

Farmers' perceptions of the incidence and severity of damage by the armyworm (*Spodoptera frugiperda* J.E. Smith) (Lepidoptera: Noctuidae) in Nyiragongo Territory

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ABSTRACT

In this study, Rusayo and Mudja present their knowledge, perceptions and management practices with regard to the armyworm (*Spodoptera frugiperda*). 120 farmers were interviewed. The majority of farmers in Rusayo and Mudja were familiar with the armyworm. They could generally identify it at the larval stage. In addition, the majority of farmers (89%) had suffered damage caused by the armyworm on their farms, resulting in an estimated yield reduction of between 0.1 and 3 tonnes per hectare. More than half of the farmers used chemical insecticides to combat the pest. A majority of 60% of farmers considered that insecticides were not effective in combating the armyworm

1. Introduction

One of the most widely grown cereals in the world is maize (*Zea mays* L.). More than 33 million hectares are occupied worldwide each year. It accounts for 41% of global cereal production and its production has been estimated at around 843 million tonnes for the period 2013-2014 [7]. In the Democratic Republic of Congo (DRC), maize is the second most important food crop after cassava [19]. Its cultivation is widespread in the DRC and domestic production has continued to increase despite climatic and social disruptions, from 118,400 tonnes in 2000 to 2,078,352 tonnes in 2018, a growth rate of 56.9%. Since 2016, the African continent has been facing threats from armyworm, which is native to America. National average yields remain low (0.7 to 1 T/ha) compared to countries in the East African Community (EAC), partly due to the low use of agricultural inputs and improved varieties [18]. According to subsequent studies, the pest is present in almost all of Africa, where it causes significant damage, especially in maize fields and, to a lesser extent, in sorghum and other crops [23]. More than 30 African countries have currently identified the pest in their countries, including the DRC [2]. Armyworm damage varies from region to region and season to season. To date, out of 145 territories, 137 territories have been surveyed in the DRC, i.e. 94.4% of the national territory, are under attack with about 77% of production destruction, including the Nyiragongo Territory [5]. It is essential to know the current perceptions of farmers on this caterpillar, its damage and its impact on yields, as well as the control strategies developed to manage this insect [25] throughout the territory of Nyiragongo. It is necessary to carry out a knowledge assessment of this insect at the level of users at the grassroots level in order to propose effective solutions, recognized and accepted by all stakeholders. The objective of this study is to determine farmers' perceptions of caterpillars, their damage and their impact on yields, as well as the control strategies developed to manage this insect.

2. Methodology

2. Materials

2.1. Study Site

The study sites are located at about 1630 m mean altitude, 1° 35' 6" S latitude and 29° 10' 14" East Longitude for the Rusayo Group, and 1587 m Mean Altitude, 1° 37' 6" East Longitude for the Mudja Group, as they are close to the equator, resulting in two rainy seasons and two relatively dry seasons from June to August and January to February. Thus, they are found at high altitudes in the mountains where temperatures fluctuate between 15 and 30 degrees Celsius. The andosols of the soil of Nyiragongo come from eruptive rocks [11].

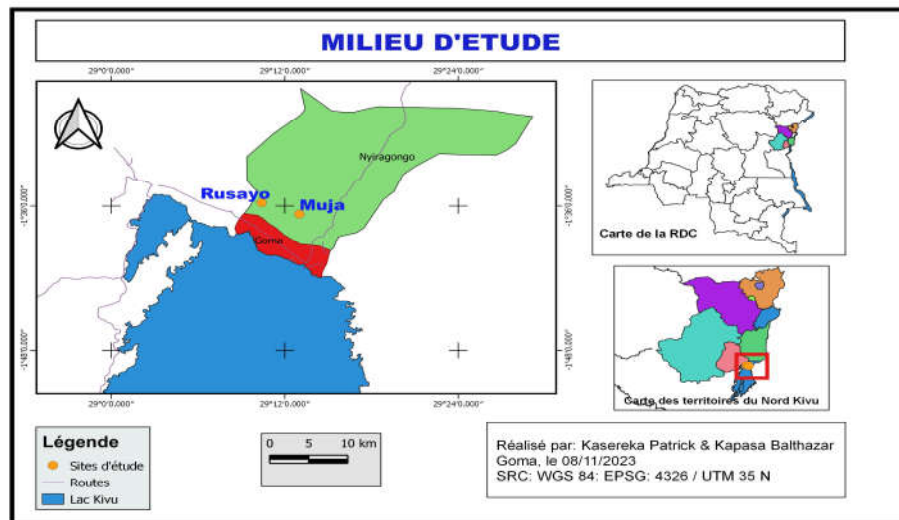


Figure 1: Location of study sites

2.1.1. Selection of participants and groupings

Two groupings were chosen based on their size and population. With the help of the Mudja Institute and the Rusayo Institute, sixty (60) maize farmers aged 18 years and over were randomly selected from each group.

