International Journal of Recent Engineering Research and Development (IJRERD)
ISSN: 2455-8761
www.ijrerd.com || Volume 06 – Issue 03 || March 2021 || PP. 08-17

Perceptions of small-scale producers in Kipushi on the damage caused by armyworm (*Spodoptera frugiperda)* in *Zea mays* fields, Haut-Katanga, DR Congo

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Résumé: Les dommages causés par la chenille légionnaire à Kipushi accentue la dégradation des conditions de vie des petits producteurs dans le contexte de la pandémie du Covid-19. Cette étude avait comme objectif dedéterminer les Perceptions des petits producteurs de Kipushi sur les dommages causés par la chenille légionnaire (*Spodoptera frugiperda)* dans les champs de *Zea mays*. Pour y arriver, des enquêtes à interviews couplées sur des observations ont été réalisées dans les champs de *Zea mays* de 39 petits producteurs. Les résultats relatifs à la description du profil socioéconomique des producteurs révèlent que, la production de maïs à Kipushi est une activité légèrement dominée par les hommes (51,90%), mariés (97%), ayant un niveau d'étude secondaire (55%) et dont l'âge moyen est de 43,86±16 ans. La quasi-totalité des répondants sont chefs de leurs ménages respectifs composés de 8 membres. Par ailleurs, les résultats en rapport avec les dommages causés par la chenille légionnaire sont caractérisés par la chute des jeunes plantes aux tiges sectionnés, la perforation de feuilles et des épis, la présence des excréments bruns et humides tout autour des trous de perforation et le retardement de la croissance des plantes. En outre, les producteurs affirment que suite à ces attaques, leur rendement est affecté négativement, se traduisant par des faibles revenus. En fin, les petits producteurs considèrent que les perturbations climatiques et les malédictions seraient les principaux facteurs de l'apparition de la chenille légionnaire dans leurs champs.

Summary: The damage caused by armyworm in Kipushi accentuates the deterioration of the living conditions of smallholder farmers in the context of the Covid-19 pandemic. The objective of this study was to determine the perceptions of smallholder farmers in Kipushi on the damage caused by armyworm (Spodoptera frugiperda) in Zea mays fields. To achieve this, interview surveys coupled with observations were conducted in the Zea mays fields of 39 smallholder farmers. The results on the description of the socio-economic profile of the producers reveal that maize production in Kipushi is an activity slightly dominated by men (51.90%), married (97%), with a secondary education level (55%) and an average age of 43.86±16 years. Almost all the respondents are heads of their respective households composed of 8 members. Moreover, the results related to the damage caused by the armyworm are characterized by the fall of young plants with severed stems, the perforation of leaves and ears, the presence of brown and wet excrements all around the holes of perforation and the delay of the growth of plants. In addition, the producers state that as a result of these attacks, their yield is negatively affected, resulting in low income. Finally, small-scale producers consider that climatic disturbances and curses are the main factors for the appearance of army worms in their fields.

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Keyword: Damage, armyworm, *Zea mays*, socio-economy, Kipushi

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1. Introduction

Native to the Americas, the fall armyworm (Spodoptera frugiperda) was first identified in Africa in 2016 in Nigeria. Currently, it has invaded 44 countries in sub-Saharan Africa where it has become a nightmare for small-scale subsistence maize farmers. Maize is one of the three most important cereal crops in the world. Its genetic diversity is so great that it is grown under a very wide range of environments (Agnes, 2019). However, the factors limiting its production are also varied, including diseases and pests, especially the Armyworm. From the high tropical and subtropical valleys to the tropical lowlands and temperate regions, these pests can invade the maize crop at all stages of its development and in storage, often causing significant damage. In particular, the armyworm feeds on both leaves, which reduces the photosynthetic capacity and development of maize, thus reducing yield (Calatayud, 2020). According to the International Center for Agriculture and Biosciences (CABI, 2018), 12 African countries could lose between 3.6 and 6.2 million U.S. dollars (USD) per year due to the armyworm invasion. In this regard, DR Congo in particular lost 74.5 million USD. However, the (CAID, 2018) report indicates that crop losses caused by Armyworm attacks on maize crops in DR Congo are estimated to average 45%, or a loss of about 0.9 million tons of maize estimated locally at 357,000,000 USD in 2017/2018. Currently, the armyworm is affecting Haut-Katanga and compromising the yield of maize which is the most consumed cereal in the region (Nyembo et al., 2019). These recorded attacks cause heavy losses in a context of shortage of the commodity and the collapse of the population's standard of living. These attacks increase the vulnerability of small-scale producers to food insecurity and poverty in the context of Covid-19. Although impacting agriculture in Haut-Katanga, in particular in Lubumbashi and its peripheries, no study has addressed the problem of identifying the damage observed in the fields attacked by this caterpillar. Thus, this study was initiated to determine the perceptions of small-scale producers in Kipushi on the damage caused by the armyworm (Spodoptera frugiperda) in Zea mays fields, one of the major supply corridors of the city of Lubumbashi.

