Original Research Article

Determinants of pesticides choice in market gardening in urban and peri-urban areas of the cities of Bobo-Dioulasso and Ouagadougou in Burkina Faso

ABSTRACT

In Burkina Faso, population growth and accelerated urbanization are accompanied by an increase in agricultural production, in order to meet the growing demand for food, especially vegetables. The objective of this study is to identify the factors that influence the use of pesticides in market gardening in urban and peri-urban areas of Burkina Faso. To this end, a cross-sectional survey was conducted in 2023 among 393 farmers, selected by proportional stratified random sampling in the two communes of Bobo Dioulasso and Ouagadougou. The average age of the surveyed population was 44.43 years. Of the total sample, 65.9% were male, and the average cultivated area was 0.28 hectares. A binary logistic regression model was used to determine the factors that influence the use of pesticide. The results show that the experience of discomfort following pesticide application, the occurrence of accidents during pesticide use, and the perception of the dangerousness of pesticides to human health and the environment are variables that exert a significant and positive influence on pesticide use. Furthermore, a greater willingness to accept effective alternatives has been found to reduce the probability of using pesticides by 97.3%, with a statistically significant coefficient and a very low p-value (0.000). Moreover, each increase in annual income is associated with a reduction in the probability of not using chemical pesticides by 0.1%, with a statistically significant coefficient and a very low p-value (0.000). In the context of the search for rational use of pesticides, it is necessary to characterize the cropping systems in the urban and peri-urban market gardening sites of Bobo Dioulasso and Ouagadougou.

Key words: Determinants, Pesticides, market garden, urban and peri-urban.

1- INTRODUCTION

The necessity to eradicate global hunger has prompted governments to implement intensive agricultural production techniques. One such practice is the use of pesticides to protect crops. Urban and peri-urban market gardening in the cities of Burkina Faso is no exception to this

reliance on chemical pest control [1,2]. However, several studies in Burkina Faso [3,4] have identified deficiencies in phytosanitary practices in market gardening. These include non-compliance with prescribed doses, non adherence to recommended protection and hygiene rules during treatments, inadequate management of empty pesticide packages, etc. The consequences are often dramatic for people (poisoning of farmers, economic dependence of farms, progressive erosion of agricultural yields), for the environment (destruction of biodiversity, soil impoverishment, pollution) and the selection of pesticide-resistant strains of bioaggressors[5,6,7,8,9]. Nevertheless, even the slightest inclination towards supporting an agroecological transition is impeded by the reality that Burkina Faso's agriculture is heavily reliant on pesticides. However, the necessity for a transition to pesticide-free agriculture is now an irrefutable means of achieving sustainability. To achieve this, it is essential to gain an understanding on the socio-economic conditions, knowledge, attitudes and practices of farmers that could influence the use of pesticides in crop protection in general and market garden crops in particular. Indeed, studies [10,11] have demonstrated that certain factors may explain the use or inappropriate use of pesticides in market gardening. Additionally, research has been conducted in Burkina Faso on the determinants of fertilization in strict rainfed rice production systems [12] and on the analysis of the decisive factors of perceptions influencing the choice of whether or not to adopt good practices by farmers in peri-urban areas [13].

However, to our knowledge, there are few references in the literature to studies that deal with the specific issue of the determinants of pesticide use in market gardening in Burkina Faso. And yet, this enquiry is necessary to better plan strategies for adopting alternatives to the use of synthetic pesticides. This study aims to identify the determinants of pesticide choice by market gardeners in order to help protect the health of farmers, consumers and ecosystems in Burkina Faso.

2- MATERIAL AND METHODS

2.1 Location of the study area

The study focused on farmers in urban and peri-urban areas of the two main urban communes of Burkina Faso. These were the communes of Bobo-Dioulasso and Ouagadougou. The commune of Bobo-Dioulasso is located in the sudanian zone, south of the parallel 11°30', with an average annual rainfall of between 900 and 1,200 mm and a six-month rainy season [14]. The commune of Ouagadougou is located in the sudano-sahelian zone, between parallels 11°30' and 14°00'N, with an average annual rainfall of between 600 and 900 mm, spread over four to five months [14]. These two cities were selected because of their leading role in the country's market

gardening activities, demonstrating a strong dynamic and significant contribution to the market gardening agriculture in Burkina Faso.

