroid	Vegetable and cereal crops	Insecticide	20.83	Yes	III
8. Dursban 450 ULV	Chlorpyriphos-éthyl, 450 g/L	Organophosphates	Arachide	insecticide	10.41	Yes	II
9. Decis 25 EC	Deltamethrin, 25g/L	Pyrethroid	Tomato	Insecticide	15.625	Yes	II
10. Decis forte 100 EC	Deltamethrin, 100g/L	Pyrethroid	Tomato	Insecticide	20.83	Yes	II
11. Emacot 050 WG	Emamectin benzoate 50g/kg	Avermectin	Cotton	Insecticide	57.29	Yes	II

Commercial specialties	Principle active	Chemical family	Recommended areas of use	Type	Citation frequency (%)	Approval by CSP	WHO class
12. Emaron	Emamectin benzoate (20g/L) Lufenuron (80g/L)	Avermectin+Benzoyl urea	Cotton	Insecticide	31.25	Yes	III
13. Emir Fort 104 EC	Acetamiprid 32g/L + Cypermethrin 72g/L	Neonicotinoid + Pyrethroid	Cotton	Insecticide	41.66	Yes	II
14.Furadan	Carbofuran 50 g/Kg	Carbamate	Vegetables, cereals, cotton	Insecticide	10.41	No	Ib
15. Hitcel 440 EC	Cypermethrin 40g/L + Profenofos 400g/L	Pyrethroid + Organophosphates	Cotton	Insecticide	15.625	Yes	II
16.Ibis A 52 EC	Alpha-cypermethrin 36 g/l + Acetamiprid 16 g/l	Pyrethroid + Neonicotinoid	Cotton	Insecticide	5.21	No	II
17. Kapaas 80EC	Emamectin benzoate +abamectin+acetamiprid	Avermectin +Neonicotinoid	Cotton, market gardening	Insecticide	5.21	No	_
18. Karaté	Lambda-Cyhalothrin	Pyrethroid	Any culture	Insecticide	3.125	No	III
19.Lambda power	Lambda –cyhalothrin 0.5% + Dimethoate 20% EC	Pyrethroid + Organophosphate	Vegetable crops, rice, cotton, cowpea, groundnut	Insecticide	31.25	No	II
20.Lambda super 2.5 EC	Lambda-cyhalothrin (25g/L)	Pyrethroid	Vegetable crops, cotton, cereals, and legumes	Insecticide	54.16	No	III
21.Mancozeb	ethylene di-isothiocyanate	Carbamate	Vegetable, fruit, cotton, and cereal crops	Insecticide	31.25	Yes	III
22.Manga plus	Mancozeb (800 g/kg)	Dithiocarbamate	Vegetable crops, cereals and fruit	Insecticide	28.125	Yes	III
23.Pacha 25EC	Acetamiprid 10g/L+Lambda- cyhalothrin 15g/L	Neonicotinoid + Pyrethroid	Vegetable and fruit crops	Insecticide	7.29	Yes	III
24. Pichen440EC	Profenofos 400g/L+ Cypermethrin40 g/L, EC	Organophosphates + Pyrethroid	Cotton	Insecticide	22.91	Yes	II
25.Thalis A 56 EC	Acetamiprid (32g/l) + Emamectin benzoate 24 g/l	Avermectin + Neonicotinoid	Cotton	Insecticide	5.21	Yes	II

Commercial specialties	Principle active	Chemical family	Recommended areas of use	Type	Citation frequency (%)	Approval by CSP	WHO class
26.Savahaler	Methomyl 250g/kg WP	Carbamate	cabbage	Insecticide	31.25	Yes	II
27.Sniper 1000EC	DDVP80% EC	Organophosphate	Market gardening, fruit, rice, cotton, etc.	Insecticide	8.33	No	Ib
28.Titan 25 EC	Acetamiprid 25g/l	Neonicotinoid	Vegetable and fruit crops	Insecticide	6.25	Yes	II

Legend: Ib: Very dangerous; II: Moderately dangerous; III: Not very dangerous; U: Unlikely to present an acute hazard

