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Farmers knowledge on Moringa production and leaves pests control in Burkina Faso

Kabré Salifou[1-2], Dao Madjelia Cangré Ebou[1], and Ouédraogo Lassané[1]

[1]Centre National de la Recherche Scientifique et Technologique, Institut de l'Environnement et de Recherche Agricole (CNRST, INERA), 03 BP 7047 Ouagadougou 03, Burkina Faso

[2]Université Joseph KI-ZERBO, Unité de Formation et de Recherche en Sciences de la Vie et de la Terre, Laboratoire d'Entomologie Fondamentale et Appliquée, 03 BP 7021 03 BP 7021 Ouagadougou 03, Burkina Faso

ABSTRACT: *Moringa oleifera* leaf production in Burkina Faso is severely affected by insects pests, which have a negative impact on yields. The aim of this study is to have more information on producers' knowledge of Moringa pest management. A survey was conducted in 16 localities of Burkina Faso. Data were collected using an interview questionnaire from 120 randomly selected Moringa growers between July and October 2021. Data collected included producers socio-demographic characteristics, production objective, production constraints, foliar insect pests and control methods. The results revealed that the majority of growers are men (62%) and 80% of growers are interested in leaf production. Insects pests are the primary constraint to Moringa production according to 72.50% of growers. To control these insects 71% of surveyed use bioinsecticides and *Azadiractica indica* is the most commonly (50.86%) used plant for this purpose.The chi^2 test showed that the methods of control of foliar insect pests were related to the production objectives (chi^2 = 21.02, ddl = 8, p <0.01). The biplot of the multiple component analysis showed that leaf production goes hand in hand with the use of bioinsecticides and the seed producers use both synthetic chemical insecticides and bioinsecticides to control insects pests. To improve yields, integrated pest management methods must be developed in order to further promote sustainable production of Moringa leaf in Burkina Faso.

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

1 INTRODUCTION

Moringa oleifera (Lam.) (Moringaceae), a woody species native to Asia [1], [2], [3] is now widely distributed in the world [3].

It-is a shrub that 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 in environment. The leaves are very rich in proteins, minerals and are increasingly used in several projects to fight against malnutrtion [4], [5], [6]. According to [7], consumption of 100 g of fresh *M. oleifera* leaves can provide between 30 and 100% of the recommended daily value for calcium and 100% of the recommended daily value for vitamin A and C. Moreover, the plant adapted to different environments and reproduces easily by cuttings and seeds [7]. The sale of the different parts of the tree constitutes a source of financial income for the actors of the sector [8], [9].

In Burkina Faso, *M. oleifera* is cultivated throughout the country by men, women and youth, mostly organized in associations [10]. However, the production objectives are not known and the yields are limited because of pests actions such as caterpillars, Orthoptera and Hemiptera [11], [12]. The damage caused is significant [13] causing significant financial losses for producers [14]. In order to contribute to the development of this sector, it is imperative to develop effective control methods against these pests, which 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 know the objectives of moringa production and to obtain more information on producers' knowledge of Moringa pest management in order to promote good pest management and sustainable production of leaves for the health of consumers.

2 MATERIALS AND METHODS

2.1 STUDY SITES

The study was conducted in Burkina Faso in 16 localities belonging to 8 administratives 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 Sudano-Sahelian type with significant rainfall variations [15]. In the north of the country, and in 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.