2.2 Data collection, processing and analysis

A cross-sectional survey was conducted among 393 farmers selected through a proportional stratified random sampling method between March and April of 2023. The sample size was determined using the [15]formula:$n = \frac{z^2 p(1-p)}{e^2}$, where n=sample size; Z=margin rate substracted from the desired level of confidence; z=1.96; P(1-P) is the variance of the variable; e is the margin of error (e= 0.05). The questionnaires, which covered the socio-economic characteristics of the farmers, their agricultural practices, and their phytosanitary practices, were completed with the farmers concerned. The data collected were entered into Rstudio 4.3.3 software, which was used to generate descriptive statistics (frequencies, means) and to estimate binary logistic regression models for determinant analysis.

2.3 Method for the analysis of the determinants of phytosanitary practices

The binary logit model [16,17] was used to determine the factors influencing pesticide use in market gardening.

The logit model is an effective method for analyzing the relationship between a binary dependent variable and a set of explanatory variables. The dependent variable in a logit model is binary, meaning it can take two possible values, usually coded as 0 and 1. In the present study, the target variable is utilization of pesticide (uses or does not) as indicated in Table 1.

The logit model includes a set of explanatory variables (or predictors) that are assumed to be associated with the dependent variable. These variables can be either continuous or categorical and are employed to predict the probability of the dependent variable taking the value No rather than Yes (in the present case). In the logit model, the relationship between the explanatory variables and the probability of the dependent variable is modeled using the logistic function (or logit function). The logisticfunctionisdefined as :

$$\text{Prob}\,[\text{Yi} = 1] = \frac{exp\,[\text{xi}\,\beta]}{1 + exp\,[\text{xi}\,\beta]}$$

The binary logistic regression model focuses on the determinants of pesticide use in market garden crop protection. In this model, the following hypothesis was made : the systematic use of pesticides (explanatory variable) depends on the farmer's sex, primary occupation, age,

experience in farming, access to credit, annual income (CFA francs), perception of the dangerousness of pesticides to human health, perception of the dangerousness of pesticides to the environment, the experience of discomfort following the application of pesticides, the perception of the risk of pesticides causing illness, the occurrence of accidents during the use of pesticides, the willingness to accept effective alternatives, the area cultivated, the city of farming (Table 1).

Subsequently, the "stepwise" method was used to select the most significant variables in successive stages. This method progressively filters out less relevant variables by reducing the p-values of many other variables that were previously insignificant.

Table 1: Coding of the dependent and independent variables used in models analyzing the determinants of pesticide use.

Variables	Code	Quantitative variables	Qualitative variables			Expectedsigns
		Mean	Modalities	Number	Proportions (in %)	
Area cultivated (ha)	SUP	.28				+
Number of farmhands	ACTIF	2.52				-
Farmer age (Year)	AGE	44.43				+
Number of campaigns performed in the year	CAMP_MEN	3.22				+
Annualincome (CFA Francs)	REVENU	567302.80				+
Utilization of pesticides	UTIL_PEST		1= Does not	10	2.50	+
			0= Uses	383	97.50	
Access to credit	ACC_CREDIT		1= Yes	29	7.40	+
			0= No	364	92.60	
Dangerousness of pesticides for human health	DANG_PEST_SAN		1= Yes	350	89.10	+
			0= No	43	10.90	
Dangerousness of pesticides for the environment	DANG_PEST_ENV		1= Yes	314	79.90	+
			0= No	79	20.10	
Experience of discomfort following pesticide application	MAL_USAG_PEST		1= Yes	125	31.80	+
			0= No	268	68.20	
Pesticides cause illness	MAL_PROV		1= Yes	255	64.90	+
			0= No	138	35.10	

Occurrence of accidents during pesticide use	AC_USAG_PEST	1= Yes	165	42.00	+
		0= No	228	58.00	
Willingness to accept effective alternatives	DISP_AL_EFF	1= Yes	371	94.40	+
		0= No	22	5.60	
Ownfunds	FONDS_PROP	1= Yes	22	5.60	+
		0= No	371	94.40	
Credit	CREDIT	1= Yes	371	94.40	-
		0= No	22	5.60	
Place of residence	ZAT	1= Ouagadougou	284	72.30	-
		0 = Bobo Dioulasso	109	27.70	
Sex	SEXE	1= Male	259	65.90	-
		0= Female	134	34.10	
Marketgardeningactivity	MARAI	1= Yes	330	84	-
		0= No	63	16	
Rain-fedfarmingactivity	AGRI_PLUV	1= Yes	52	13.20	-
		0= No	341	86.80	

3- RESULTS

3.1 Socio-economiccharacteristics of farmers

An analysis of the quantitative and qualitative variables associated with the farmers provides an essential insight into their socio-economic characteristics (Table 2). The results of the descriptive statistics show that there was a significant gap between the extreme values of certain variables such as area (0.33), number of campaigns (2.11), number of workers (2.17), age (12.98) and annual income (685483.85 FCFA).

