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FARMERS' DECISION-MAKING PROCESS REGARDING PESTICIDE APPLICATION IN THE REPUBLIC OF CONGO

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Abstract: Congolese agriculture has long grappled with persistently low productivity levels, a trend that has endured since the 1960s. This deficiency in agricultural performance is primarily attributed to the widespread reliance on traditional farming practices, which occupy a staggering 81% of cultivated land. These traditional methods are characterized by their low productivity and meager yields, exemplified by maize production at a mere 690 kg/ha—dramatically lower than the global average of over 3 T/ha observed in developing countries and 1.2 T/ha in sub-Saharan Africa (MEPATI, 2012).
Additionally, findings from the Economic Diversification Support Project (PADE, 2018) reveal a concerning pattern within the Congolese agricultural landscape. Of all the agricultural sectors, it is the market gardening sector that employs the highest quantities of pesticides. Notably, these market gardeners acquire pesticides in small, often unmarked packaging, with volumes ranging from 50 to 100 ml for liquid products and sachets containing less than 50 g for powders. Worryingly, many of these farmers lack essential knowledge regarding the specific pests they aim to combat, the appropriate concentrations or formulations of the pesticides, the correct dosage to apply, and the proper calibration and maintenance of treatment equipment (PADE, 2018). Equally concerning is the lack of adherence to protective precautions during pesticide application, with safety intervals before harvesting treated vegetables consistently disregarded (PADE, 2018).
Keywords: Congolese agriculture, Low productivity, Traditional farming, Pesticide misuse, Agricultural development

Introduction

Congolese agriculture is characterized by low productivity performance that it records in a decreasing way from the 1960s to the present day. These poor performances are due, on the one hand, to the dependence of farmers on the traditional production system, occupying 81% of cultivated land and characterized by low productivity, low yields, for example corn represents only 690 kg /ha against more than 3 T/ha for all developing countries and 1.2 T/ha for sub-Saharan Africa (MEPATI, 2012).
It appears from the Economic Diversification Support Project (PADE, 2018) that, of all the agricultural sectors, only the market gardening sector uses more pesticides in Congo. These market gardeners buy pesticides in small

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quantities, often repackaged in 50 to 100 ml bottles for liquid products, and in sachets of less than 50 g for powders, without labels. Unfortunately, some of them do not know the specific bio-aggressors to combat, nor the concentration or formulation of the product, nor the dose to use, and the treatment equipment is not calibrated and maintained correctly (PADE, 2018). Protective precautions are not taken into account during treatment and safety intervals before harvesting treated vegetables are never respected (PADE, 2018).

Technological innovation policies in the agricultural sector are less present, in addition, farmers are often abandoned to their fate, they hardly benefit from training and information-awareness on good practices and techniques that can improve productivity, and also the lack of shops selling pesticides and agricultural inputs in rural centers is a handicap for the use of pesticides in agriculture (PADE, 2018).

According to the study carried out as part of the pilot project supporting the "identification of cases of intoxication or poisoning due to pesticides and other chemical products" in Brazzaville, market gardeners in the Brazzaville belt have the access to the use of pesticides thanks to the sales shops installed in the city and to itinerant traders. It has been found that, pesticide application is basically a male activity. The age criterion was not taken into account, but the study shows that men under the age of 40 are the main. Pesticide applicators, and most of these producers have been trained regardless of their level of education.

The intervention of the Congolese State in the process of development of the agricultural sector requires more efforts, because the few supports from which farmers benefit are those of IFAD, the World Bank, the FAO and the European Union (ADF, 2008). For example, IFAD financed the Development Revival Project focused on the rehabilitation of rural roads, the promotion of local initiatives, the revival of the marketing of agricultural products, and the development of financial services in the Plateaux Departments, Cuvette, Cuvette Ouest, Niari, Bouenza and Lékoumou (PRODER), up to $15.1 million;

The World Bank financed the Agricultural Development and Rural Roads Rehabilitation Project (PDARP), focused on the reconstruction of priority infrastructure in the social (schools, health, etc.) and economic (roads, slaughterhouses, markets, etc.) p to $40 million, including $20 million in Congolese cofinancing (FAD, 2008).

The financing of the agricultural sector is handicapped by the inadequacy of credit access policies. This sector does not seem to be a priority either in public financing or in that provided by private financial institutions, notably banks and microfinance institutions (FAD, 2008). In view of the above-mentioned concerns, the need for this study is to identify the factors that promote or slow down the use of pesticides in agriculture. To this end, the question of this study is formulated as follows: What are the factors that influence the use of pesticides by farmers in Congo? The objective of this research is to analyze the determinants of pesticide use in the Republic of Congo. This work is structured in three (3) parts: 1 the literature review, 2 the metrology and 3 the results and discussions.