**Table 4. Formulation of natural biopesticides (n=96)**

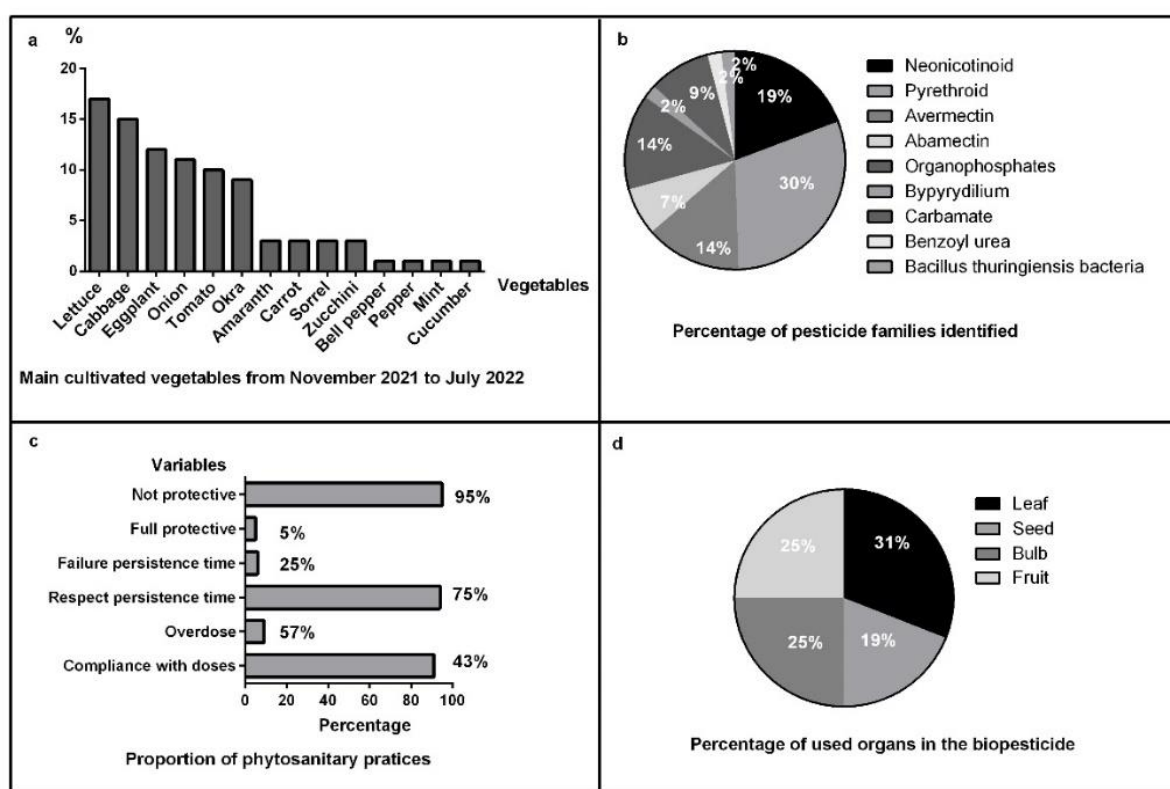
Species	Main Organ/ Quantity	Secondary ingredient and quantity						Preparation	Mode of use	Frequency of Citation (%)
		On	Ga	Pe	So	Wt	Ash			
<i>Azadirachta indica</i> (A.) Juss	Leaf/2kg	-	-	-	5g	10L	-	Ma+24h	Spreading	3.125
	Leaf/2kg	-	-	2g	5g	10L	-	Ma+24h	Spreading	1.04
	Leaf/2kg	-	1Bulb	2g	5g	10L	-	Ma+24h	Spreading	1.04
	Leaf/2kg	1bulb	1 Bulb	2g	5g	10L	-	Ma+24h	Spreading	1.04
	Seed/200g	-	-	-	-	10L	10g	Ma+24h	Spreading	7
	Seed/500g	2 bulbs	2 bulbs	2g	5g	10L	-	Ma+2 weeks	Spreading	3.125
	Seed oil/125 mL	-	-	-	2g	10L	-	Mixture	Spreading	1.04
<i>Carica papaya</i> L	Leaf/500g	-	-	-	5g	10L	-	Ma	Spreading	4.16