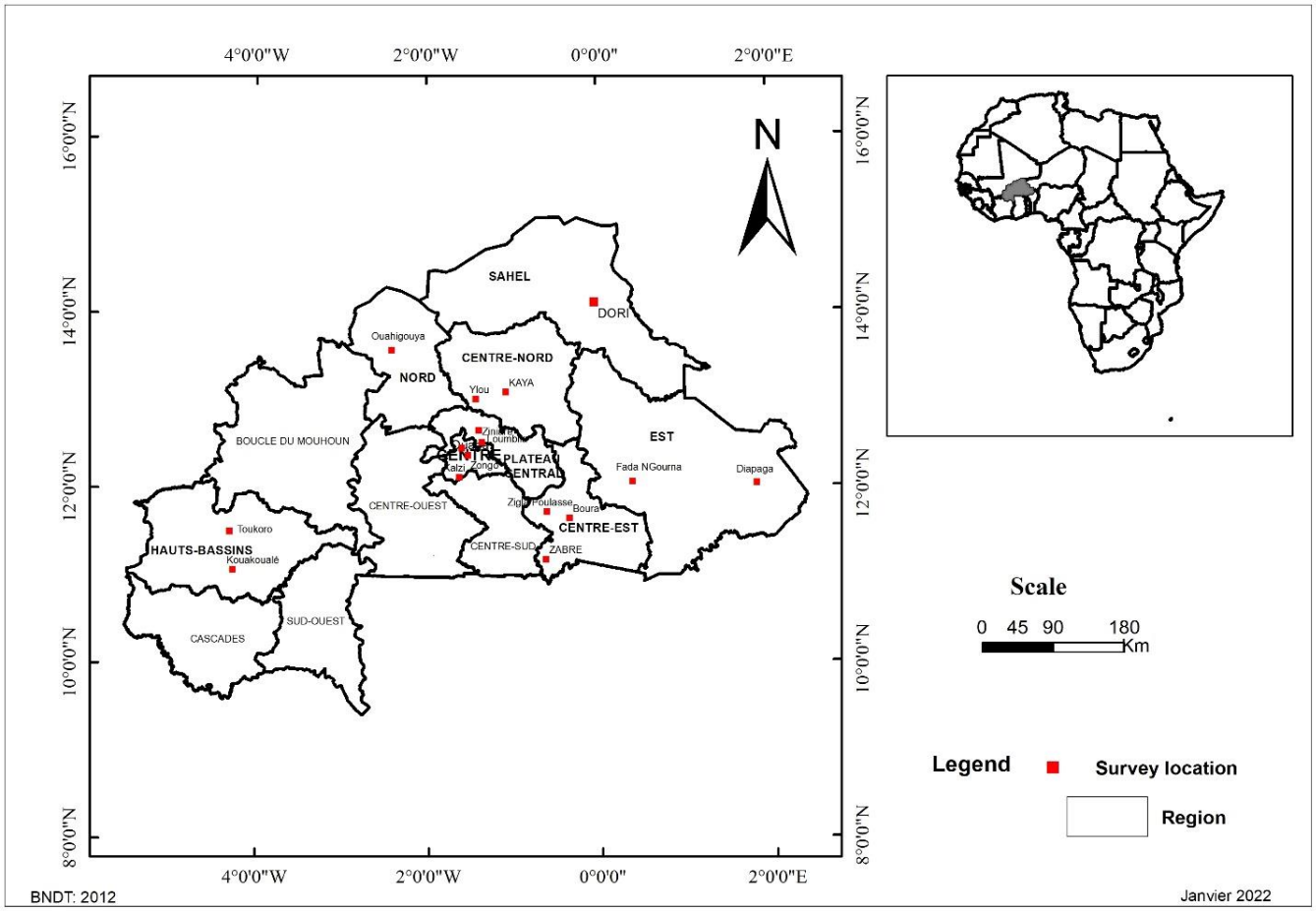

Fig. 1. Study sites

2.2 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:

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

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 leaves 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, size of the study was estimated at 120 producers (table 1).

Table 1. Distribution of surveyed

Survey location	Administrative region name	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	Total	120

2.3 DATA COLLECTION AND PROCESSING

A semi-structured questionnaire was used for individual interviews. The data collected were the socio-demographic characteristics of producers, the farms characteristics, the production objective, the production constraints, the foliar insect pests and control methods used. The data were collected from 1st July to 30th October, 2021. The producers surveyed were 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.

2.4 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 chi^2 test was used to search for an association between control method used against insects pests and the some variables of the study. The level probability was set at 5%. A biplot of component analysis was used to explore relation between control method and production objectives.

3 RESULTS AND DISCUSSION

3.1 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE PRODUCERS SURVEYED AND FARMS CHARACTERISTIC

The result revealed that the average age of the farmers was 46.48 ± 0.91 years old. Men (62%) dominated the production. However, women farmers dominate production in the *Centre* (92%), *Est* (67%) and *Plateau Central* (57%) regions. A total of 54%, 36% and 10% of Moringa farmers were enrolled to school; were not in school and have attended a literacy program, respectively.

