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Fight against two corn pests, Zonocerus variegatus and spodoptera frugiperda in the province of Tshopo, DR Congo

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Abstract
The general objective of this study is to control two corn insect pests (zonocerus variegatus and spodoptera frugiperda) in the Alibuku Axis, Tshopo, DR Congo.
The results obtained are presented as follows: Corn crop pests are practiced in the study area, including Zonocerus variegatus and the armyworm and the means of control.
The peasants of ALIBUKU village practice both means of control, including mechanical and chemical control. Almost half of the population practices mechanical control methods, whereas 100% of the peasants do this and only 10% do chemical control in ALIBUKU village; the situation is the same in AZUNU village and; finally, PUMUZIKA, they practice mechanical and chemical control equally, making multiple crops
To combat maize pests, farmers in the study area use two control methods, namely chemical control and mechanical control. Regarding the control of maize weevils, 70% of farmers resort to storing very dry grains in the store, while 30% of farmers prefer to spread kitchen ash in the field as a preventive control method to limit attacks by this insect from the field before storage. As for the white mealybug, 57% of farmers prohibit the opening of husks before maturity and 43% spread ash on all young plants throughout the field. In addition, 39% of farmers resort to spreading soil throughout the field on all young plants, and 61% say they remove webs using a stick to combat the green spider.

Keywords: Zonocerus variegatus, spodoptera frugiperda, mechanical and chemical control, maize pest management, farmer practices in dr Congo

Introduction

Maize is the third most important cereal for people in tropical regions, after wheat and rice (NGuetta *et al.*, 2005; Amiruzzaman *et al.*, 2010). Its cultivated area worldwide is smaller than that of wheat and rice, but its average yield of 5.5 t. ha $^{-1}$ is far higher than that of wheat and rice (Ofori *et al.*, 2004; Issa *et al.*, 2011). Regarding human consumption in Mexico or South Africa, for example, the figures can reach 50 to more than 10 kg/year/person of corn consumed.

In the Democratic Republic of Congo (DRC), it constitutes the second most important food crop after cassava (Nyembo *et al.*, 2014) [61]. In the DRC, it is the main cereal and has gained in importance in recent years (Malumba *et al.*, 2008). In Kinshasa, for example, annual consumption (kg/head) of grain maize increased from 2.84 kg in 1975 to 6.68 kg in 2000, an increase of 235%. (FAO 2016) Maize flour is increasingly mixed with cassava flour when preparing " fufu " (Tollens, 2004).

Corn is grown for human and animal food, but also for many uses in the textile and pharmaceutical industries, in the production of biodegradable plastic and biofuel (Saeed *And al.*, 2000; Morris, 2002; Malumba *And al.*, 2008; Issa *et al.*, 2011; Kaho *et al.*, 2011; Useni *et al.*, 2014) [49].

Maize cultivation is widespread in the DRC and national production has continued to increase despite climatic and social disruptions, rising from 1,101,130 tonnes in 1996 to 1,154,570 tonnes in 2002, a growth of 4.85% (SENASEM/CTB, 2009). At the same time, during the same period, cultivated areas increased from 1,378,135 to 1,808,948 ha, an increase of 31%

(Malumba, 2008). This shows, however, that the increase in maize production is dependent on the increase in cultivable areas. Average national yields remain low (0.8 to 1 t. ha $^{-1)}$

Although maize production in Katanga province ranks first among the DRC provinces (22% of national production), overall demand in 2008 was 988,156 tonnes and supply 500,854 tonnes, a supply/demand ratio of more or less 0.5 (Anonymous, 2008 in Nyembo, 2010). This situation creates food insecurity for around 9 million inhabitants. This permanent deficit is generally filled by imports from southern Africa. Indeed, in Katanga, in rural areas, the average maize yield fluctuates between 800 and 1000 kg. Ha $^{-1}$ compared to 3000 to 4000 kg ha $^{-1}$ and 6000 to 8000 kg ha $^{-1}$ in large farms and research stations respectively (Adrille, 2003; Nyembo *et al*, 2013). This is how research has been directed towards improving cultivation techniques to increase the yield of grain maize in Katanga.

