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Farmers' knowledge on Moringa leaves pests control in Burkina Faso

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ABSTRACT: *Moringa oleifera* leaves production in Burkina Faso is severely affected by insect pests, which considerably reduce the yield. This study aimed to obtain more information on producers' knowledge of Moringa insect pest management. Data were collected using an interview questionnaire from 120 randomly selected Moringa growers in 16 localities of Burkina Faso, from July to October 2021. Data collected included producers' socio-demographic characteristics, area of the fields, production objectives, production constraints, foliar insect pests and control methods. The results showed that 61.67% of Moringa producers are men and the leaves are the most produced with 80% of citation rate. According to 72.50% of producers, Insect pests are the primary constraint to Moringa production. To control these insect pests 67.5% of surveyed affirmed that they use bioinsecticides. *Azadiractica indica,* with a 50.86% citation rate is the plant most commonly used to manage insect pests The chi2 test showed that the methods of control of foliar insect pests were related to the production objectives (chi2 = 21.02, ddl = 8, p <0.01). The biplot of the multiple component analysis showed that leaf production goes hand in hand with using bioinsecticides, and the seed producers use synthetic chemicals and bioinsecticides to control insect pests. To improve yields, integrated pest management methods must be developed to promote sustainable production of Moringa leaves in Burkina Faso.

KEYWORDS: *Moringa oleifera,* insect pest, Integrated pest management, bioinsecticides.

1 INTRODUCTION

Moringa oleifera (Lam.) (Moringaceae), commonly known as Moringa, is a woody species native to Asia [1], [2], [3] which is now widespread throughout the world [3]. This shrub can reach 7 to 8 meters high [3] with alternate leaves, tripinnate at the base and bipinnate at the top. The flowers are creamy white. The fruits are in the form of elongated pods with three dehiscing valves [3].

The species has many virtues in medicine, diet, and environment. For example, the leaf is very rich in proteins and minerals and is increasingly used in several projects to fight against malnutrition [4], [5], [6]. According to [7], consumption of 100 g of Moringa fresh leaves can provide between 30 and 100% of the recommended daily value for calcium and 100% of the recommended daily value for vitamins A and C. Moreover, the plant adapted to different environments and reproduces easily by cuttings and seeds [7]. The sale of the various parts of the tree constitutes a source of financial income for the sector actors [8], [9].

In Burkina Faso, *M. oleifera* is cultivated throughout the country by men, women and youth, mostly organized in associations [10]. However, the yields are limited because of insect pest actions such as caterpillars, crickets and grasshoppers [11], [12]. The damage caused is significant [13] causing financial losses for producers [14]. To contribute to the development of this sector, it is imperative to develop effective control methods against these pests. This first requires knowledge of the control methods used by local producers. Very few studies have focused on these local methods of controlling foliar pests of Moringa, so the literature is almost non-existent.

Thus, this study aims to obtain more information on Moringa production and producers' knowledge regarding Moringa pest control. This will promote good pest management and sustainable leaf production for the health of consumers.

1.1 STUDY SITES

The study was conducted in Burkina Faso in 16 localities belonging to 8 administrative regions which are *Centre, Centre-Nord, Centre-Est, Plateau Central, Est, Hauts-Bassins, Nord* and *Sahel* (figure 1). The chosen sites were characterized by a dry tropical climate of the Sudano-Sahelian type with significant rainfall variations [15]. In the north of the country, and the Sahel rainfall is low and temperatures vary between 15° and 45°. In the south, rainfall is more frequent and temperatures are a little lower.