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 (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%)
Men	3 (8.3%)	25 (100%)	27 (96%)	2 (33%)	9 (75%)	3 (75%)	3 (43%)	2 (100%)	74 (62%)
Level of 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%)
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									
Agrobusinessman	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 category (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 farms (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%)

3.2 PRODUCTION OBJECTIVES

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

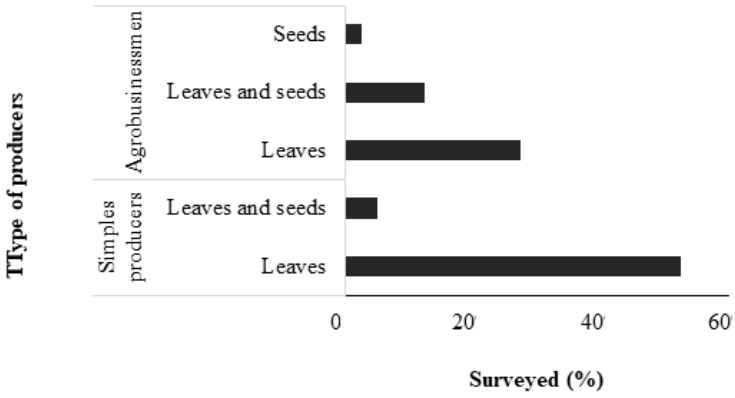

Fig. 2. Moringa production objectives by producers type

3.3 MORINGA PRODUCTION CONSTRAINTS ACCORDING TO PRODUCERS

Insect pests, cryptogamic diseases and lack of seeds were the majors constraints identified by Moringa producers. Between these constraints, insects pests were cited by 72.50% of surveyed followed by fungal disease (10%) and lack of seed (6.67%). The others constraints represent less than 12% of all constraints cited (table 3).

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

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

3.4 CONTROL METHODS FOR MORINGA INSECTS PESTS MANAGEMENT

Several methods were adopted by Moringa producers to control insect pests attacks (figure 3). These methods are either used alone or in combination. Among them bioinsecticides was cited as the most used method (71%), followed by synthetic chemical insecticides (17%). Some producers combine bioinsecticides with silvicultural practices such as pruning of plants (8%). The used of silvicultural practices were the lowest cited producers

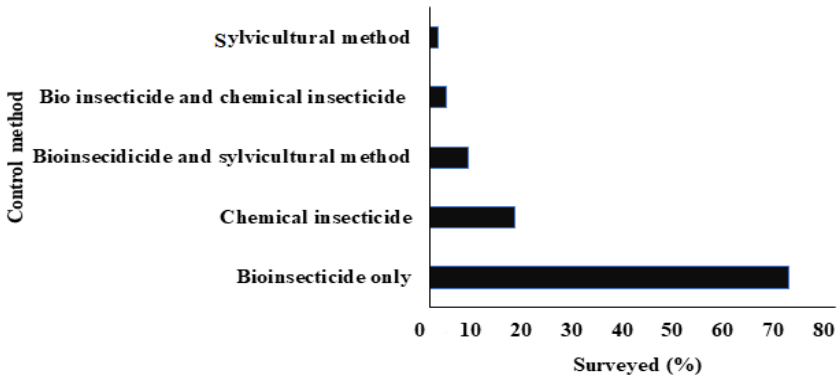

Fig. 3. Control methods of Moringa foliar insect pests

3.5 RELATION BETWEEN CONTROL METHOD AND THE OTHERS VARIABLE

Table 4 showed that the control method used by producers is only depended to the production objective ($chi^2 = 22.88$, $p < 0.01$).

Table 4. Relation between control method and others variables

Dependant variable	Independant 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 farm	4	3.53	0.47	120
	Growing system	4	3.48	0.47	120
	Experience category	8	12.97	0.94	120
	Production objective	8	22.88	<0.01**	120
	Level of education	16	21.02	0.18	120

***: 0.0001 < p ≤ 0.01;*

The component analysis (CA) of biplot between control method and production objectives showed that dim1 (86.3%) and dim2 (13.7%) represent 100% of variability (Figure 4). The Dim 1 axis opposes the group of leaves and seeds producers, bioinsecticides-silviculture, bioinsecticide-chemical users and seed producers only to the group of leaves producers, bioinsecticides, chemical users and producers of seeds. While Dim 2 opposes the group of bioinsecticides, leaves-seeds and leaves producers against the group of silvicultural bioinsecticides, seeds only, chemicals and chemical bioinsecticides.

Looking at the dim 1 and dim 2 axis, it emerges that the leaves producers used bioinsecticides, and the seeds producers used both bioinsecticides and sylvicultural method to fight against insects pests.