In the United States of America, of the 100% increase in corn yield, 60% is related to genetic improvement and corn yields increased from 1 t. ha $^{-1}$ in the 1930s to 7 t. ha $^{-1}$ in the 1990s (Troyer, *et al.*, 1990). In France, 58% of corn yield gains are due to genetic improvement (Cauredon, et *al.*, 2004).

In the context of the Katanga province, local varieties adapted to climatic conditions are degenerated and no longer allow good yields to be achieved Nyembo, et *al* 2010. In addition, with the climate change observed in recent decades (Aubry, 2000), the desired maize genotypes must have both good tolerance to this stress and good grain yield potential (Nyembo, *et al.*, 2010).

Sub-Saharan Africa is an area where the demographic transition is expected by 2050, like the global one where it is projected that there will be between 8 and 11 billion inhabitants to feed (Fréderic *et al*, 2012). This area is located in the tropical region where the soils by their nature (acid soil) undergo the degradation of physicochemical properties due to the aggressive nature of the climate of the region; they lose more of their qualities and become infertile (Batiano, 2006).

In such soils, agricultural production is sufficiently low, especially for cereals such as corn (*Zea mays* L.) to cover the food needs of an ever-growing population (FAO, 1999).

Maize is one of the most widely grown food grains in tropical areas, and requires good soils for good yields. Its production leads to soil depletion, especially when management becomes inadequate, as the balance between maize output and available soil stock becomes inadequate. These two factors are the main factors responsible for declining field maize yields.

Generally speaking, agriculture in Sub-Saharan Africa is characterized by low productivity due mainly to the decline in soil fertility and the difficulties encountered by farmers in responding to it (Kidinda *et al.*, 2015).

The Democratic Republic of Congo (DRC) is a country in the Sub-Saharan region where agriculture is the sector that employs more or less 70% of the population (INS, 2014), but food availability is characterized by a shortage for a large part of its population.

Maize is one of the main cereals grown in the DRC (Lumpungu *et al.*, 2019). Like most developing countries, maize remains the main staple diet for the population compared to other cereals such as millet and sorghum (Gichuru *et al.*, 2003; Guèye et *al.*, 2011) [46]. Consumed in many provinces of the country, its production and price have become real political issues in certain provinces as is the case in the Katanga and Kasai areas (Vanden, 1981). The diversity of environments in which maize is grown is greater than that of all other crops (Ripusudan *et al*., 2002).

Environment, Materials and Methods

2.1 Medium

This study was conducted in the Alibuku region, Bafwasende Territory, Tshopo Province, located north of the city of Kisangani, on the Kisangani, NGENO road axis, from 36km to 120km.

This area is inhabited by the population belonging to the Bali and Mbole tribes. These two tribes are widely scattered throughout this entity and very little is known about localities with more than 1000 inhabitants (Mulongo, 1995). The main activity of this population remains agriculture (Musasa, 1997).

2.2. Materials

We used two kinds of materials, biological and non-biological.

2.2.1. Biological materials

Pest insects and different crops (cassava, banana, rice, beans, etc.).

2.2.2. Non-biological materials

- Tape measure allowed us to delineate the experimental field and collect vegetative growth parameters;
- The nylon thread and stakes allowed us to demarcate the experimental plots;
- Machete allowed us to clear the land well;
- GPS allowed us to have the geographic coordinates
- The pen and notepad allowed us to record the data well;
- Plastic boxes allowed us to store insects well;
- 70° alcohol to preserve insects;
- Binocular microscope and cold light;
- Entomological needles;
- Motorcycle and bicycle helped us as a means of transportation.

2.3.1 Methods

This study was carried out in two phases to collect information relating to the objectives pursued in this research, namely:

- Installation of the three experimental fields in three sites chosen on the axis following the same experimental device considering as cultivation system, maize in pure culture, maize in binary association and maize in multiple association;
- Surveys or observations in farmers' fields in each site selected where we set up our experiments.

In our trial, after choosing the land on the Alibuku axis, we set up 3 experimental fields in 3 sites (villages) to carry out our study. We also chose 4 farmers' fields in 4 other sites still on the same axis in order to evaluate the attacks of *Z. variegatus* and armyworms.

2.3.1.1. Experimental device and treatments

The experimental design we adopted was that of randomized complete blocks comprising 3 treatments that were repeated three times. Figure 1 illustrates the experimental design of our study.