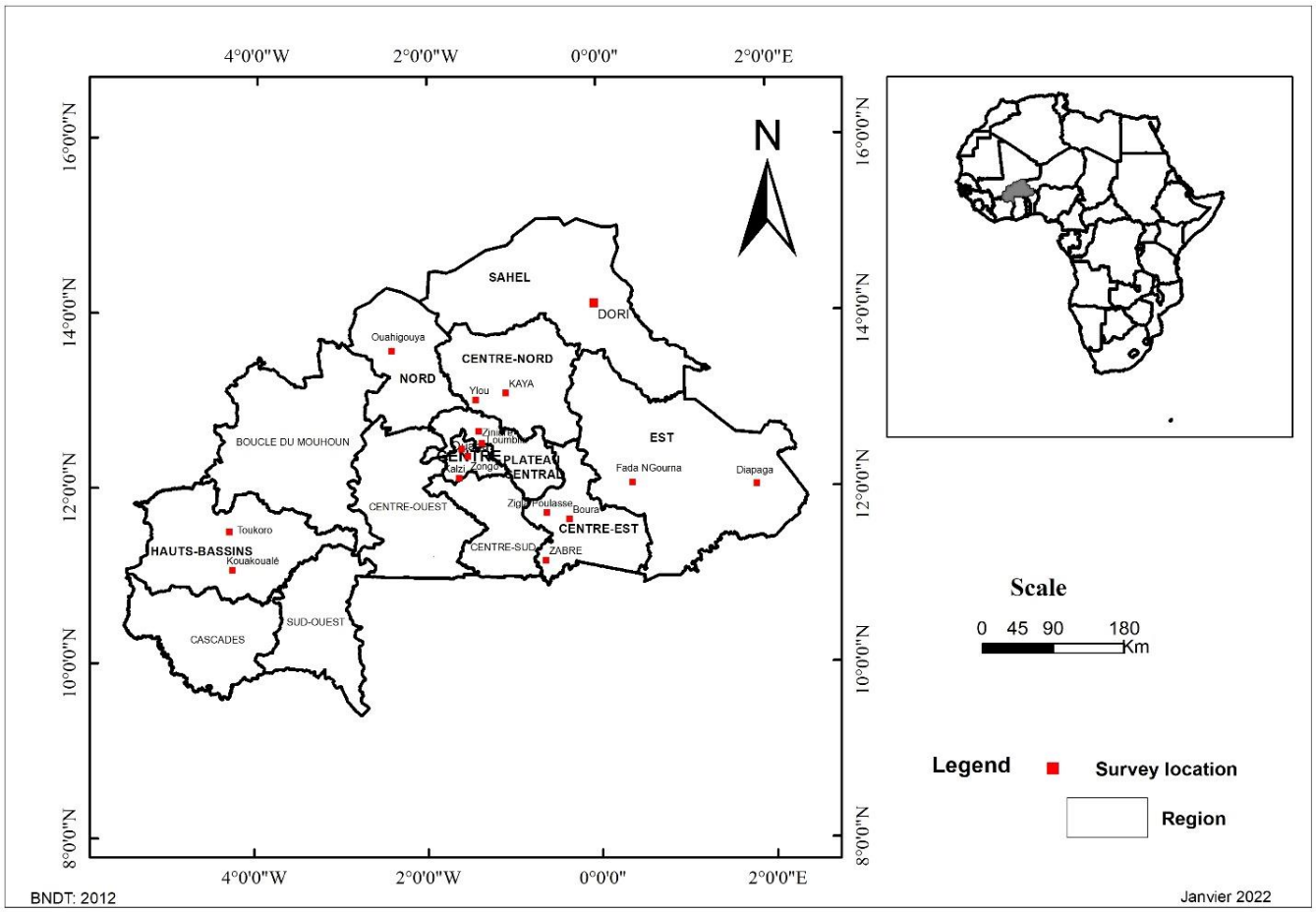

Fig. 1. Study sites

1.2 SAMPLING

An exploratory survey was conducted in July 2020 on thirty (30) Moringa producers. The size of producers to surveyed was determined based on [16] formula which is:

$$N = \frac{Pi\,(1-Pi)}{d^2}\,\mu^2_{1-\alpha/2}$$

Where: *N*: total number of Moringa farmers to be surveyed (sample); *Pi* was determined from the survey and represents the proportion of producers who answered yes to the question "Have you ever observed Moringa leaf attacks in your field?"; $\mu^2_{1-\alpha/2} = 1.96$ represents the value of the normal random variable for a risk α equal to 0.05.

