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Research Paper

Effect of aqueous extracts of four local plants on the incidence and severity of the fall armyworm (*Spodoptera frugiperda* J. E. Smith) of maize (*Zea mays* L.) with a view to biological control in Gbadolite, Democratic Republic of Congo

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Abstract

The present study was initiated to compare the effects of 4 biopesticide plants on the incidence and severity of Fall armyworm (CLA), Spodoptera frugiperda, in the field at Gbadolite, DRC. The experimental set-up chosen for this study was that of a complete randomized block on a 28 m x 16 m plot divided into 3 blocks, each block having 5 plots. Leaf area was 11.7 cm²; 14 cm²; 13 cm²; 11 cm² and 11.6 cm² respectively for the control, Canabis indica, Ocimum sp, Chromolaena odorata and Schlorodophleus zenkeri. The level of severity was 5; 2; 2; 3; 3 respectively for the control subjects, Canabis indica, Ocinum gratissimum, Chromolaena odorata and Schlorophleus zenkeri. Incidence was 60%; 28%; 30%; 35.3% respectively for control subjects, Canabis indica, Ocinum sp & Chromolaena odorata and Schlorophleus zenkeri.Aqueous extracts reduced the incidence and severity of armyworm.

Key words: *extracts, aqueous, fall armyworm, maize, Gbadolite*

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I. Introduction

In the Democratic Republic of Congo, the pest *Spodoptera frugiperda* causes significant damage to maize crops and has a negative impact on agricultural production. Losses are estimated at 2.5 to 6.2 billion dollars per year in twelve African countries. The increasing and uncontrolled use of insecticides to control this pest, destroys biodiversity (natural enemies) and causes the appearance of resistant insect populations (FAO, 2018).

For human consumption in Mexico and South Africa, for example, figures can range from 50 to over 100kg/year/person of maize consumed.In the DRC, maize is the second most important food crop after cassava. It is widely grown, and national production has continued to increase despite climatic and social disruptions (Nyembo *et al.,* 2012).

In North Ubangi, maize is the second most important crop after cassava, and is used to combat food insecurity (WFP & FAO, 2019). Maize is grown for human and animal consumption, but also for numerous uses in the textile, pharmaceutical, biodegradable plastic and biofuel industries (Nyembo *et al.,* 2012).

Average national yields remain low (0.8 to 1 t/ha) compared with those of countries such as Italy (9.53 t/ha); Tahir *et al.,* 2009) and this is partly due to the low use of improved varieties and agricultural inputs (Useni *et al.,* 2014) and the extent of damage caused by various pests (Issa *et al.,* 2011).

This situation is a permanent source of food insecurity for around 9 million inhabitants (Nyembo, 2014), production of this crop is limited by several concepts including insects diseases and weeds that cause considerable damage in the order of 20 to 50 percent among small producers (FAO, 2016).

Since 2015, this pest has not been reported in any other part of the world apart from America.Identified for the first time in Central and West Africa in 2016, this insect is currently spreading across most of the African continent, with the exception of the Maghreb. Its presence has also been reported on the Asian continent. *Spodoptera frugiperda* attacks over 80 plant species, making it one of the most damaging crop pests (Prasanna *et al.,* 2018 ; Cokola, 2019).

This pest has a preference for maize, which is the main staple food for the population of Sub-Saharan Africa.It can also attack many other important crops including sorghum, wheat, sugarcane, cabbage, beet, groundnut, soybean, onion, pasture grasses, millet, tomato, potato, alfalfa, oats, bean, castor, sesame, melon, sunflower and cotton among others (Munene, 2019).

Losses caused by *Spodoptera frugiperda* range from 8.3 to 20.6 million tonnes of maize each year in the absence of effective control methods for the 12 largest maize producers in Africa (Day *et al*., 2017).

In the case of the Democratic Republic of Congo, losses on the maize crop can reach around 633,000 tonnes per year.For other crops under attack, notably vegetables, losses remain unknown (Cokola, op.cit).