B I	T1	T3	T2
B II	T3	T2	T1
B III	T2	T1	T3

Fig 1: Experimental design

- **T** $_{1:}$ pure corn culture (yellow variety);
- **T** $_{2:}$ associated crops (corn and cassava) and
- **T** $_{3:}$ mixed farming (corn, cassava, banana and rice).

2.3.1. 2.Data collection in experimental fields

Our study was carried out over time from March to August 2023 in experimental maize fields including farmers' fields on the Alibuku axis from PK 36 to PK 70.

The insect inventory in the three fields that we installed ourselves.

The surveys were conducted in all fields, a total of 7 sites for data collection. Our observations focused on these 7 corn fields, assessing attacks by *Z.variegatus* and armyworms and finally quantifying the frequency of these two pests.

Pest diagnosis in the fields consisted of observing armyworm on maize plants. To achieve this, and in an effort to cover a large proportion of the experimental field, we used the "W" sampling method used by FAO (2017).

Each plot had an area of (5 mx 5 m). Observations focused on the plants in the plot, avoiding border plants which were not taken into consideration). After choosing and delimiting the plot, we proceeded to count all the plants in the plot using the W method developed by FAO (2017) by observing the plants showing damage and determining the attack rate in each plot.

Inventory of insects.

- The number of major insect pests in the field;
- The means of struggle used by peasants by survey.

II.3.5. Statistical analysis

Analysis of variance and Bonferroni post hoc test were performed to compare the number of insects attracted to these three cropping systems (pure maize; maize and cassava and multiple crops) using GraphPadPrism5 software at the 5% significance level.

III.4.1. Chemical control

The different means used against certain insects in the environment are as follows:

- To combat corn weevils, 70% of farmers store very dry grains in the warehouse, while 30% of those surveyed prefer to spread kitchen or wood ash in the field as a preventative means of control, limiting attacks by this insect from the field before storage;
- Regarding the white scale insect, 57% of farmers prohibit the opening of spathes before maturity and 43% spread ash on all young plants throughout the field;
- As for the green spider mite, there are also two local methods of control used for this purpose. Thirty-nine percent of respondents say they resort to spreading soil throughout the field on all young plants, and 61% say they remove the webs using a stick.

Mechanical control options involve managing and controlling pests using physical means such as hand-harvesting egg masses and larvae, crushing, or creating physical barriers. This includes weeding and modifying the microclimate (e.g., temperature) to control pests.

III.4.2. Mechanical control of CLA (A LIBUKU)

As for the caterpillar, no means of control are currently practiced because for them this caterpillar hides inside and they only notice the holes, therefore difficult to control. They cut the inflorescences to prevent the entry of moths. They use the following practices:

- Regular field visits (twice a week) to crush egg masses and larvae;
- Pour sand, sawdust or soil into the whorls to hinder the movement of the larvae;
- Pour water into the corn whorl to drown the larvae and
- Bafwasende farmers harvest grubs for food chicks for poultry production.

The CLA can be considered as a good complementary source of protein in countries where insects are consumed.

Mechanical and chemical control of Zonocerus varigatus and CLA: Farmers spread mud throughout the field to drive away the locusts. For the Alibuku axis, farmers use plant products extracted or derived from plants with insecticidal properties. Normally, a determined quantity of the product plant is picked, crushed and soaked in water for a few days.

The mixture is then filtered to remove the remaining plant debris and fibers. The solution can then be diluted with water or applied directly to the corn to act as a repellent against FAW. The options botanicals applicable for the management and control of fall armyworm can include:

- Mexican sunflower (Tithonia);
- Indian lilac;
- Acacia;
- Hot pepper (chili pepper);
- Onion;
- Tobacco;
- Wild sunflower;
- Lemongrass.

Example: For the use of Tobacco and Ash, Peasants use:

- 500 g of wood ash
- 4 tablespoons of tobacco
- 22 liters of water

III.4.5. Means control used by farmers within each site

The figure below shows the different means of control used by farmers in each site.