Table 2: Socio-economic characteristics of farmers

Variables	Mean	Proportion %
Men	-	65.90
Women	-	34.10
Age (years)	44.43 ±12.98	-
Acceptance of effective alternatives	-	94.40

Area (ha)	.28 ±.33	-
Workers (people)	2.52 ±2.17	-
Number of campaigns/year	3.22±2.11	-
Ownfunds	-	5.60
Access to credit	-	94.40
Annualincome (CFA) francs	567303±685483.85	-

3.2 Factorsassociatedwith pesticide use

3.2.1 Results of the logistic regression with all independent variables

The factors involved in the adoption of pesticide use practices, with all variables taken into account in the model, are presented in Table 3.

The variables that explain these pesticides use include the farmer's sex, age, the occurrence of accidents during pesticide use, willingness to accept effective alternatives, the number of agricultural campaigns conducted in the year, the annual income, and the perception of the dangerousness of pesticides to human health.

Males were 0.032 times less likely to have the binary outcome than females. This association is statistically significant, with a p-value of 0.008.

For farmer age, each year increase in the farmer’s age is associated with an 11.70% decrease in chemical pesticide use (odd ratio of 0.88), with high statistical significance (p-value < 0.001).

The occurrence of accidents during pesticide use, the willingness to accept effective alternatives, the number of agricultural campaigns performed in the year, and the annual income have significant estimated coefficients and p-values <0.05, indicating a significant association with pesticide use.

On the other hand, several variables such as the area cultivated, utilization of own funds, access to credit, market gardening as primary occupation, rain-fed farming as primary occupation, as well as perception of the dangerousness of pesticides to human health and environment, experience of discomfort following pesticide application, and the perception that pesticides cause illness, showed no significant association with pesticide use.

Table 3: Result of the estimation model of pesticide adoption factors with all variables considered in the model.

Variables	Coefficient	Odds ratio	P value
Place of residence (Ouagadougou)	16.54	15.19	.99 ns
Sex (Male)	-3.44	.03	.008**
Farmer age (Years)	.124	.88	.000***
Farmhands	.16	1.17	.41 ns
Occurrence of accidents during pesticides use	-4.36	.01	.000***
Willingness to accept effective alternatives	-11.94	6.56	.000***
Area cultivated (ha)	-2.32	.10	.46 ns
Number of campaigns performed in the year	-1.66	.19	.000***
Annualincome (CFA francs)	.00	1.00	.000***
Marketgardeningactivity	21.76	28.10	1.00 ns
Rain-fedfarmingactivity	17.68	.48	1.00 ns
Utilization of ownfunds	-13.31	1.65	1.00 ns
Utilization of credit	-22.63	1.49	.43 ns
Dangerousness of pesticides for human health	2.66	14.27	.07*
Dangerousness of pesticides for the environment	6.14	461.54	.33ns
Experience of discomfort following pesticides application	1.07	2.90	.10ns
Pesticides cause illness	.57	1.77	.99ns

NB: *, **, *** indicate significance level at 10%, 5%, 1%, respectively. ; ns= not significant.

3.2.2 Results of the stepwise model with more significant variables selected

The factors influencing the adoption of pesticide practices, using the "stepwise" method, with the selection of the most significant factors, are presented in Table 4.

The Akaiké Information Criterion (AIC) of the model obtained is 156.65, which provides a measure of the quality of the fitted model.

The results of this analysis highlight a number of significant variables at different thresholds. These include sex, farmer age, occurrence of accidents during pesticide use, willingness to accept effective alternatives, number of campaigns performed in the year, annual income, perception of the dangerousness of pesticides for the environment, experience of discomfort

following pesticide application and perception of the dangerousness of pesticides for human health.

Sex: Men are 81.00% more likely to use pesticides than women. This coefficient is statistically significant with a very low p-value (0.000).

Age: The negative relationship between farmer age and pesticide use indicates that older farmers are less likely to use pesticides. For each additional year of age, the probability of using pesticides decreases by 4.78%. This coefficient is statistically significant with a very low p-value (0.000).