2. Environment and methods

2.1. Presentation of the city of Kipushi

Kipushi is a deconcentrated territorial entity created on July 17, 1956 by ordinance law n°21/213. Kipushi is the capital of the territory of Kipushi in the province of Haut-Katanga in the Democratic Republic of Congo. It is located at 10°45'-12°30" South latitude, 27°00'-28°10' East longitude and 1300 m altitude. The territory of Kipushi extends over two chiefdoms and one sector (the chiefdom of Kaponda, Kinama, and the sector of Bukanda). It is bordered to the north by the territory of Kasenga, to the south by the territory of Sakania, to the east by the Republic of Zambia and to the west by the territory of Kambove. Kipushi covers an area of 12,059 km2 and currently has an estimated population of 376,447 (CAID, 2017). The figure below shows the location of the city of Kipushi.

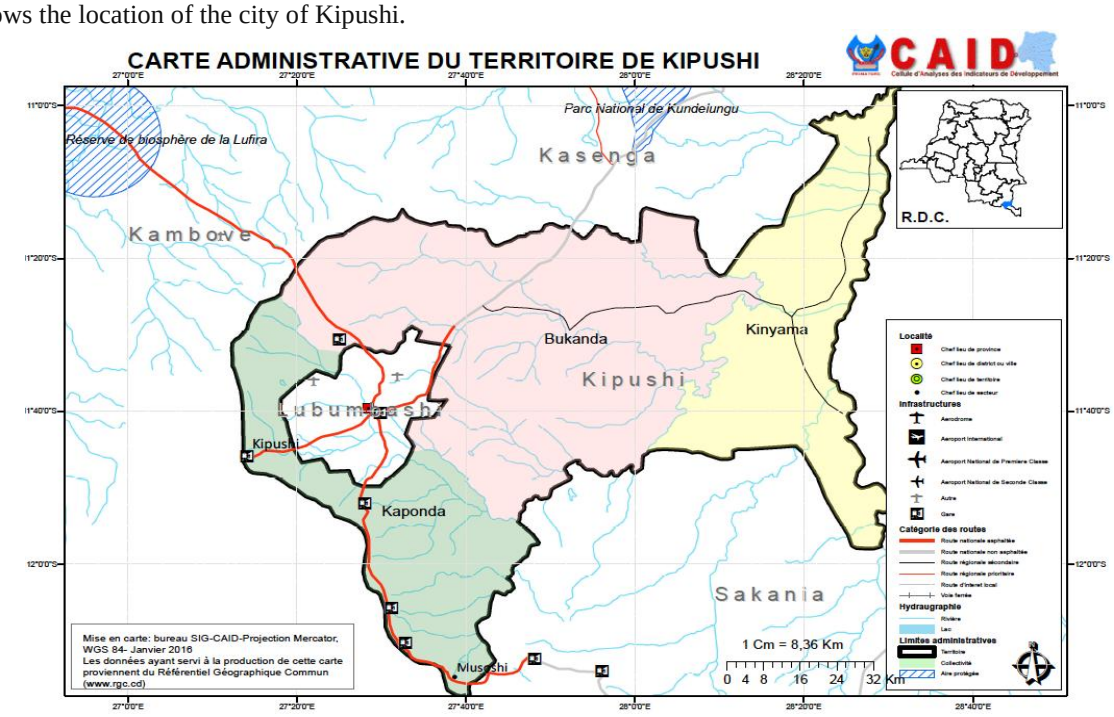

Figure 1. Location of the city of Kipushi

2.1.1. Climate

According to Köppen's classification, the city of Kipushi is characterized by the CW6 type of climate. The average annual rainfall during the last 15 yearsis 1260 mm. The average annual temperature is about 19.8°C.