The expected margin of error *d* for any parameter to be estimated from the survey was 5%. According to this formula, the size of the study was estimated at 120 producers (table 1).

Table 1. Distribution of surveyed

Survey location	Administrative region	Number of surveyed
Zongo	*Centre*	9
Kalzi		9
Loumbila		9
Ouagadougou		9
Zabré	*Centre-Est*	9
Zigla		8
Bourra		8
Kaya	*Centre-Nord*	10
Yilo		18
Diapaga	*Est*	3
Fada		3
Kouakoualé	*Hauts-Bassins*	6
Toukoro		6
Ouahigouya	*Nord*	4
Ziniaré	*Plateau Central*	7
Dori	*Sahel*	2
Total		120

1.3 DATA COLLECTION AND PROCESSING

A semi-structured questionnaire was used for individual interviews. The data collected were the socio-demographic characteristics of producers, the field characteristics, the production objective, the production constraints, the foliar insect pests and the control methods used. The data were collected from 1st July to 30th October, 2021. The producers surveyed were randomly chosen between the members of the West African Network of Researchers in the Field of Natural Substances (WANNPRES) in Burkina Faso. This network includes researchers and associations of Moringa producers and is represented in the 13 regions of the country by representatives called regional focal points. It's through these focal points, that producers were identified and surveyed according to their availability.

1.4 DATA ANALYSIS

The statistical analysis was carried out using R software (4.1.1). It consisted of the descriptive analysis of the data and the calculation of the percentage of the categorical variables. The chi2 test was used to search for an association between the control methods used against insect pests and some variables of the study. The level probability was set at 5%. A biplot of component analysis was used to explore the relation between the control method and production objectives.

2 RESULTS AND DISCUSSION

2.1 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE PRODUCERS SURVEYED AND AREA OF FIELDS

The result revealed that the average age of the farmers was 46.48 ± 0.91 years old. Men are the most numerous Moringa growers, with 61.67% rate of citation. However, women farmers dominate production in the *Centre* (92%), *Est* (67%) and *Plateau Central* (57%) regions. Respectively 54%, 36% and 10% of Moringa growers were enrolled in school, not in school and had attended a literacy program. Some producers are agrobusinessmen, while others are simply occasional producers. The average cultivated area was 0.83 ± 0.96 ha. The most important number of Moringa producers experience is found in the interval of 0 to 5 years and 72% of respondents grow Moringa in association with other crops (Table 2).