Legend: As: Ash; Ga : Garlic ; Ma +24 h: Maceration and then left to stand for 24 hours; Ma+ 2 weeks: Maceration and then left to stand for 2 weeks. On : Onion ; Pe : Pepper; Pt : Preparation ; So: Soap; Wt : Water

**Table 5. Plant species and used organs as bioinsecticides**

Species	Vernacular names	Family	organ used
<i>Allium cepa</i> L.	M: Djabá E: Onion	Liliaceae	Bulbs
<i>Allium sativum</i> L.	M: Lyele E: Garlic	Liliaceae	Bulbs
<i>Azadirachta indica</i> (A.) Juss	M: Nim E: Neem	Meliaceae	Leaves, seeds
<i>Capsicum annuum</i> L.	M: Kiparé E: Pepper	Solanaceae	Powder of dried fruits
<i>Carica papaya</i> L.	M: Papay tiiga E: Pawpaw	Caricaceae	Leaves

Legend: M: Mooré, E: English



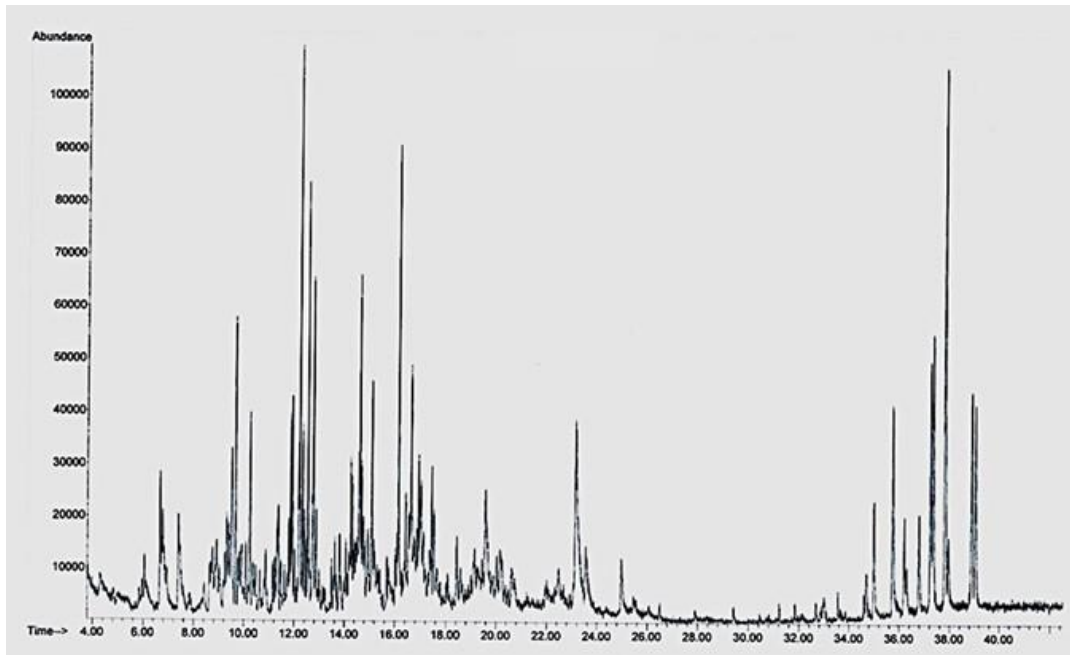
**Fig. 2. Pesticides use by market gardeners and phytosanitary practices**

Regarding the main peaks in lettuce (*Lactuca sativa* L.) 9 groups were identified including the hydrocarbon group (Heptadecane, 8-methyl-, Tetratetracontane, Pentadecane, Heneicosane, Hexadecane, 10-Methylnonadecane, Heptadecane, Triacontane, Pentacosane, Heptacosane, Octacosane, Hexacosane; phenol (phenol, 2,5-bis (1,1-dimethylethyl)); cyclic ethers (dichloroacetic acid, tridecyl ester); organoiodides (tridecane, 1-iodo-); organooxygen compounds (dichloroacetic acid, sulfurous, butyl dodecyl ester); epoxide (oxirane,