2.2. Methods

2.2.1. Data collection tools

This questionnaire focused on questions relating to their social characteristics, their techniques for recognizing and managing *S. frugiperda* and its impacts, and their perception of the evolution of maize production from 2018 to 2022. Prior to the survey phase, the questionnaire was submitted to farmers in their local languages after a pre-survey that allowed for its improvement and validation. The data was first collected and processed using MS Excel 2016 software and KoboCollect. Geographic coordinates were obtained using Garmin Estrex10 GPS. The present study was conducted from September 2023 to October 2023 and was based on a semi-open-label questionnaire on 120 maize farmers due to 60 farmers in each group.

2.2.2. Measured parameters

The social characteristics of maize farmers in Nyiragongo, the detection of *S. frugiperda*, the severity of the insect attack on maize yield variations and the different control techniques were measured. The most important information gathered was about the control techniques used.

2.2.3. Statistical analysis of data

An analysis of variance (ANOVA) was used in the SPSS (Statistical Package for the Social Sciences) version 21.1 software with the "Bivariate Linear Regression" procedure, and then the Student-Newman test was used to compare means and qualitative data.

3. Results and Discussion

Table 1. Survey Questionnaire Reliability Test

Reliability statistics	
Cronbach's Alpha	Number of Items
,736	29

The internal coefficients of the questionnaire used are satisfactory since Cronbach's alpha is greater than 0.70.

Socio-economic profiles of farmers

The various interviews conducted with 120 maize farmers in two groups made it possible to collect the socioeconomic characteristics of the respondents (Table 2).

Table 2. Socio-economic profiles of farmers

Variable quantitative	Moyenne ± Ecart type	Actual	Freq(%)
Age	2.09 ± 0.661	18-25 years old	20 16,7
		26-33 years old	70 58,3

		34-41 years old	29	24,2
		42-49 years old	1	0,8
Agricultural Experience	1.77 ± 0.530	1-4 years	33	27,5
		5-8 years	83	69,2
		9-12 years old	3	2,5
		More than 12 years old	1	0,8
Area of land under maize	1.91 ± 0.622	Subsistence (<0.5 ha)	29	24,2
		Small scale (0.5 - 4.9 ha)	73	60,8
		Echelle moyen (5 - 10 ha)	18	15
		Long scale (> 10 ha)	0	0
Variable qualitative	Moyenne ± Ecart type		Actual	Freq(%)
Genre	1.61 ± 0.490	Masculine	47	39,2
		Feminine	73	60,8
Level of education	2.84 ± 0.830	No level	7	5,8
		Primary	31	25,8
		Secondary	56	46,7
		University	26	21,7
Strong point	1.74 ± 1.247	Crop production	77	64,2
		Animal production	23	19,2
		Food Processing	1	0,8
		Commerce	14	11,7
		Employee (public or private)	3	2,5
		Other activities (motorists and motorcycle taxis)	2	1,7
Secondary activity	3 ± 1,572	Crop production	37	30,8
		Animal production	13	10,8
		Food Processing	1	0,8
		Commerce	56	46,7
		Employee (public or private)	8	6,7
		Other activities (motorists and motorcycle taxis)	5	4,2
Member of a farmers' organization	1.75 ± 0.435	Yes	30	25
		Not	90	75
Participation in pest management trainings	1.47 ± 0.501	Yes	64	53,3
		Not	56	46,7
Contact with research or extension services	1.83 ± 0.382	Yes	21	17,5
		Not	99	82,5

The producers surveyed were mainly women (60.8%). The results showed that the majority of the farmers surveyed were between 26 and 33 years old (58.3%). On average, corn production time was 1.77 years. In terms of the educational attainment of the population, secondary education was the majority (46.7%). Crop production was the main activity of 64.2% of respondents and trade was the secondary activity of 46.7% of respondents. Only 25% are members of at least one farmers' organization, 53% have already participated in pest management trainings, and 17.5% are in contact with research or extension services.

Growers' perceptions of *S. frugiperda* and its damage to maize

Table 3. Summary Table of Farmers' Perception Models

Summary of Models

Model	R	R-Two	Adjusted R-two	Standard Error of Estimation	Durbin-Watson
1	,282 a	,580	,575	1,497	2,114

a. Predictors: (Constant)

Since adjusted R-two is 0.580, farmers' perceptions of *S. frugiperda* and its damage are 58% explained by farmers' level of education. DW = 2.114 which is close to 2 and therefore there is no collinearity between the variables. The model is good.