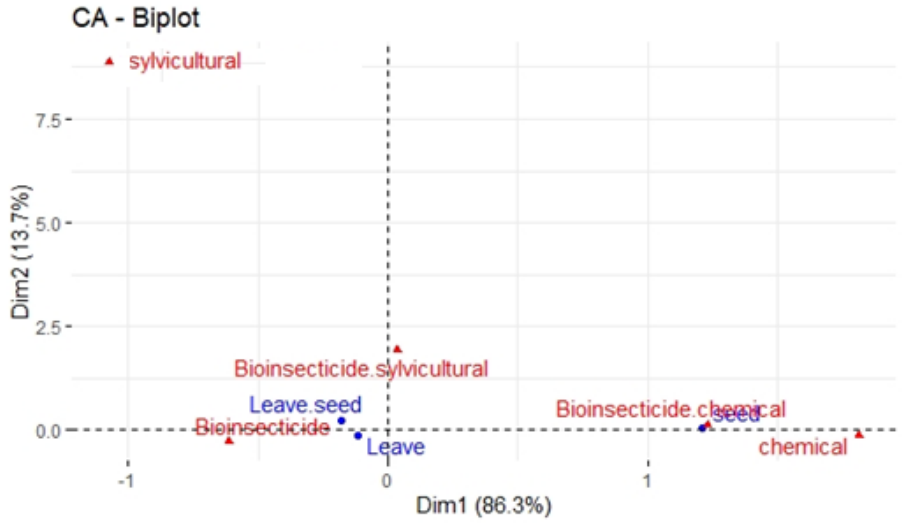

Fig. 4. CA-Biplot between control method and production objectives

3.6 PLANTS SPECIES USING BY FARMERS TO CONTROL THE FOLIAR INSECT PESTS

A total of 14 plants species belonging to 12 families were cited by the producers as bioinsecticides 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

3.7 CHEMICALS PRODUCTS USING IN THE FOLIAR INSECT PESTS CONTROL BY FARMERS

Investigations have hinted that some growers used chemicals insecticides to control leaf 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).

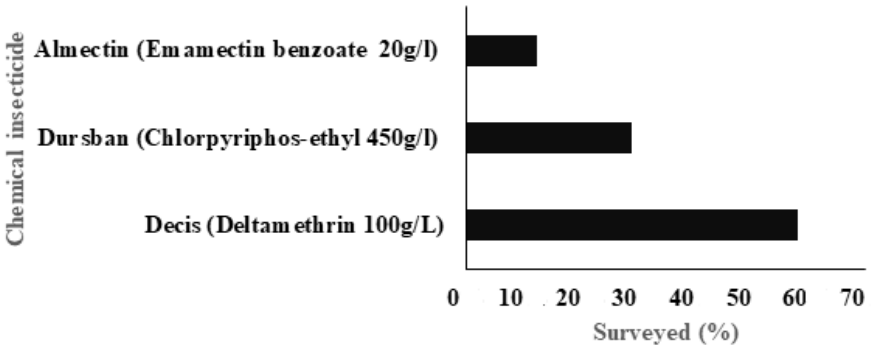

Fig. 5. Synthetic chemical insecticide used by Moringa producers

4 DISCUSSION

Moringa men producers were more important than women. The high rate of men could be explained by the difficulties to access 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 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 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. 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 seeds producers can be due to the exigence of cultivation that require 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 presence of fungal diseases in Moringa was reported by [19] who identified 24 species of fungi on Moringa leaves in 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 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 lack of good quality seeds was reported by the producers. This result can be explained by the fact that there are few structures that market Moringa seeds. The kilogram of Moringa seeds is selled 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 plants wilting when the seedlings emerge.

As state by the producers, the majority of insects 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 insects 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 result in a reduction in the yields of the parasitized plants and in the quality of the leaves produced. Spiders were also cited by surveyed. The latter, although being strict predators that feed on insects [24], weave their webs around Moringa leaves which change color and dry out and fall [11].

To control foliar insect pests from Moringa, the majority of producers use bioinsecticides. The use of bioinsecticides is related to the objective of leaves 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].

Silvicultural practices that consist of pruning plants are also used by producers. 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 surveyed, 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* extracts contain azadirachtin [34], [35] having a repellent [36] or larvicidal [37] effect on a wide range of crop pest insects. In addition, the use of bioinsectides 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].

In other side, regarding all these practice to control Moringa leaves pest 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. All the chemical insecticides used by producers were authorized by the Sahelian pesticide committee [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.

5 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* is 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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