Identifying the bio-aggressor is a vital element in decision-making in terms of management strategies (Cokola, op.cit). The paucity of information on this bio-aggressor in the agro-ecological environment of Gbadolite inspired us to design this study with a view to evaluating the effects of liquid extracts of four plants presumed to be botanical insecticides, namely: *Canabis indica*, *Ocimum gratissimum*, *Chromolaena odorata* and *Schlorophleus zenkeri*.

This study seeks to answer the following research question : are aqueous extracts of local plants capable of attenuating the severity of CLA incidence ?

The present study answers the following specific questions :

- Can the rainy period have a negative impact on the persistence of these aqueous extracts ?
- Can these aqueous extracts improve crop size ?

The main hypothesis of this study is to verify whether aqueous extracts of local plants would be able to mitigate the severity and incidence of CLA.

This study exploits the following specific hypotheses:

- The rainy period would have a negative impact on the persistence of aqueous extracts,
- Aqueous extracts from local plants would improve crop size.

The aim of the present study is to determine an effective, ecological and sustainable treatment formula against *Spodoptera frugiperda* in maize fields in Gbadolite.

The specific objectives pursued by the present study are :

- Determine the efficacy of *Canabis indica* extracts in the fight against CLA,
- Evaluate the efficacy *of Ocimum* gratissimum on CLA activity,
- Assess the effect of *Schlorodophleus zenkeri* aqueous principles on CLA infestation.

The work is limited to studying the effect of aqueous extracts on the incidence and severity of fall armyworms of maize in the agro-ecological region of Gbadolite, in the commune of Gbadolite, quartier Pangoma during the season from July 16, 2024 to August 16, i.e. 1 month.

II. Material and methods

Study site

The present study was conducted in Gbadolite, in the province of North Ubangi in the Democratic Republic of Congo, in the Pangoma district from July 16 to August 16, 2024, i.e. one month.

The town of Gbadolite is located in the north-west of the Democratic Republic of Congo, stretching from the Ubangi river basin to 25 km from the Central African Republic (CAR). The geographical coordinates of the experimental site using GPS were as follows: North Latitude : 4° 15′ 46.0674″; East Longitude : 20°59'14.59932″ East and Altitude: 403.1 m and with an accuracy of 3.32 m.

The town of Gbadolite is bounded :

- To the North : by the commune of Nganza, bounded by the Ubangi river,

- To the South : by the commune of Molegbe, bounded by the equatorial forest, the source of the Lowa river and the Sokoro river,
- To the east: through the commune of Nganza and the village of Nyaki, Mobayi-Mbongo territory, Sokoko river,
- To the west: through the commune of Molegbe, bounded by the Mbimbi river, the Bosobolo road and the Loba river on the Businga road.

The prevailing climate is tropical, with two seasons :

- The dry season: 4 months, from November 15 to March 15 and from June 15 to July 15 respectively,
- The rainy season: 8 months, from March 15 to June 15 and August 15 to November 15, the short and long rainy seasons respectively.

The soil is generally clayey-sandy. The vegetation was once characterized by an evergreen rainforest. However, this has been replaced by a grassy savannah dominated by *Imperata cylindrica, Penisetum purperum and Chromolaena odorata* (Molongo *et al.,* 2023; Molongo, 2024).

Material

The material used in this study consisted of samaru, an improved variety of maize, and aqueous extracts of the following plants : *Ocimum gratissimum, Chromolaena odorata, Schlorodephleus zenkeri and Canabis indica*.