Table 2. Characteristics surveyed and their farms

	Centre	*Centre-Est*	*Centre-Nord*	*Nord*	*Hauts-Bassins*	*Nord*	*Plateau-Central*	*Sahel*	Total
Socio-demographic characteristics of the producers									
Age (Standard error)	46.86 (0.33)	45.80 (0.26)	48.32 (0.41)	43.00 (1.48)	44.08 (0.52)	43.50 (3.5)	47.86 (1.05)	48 (4.95)	46.48 (0.91)
Sex									
Women	33 (92%)	0 (0%)	1 (3.6%)	4 (67%)	3 (25%)	1 (25%)	4 (57%)	0 (0%)	46 (38.33%)
Men	3 (8.3%)	25 (100%)	27 (96%)	2 (33%)	9 (75%)	3 (75%)	3 (43%)	2 (100%)	74 (61.67%)
Education									
Literate	4 (11%)	8 (32%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	12 (10%)
Not in school	25 (69%)	7 (28%)	5 (18%)	2 (33%)	0 (0%)	1 (25%)	3 (43%)	0 (0%)	43 (36%)
Primary	1 (2.8%)	6 (24%)	17 (61%)	0 (0%)	3 (25%)	0 (0%)	3 (43%)	0 (0%)	30 (25%)
Secondary	4 (11%)	4 (16%)	6 (21%)	4 (67%)	3 (25%)	1 (25%)	1 (14%)	1 (50%)	24 (20%)
University	2 (5.6%)	0 (0%)	0 (0%)	0 (0%)	6 (50%)	2 (50%)	0 (0%)	1 (50%)	11 (9%)
Principal occupation									
Farmer	16 (44%)	25 (100%)	22 (79%)	3 (50%)	3 (25%)	1 (25%)	4 (57%)	1 (50%)	75 (62%)
No farmer	20 (56%)	0 (0%)	6 (21%)	3 (50%)	9 (75%)	3 (75%)	3 (43%)	1 (50%)	45 (38%)
Type of producer									
Agro businessman	17 (47%)	14 (56%)	2 (7.1%)	1 (17%)	8 (67%)	2 (50%)	7 (100%)	1 (50%)	52 (43%)
Simple producer	19 (53%)	11 (44%)	26 (93%)	5 (83%)	4 (33%)	2 (50%)	0 (0%)	1 (50%)	68 (57%)
Experience (years)									
>10	6 (17%)	5 (20%)	4 (14%)	3 (50%)	2 (17%)	1 (25%)	0 (0%)	0 (0 %)	25 (21%)
0 – 5	21 (67%)	5 (20%)	21 (75%)	1 (17%)	1 (8.3%)	2 (50%)	6 (86%)	2 (100%)	59 (49%)
5 – 10	5 (17%)	15 (60%)	3 (11%)	2 (33%)	9 (75%)	1 (25%)	1 (14%)	0 (0%)	36 (30%)
Farms characteristics									
Area of the field (ha)	0.97 (0.03)	0.63 (0.02)	0.46 (0.01)	0.50 (0.04)	1.71 (0.11)	1.38 (0.44)	0.79 (0.03)	0.75 (0.17)	0,83 (0.96)
Growing system									
Association	33 (92%)	22 (88%)	6 (21%)	6 (100%)	8 (67%)	3 (75%)	6 (86%)	2 (100%)	86 (72%)
Monoculture	3 (8.3%)	3 (12%)	22 (79%)	0 (0%)	4 (33%)	1 (25%)	1 (14%)	0 (0%)	34 (28%)

2.2 PRODUCTION OBJECTIVES

Moringa is cultivated for the leaves, the seeds, or both (Figure 2). The leaf is produced by 80% of surveyed (52.50% of simple producers and 27.50% of agro businessman). As for the combined production of leaf and seed, it is carried out by 17.50% of the surveyed (12.50% of agro businessmen and 2.59% of simple producers). The production of seeds concerned only 2.50% of agro businessmen.

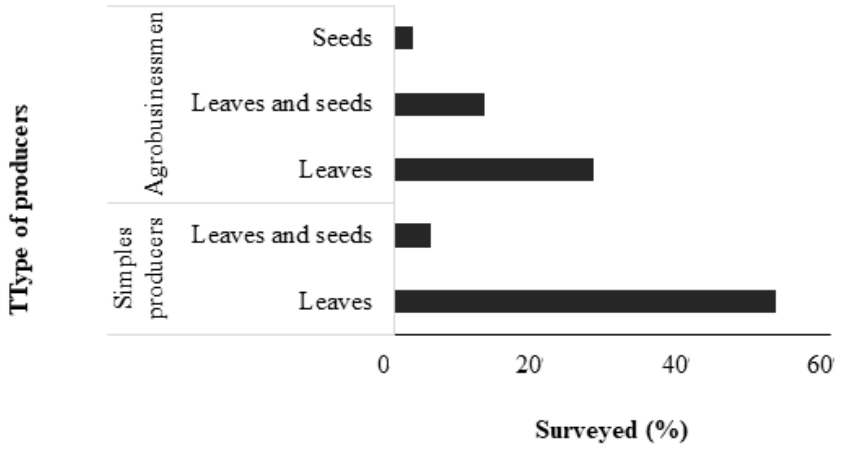

Fig. 2. Moringa production objectives by producer types

2.3 MORINGA PRODUCTION CONSTRAINTS ACCORDING TO PRODUCERS

Insect pests, cryptogamic diseases and lack of seeds were the major constraints identified by Moringa producers. Between these constraints, insect pests were cited by 72.50% of surveyed followed by fungal disease and lack of seed respectively with 10% and 6.67% of citation rates.