1 Literature review

It is a question of presenting in this part the works relating to the adoption or the use of new techniques in agriculture.

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The study conducted by Nkamleu et al (2000) in the coffee and cocoa plantations of peasant communities in southern Cameroon using a multinomial Logit model showed that the age of the farm manager, his level of education, the number of years of experience, contact with extension services and the perception of an off-farm income, are the elements having an influence on the probability of choosing chemical pesticides as a method of crop protection.

According to the analyzes of Kpadé et al, (2013) in a study of the factors of adoption of an alternative cotton protection technology, targeted stage control (LEC), as well as those affecting the intensity of adoption of within the cotton farms of northern Benin are identified through Heckman's two-step model and revealing that institutional factors and the appreciation of the quality of LEC insecticides positively affect the adoption of LEC while specialization in cotton hinders this adoption. The supply of LEC insecticides alone does not guarantee the large-scale dissemination of LEC, they must be delivered on time and the institutional factors that contribute to the correct application of the technology must be met.

On the other hand, Rabe et al (2017) based on the Logit regression model, the study results concerning a sample of 300 cowpea producers from the farmer field school project in the regions of Maradi and Zinder in Niger show that the main insect pests of the crop (the brown plant bug and the aphid), training, access to credit, gender and age, significantly influence the adoption of agricultural technology, specifically the use of pesticides and fertilizers chemicals.

Nabie (2018) in a study analyzing phytosanitary practices and identifying the factors that influence the adoption of integrated pest management practices in tomato, cabbage and lettuce production in the city of Ouagadougou and a survey of 117 producers sampled on three market gardening sites by a simple random draw based on the lists of market gardeners was conducted. Using the Logit regression model, the results show that for the pest control, tomato (100%), cabbage (95.6%) and lettuce (98%) producers use synthetic pesticides, 49% of which are not approved by the CSP and nearly 43% are intended for the protection of the cotton plant.

The majority of producers use chemicals without any adequate protection (68%), nor compliance with the prescribed doses. A low level of adoption of integrated pest management practices (IPM) except the use of resistant varieties and crop rotation was revealed among producers. The adoption of most GIN practices is positively influenced by the training received in GIN, experience in vegetable production, the level of education of the producer and the mode of land tenure. Contact with an extension agent, gender, household size, number of farm workers and membership of a cooperative or group have very little influence on the adoption of GIN practices.

Ahouangninou et al (2019) also from a cross-sectional study conducted with 197 producers selected by the proportional stratified random draw method in three municipalities in southern Benin, using the binary logistic regression model, the results show that experience, age, crop rotation and location significantly influence the systematic use of pesticides according to a pre-established schedule at the 5% threshold. In addition, Oula Pabo et al, (2020) by examining the use of Phytopharmaceutical Products (PPPs) by producers in Côte d'Ivoire in the

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case of off-season vegetable production, a representative sample of 100 producers on the he entire national territory was selected and asked about the nature and use of PPPs. By relying on Bootstrap's statistical inference technique to build an econometric binary logistic regression model intended to identify the explanatory factors for inappropriate use of PPPs.

The results show that chemical protection remains the main method of combating bioaggressors in market gardening in Côte d'Ivoire, with an inappropriate rate of use of PPPS by producers reaching 97%. The results confirm the importance of land ownership for the proper use of PPPs. Above all, these results show that the age of producers and their experience in market gardening are decisive factors for good management of PPPs.

2 Methodology

This section consists of two parts; the first is devoted to the presentation of the method used and the second is devoted to the presentation of the variables.

2.1 The method used

In this research the logit model is used to determine the factors that influence the adoption of pesticides by farmers. Indeed, the Logit model is represented by the following equation:

$$Y_i = \beta X_i + \varepsilon_i \quad \ldots\ldots (1)$$

With the Y_i dependent variable of the study (the decision to use pesticides) and Xi being the set of variables that influence the use of pesticides.

2.2 Presentation of model variables

The variable of interest, the use of pesticides and all the explanatory variables used in our model are as follows:

• Explained variable or variable of interest

The explained variable of our study is the use of pesticides. It is a binary qualitative variable. In effect. It takes the value 1 if the farmer uses pesticides and the value 0 if the farmer does not use pesticides.

• Explanatory variables or independent variables:

Access to credit: access to credit a binary variable, taking the value 1 if the farmer has access to credit and 0 if he does not have access to credit. Access to credit improves the financial capacity of the farmer, which in turn promotes (financial) access to pesticides, and therefore the possibility of using pesticides (Adekambi et al. 2020). Indeed, we expect a positive influence of the access to credit variable on the “pesticide use” variable.

Experience: the number of years of experience in agriculture is a continuous variable. Agricultural producers with several years of experience have had time to realize the positive contribution of phytosanitary treatments on yields (Adetonah et al, 2011). The positive sign is expected from the experience variable.