2.1.2. Hydrography

The territory is watered by several rivers and streams, including the Kafubu River, which is about 135 km long and has its source in the village of Shimpauka in the Inakiluba group (Kaponda chiefdom), running through the territory from east to west, and flowinginto the Luapula River at the village of Kanga in the Kinama chiefdom (one of the territory's tourist sites) The main rivers are: Bwishibila, Munama, Musoshi, Kafubu, Kifumanshi, Kiswishi and Luapula.

2.1.3. Vegetation and soil

The territory of Kipushi is generally dominated by the Miombo open forest characterized by the predominance of species of the grass and fabaceae families. However, the soil is generally sandy-clay.

2.1.4. Socio-cultural aspect

Kipushi is made up of the large ones, namely, Lamba, Aushi, Kaonde and Bemba. As for their location, the Lamba are in the Buk and a sector and the Kaponda chiefdom; the Aushi in the Kinama chiefdom; the Kaonde in the Kaponda chiefdom; and the Bemba are in the Bukanda sector. However, the mining activity in Kipushi has attracted many other tribes from the DR Congo as well as from Africa in general.

2.1.5. Economic situation

Agriculture is the main activity and source of income for the population of Kipushi. This is followed by mining, where part of the population works in the mining industries. On the other hand, a small number of the population survives through small businesses and charcoal production.

2.2. Methods

2.2.1. Procedure

Information was collected on the socio-economic characteristics of the producers who were the heads of the farms, the producers' perceptions of the damage and the evaluation of the economic performance of the farms that were attacked.

2.2.2. Techniques used

- **Documentary technique**

The use of scientific articles and reports from different organizations allowed us to contextualize the attacks caused by the armyworm in the corn fields of small producers.

- **Survey technique with interviews and observations**

This survey was conducted in the form of an interview with small-scalemaize farmers in Kipushi. The survey was conducted between 8:00 am and 2:00 pm. The choice of this time slot was justified by the presence of the producers in the fields. Direct observations on the maize plots made it possible to reconcile the information provided by the producers during the survey with the damage observed in their fields.

- **Sampling technique**

The survey involved 39 small-scale producers selected on the basis of the presence of attacks in their maize plots. The survey was conducted using an open and closed-ended questionnaire.

2.2.3. Site selection criteria

The choice of Kipushi was justified by the increasing damage caused by armyworm on the fields of small producers and because of its role in supplying Lubumbashi.

2.2.4. Analysis of the data

The collected data were entered and saved in an Excel file and analyzed using R software version 3.5.3 (2019-03-11). The presentation of the data is done in table and graph form. The descriptive analys is allowed the presentation of quantitative variables as mean, plus or minus standard deviation, and qualitative variables as numbers. The intermediate consumption, which is the total of goods and services that are completely consumed during a maize production cycle, was found by the formula, IC = cost of seed + cost of fertilizer + cost of

pesticide. To calculate the gross product (revenue) which is the value of production, that is, the quantities produced multiplied by the unit price of Chinese cabbage, we used the following formula: PB = production in kg x unit price in CDF.

3. Results

3.1. Socio-economic profile of producers

Table 1. Socio economic characteristics of producers

Variables		Percentage (%)
Gender	Women	48,10
	Men	51,90
	Total	**100**
Civil status	Married	97,00
	Singles	3,00
	Total	**100**
Age	Averageage (years)	*43,86±16*
Level of education	Did not attend school	24,00%
	Primary	18,00
	Secondary	55,00
	University	3,00
	Total	**100**
Status of the producer in the household	Head of household	95,00
	Is not the head of the household	5,00
	Total	**100**
Household size	Household members	7,82±3,15
	Total	**100**
Market gardening as the main activity of the producer	Yes	94,10
	No	5,90
	Total	**100**

The results in table 1 above show that market gardening in Lubumbashi is an activity slightly dominated by men (51.90%) as opposed to 48.10% of men. In terms of marital status, the vast majority of market gardeners are married (97.00%) and single (3.00%). The average age of the market gardeners in the sample was 43.86±16 years. The results of this study show that most of the market gardeners in the sample, 55.00%, had a secondary level of education, followed by those who had no education, then those who had a primary level of education, 18.00%. Finally, those with a primary level of education 3.00%. As for the status of the producer, the majority of respondents, i.e. 95.00%, are heads of their respective households, against only 5.00% who are not heads of their households. Agricultural households in Kipushi are composed of an average of 7.82±3.15 persons. As for the activity of the respondents, 94.10% or the vast majority consider maize production as the main income generating activity of the household, against only 4.90% who consider it as a secondary activity.