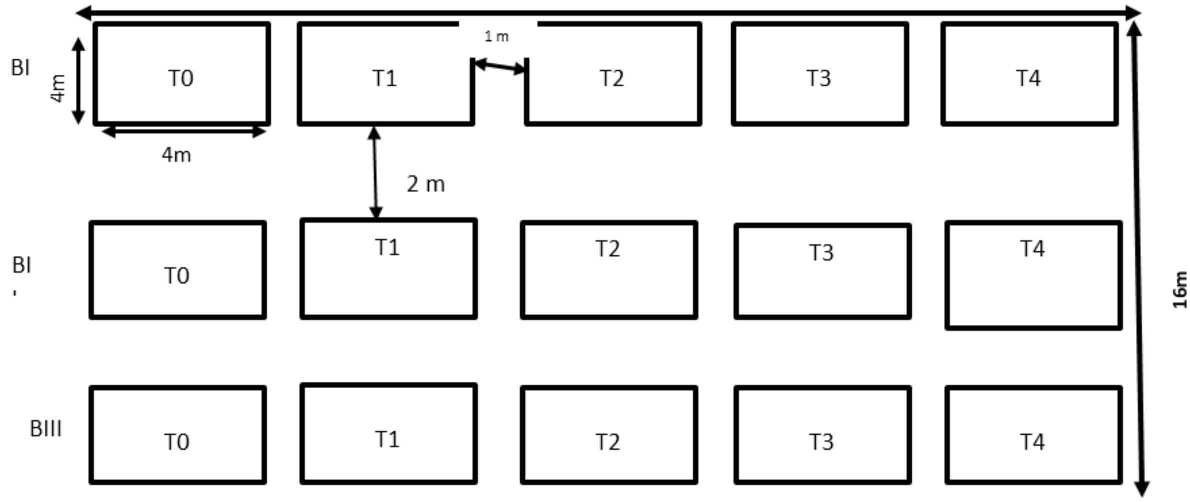
Severity, which is the level of pest damage on leaves, was assessed using the scale (CYMMIT, 2008; Prasanna et *al*., 2018) :

- Level 1 : no visible attack,
- Level 2 : few small holes on one or two older leaves,
- Level 3 : several perforation lesions on a few leaves and a small circular hole damaging the leaves,
- Level 4 : several perforation lesions on 6 to 8 leaves or small circular lesions,
- Level 5 : elongated lesions on 8 to 10 leaves and a few small and medium-sized irregularly-shaped holes on the upright and/or rolled leaves,
- Level 6 : several large elongated lesions on several whorls and or several large irregularly-shaped holes on whorled and rolled leaves,
- Level 7 : numerous elongated lesions of all sizes on several whorled and rolled leaves,
- Level 8 : numerous elongated lesions of all sizes on most whorled and rolled leaves, as well as numerous medium-sized and large holes,
- Level 9 : the whorled and rolled leaves are almost completely destroyed, and the plant dies as a result of the considerable damage.

Methods

The experimental set-up chosen for this study was that of a complete randomized block on a 28 m x 16 m plot divided into 3 blocks, each block having 5 plots. Each plot measured 4m x 4m, with a 2m inter-plot distance and a 2m inter-block distance with a 1m aisle separating the plots.

The figure 1 illustrates the experimental set-up.



Légende : T0 : Witness ; T1 : *Canabis indica* ; T2 : *Ocimum gratissimum* ; T3 : *Chromolaena odorata* ; T4 : *Schlorodophelus zenkeri*

Figure 1 : Experimental set-up

Observations

Observations were made on the following parameters:

– Emergence rate (TL%) $= \frac{\text{Number of emerged plants per plot}}{\text{Total number of plants per plot}}\ x\ 100$ using the following formula: (Molongo, 2024),

– Plant height using a tape measure,

– Leaf index or leaf length to width ratio,

– Pest severity using the CYMMIT (2008) and Prasanna et *al.* (2018) scale,

– Attack rate or incidence by the following ratio: IC (%) = $\frac{\text{Number of plants attaked per plot}}{\text{Total number of plants sown per plot}}\ x\ 100$ (Prasanna *et al.*, 2018).

III. Results

Recovery rate

The recovery rate is shown in Figure 2.