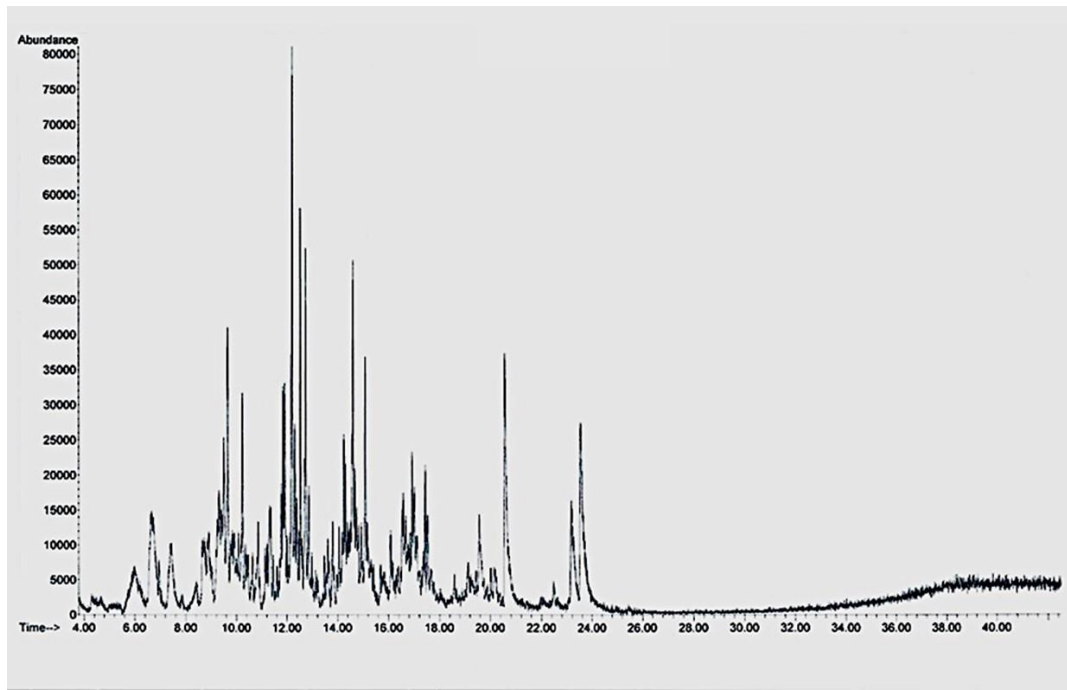
hexadecyl-); fatty amide (octadecenamide, (z)-); esters (carbonic acid, isobutyl dodecyl ester); phytosterol (beta. -sisterol) and triterpenoids (A'-Neogammacer-22(29)-en -3-ol, acetate, (3.beta., 21.beta.).

According to the range of compounds the most dominant compounds identified in lettuce were octadecenamide, (z)-(4.60%), A'-Neogammacer-22(29)-en-3-ol, acetate, (3.beta.,21 beta)-(2.79%) and heptadecane,8-methyl-(2.72%).





**Fig. 3. TIC chromatogram of total chemical compounds of lettuce samples**



**Fig. 4. TIC chromatogram of total chemical compounds of cabbage samples**

GC/MS research on cabbage (*Brassica oleracea* L.) allowed us to determine 5 groups: fatty acids (organooxygen compounds); fatty and conjugated acids (nonahexacontanoic acid); hydrocarbons (heneicosane, heptadecane, octadecane, dodecane, nonadecane, Tetratriacontane, Eicosane,

Tetratetracontane, Cyclododecane, Octacosane, Pentacosane, Heptacosane, Hexacosane, Pentadecane, 2,6,10-trimethyl-); phenol (Phenol, 2,4-bis (1,1-dimethylethyl)) and fatty amides (Hexadecanamide, Octadecanamide).