3.2. damage caused by armyworm

The figures below show caterpillar attacks on corn leaves in the surveyed plots. It appears from our field observations and these images below that the armyworm attacks maize leaves by the following means: (i) perforation of the leaves, (ii) the presence of brown and wet excrements near the holes on the leaves. From these results we can see the extent of the caterpillar damage on the maize plant (Figure 2).

Figure 2: Illustration of damage

The results in the graphs below show that armyworms attackyoung plants by severing theirs talks and ravage the corn cobs. ***(Figure 3)***.

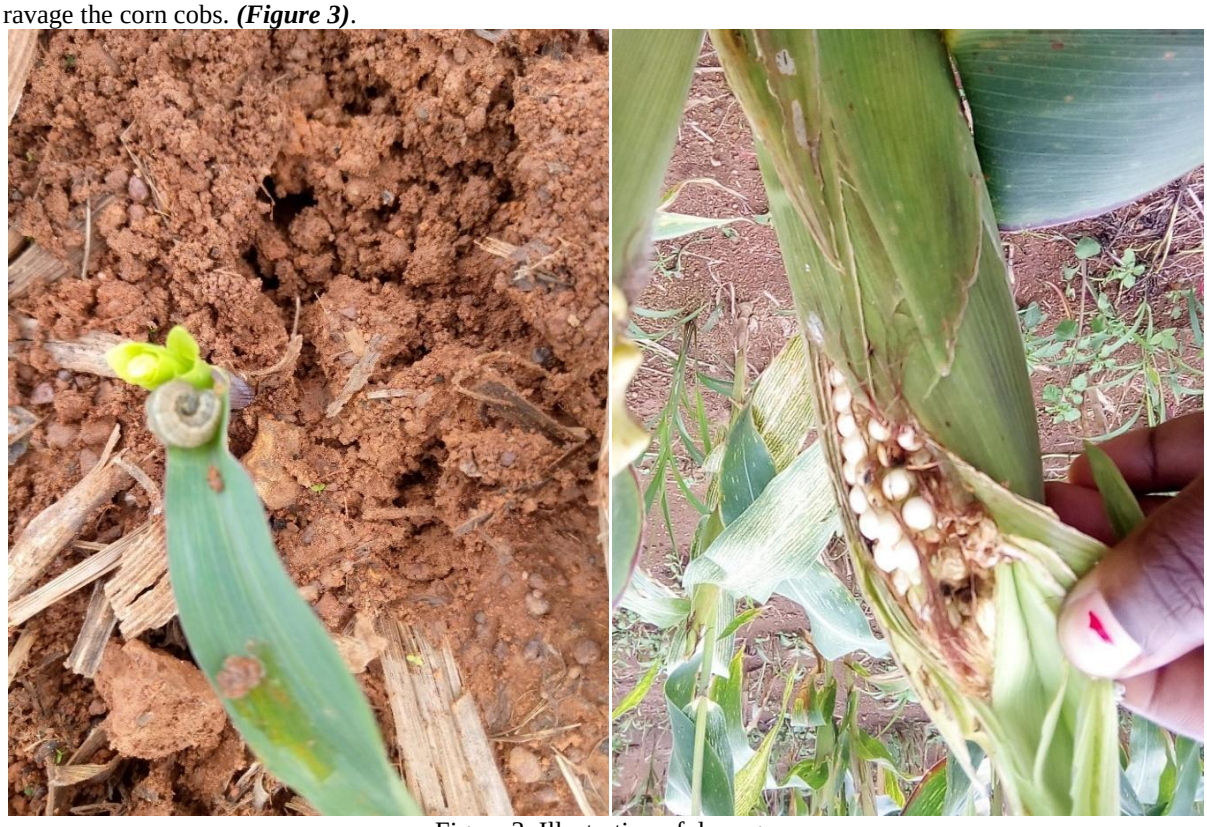

Figure 3: Illustration of damage

The figure below shows the caterpillar attacks in the fields of small-scale producers. From these results, it was found as shown in the image below that maize attacked by the caterpillar suffered stunted growth (4).