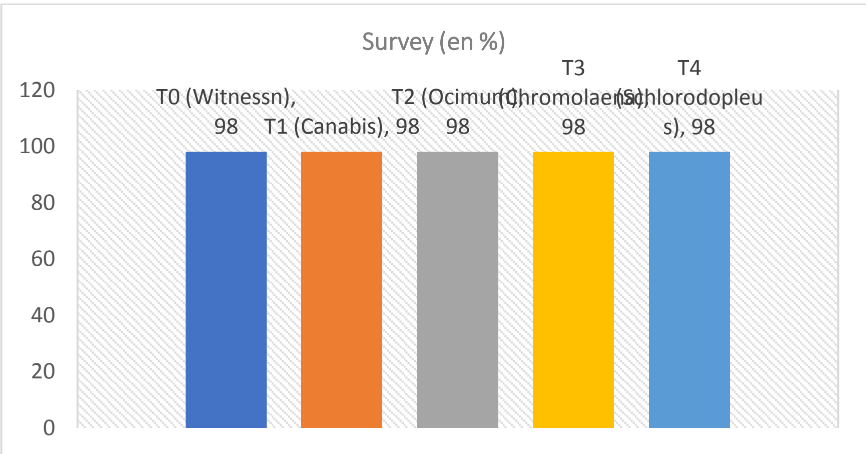


Figure 2 : Recovery rate (%)

The results in Figure 2 show that the recovery rates were 98% and 98.3% respectively for control subjects and subjects given aqueous extracts of *Canabis indica*, *Ocimum* sp, *Chromolaena odorata* and *Sclorophleus zenkeri*.

Plant height

Plant height is shown in figure 3.

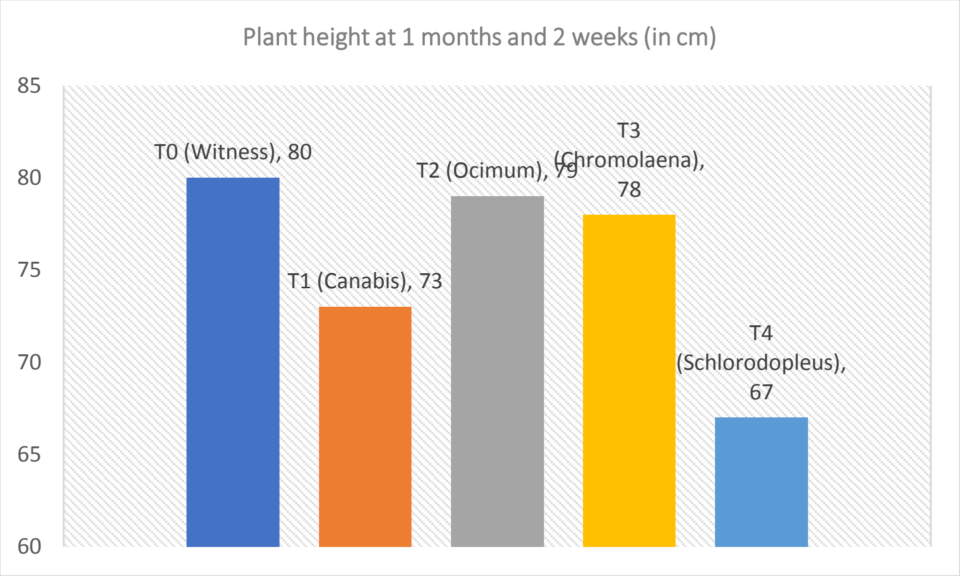


Figure 3 : Plant height (cm)

The results in Figure 3 show that plant heights were 80.3 cm, 73 cm, 79 cm, 77.6 cm and 67 cm respectively for the control, *Canabis indica*, *Ocinum gratissimum*, *Chromolaena odorata* and *Schlorophleus zenkeri* treatments. These results show that the control subjects developed a higher height.

Leaf area index

Leaf area is shown in figure 4.