**Table 6. The main peaks of the compound in the Lettuce sample**

Number	Peak number	Retention time	Area%	Library/ID	Molecular formula	Molecular weight (g/mol)	Nature of compound	CAS	Qual
1	17	9.654	2.72	Heptadecane,8-methyl-	C <sub>18</sub> H <sub>38</sub>	254.5	Branched alkane	013287-23-5	83
2	29	11.223	0.39	Tetratetracontane	C <sub>44</sub> H <sub>90</sub>	619.2	Acyclic alkane	007098-22-8	90
3	30	11.315	0.87	Pentadecane	C <sub>15</sub> H <sub>32</sub>	212.41	Acyclic alkane	000629-62-9	90
4	31	11.362	0.81	Heneicosane	C <sub>21</sub> H <sub>44</sub>	296.57	Acyclic alkane	000629-94-7	86
5	35	11.910	1.85	Hexadecane	C <sub>16</sub> H <sub>34</sub>	226.44	Acyclic alkane	000544-76-3	90
6	36	12.002	0.35	10-Methylnonadecane	C <sub>20</sub> H <sub>42</sub>	282.5	Branched alkane	056862-62-5	90
7	39	12.313	1.17	Heptadecane	C <sub>17</sub> H <sub>36</sub>	240.471	Acyclic alkane	000629-78-7	90
8	42	12.527	2.35	Phenol, 2,5-bis (1,1-dimethylethyl)	C <sub>14</sub> H <sub>22</sub> O	206.3239	Diphenylmethanes	005875-45-6	95
9	46	13.479	0.29	Dichloroacetic acid, tridecylester	C <sub>15</sub> H <sub>28</sub> Cl <sub>2</sub> O <sub>2</sub>	311.3	Alpha-halocarboxylic acids and derivatives	1000280-48-3	87
10	55	14.575	0.71	Triacotane	C <sub>30</sub> H <sub>62</sub>	422.8	Acyclic alkane	000638-68-6	90
11	57	14.673	0.54	Pentacosane	C <sub>25</sub> H <sub>52</sub>	352.7	Acyclic alkane	000629-99-2	90
12	58	14.748	0.33	Heptacosane	C <sub>27</sub> H <sub>56</sub>	380.7	Acyclic alkane	000593-49-7	87
13	59	14.921	0.52	Octacosane	C <sub>28</sub> H <sub>58</sub>	394.8	Acyclic alkane	000630-02-4	87
14	60	15.088	1.95	Tridecane, 1-iodo-	C <sub>13</sub> H <sub>27</sub> I	310.26	Organoiodides	035599-77-0	86
15	69	16.571	0.46	Sulfurous acid, butyl dodecyl ester	C <sub>16</sub> H <sub>34</sub> O <sub>3</sub> S	306.5	Organooxygen compounds	1000309-17-9	91
16	75	17.431	0.92	Hexacosane	C <sub>26</sub> H <sub>54</sub>	366.71	Acyclic alkane	000630-01-3	83
17	78	18.411	0.82	Oxirane, hexadecyl-	C <sub>18</sub> H <sub>36</sub> O	268.5	Epoxide	007390-81-0	83
18	86	23.136	4.60	Octadecenamide, (z)-	C <sub>18</sub> H <sub>35</sub> NO	281.5	Carboximidic acids	000301-02-0	91
19	88	24.970	0.89	Carbonic acid, dodecyl isobutyl ester	C <sub>17</sub> H <sub>34</sub> O <sub>3</sub>	286.4	Ester	1000314-60-9	83
20	90	34.991	1.66	Beta.-Sisterol	C <sub>29</sub> H <sub>50</sub> O	414.71	phytosterol	000083-46-5	93
21	99	38.885	2.79	A'-Neogammacer-22(29)-en-3-ol, acetate,(3.beta.,21.beta. )	C <sub>32</sub> H <sub>52</sub> O <sub>2</sub>	468.8	Triterpenoids	002085-25-8	91

Legend: Area %: Percentage of the total measured area in the total ion chromatogram, CAS: CAS Number, Qual: Quality of identification, above 80 % of the compounds is regarded as identified