Table 4. ANOVA's Table of Farmers' Perceptions

ANOVA

Model	Sum of squares	ddl	Medium Square	F	Say.	
1	Regression	2,385	7	,341	1,382	,220b
	Residue	27,615	112	,247		
	Total	30,000	119			

has. Dependent variable: Profils_socio_conomi_enqu_t_Groupement

b. Predictors: (Constant)

This ANOVA table indicates that $F = 1.382 < 2$ and $p\text{-value} = 0.220 > 0.005$, leading to the conclusion that farmers' perceptions of *S. frugiperda* and its damage have a significant effect on how this pest is managed.

Table 5. Table of linear regression coefficients

		Coefficient				
		Non-standardised coefficients		Standardised coefficients		
Model		B	Standard Error	Beta	t	Say.
1	(Constant)	2,360	,358		6,600	,000
	Damage Awareness	,282	,131	,201	2,146	,034
	Knowledge of stages of development	,016	,065	,023	,249	,804
	Source of information	,022	,032	,064	,689	,492
	Perception of vulnerability	,038	,046	,079	,829	,409
	Period of attacks	,003	,055	,006	,058	,954
	Evolution of the Spread of Attacks	,101	,081	,124	1,235	,219
	Farmers' perception of damage	,027	,032	,093	,852	,396

has. Dependent variable: Profils_socio_conomi_enqu_t_Groupement

Most farmers have recognized the damage of *S. frugiperda* to maize crops. The majority of them were able to identify the pest at its larval stage. For most farmers, maize plants were most vulnerable from the first to fourth week after planting, and attacks were severe during periods of low rainfall. A few farmers felt that *S. frugiperda* caused more damage than other corn pests they encountered in their fields. In this case, $p\text{-value} = 0.0001 < 0.05$ and so there is a linear regression. When knowledge level increases by one unit, *S. frugiperda* perceptions and damage also increase by 0.27.

Farmers' Farming Practices

Table 6. Summary Table of Farmers' Cultivation Patterns

Summary of Models

Model	R	R-Two	Adjusted R-two	Standard Error of Estimation	Durbin-Watson
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1	,424 a	,791	,651	,772	1,100
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a. Predictors: (Constant), Pratiques_culturales_s_de_ma_s_cultiv_es,

Since adjusted R-two is 0.651, 65.1% of cultivation practices are explained by the application of fertilizers and the type of varieties used. DW = 1.100 which is less than 2 and therefore there is a positive collinearity between the variables.

Table 7. ANOVA's Table on Farmers' Farming Practices

ANOVA

Model		Sum of squares	ddl	Medium Square	F	Say.
1	Regression	15,254	2	7,627	12,796	,000b
	Residue	69,738	117	,596		
	Total	84,992	119			

has. Dependent variable: Pratiques_culturales_s_de_culture_du_ma_s

b. Predictors: (Constant), Pratiques_culturales_s_de_ma_s_cultiv_es

This ANOVA table indicates that $F = 12.796 > 2$ and $p\text{-value} = 0.0001 < 0.005$, leading to the conclusion that fertilizer application and varieties used have a non-significant effect on the management of this pest.

Table 8. Table of linear regression coefficients

Coefficient

Model		Non-standardised coefficients		Standardised coefficients	t	Say.
		B	Standard Error	Beta		
1	(Constant)	2,530	,184		13,776	,000
	Fertilizer application	,208	,062	,282	3,353	,001
	Types of Varieties Grown	-,360	,089	-,340	-4,043	,000

has. Dependent variable: Pratiques_culturales_s_de_culture_du_ma_s

In this case, $p\text{-value} = 0.0001 < 0.05$ and so there is a linear regression. When the level of knowledge increases by one unit, cultural practices are also effective by 0.184.

Indicators of S. frugiperda damage according to farmers

Table 9. Summary Table of Damage Indicator Models

Summary of Models

Model	R	R-Two	Adjusted R-two	Standard Error of Estimation	Durbin-Watson
1	,188a	,350	,340	,511	1,001

a. Predictors: (Constant)

Since adjusted R-two is 0.340, 34% of the damage indicators are explained by infestations of fields, ears, leaves, etc. DW = 1.001 which is less than 2 and therefore there is positive collinearity between the variables.

Table 10. ANOVA's Damage Indicators Table

ANOVA

Model		Sum of squares	ddl	Medium Square	F	Say.
1	Regression	1,063	8	,133	,510	,847b
	Residue	28,937	111	,261		
	Total	30,000	119			

has. Dependent variable: Profils_socio_conomi_enqu_t_Groupement

b. Predictors: (Constant)

This ANOVA table indicates that $F = 0.510 < 2$ and $p\text{-value} = 0.847 > 0.005$, leading to the conclusion that field infestations have a significant effect on the yield in Kg/ha of infested fields.