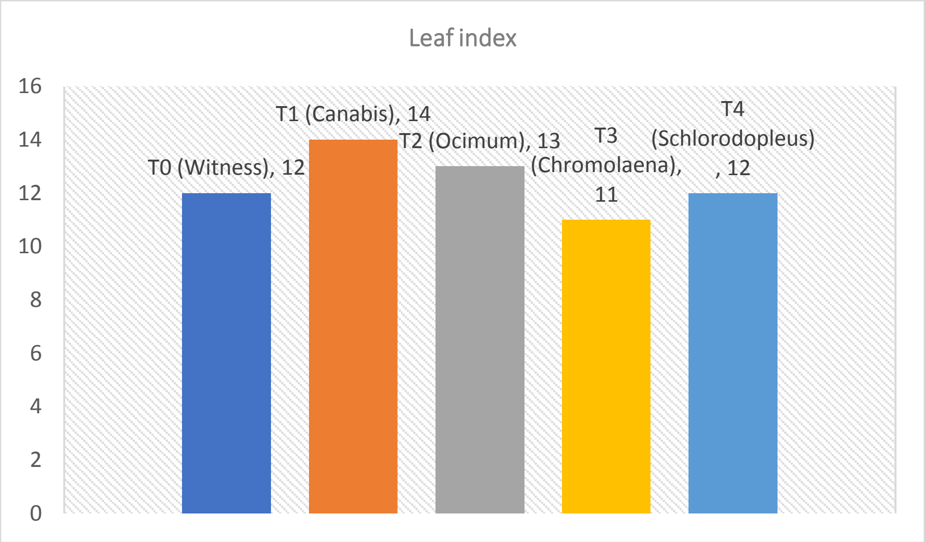


Figure 4 : Leaf area index

Figure 4 shows that the leaf area index was 11.7 ; 14 ; 13 ; 11 and 11.6 for the control, *Canabis indica*, *Ocimum gratissimum*, *Chromolaena odorata* and *Schlorodophleus zenkeri* respectively.

Incidence

Incidence is shown in figure 5.

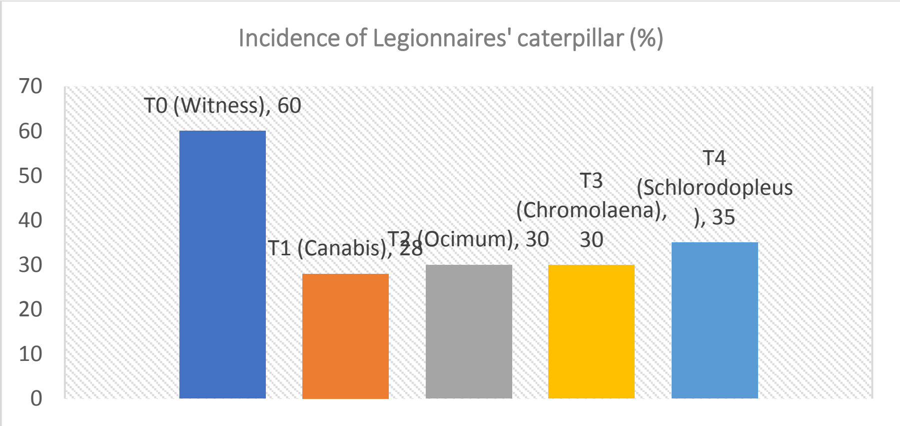


Figure 5 : Incidence (%)

Incidence was 60% ; 28% ; 30% ; 35.3% respectively for control subjects, *Canabis indica*, *Ocimum gratissimum & Chromolaena odorata* and *Schlorophleus*.Statistical analysis showed a significant difference. Tukey's test grouped the treatments as follows: control subjects had a higher percentage of the other treatments. This result shows that aqueous extracts are effective against armyworms.

Severity

Severity is shown in figure 6.

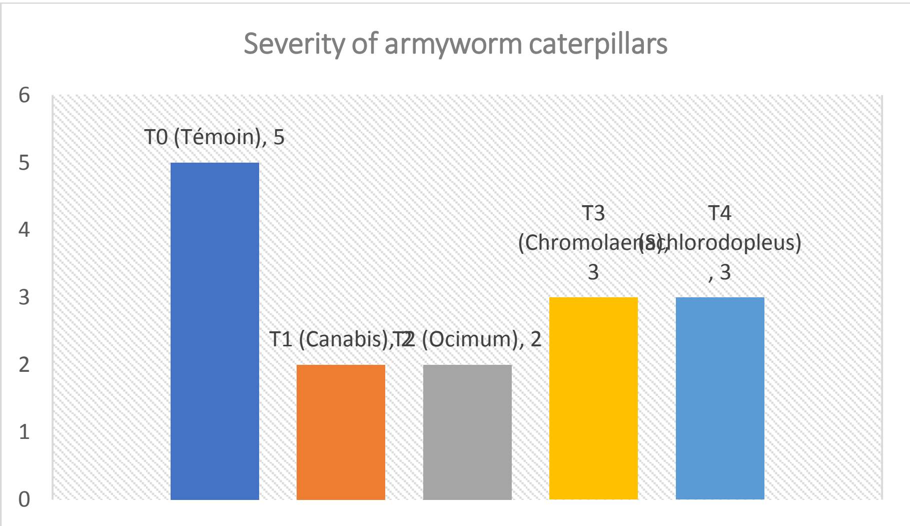


Figure 6 : Severity (%)