**Table 7. The main peaks of the compound in the cabbage sample**

Number	Peak number	Retention time	Area%	Library/ID	Molecular formula	Nature of compound	CAS	Qual
1	23	11.315	1.74	Sulfurous acid, 2-propyl tetradecyl ester	C <sub>17</sub> H <sub>36</sub> O <sub>s</sub>	Organooxygen compounds	1000309-12-5	90
2	24	11.362	0.87	Heneicosane	C <sub>21</sub> H <sub>44</sub>	Acyclic alkane	000629-94-7	86
3	27	11.783	1.04	Heptadecane	C <sub>17</sub> H <sub>36</sub>	Acyclic alkane	000629-78-7	83
4	29	11.915	2.83	Octadecane	C <sub>18</sub> H <sub>38</sub>	Acyclic alkane	000593-45-3	90
5	37	12.527	3.21	Phenol, 2,4-bis (1,1-dimethylethyl)	C <sub>14</sub> H <sub>22</sub> O	Diphenylmethanes	000096-76-4	96
6	38	12.740	4.75	Dodecane	C <sub>12</sub> H <sub>26</sub>	Acyclic alkane	00112-40-3	93
7	44	13.606	0.45	Nonadecane	C <sub>19</sub> H <sub>40</sub>	Acyclic alkane	000629-92-5	90
8	48	14.050	0.76	Tetratriacontane	C <sub>34</sub> H <sub>70</sub>	Acyclic alkane	014167-59-0	90
9	58	14.742	0.31	Eicosane	C <sub>20</sub> H <sub>42</sub>	Acyclic alkane	00112-95-8	86
10	60	15.088	3.00	Tetratetracontane	C <sub>44</sub> H <sub>90</sub>	Acyclic alkane	007098-22-8	90
11	63	15.683	0.45	Cyclododecane	C <sub>10</sub> H <sub>20</sub>	Cyclic alkane	000294-62-2	92
12	64	16.086	0.84	Octacosane	C <sub>28</sub> H <sub>58</sub>	Acyclic alkane	000630-02-4	86
13	70	16.571	0.48	Nonahexacontanoic acid	C <sub>69</sub> H <sub>138</sub> O <sub>2</sub>	Fatty acids and conjugates	040710-32-5	83
14	74	16.917	1.18	Pentacosane	C <sub>25</sub> H <sub>52</sub>	Acyclic alkane	000629-99-2	86
15	75	17.004	1.30	Heptacosane	C <sub>27</sub> H <sub>56</sub>	Acyclic alkane	000593-49-7	90
16	77	17.367	0.5	Hexacosane	C <sub>26</sub> H <sub>54</sub>	Acyclic alkane	000630-01-3	83
17	79	17.523	1.29	Pentadecane, 2,6,10-trimethyl-	C <sub>18</sub> H <sub>38</sub>	Sesquiterpenoids	003892-00-0	86
18	89	20.563	7.80	Hexadecanamide	C <sub>16</sub> H <sub>33</sub> NO	Fatty amides	000629-54-9	86
19	92	23.534	6.05	Octadecanamide	C <sub>18</sub> H <sub>37</sub> NO	Carboximide acids	000124-26-5	91

Legend: Area %: Percentage of the total measured area in the total ion chromatogram, Ref: Reference Number, CAS: CAS Number, Qual: Quality of identification, above 80 % of the compounds is regarded as identified

The most abundant compounds by distribution area in cabbage were hexadecanamide (7.80%), octadecanamide (6.05%), and dodecane (4.75%).

#### **4. DISCUSSION**

During this study, men were more important and critical than women, which can be explained by women's reluctance to give information. Men and women of every age are increasingly interested in market gardening. This enthusiasm for market gardening could be linked to the fact that this activity is a source of income for households [4].

Thus, in market gardening activities, several pesticides are used to control pests. The use of insecticides on the surveyed sites depended on the nature of the pest and its resistance. Sometimes growers apply pesticides to crops in excess of the recommended doses. However, in our study, more than half of the people surveyed did not respect the recommended doses. Indeed, Naré et al. [17], reported that growers did not respect pesticide application rates. Producers sometimes use cotton insecticides not approved by CSP for vegetable production. Grunder et al. [18] mentioned this case of using not approved pesticides in their report on culture protection. This fact would be ignorance and can cause contamination in the short or medium term of the vegetables. In general, the most cited pesticides used in market gardening contain active molecules such as emamectin benzoate, lambda-cyhalothrin, acetamiprid, and cypermethrin and belong to the family of Avermectin, Pyrethroid, Neonicotinoid, and Pyrethroid respectively. This family of pesticides was emphasized in the work of Son et al. [19], Grunder et al. [18], and Sawadogo et al. [20] in the market gardening of tomatoes in Burkina Faso and this confirms our results. The pyrethroid family was the most representative in the use of pesticides in market gardening during this study. This chemical group was also mentioned in the work of Kpiagou et al. [21] in Togo (A West African country, neighboring Burkina Faso) as the most important chemical group in market gardening. This confirms our results and its wide use in the sub-region. Thus, non-compliance with regulations could lead to significant risks for the grower, firstly, consumers and the environment.