Table 3. Constraints of Moringa production according to the type of producers

Constraints	Simples producers (%)	Agrobusinessmen (%)	Total (%)
Insect pests	44.17	28.33	72.50
Fungal diseases	2.50	7.50	10.00
Lack of seeds	4.17	2.50	6.67
Insect pests and spiders	2.50	0.83	3.33
Insect pests and fungal diseases	0.00	2.50	2.50
Lack of seed and insect pests	2.50	0.00	2.50
Lack of seed, insect pests and fungal disease	1.67	0.83	2.50

2.4 CONTROL METHODS FOR MORINGA INSECT PESTS MANAGEMENT

Several methods were adopted by Moringa producers to control insect pest attacks (figure 3). These methods are either used alone or in combination. Among them, bioinsecticides were cited as the most used method (67.50%), followed by synthetic chemical insecticides (20,83%). Some producers combine bioinsecticides with silvicultural methods such as pruning of plants (7.5%). The use of silvicultural methods was the lowest method cited by producers (0.88%).

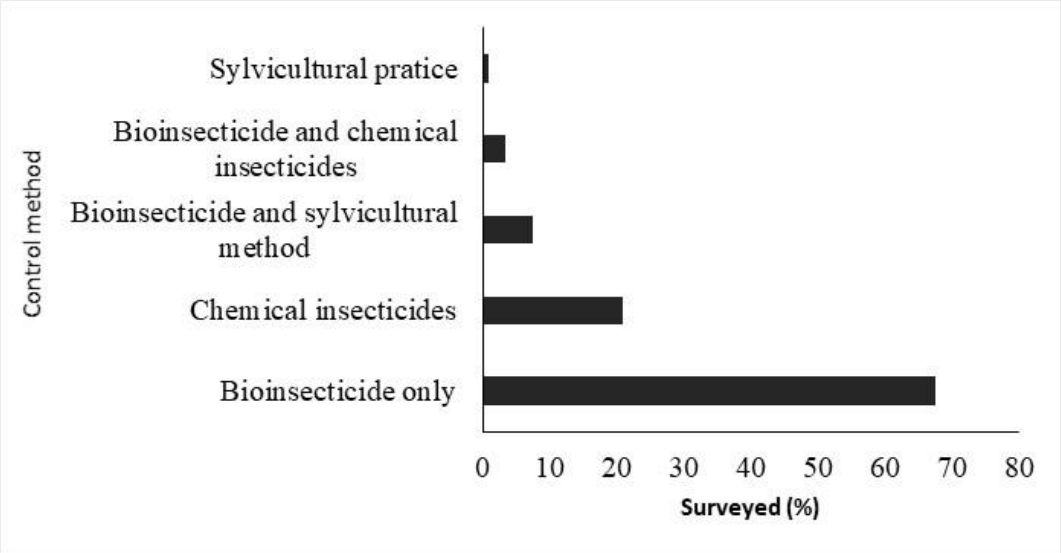

Fig. 3. Control methods of Moringa foliar insect pests

2.5 RELATION BETWEEN CONTROL METHOD AND THE OTHER VARIABLES

Table 4 shows that the control method used by producers is only dependent on the production objectives ($chi^2 = 22.88$, $p < 0.01$).

Table 4. Relation between the control method and other variables

Dependent variable	Independent variable	ddl	Khi²	p-value	N
Control method	Type of producer	4	2.45	0,65	120
	Sex of producer	4	2.41	0.66	120
	Area of the field	4	3.53	0.47	120
	Growing system	4	3.48	0.47	120
	Experience	8	12.97	0.94	120
	Production objectives	8	22.88	<0.01**	120
	Education	16	21.02	0.18	120

***: 0.0001 < p ≤ 0.01;*

The component analysis (CA) of the biplot between the control method and production objectives showed that dim1 (86.3%) and dim2 (13.7%) represent 100% of the variability (Figure 4). The biplot analysis shows that growers who produce leaves alone or in combination with seeds mainly use bioinsecticides and silvicultural methods, while those who produce seeds alone mainly use chemicals and bioinsecticides in insect pest control.