Table 11. Table of linear regression coefficients

Model		Coefficient				
		Non-standardised coefficients		Standardised coefficients		
		B	Standard Error	Beta	t	Sig.
1	(Constant)	1,234	,279		4,432	,000
	Infested corn fields	,016	,122	,016	,132	,895
	Infested corn plants	,103	,170	,097	,608	,545
	Infested corn cobs	,059	,158	,061	,371	,711
	Yield losses in Kg/ha	,039	,161	,026	,239	,812
	Gravity on leaves	-,104	,139	-,113	-,748	,456
	Severity on ears	,028	,129	,034	,217	,828
	Management Practices	,003	,032	,008	,082	,935
	Damage Perception	,040	,040	,103	,994	,323

has. Dependent variable: Profils_socio_conomi_enqu_t_Groupement

In this case, $p\text{-value} = 0.0001 < 0.05$ and so there is a linear regression. When cultural practices are well done, infestations are also reduced by 0.279.

In this study, the majority of corn growers recognized and identified damage caused by *S. frugiperda* in the larval stage. A better understanding of the pest's biology is needed to identify these developmental stages [24]. Some farmers reported the first attack of *S. frugiperda* in 2015. According to Goergen *et al.* [6], *S. frugiperda* attacks were first reported in West and Central Africa in early 2018. In addition, the study found that farmers' knowledge and perceptions of *S. frugiperda* were related to how they viewed infestations in the field. However, despite the geoclimatic differences, the institutional environment of farmers could play an important role in the sustainable management of the pest. *S. frugiperda* was present on all target communities and the life cycle of the pest lasts an average of thirty days, and ideal temperatures for adults and larvae are 25 to 30 degrees Celsius [15].

Before the *S. frugiperda* invasion, farmers harvested an average of 813 kg of maize per hectare. The Centre for Agriculture and Bioscience International (CABI) has estimated that *S. frugiperda* could reduce average annual maize production in Benin by 40% [10]. Levels of infestation, which may depend on climatic factors, management methods used by farmers, environmental conditions, and availability of insecticides, may explain differences in yield losses between countries. In Nicaragua, Hruska and Gould, cited by Hougbo *et al.* [8], showed that yield losses and *S. frugiperda* infestation levels were positively correlated.

Infestations of 55-100% of corn plants can result in yield losses of 15-73% for corn plants. Cropping systems were not significantly related to the severity of pest attacks. According to Balde [3], intercropping was less affected by *S. frugiperda* than monocultures and could reduce damage by up to 30%. In addition, weeding and no-till have been shown by Urge *et al.* [27] to reduce *S. frugiperda* damage. The severity of *S. frugiperda* attacks has also been linked to the maize varieties grown. Modern varieties were more vulnerable to attack than traditional varieties. To control *S. frugiperda*, most farmers in Rusayo and Mudja use synthetic pesticides. Other African countries such as Ghana, Zambia, Nigeria, Kenya, and Ethiopia have also seen the same [12].

Farmers can easily obtain synthetic pesticides. Low use of artificial pesticides is recommended by agencies such as USAID and other organizations such as FAO. However, there is no evidence that farmers are following the advice of these organizations that advocate limited and reasonable use of synthetic pesticides. However, there is no evidence that farmers are complying with the recommendations of these organizations that advocate rational and limited use of synthetic pesticides. This implies that an effort remains to be made by extension services regarding the use of synthetic pesticides against *S. frugiperda*.

Farmers found that chemical control was quite effective in Nyiragongo. Chemical control was found to be quite effective by farmers. Farmers have different perceptions of the effectiveness of chemical control. For example, farmers in Ethiopia found

chemical control effective against *S. frugiperda*, but about 60% of farmers in Kenya found synthetic pesticides ineffective [12]. Some farmers thought that botanical pesticides were more effective against *S. frugiperda* than synthetic pesticides. However, these botanical pesticides have been little used.

4. Conclusion

This study showed that all farmers in Rusayo and Mudja fully recognize armyworm because the production activity is owned by men and generally has a relatively low level of education. The caterpillar is known to be extremely destructive during all stages of production, and especially during the vegetative phase, it can significantly reduce the productivity of the crop. According to the study, there is a link between knowledge of *S. frugiperda* and the use of management practices. In addition, there is a correlation between knowledge of the harmful organism and different management methods. Thus, the study confirms that farmers' knowledge of pests is an important factor in their decision to control pests.

Other research is to refine and standardize management practices deemed effective by farmers and to analyze farmers' willingness to pay for improved management and farmers' willingness to pay for improved management practices.

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