Figure 4: Illustration of damage

The figure below shows the distribution of the respondents according to the means of control of the armyworm. The results show that 36.80% of the producers use chemical control, 34.20% use natural substances, 15.80% use integrated control, i.e. a combination of natural substances and chemical products, and even preventive control, 7.90% do not use any means of control and 5.30% use only preventive control (Figure 5).

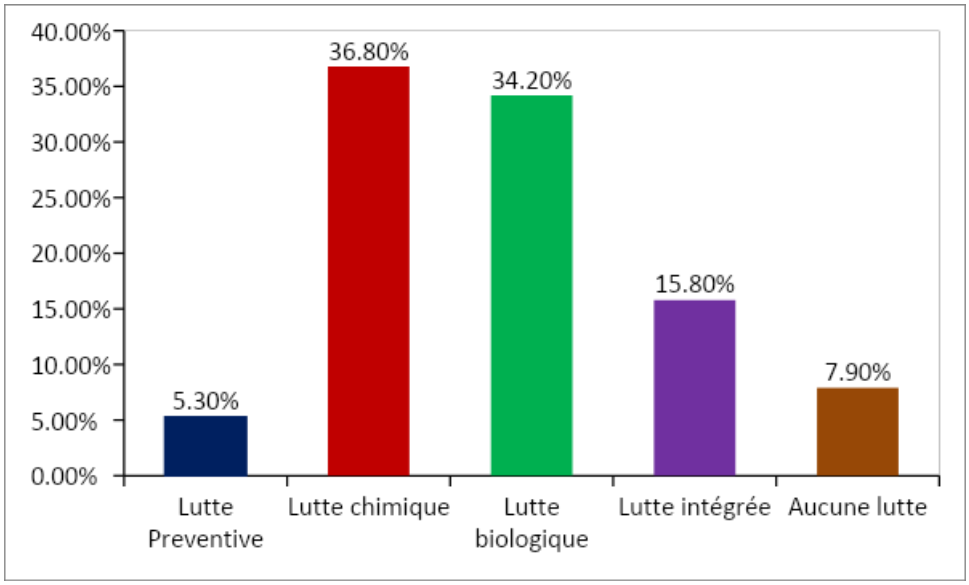

Figure 5: Legionnaires' caterpillar control

3.3 Estimation of the economic performance of the farmssurveyed

Table 2. Area and intermediateconsumption

N	Seed (CDF)	Fertilizercost (CDF)	PPS (CDF)	Total CI (CDF)
39	54092±47590	185700±410980	9842±15853	190631±130810

The results presented in Table 1 indicate that maize producers spend an average of 54,092±47,590 CDF on seed purchases, 185,700±410,980 CDF on fertilizer materials including UREE and NPK, and 9,842±15,853 CDF on plant protection products. Their average expenditure for intermediate consumption per production cycle is 190,631±130,810 CDF. The cost of acquiring fertilizer materials represents 74.39% of the total cost, seeds represent 21.67% and phytosanitary products represent only 3.94% (Table 2).

Table 3. Income Estimates

N	Area (ha)	Total production (ton)	Self-consumption (ton)	Income (CDF)
39	0,46±0,44	0,75±0,73	0,40±0,56	317065±254399

The results in Table 2 show that maize farmers in Kipushi plant an average of 0.46±0.44 hectares and obtain an average production of 0.75±0.73 tons per production cycle. Of the total production, 0.40 tons or 53.33% is for household consumption.