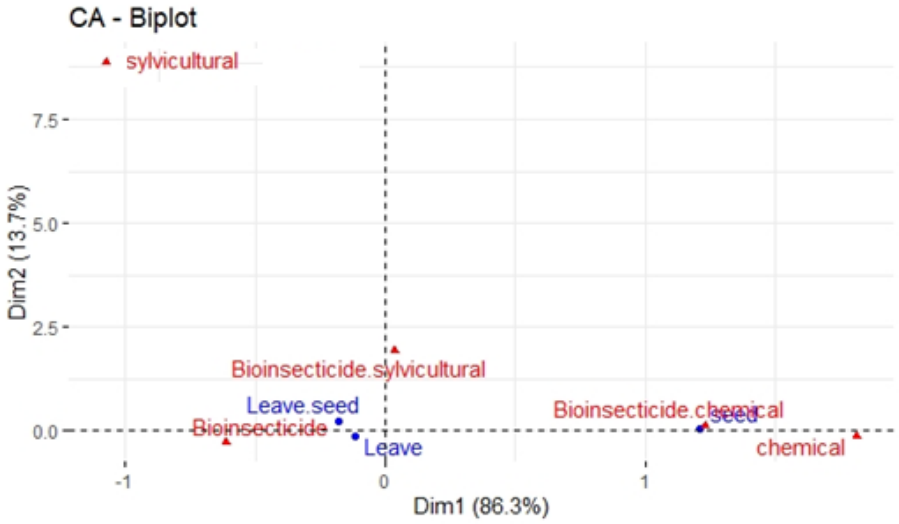

Fig. 4. CA-Biplot between control method and production objectives

2.6 Plant Species Used To Control Leaves Insect Pests

A total of 14 plant species belonging to 12 families were cited by the producers as bioinsecticide plants (Table 5). Among these species, *Azadirachta indica* (A.) Juss is used by 50.86% of producers followed by *Carica papaya* L. and *Capsicum annuum* L. (12.83%). Species like *Eucalyptus camadulensis* Dehnh, *Vernonia colorata* (Wild.), *Cymbopogon citratus* (DC.), *Zingiber officinale* Roscoe, and *Allium sativum* L. were each cited by 0.86% of the producers (Table 5).

Table 5. Plants species using as bioinsecticides

Usual name	Local name	Scientific name	Family	Surveyed (%)
Neem tree	Nim (Mooré)	*Azadirachta indica* (A.) Juss	Meliaceae	50.86
Pepper	Kiparé (Mooré)	*Capsicum annuum* L.	Solanaceae	12.83
Pawpaw	Papay (Mooré)	*Carica papaya* L.	Caricaceae	12.93
Desert date tree	Kyegelega (Mooré)	*Balanites aegyptiaca* (L.) Del.	Balanitaceae	6.3
Cailcedrat	Kuka (Mooré)	*Khaya senegalensis* (Desr.) A. Juss	Meliaceae	3.45
Moringa	Arzantiga (Mooré)	*Moringa oleifera* Lam.	Moringaceae	2.59
Tobacco	Taba (Mooré)	*Nicotiana tabacum* L.	Solanaceae	2.59
Calotropis	Putrupuga (Mooré)	*Calotropis procera*	Apocynaceae	2.59
Cassia	Cassia (Français)	*Senna siamea* Lam.	Fabaceae	1.72
Eucalyptus	Eucalyptus (Français)	*Eucalyptus camadulensis* Dehnh	Myrtaceae	0.86
Vernonia	koá safàn vãadò (Mooré)	*Vernonia colorata* (Wild.) Drake	Asteraceae	0.86
Citronnella	Sitronɛl (Mooré)	*Cymbopogon citratus (*DC.) Stapf, 1906	Poaceae	0.86
Ginger	Yamakú (Mooré)	*Zingiber officinale* Roscoe	Zingiberaceae	0.86
Garlic	Lɛy (Mooré)	*Allium sativum* L.	Liliaceae	0.86