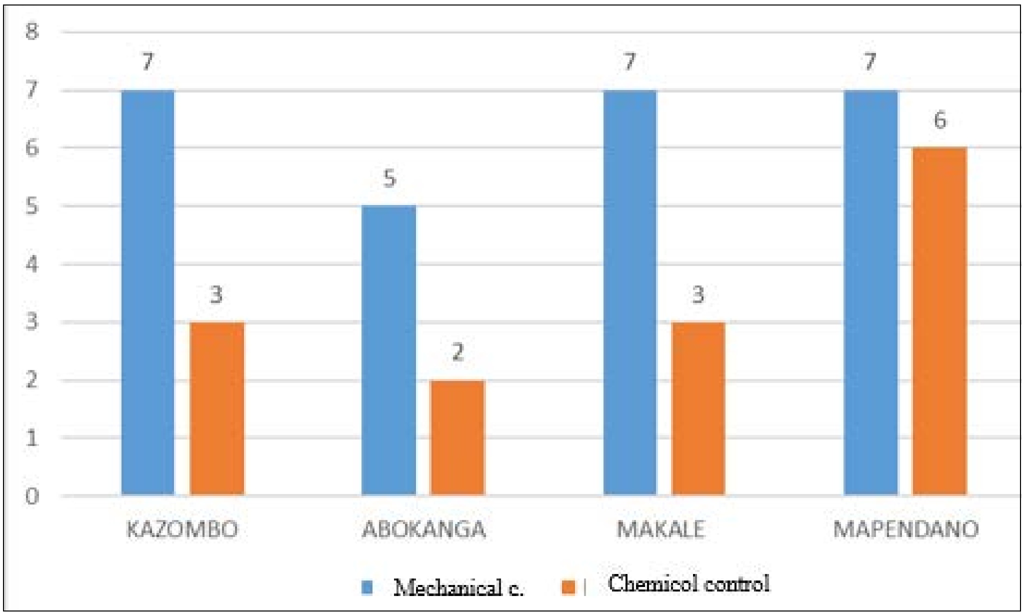

Fig 10: Means of control used by farmers

The results of this figure show that at the level of Kazombo out of 7 people surveyed, all practice mechanical control while 3 people do chemical control; and for the villages of Abokanga 5 people practice mechanical control and 2 people who carry out applications of chemical control; for Makale 7 people do mechanical control and 3 people who practice chemical control finally, in Mapendano 7 people who practice mechanical control and 6 people who do chemical control.

III.5.3. Means of control

The results of the present study confirm the presence of *Zonocerus variegatus and Spodoptera fruit-eater in the* Alibuku axis This same constant was made in other Provinces of the country for the association: corn-peanut, corn-rice (MINAGRI *et al*, 2018) moreover, the attack rate of the fall armyworm was lower compared to *Zonocerus variegatus.*

To combat maize pests, farmers in the study area use two methods: chemical and mechanical control. To combat maize weevils, 70% of farmers store their grains well dried in the warehouse, while 30% prefer to spread kitchen ash in the field as a preventative control method to limit attacks by this insect from the field before storage.

As for the white cochineal, 57% of farmers prohibit the opening of spathes before maturity and 43% spread ash on all young plants throughout the field. In addition, 39% of farmers resort to spreading earth throughout the field on all young plants and 61% who say they remove the webs using a stick to fight against the green spider. For mechanical control, farmers spread mud throughout the field to drive away the stinking grasshopper (*Zonocerus. varigatus)*, sometimes they cut the inflorescences to prevent the entry of moths.

Other authors have worked on ways to combat insect pests in crops in general and maize in particular. Reamackers (2001) worked on the control of insect pests adapted to regional problems and environmental conditions. He cited the chemical and mechanical means used in different farming environments. Dominique and Olivier (2000) reported on the mechanical and chemical control of insect pests in maize crops. These results show that there are varied and diversified means of controlling insect pests of maize in the farming environment. These means, although elementary, constitute a solution to these problems, according to them.

The results show that *Zonocerus varigatus* is the most important pest on maize crops in the study area with an average of 60.8±9.2 insects compared to only an average of 16.3±2.9 insects for *Spodoptera frigiperda*. This proves that for the moment, *Zonocerus. varigatus* represents the greatest threat, followed by the fall armyworm for the maize crop although there are other insects (grain weevil, white scale insect and green spider). The results also show that farmers use two methods of controlling insect pests. These are chemical and mechanical means.

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