Accident: The occurrence of accidents while using pesticides reduces the probability of using pesticides by 88.80%. This coefficient is statistically significant with a very low p-value (0.000).

Alternatives: A greater willingness to accept effective alternatives reduces the probability of using pesticides by 97.30%. This coefficient is statistically significant with a very low p-value (0.000). Furthermore, farmers' willingness to adopt effective alternatives plays a key role in their decision whether or not to use pesticides.

Number of campaigns: The number of agricultural campaigns is negatively associated with pesticide use. Each increase in the number of campaigns in the year reduces the probability of using pesticides by 49.30%. This is a statistically significant coefficient with a very low p-value (0.000).

Annual income: there is a negative relationship between annual income and pesticide use, suggesting that higher-income farmers are less dependent on these products. Each increase in annual income reduces the probability of not using chemical pesticides by 0.10%. This coefficient is statistically significant with a very low p-value (0.000).

Environment: an increased perception of the environmental dangerousness of pesticides increases the likelihood of not using them. A farmer who has a good perception of the dangerousness of pesticides for the environment is 10.26 times more likely not to use them. This coefficient is statistically significant, with a very low p-value (0.000).

Health: an increased perception of the health hazards of pesticides increases the probability of not using chemical pesticides by 1.25 times. This coefficient is statistically significant, with a very low p-value (0.000).

Discomfort: there is a significant association between experience of discomfort and pesticide use. Farmers who reported experiencing discomfort after using pesticides were approximately 1.77 times more likely to refrain from using pesticides, all else being equal.

Conversely, market gardening as the primary occupation, access to credit, and place of residence were not significant factors in the use of pesticides at the 10.00% level of significance (Table 4).

Table4: Result of the estimation model of the factors of adoption of pesticide practices using the "stepwise" method, with the selection of the most significant factors.

Variables	Coefficient	Odds ratio	P value
Place of residence (Ouagadougou)	5.00	147.90	.98ns
Sex (Male)	-1.66	.19	.000***
Farmer age (years)	-.05	.95	.000***
Occurrence of accidents during pesticide use	2.18	.11	.000***
Willingness to accept effective alternatives	-3.60	.03	.000***
Number of campaigns performed in the year	-.68	.51	.000***
Annualincome (CFA francs)	-2.60	1.00	.000***
Marketgardeningactivity	6.87	964.70	.98ns
Utilization of credit	-6.65	.00	.99 ns
Dangerousness of pesticides for the environment	2.33	10.26	.000***
Experience of discomfort following pesticides application	.57	1.77	.05**
Dangerousness of pesticides for human health	.22	1.25	.000***

NB: *, **, *** indicate significance level at 10%, 5%, 1%, respectively. ; ns= not significant.

4- DISCUSSION

4.1 Socio-economiccharacteristics of farmers

An examination of the variables pertinent to farmers offers invaluable insight into their agricultural practices. The average area cultivated by farmers is 0.28 hectares. Indeed, market gardening in Burkina Faso is predominantly conducted on a small scale. Furthermore, in Bobo Dioulasso and Ouagadougou, demographic pressure is leading to a reduction in the size of arable land. A comparable outcome was observed by [18] among strawberry growers in Ouagadougou, with an average area of 0.24 ha. The average age of farmers is 44.43 years. Given that vegetable gardening is a physically demanding activity, it is unsurprising that older people are becoming

increasingly disinclined to engage in this pursuit. Nevertheless, some authors [19] have demonstrated that the average age of farmers is 49 years, which is slightly higher than the average age observed in this study. Other studies on this topic have corroborated the finding that market gardeners are predominantly young people [20,21,22)]. The use of chemical pesticides can be attributed to a number of factors, including the accessibility of these products, the cultivation of sensitive crops, the prevalence of pests and diseases, and other considerations. The majority of farmers (94.50%) indicated a willingness to accept effective alternatives. Finally, with regard to sex distribution, although the majority of respondents were male (65.9%), it is important to recognize the significant presence of female farmers (34.10%). This proportion differs from that reported by [23], who demonstrated that market gardening is predominantly practiced by a male-dominated population (92.5%). Some rare studies, such as those of [20], have demonstrated that there are more women (61.70%) than men (38.30%) engaged in market gardening in the communes of Ouagadougou and Loumbila in Burkina Faso.

4-2. Factors associated with pesticide use

Nine determinants associated with chemical pesticide use were identified. These factors are considered significant in explaining pesticide use in this study.