2.7 CHEMICALS USED IN THE FOLIAR INSECT PESTS CONTROL

Investigations have hinted that some growers used chemical insecticides to control leaves insect pests of Moringa. Among the synthetic chemical insecticides identified, Decis (Deltamethrin 100 g/l) was the most cited (58%), followed by Dursban (Chlorpyrifos-ethyl 450 g/l) with a rate of 29 %, and Almectin (Emamectin benzoate 20 g/l) with a 13% of producers (figure 5).

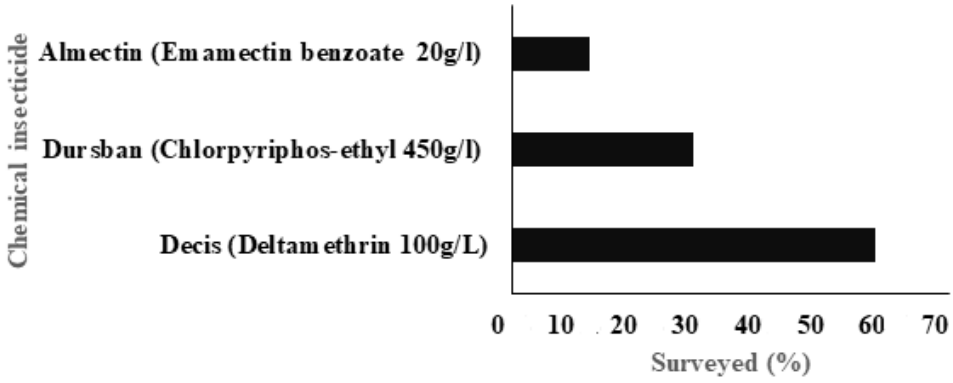

Fig. 5. Synthetic chemical insecticide used by Moringa producers

3 DISCUSSION

Moringa men producers were more important than women. The high rate of men could be explained by the difficulties in accessing land for women. Generally, land belongs to men, and women are then forced to rent it to do their agricultural activities [17]. In addition, the Moringa is perceived as a cash crop which leads to a strong involvement of men in this culture. For example, in Niger, women are generally responsible for collecting and selling the leaves in the markets [18]. However, in the administrative region of *Centre*, the rate of women growing Moringa is higher than that of men. These results could be explained by the fact that in this region, there are many associations of women vegetable producers compared to other regions. By producing vegetable crops, they usually combine moringa cultivation.

The survey results also showed that the larger part of Moringa producers had leaves as their objective. This result could be explained by the fact that actually people know the virtues of Moringa leaves. It demands increases and the sale of fresh or processed Moringa leaves constitutes a source of currency for producers. According to [14], Moringa leaves powder is one of the most sold Moringa products. The low seed producers can be due to the exigence of cultivation that requires large areas of farms [7]. Moreover, the virtues of the seeds are little known by the populations which use them very rarely.

Insect pests, cryptogamic diseases, and lack of seeds were the constraints of production listed by Moringa producers. Among these constraints, insect pests have been cited as the main constraint to Moringa cultivation. These results corroborate those of [13] in Niger and

[12] in Burkina Faso. All of these authors have shown that Moringa leaves are attacked by phytophagous insects which devastate the leaves produced.

The fungal diseases in Moringa were reported by [19] who identified 24 species of fungi on Moringa leaves in the Philippines. [20] identified 3 species of fungi responsible for the dieback of Moringa plants in Niamey region (Niger). In Ghana [7] reported the presence of certain fungi such as *Cercospora spp, Septoria lycopersici* var. malagutii. and *Alternaria solani* Sorauer. These organisms cause the yellowing of the leaves or the appearance of angular black-brown spots with concentric circles on the leaves and sometimes on the branches, which eventually die.