Contact with extension services: knowledge of the existence of pesticides through information and extension, increases its use. Indeed, a producer can only adopt a technology if he knows that it exists, that it is available and that it provides advantages compared to the costs of its acquisition and practice. The degree of access to information is characterized by visits by extension and research agents, by demonstrations in the real world or by contact with the media. The lack of awareness to demonstrate, inform and give the producer confidence in the

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comparative advantages of pesticides is hampering the momentum of its use (Asfa, 2016). The positive sign is expected for the "contact with extension" variable.

Farmer income: It represents the financial gain of the farmer per day or per month. It is a quantitative variable expressed in monetary unit (FCFA). The income available to the farmer has a positive influence on the adoption of technologies (Ngondjeb and 2011). Farmers with more income will have more opportunity to use pesticides. The positive sign is expected for the coefficient of this variable.

Gender of the farmer: This is the gender of the head of the farm or the agricultural operator, it is a variable that takes the value 0 if the agricultural operator is a woman and 1 if he is a man. Men have more access to information and inputs than women (Dey, 1981). Since men have a greater probability of using pesticides than women, the positive sign is expected for the coefficient of the sex variable.

Level of education of the farmer: We consider as educated, any individual who has attended a class of formal school or informal school, therefore the one who can at least read or write in French. The education level variable takes the value 0 if the farmer is not educated and 1 if he is educated. The level of education can be a determining variable in the adoption of innovations, in the sense that the intellectual capacity of the educated individual allows him to better assimilate the conditions of use of pesticides (Nkamleu et al, 2000). The level of education increases the sense of embracing innovation, skill and ease of appreciating new technologies. The positive sign is expected for the coefficient of this variable. The area sown: The size of the area sown by the producer has a different impact on the decisions to use pesticides or not to use them.

In the context of the adoption of innovations, the large farm size is perceived as a means of managing the risks inherent in the new technology, so the larger the farm size, the greater the probability of adopting (Adekambi and al, 2020). The influence of this variable on the decision to use pesticides can be positive or negative.

Membership of an agricultural association: Membership of an agricultural association is a binary variable that takes the value 1 if the farmer belongs to a farmers' association and the value 0 if the farmer does not belong to an association. Membership of an agricultural association has a positive influence on the likelihood of using pesticides. In fact, in addition to facilitating members' access to information about innovations, associations also serve as a means of access to credit, especially input credit, thus helping to reduce the financial constraint on the acquisition of pesticides (Fafchamps and Minten, 2002). The positive sign is expected from the variable belonging to an agricultural association.

2.3 Presentation of data

In this work, we use data from the survey on the study of the agricultural sector (ESA) in Congo in 2011.

This survey was carried out in the twelve (12) departments of the Republic of Congo under the direction of the Ministry of Agriculture and Livestock in partnership with the French Society for Study and Consulting (SOFRECO) and the Center for Study and Research on Economic Analysis and Policy (CERAPE). The survey aims to develop basic data for the various sub-sectors of Congolese agriculture. Indeed, it deals with questions on the characteristics of farms, the characteristics of agricultural production systems, the supply of agricultural inputs and equipment and the sample of agricultural households is made up of 1844 households.

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3 Results and Discussion

This part of our study first presents the descriptive statistics followed by the results of the estimation of the model.

3.1 Descriptive statistics

They are presented in two separated tables from which, on the one hand, we find the descriptive statistics of the qualitative variables, on the other, the descriptive statistics of the quantitative variables.

Descriptive statistics of qualitative variables

The analysis of the descriptive statistics of these qualitative variables points out that, out of the 1844 farmers surveyed, barely 434 farmers use pesticides, i.e. a percentage of 23.54 and 1,410 farmers who do not use pesticides, i.e. 76.46%. This low proportion can be explained by a lack of extension and training policies and the lack of membership in agricultural associations. Regarding contact with extension services, 460 farmers are in contact with extension services and 1383 farmers are not. The survey reveals that men are predominant and women in agricultural practice are 1004 men and 516 women, this predominance is justified by the fact that in Congo land is managed by men and inheritance is often transmitted from man to man. Women who own land acquire it either through marriage or purchase.

It appears in this survey that educated farmers are in the majority than the uneducated, ie 1241 educated farmers and 273 uneducated. We also notice barely 376 farmers belong to an agricultural association and 1141 farmers have no membership in an agricultural association. Also, barely 68 farmers have access to credit, i.e. 3.69%, and 1,776 farmers do not have access to credit, i.e. 96.31%, which explains why the agricultural sector is handicapped by the lack of development policies. financing incentive by the banks.