Men were 81.00% more likely to use pesticides than women. The fact that sex was significantly associated with pesticide use indicates that there are differences in market gardening practices between men and women. Pesticides are costly, and since women have less purchasing power, they tend to produce vegetables that are less susceptible to pests and diseases. This finding is consistent with a study conducted in Ghana. The authors claim that the use of chemical pesticides remains much more the domain of men [24].

The negative association between farmer age and pesticide use indicates that older farmers are less likely to use pesticides. This means that an increase in age leads to a decrease in pesticide use in market gardening. This could be due to greater experience and knowledge of alternative farming practices, or increased awareness of health and environmental risks. More experienced farmers tend to use integrated pest and disease management. They do not systematically use pesticides according to a predetermined schedule, but often monitor their crops and adopt strategies that use fewer chemical pesticides [25]. This finding contrasts with that of [10], who showed that systematic pesticide use increases significantly with the farmer’s age.

The occurrence of accidents during pesticide use results in a 88.80% decrease in the probability of using pesticides. Indeed, only a limited number of farmers comply with the requisite hygienic standards during the application of pesticides [26,27]. This provides an explanation for the cases of acute poisoning that have been reported by farmers and observed by other authors [5,28,29]. Skin irritation, headache, cough, dizziness, respiratory problems, fatigue, diarrhea, and other symptoms are indicative of pesticide intoxication [30,5,1].

A greater willingness to accept effective alternatives reduces the likelihood of pesticide use by 97.30%. As a substitute for the use of synthetic chemical pesticides, plant-based pesticides are an ancient practice in Africa. Indeed, many plants are known and used for their biocidal activities (toxic, repellent, anti-appetizing) against a wide range of pests. They can be used in the form of plant extracts for foliar protection [31,32] or in combination with other crops [33,34]. Essential oils (concentrated liquid volatile organic compounds from plants) or whole plants are also used in stored food granaries [35] Although synthetic pesticides may be more effective, cost-benefit studies show the economic viability of using biopesticides [36].

Each increase in the number of agricultural campaigns per year reduces the probability of pesticide use by 49.30%. Short cycle crops grown on small plots allow the maximum number of campaigns per year and are better maintained. These are usually leafy vegetables, which are mainly produced by women. This result confirms the results obtained by authors such as [37,38], who have shown that women are more in favor of organic production than men.

Each increase in annual income reduces the probability of not using chemical pesticides by 0.10%. This result suggests that farmers would be much more motivated if alternatives allowed them to improve the quality of vegetables for export, even if this meant paying additional costs. Moreover, several studies [39,40,41] show that farmers are willing to pay a premium to buy biopesticides, which are more viable alternatives to synthetic pesticides. The implication of this result is that public authorities need to provide incentives for the adoption of biopesticides, such as free registration and tax exemption on biopesticide imports.

An increased perception of the environmental dangerousness of pesticides increases the likelihood of not using them. A farmer who has a good perception of how dangerous pesticides are for the environment is 10.26 times more likely not to use them. Similarly, an increased perception of the dangerousness of pesticides for human health increases the probability of not using chemical pesticides by 24.70%. It can be seen that farmers' perceptions of the dangerousness of pesticides to human health and the environment have a significant impact on

their utilization. To this end, [42] have shown that market gardeners do indeed perceive the risks to human health from handling chemical pesticides in Kinshasa.

The experience of discomfort after pesticide application is significantly associated. In fact, several studies [26,43,44,1,42,45] have shown that most of the farmers encountered reported having felt the effects of treatments on their health after using pesticides. Pesticides are designed to act on the vital functions or reproduction of harmful organisms by disrupting the nervous system, metabolism, cell respiration, cell signaling and division, or the synthesis of proteins necessary for the survival of these organisms. However, the toxicity of such a product to a pest is not specific, and its toxic potential may extend to other organisms [46].

5- CONCLUSION

This study identified the determinants of pesticide use by market gardeners in the cities of Bobo Dioulasso and Ouagadougou. Descriptive statistics show that the average area cultivated by farmers is 0.28 hectares. The average age of the farmers is 44.43 years and the number of farmhands is 2.17. The study s.hows that the annual income per farmer in the urban and peri-urban areas of Bobo Dioulasso and Ouagadougou is 685,483.85 FCFA. The various factors that determine the use of pesticides by farmers include the farmer's age, the occurrence of accidents when applying pesticides, the willingness to accept effective alternatives, the number of agricultural campaigns performed per year and the annual income. Intensifying activities to support young people in their agroecological transition is essential if farmers are to produce healthily and sustainably.

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