The producers reported also a lack of good-quality seeds. This result can be explained by the fact that few structures are marketing Moringa seeds. The kilogram of Moringa seeds is sold at 18 000FCFA (around 27.61 Euro) at the *Centre National de Semences Forestières (CNSF).* Thus, this price is expensive for small farmers who prefer to acquire seeds from other farmers. These seeds are not always saved in good condition or can be parasitized by fungi. This can reduce the rate of germination or plant wilting when the seedlings emerge.

As stated by the producers, the majority of insect pests belong to the orders of Lepidoptera (caterpillars), Orthoptera (locusts) and Hemiptera. These results confirm the study of [12] on the diversity of pests from Moringa leaves in Burkina Faso which found the same orders of insect pests on Moringa. Caterpillars and locusts have grinding mouthparts that allow them to cut, tear and chew solid food [21]. These insects eat the leaves and buds of young plants of Moringa leading them to dry out and then die if no action is taken. According to [22], caterpillars can cause 100% defoliation of Moringa plants depending on the season. Insects of Hemiptera order, with their sucking mouthparts, puncture the sap of plants and can transmit phytoviruses to them [23]. This reduces yields and the quality of the leaves produced. Spiders were also cited in the survey. Though they are strict predators and feed on insects [24], they build their webs around the Moringa leaves, which change color, dry out and fall off [11].

To control foliar insect pests from Moringa, the majority of producers use bioinsecticides. The use of bioinsecticides is related to the objective of leaf production. This result can be explained by the fact that most producers pursue the international market for the sale of their production, especially the leaves. Thus, some of these producers are looking for or already have certification standards, which forces them to use good farming practices. Also, producers emphasize plant-based insecticides to minimize the risks of toxicity that could arise from the use of synthetic chemical insecticides. However, some producers use synthetic chemical insecticides. This use could be explained by the slow effect of bioinsecticides, their low persistence and their very reduced spectrum of action [25].

Producers also use silvicultural practices that consist of pruning plants. Pruning eliminates the food substrate for insects, which can limit the spread of pests [26], [27], [28]. According to these authors, pruning plants not only helps to control insect pests but also increases plant vigor and the number of leaves produced.

According, to the survey, bioinsecticides were prepared using plant extract. The use of plant extract in crop protection is an ancestral practice [29], [30]. Many plants are indeed known and used for their biocidal activities (toxic, repellent, anti-feedant) against a wide range of bioaggressors [31], [32]. Among these species mentioned, *A.indica* is the most used for the preparation of bioinsecticides. The insecticidal effect of *A.indica* had already been demonstrated in previous work [33], [34]. *A. indica* extract contains azadirachtin [34], [35] having a repellent [36] or larvicidal [37] effect on a wide range of crop pest insects. In addition, the use of bioinsecticides is advantageous because they contain natural active molecules (nimbidine, solanine, deacetylazadirchtinol and meliantriol) that have the property of disrupting the morphogenesis and embryonic development of insects [38].

On the other side, regarding all these practices to control Moringa leaf pests, it appears that producers practiced Integrated pest management to improve their production, and to reach the international and local market. By using IPM and less toxic chemicals for the cultivation of Moringa, the farmers reduce the massive use of pesticides in their production. In the same way [39] said that IPM aims to reduce environmental harmful pesticides by using less toxic chemical-approved products. The Sahelian pesticide committee authorized all chemical insecticides used by Moringa producers [40]. This shows that the producers respect the production standards to give value to their product. An integrated fight incorporating recommended doses of chemicals makes it possible to fight pests effectively and pollute the environment less. This method of pest management can lead to sustainable production of Moringa leaves and seeds.

4 CONCLUSION

The study showed that Moringa production is mainly confronted with the action of foliar insect pests. To face it, the producers use mainly bioinsecticides prepared from several species of plants among which *Azadirachta indica* was the most cited. Thus, for a healthy and sustainable production of Moringa leaves and seeds, it would be desirable to consider an integrated pest management method. It must take into account the use of plant extracts, the sylvicultural methods and some approved synthetic chemical insecticides at recommended doses.

CONFLICTS OF INTEREST

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

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