The level of severity was 5 ; 2 ; 2 ; 3 respectively for the control subjects, *Canabis indica*, *O. gratissimum*, *C. odorata* and *S. zenkeri*. Statistical analysis showed that there was a significant difference between treatments. The Tukey test grouped the treatments as follows: the control subjects were similar to the *S. zenkeri, C. odorata and O. gratissimum* treatments, but different from *Canabis indica*.

IV. Discussion

The results of this study were subjected to a single-criterion analysis of variance without sampling (ANOVA 1SE), using the F Fisher and Tukey tests.

The recovery rate varied at 100% for all treatments. These results are interesting in view of the fact that it will not be necessary to use an additional quantity of seed to replenish the gaps. According to Nyembo (2010), good climatic conditions, good seed quality, the use of a good cultivation technique and, above all, the absence of termites in the soil could have all contributed to this good recovery result.

The different heights obtained with the varieties under evaluation were almost similar except for the fourth treatment, which was below average Nyembo et al. (2012) indicate that this is a very important characteristic in the choice of varieties, as it has an influence on resistance to lodging: the higher the plant height, the more susceptible the plant is to lodging.

The results obtained showed that the influence of the genotype was more masked by that of the environment, given that the non-significant differences detected after the ANOVA. On the other hand, Dufumier (2004), adds that nitrogen contributes to the vegetative development of all the aerial parts of the plant.

Leaf area, according to Chausse et al. (2012), depends on the type of bud on the one hand, and on the apex on the other.This number remains standard on the other hand, for our result the leaf area has evolved in a symmetrical way, the results are close to close to the initial average.

This could be explained by the fact that leaf lobes evolve with plant age and height. The leaf area for our result is 11.7 for untreated plants (T0), 14 for *Canabis indica* treated plants (T1), 13 for*Ocimum gratissimum* sprayed plants (T2), 11.2 for *Chromolaena odorata* treated plants (T3) and 11.5 for *Schlorodephleus zenkeri* treated plants (T4).

According to Dufumier (2004), this could influence the drop in yield, as the leaves deteriorate and the leaf surface is reduced. The Kimwenza area and the climatic conditions of this environment are favorable to their proliferation, whereas in our study area, this condition is not very favorable due to certain climatic hazards.

The rate of leaf attack by these caterpillars in various treatments is not very high. Symptoms analyzed include leaf surface and chlorophyll photosynthesis curling. The alteration of the plant, the elaboration of carbohydrates by the plant (Chausse, 2012).

This deterioration represents a major risk of yield loss and a concern for plant growth. It is often a function of several factors, and varies according to variety, cultivation practices and health status.The results presented here unambiguously show that the degree of attack by chlorosis or stunting slows down the nutrition necessary for growth.

VI. Conclusion

The present study is to determine an effective, ecological and sustainable treatment formula against *Spodoptera frugiperda* in maize fields at Gbadolite.

It was found:

Leaf area was 11.7 ; 14 ; 13 ; 11 and 11.6 respectively for the control subject, *Canabis indica*, *Ocimum gratissimum*, *Chromolaena odorata* and *Schlorodophleus zenkeri* which confirms the second specific hypothesis.

- The level of severity was 5; 2; 2; 3 & 3 respectively for the control subjects, *Canabis indica*, *Ocinum gratissimum*, *Chromolaena odorata* and *Schlorophleus zenkeri*. This result confirms the main hypothesis that aqueous extracts attenuated the level of severity.
- The incidence was 60% ; 28% ; 30% ; 35.3 % respectively for control subjects, those treated with *Canabis indica*, *Ocinum gratissimum & Chromolaena odorata* and *Schlorophleus zenkeri*.

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