Table 1: Descriptive statistics of qualitative variables

Variables	Modalities	Obs.	frequencies
Pesticides use	0 no	1410	76.46
	1 yes	434	23.54
Contact with extension services	0 no	1383	75.04
	1 yes	460	24.96
Gender	0 no	516	33.95
	1 yes	1004	66,05
Education level	0 no	273	18.03
	1 yes	1241	81.97
Membership of agriculture association	0 no	1141	75.21
	1 yes	376	24.79

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Crédit acces	0 no	1776	96.31
	1 yes	68	3.69

Source: author based on data from ESA (2011)

Descriptive statistics of quantitative variables

It appears in this table 2 of the quantitative variables that the average years of experience of the farmer is 13.48 years with a minimum experience of 0 years, that is to say that the farmer has just started. in the agricultural sector, and the maximum experience is 60 years. The average production is 2,898.01 tons, the minimum production is 0 tons, i.e. the first crop harvest has not yet taken place, and the maximum production is 750,000 tons. The average sown area is 2.48 hectares, the minimum area is 0.09 hectares and the maximum area is 9.8 hectares. We also note that the average income is 297,991.40 CFA francs, the maximum income is 1,200,000 and the minimum income is 0 Fr, that is to say that agricultural production is intended for self-consumption no sale is made. Taking these incomes into account, we deduce that most farmers do not invest their income in the purchase of pesticides to improve their production. Indeed, if the income were invested in the purchase of pesticides, many would have to use pesticides, which should encourage an increase in production and the area sown.

Table 2 : Descriptive statistics of quantitative variables

Source: author based on data from ESA (2011)

Variables	Mean	Minimum	Maximum	
Years of experience	1.48	0	60	
Income	297 991.40	0	1 200 000	
Production	2 898.01	0	750 000	
Area	2.48	9	98	

3.2 Model estimation results

The results in Table 3 show the variables the variables: age, experience, income, sex, level of education, production produced and membership of an agricultural association are not significant, which means that these variables have no influence on the use of pesticides by farmers. On the other hand, the variables of sown area and contact with extension services are significant. Which means that these two have an influence on the use of pesticides. The area variable has a negative and significant coefficient at the 1% level. In other words, the area negatively influences the decision of farmers to use pesticides. Indeed, the more the sown area increases, the farmers become hostile to the use of pesticides. These results are in line with those achieved in the context of the socio-economic determinants of the adoption of agro-ecological practices in vegetable production in the Niger Valley in Benin by Kpadenou et al (2019).

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The contact with extension services variable has a positive and significant coefficient at the 1% level. Indeed, contact with extension services has a positive influence on farmers' decision to use pesticides. This is explained by the simple fact that the extension services, being the structures operating for the development of the agricultural sector, provide the farmers with information relating to the advantages or assets that pesticides may have in improving yields or production, which therefore encourages farmers to use these techniques to protect fields against insects and weeds. This result is consistent with the results of the study carried out by Nkamleu et al (2000) on the choice of pest control methods in cocoa and coffee plantations in Cameroon.

Table 3 : Result of the estimation of the logit model

Use of pesticides	Coefficients	Probabilities
Education level	1.036	0.301
Area	-1.311	0.000
Production	0.0001	0.382
contact with extension services	3.728	0.002
Membership of agriculture association	0.321	0.593
Gender	0.302	0.660
Revenu	8.38e-08	0.663
Years of experience	-0.013	0.652
Age	0.011	0.684
Constante	1.250	0.476
R2	0.36	

Source: author based on data from ESA (2011)

Results of the marginal effects estimation

The results in Table 4 show the marginal effects of the variables that explain the use of pesticides. Indeed, the area variable has a coefficient of -0.181, significant at the 1% level. This means that a 1% increase in the area sown leads to an 18% decrease in the chance that a farmer will use pesticides.

The contact with extension services variable has a coefficient of 0.515, significant at the 1% level. This means that a 1% increase in contact with extension services increases a farmer's chance of using pesticides by 51%.

Table 4 : marginal effects

Use of pesticides	Coefficients	Probabilities
Education level	0.143	0.290
Area	-0.181	0.000
Production	0.0001	0.378
Contact with extension services	0.515	0.000

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Membership of agriculture association	0.044	0.590
Gender	0.048	0.659
Income	1.16e-08	0.662
Years of experience	-0.001	0.650
Age	0.001	0.683

Source: author based on data from ESA (2011)

Conclusion

This work try to analyze the determinants of pesticide use in the Republic of Congo. To achieve this objective, data from the ESA survey (2011) and a logit model are used. The results obtained show that factors such as: the area sown and contact with extension services significantly influence the use of pesticides. Area sown has a negative effect on pesticide use and contact with extension services has a positive influence on pesticide use. However, factors such as age, experience, income, production achieved, sex, level of education and membership of an agricultural association have no significant influence on the use of pesticides.

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