3.4. Perception of the productions in front of the attacks of the armyworm

The figure below presents the distribution of the respondents according to their perception of the attacks related to the armyworm. It appears from these results that 71.00% of the producers confirm climatic disturbances as a main cause of the spread of the armyworm, 13.90% think that it is a curse, 13.10% do not know the cause and 2.00% ***(figure 4).***

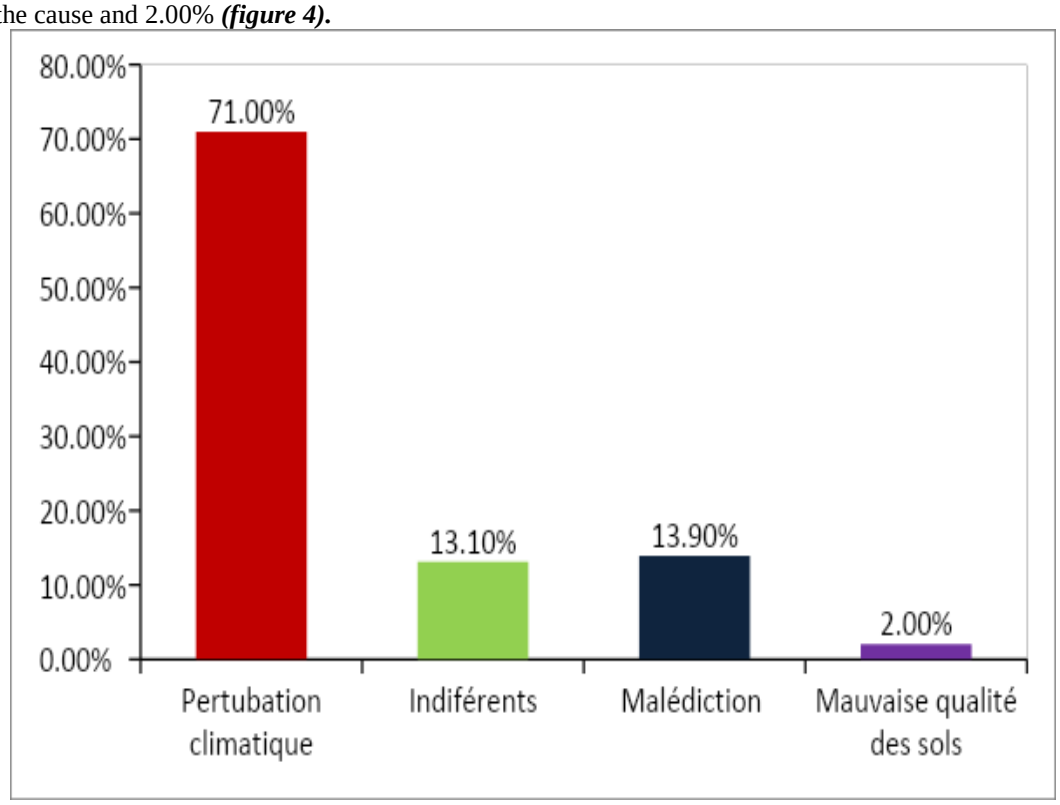

Figure 4. Producers' perception of army wormattacks

4. Discussion of the results

4.1. Description of the socio-economic profile of producers

The results of this study show that maize production in Kipushi is an activity practiced by married people (97%) with secondary education (55%) and an average age of 43.86±16 years. These producers are generally heads of households (95%) composed of 7.82±3.15 members.

These results are similar to those found by Mushagalusa et al, (2015), in their study on "food consumption in Mimbulu: description of units of measurement and dietary patterns of rural households in Katanga". The results of their survey showed that most agricultural households in rural Katanga consist of 7 persons, 79.7% of household heads were male with an age of 44±13 years. These results can be explained by the fact that in rural areas, men are held in special esteem, and in the context of a family, such an age would reflect maturity and a sense of responsibility.

In addition, Book Three of the DRC Family Code gives the man the management of the household in its articles 444 and 445. 86% of these heads were farmers with an average annual income of $955. This situation is explained by the fact that employment opportunities are rare in rural areas and agriculture is a refuge sector despite its low productivity.

4.2. Damage caused by armyworms

The results of our observations on the plots of maize regarding the identification of the damage caused by armyworms showed that to ravage, the caterpillar perforates the leaves of the maize, leaving these brown and wet excrements near the holes on the leaves and stems (figure 10), attacks the young plants by cutting their stems, the caterpillars were observed inside the ears (figure 11) and delays of the growth were even observed in the attacked ones (figure 12).