In addition, complex formulations have been used in the gardening field and these formulations can be mixtures of insecticides and

biopesticides or insecticides and soap to overcome the parasite. This case has been found in most of the fungal control encountered on the leaves and fruits of okra. These mixtures can increase health and environmental risks [22]; in fact, products at low doses may not present a health risk, but their mixture may increase risk.

On the other side, a small number of market gardeners use biopesticide formulations. These market gardeners producing the biopesticides do so according to them for a particular category of customer. Biopesticides could be very important in controlling vegetable pests and diseases. Indeed, biopesticides based on Neem (leaf, seed, and oil) would contain an active ingredient azadirachtin [23]. A study carried out in Burkina Faso in the North-Central region on biopesticides showed that treatments based on Neem seeds had similar effects to treatments based on pesticides [24]. This shows that biopesticides based on Neem extracts are known and used by market gardeners and remain to be developed for greater use. Biopesticides containing onion and garlic contain active ingredients such as alliin and alliin [25]. Garlic and onion juice contain several compounds that control pests [26, 27]. Biopesticides containing pepper would contain capsaicin [28]. Capsaicin can be used as a repelling for pests. Hot peppers are sometimes used to treat certain fungal diseases of plants [29]. Biopesticides made from papaya leaves are full of active ingredients, such as papain, used to fight against insect pests of okra [30].

The use of soap in biopesticide formulation may be due to its action as an adjuvant and contributes to killing the pest. Some authors show that soap disturbs the pest membrane and cuticle and permits to control of the pests [31]. Neem seed oil is an insecticide and can be used as an insect repellent.

Phytosanitary practices concerning the means of protection during the application of pesticides are lacking. This could be due to the ignorance and poverty of growers, leading them to neglect protection when using pesticides in the field.

In this study, GC/MS analysis showed that most identified compounds in lettuce are hydrocarbons characterized by their volatility. This richness of lettuce in its compounds could be explained by external factors (environmental, climate change, etc.) and internal factors (physiology, genetics) [32, 33].

The majority of compounds found in lettuce agree with the works of some authors who find in lettuce phytoconstituent as hydrocarbon, phytosterol, fatty amide, ester, and triterpenoids [33, 5].

The results of GC/MS analysis in cabbage are similar to those of Wei et al. [34] who identified hydrocarbons, fatty acids, and conjugates in their work entitled "Development and comprehensive HS-SPME/GC-MS of different cabbage cultivars volatile components. In our analysis of cabbages, we also note that most of the compounds identified are volatiles.

GC/MS screening in lettuce and cabbage did not indicate the presence of any hazardous chemical compound. These results would confirm our investigation, which showed that growers respected the persistence time of chemicals used in the treatment of pests and diseases on speculation. The low rate of absorption of pesticides by the two plants could also explain why we could not identify dangerous chemical compounds during GC/MS analyses. Generally, the most dangerous pesticides are those of class Ia and Ib [35]. On the other hand, work carried out in Bamako in Mali (a neighboring country to Burkina Faso) showed possible contamination of vegetables by pyrethroids, which would cause a risk to health and the environment [36]. This observation may be due to the fact that this work was carried out based on samples of river water, backwaters and wells which could be places for rinsing sprayers, buckets or equipment already contaminated by pesticides.

## 5. CONCLUSION

In market gardening, several pesticides are used in the field of production. According to the survey periods, lettuce and cabbage are the most cultivated speculations. Several pesticides and their mixtures are used to control pests, which could lead to significant risks for growers and the environment due to non-compliance with regulations and the use of mixtures of pesticides. GC/MS screening in lettuce and cabbage does not indicate the presence of any hazardous chemical compound. Growers in market gardening need training and support on sanitary practices to reduce health and environmental risks.

## CONSENT

As per international standard or university standard, respondents' 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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