These same observations were also made by Kouakou *et al,* (2019). The results of their study on the detection of the Fall Armyworm, *Spodoptera frugiperda* (J. E. Smith, 1797) (Coleoptera: Noctuidae) and First Observations on its Biology in Côte d'Ivoire show that in heavily attacked plantations, on young maize plants, the caterpillars fed by drilling holes. Their presence was accompanied by reddish-brown, moist excrement near the holes. Damage was also observed on older plants. Caterpillars were even observed inside the ears. The damage was reflected in the grooves in the kernels, making these fruits unsuitable for the fresh produce market.

The results corroborate to those found by Agnes (2019). The results of her research show that with a predilection for corn: "as soon as a Legionnaires' caterpillar sees it, it pounces on it. It feeds on both the leaves, which hinders photosynthesis and plant development, but it also attacks the ears. It's very impressive.

The results of our study show that 63.2% of the small-scale farmers surveyed use non-chemical control methods to control armyworm attacks in their maize plots, and only 38.8% use chemical control methods.

This compares to the results found Djiby *et al,* (2018) which shows that only insecticide treatments significantly reduce the incidence of armyworm at the vegetative and productive stage. The means of control adopted by most of the small-scale producers surveyed seem to have evolved in disagreement with the recommendations of scientists.

This situation is explained by the fact that employment opportunities are rare in rural areas and agriculture is a refuge sector despite its low productivity. These farming households are poor in terms of their income and living conditions. This compromises these producers' access to insecticides, which are generally expensive in relation to their income. Faced with caterpillar attacks, these farmers resort to so-called ancestral pest control practices.

4.3 Estimation of the economic performance of the farms surveyed

The results of our study show that for a maize production cycle of about six months, smallholder farmers in Kipushi record an income of 317065±254399 CDF. Compared to the UNDP threshold of 1.25 USD/person/day, the income from agriculture in Kipushi does not allow households to reach or exceed the poverty line, so Kipushi farmers are poor.

According to the results found by Agnes, (2019) the poor performance of smallholder farms could be explained by armyworm attacks and by the low effectiveness of the control methods adopted by these farmers.

According to the International Center for Agriculture and Biosciences (CABI), the DR Congo lost 74.5 million USD to the armyworm invasion in 2018. However, in Africa 12 countries could lose between 3.6 and 6.2 million USD per year for the same cause.

From the results we can deduce that small-scale maize farmers in the Kipushi region would suffer economic impacts from army worm attacks

4.4. Perception of the productions in front of the attacks of the armyworm

The results of our study show that the vast majority of small-scale farmers surveyed confirm that the appearance of armyworm in their maize plots is linked to the problem of climatic disturbance.

The perceptions of smallholder maize farmers in Kipushi about army worm attacks are in harmony with the results of scientific research.

According to The report of the convening of a regional conference, from 10 to 12 September 2019, in Ouagadougou, Burkina Faso on the severity of army worm attacks. Africa is facing the effects of climate variability and change with adverse consequences on agro-sylvo-pastoral productions, and therefore on the living conditions of the populations. Floods, droughts, extreme temperatures, seasonal shifts, disruption of rainfall patterns, land degradation and declining soil fertility, the resurgence of certain crop pests, the appearance of emerging diseases and/or exotic pests; the continuous degradation of the environment. In addition, there are crop pests such as locusts and grasshoppers, fruit flies, granivorous birds and rodents.

Conclusion

The objective of this study was to determine the perceptions of smallholder farmers in Kipushi on the damage caused by armyworm (Spodoptera frugiperda) in Zea mays fields. To this end, interview surveys coupled with observations were conducted in the Zea mays fields of 39 smallholder farmers. The collected data were captured, saved in an Excel file and analyzed using R software version 3.5.3 (2019-03-11). The results

relating to the description of the socio-economic profile of the producers reveal that, maize production in Kipushi is an activity slightly dominated by men (51.90%), married (97%), with a secondary education level (55%) and whose average age is 43.86±16 years. Almost all the respondents are heads of their respective households composed of 8 members. Moreover, the results related to the damage caused by the armyworm are characterized by the fall of young plants with severed stems, the perforation of leaves and ears, the presence of brown and wet excrements all around the holes of perforation and the delay of the growth of plants. In addition, the producers affirm that as a result of these attacks, their yield is negatively affected, resulting in low income. Finally, small-scale producers consider that climate change disturbances and curses are the main factors for the appearance of army worms in their fields.

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