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Original Research Article

## Evaluation of the bio-insecticidal effect of geraniol on the larvae of *Spodoptera frugiperda*

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### Abstract

To offer corn growers a way to fight *Spodoptera frugiperda* while preserving their health and the environment, we have evaluated the effectiveness of the bio-insecticidal effects of geraniol on the larvae of *Spodoptera frugiperda* in the laboratory and in the open fields at the DPV of Dakar. In the laboratory, we noted a significant difference between the mortality of L3 larvae treated with the geraniol and control larvae treated with distilled water ( $P < 0.014$ ). On the other hand, there is no significant difference between the mortality of L5 larvae fed on leaves treated with bio-insecticidal and control L5 larvae after 24 hours and 72 hours of exposure. In the open field, the treatment had a significant effect on the corn infestation rate ( $F = 58.54$ ;  $P = 0.00$ ) and on the larval population ( $F = 98.00$ ;  $P < 0.0001$ ). Applications with the geraniol resulted in a 38.5% reduction in the infestation rate of *Spodoptera frugiperda* following both treatments.

**Keywords** *Spodoptera frugiperda*, Geraniol, Larvae

### Introduction

Maize, traditionally practiced in rainfed and declining in Senegal, is a crop introduced for the rotation of irrigated areas in 1970 following extensive research and development work and a sustained extension effort. Nowadays, it intends to become a new agro-industrial sector in its own right, in the same way as industrial tomatoes and rice (SAED, 2009). However, the entry of *Spodoptera frugiperda* into Africa in 2016 may be a limiting factor for the development of maize cultivation in Senegal. The fall armyworm (FAW) is a pest of the Lepidoptera family that feeds in large numbers on the leaves and stems of more than 80 plant species including corn (CABI, 2017). It attacks all stages of maize from seedling emergence to ear development (Njuguna et al., 2021). FAW is native to America and was first reported on the African continent in January 2016 (Goergen et al., 2016). Nowadays, studies have revealed that the pest is present in almost all of sub-Saharan Africa, where it causes considerable damage, especially in cornfields and to a lesser extent in sorghum and many other crops (Prasanna et al., 2018). Before the massive introduction of imported chemicals, Africans knew about the

means of control and especially the substances available in the mineral, plant, and animal worlds capable of effectively controlling the populations of harmful insects (Badji, 1998). This is why we have chosen to test the effectiveness of a biological insecticide on *Spodoptera frugiperda*, to offer corn growers a way to control this pest while protecting their health and the environment. The objective of this work is to evaluate the effectiveness of the bio-insecticidal effects of geraniol on the larvae of *Spodoptera frugiperda* in the laboratory and the field.

### Methodology

#### Study site

This study was carried out in the laboratory and the field at the Directorate of Plant Protection (DPV) of Dakar from August to November 2019.

## Bio laboratory tests

Larvae of *Spodoptera frugiperda* were obtained from a colony maintained in culture at the DPV entomology laboratory, which was originally collected and identified on maize plants. Laboratory bioassays consisted of evaluating the toxicity of geraniol by contact and ingestion on two larval stages of *Spodoptera frugiperda* (L3 and L5). The method used is that of soaking the leaves.

## Breeding of *Spodoptera frugiperda* larvae

The rearing of larvae is carried out as follows

### From egg to third larval instar

*Spodoptera frugiperda* eggs collected from a corn field are placed at the bottom of a Petri dish (type A dishes Fig.1) in which leaves of a corn plant cut into small pieces are placed. After hatching, the contents of the Petri dishes are transferred to type B dishes (Fig. 2) until the larvae reach the third instar.



Fig. 1 Type-A dishes



Fig. 2 Type B dishes

### From the third to the last larval instar

The cannibalism being more marked from the fourth to the last larval instar, the caterpillars are transferred individually using a flexible clamp from the third instar, into type C (Fig. 3) boxes previously covered with corn leaves cut into small pieces for individual breeding of these larvae.



Fig. 3 Type C dishes

## Conduct of Bioassays

The test was conducted as follows:

a) Preparation of the corn husks: this step consisted of washing the leaves in sodium hypochlorite solution, then rinsing them in distilled water;

b) Preparation of solutions for treatment: this step consisted of diluting the insecticide in distilled water

c) Soaking the leaves in a solution of 250 ml of geraniol solution for 10 seconds

d) Removing excess water from the leaves with blotting paper

e) Introduction of leaves into breeding boxes

f) Introduction of the larvae into the boxes

## Monitoring of bioassays

The test was performed in the laboratory under controlled conditions with a temperature of  $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ , relative humidity of  $70 \pm 10\%$ . The condition of the larvae and the mortality were recorded 24 and 72 hours after their introduction into the breeding boxes.

The mortality rate is calculated by the following formula:

$$\text{MT} = \text{Number of Dead larvae} / \text{Total number of larvae} \times 100$$

## Field trials

### Experimental apparatus

The experimental setup is how the experimental units are arranged in the field of experimentation (Bal, 2006). Thus, we carried out a test according to an experimental set-up which includes 4 repetitions or independent blocks separated by 2 m. Each block consists of two elementary plots, one of which is treated and the other untreated (control plot) which are 1 m apart. The experimental study is carried out during the period from August to November 2019, on sandy clay soil.

### Characteristics of elementary plots

Number of blocks: 4

Number of plots: 8

Distance between plots: 1 m;

Surface area of each plot:  $5\text{m} \times 4\text{m} = 20\text{m}^2$

Number of lines per plot: 10

Number of pockets per line: 20

Number of grains per pocket: 2

Number of plants per plot: 200

Spacing: 60cm x 25cm

## Culture management

The chronology of the following cultivation operations was respected: The installation of the trials is preceded by the preparation of the soil. In the open fields, the land was cleared beforehand by removing weeds and other plants that could harbor pests. Then a cross off set which is a type of plowing has turned the soil over and burying the plant debris that can be used as green manure. Compost has been used as organic manure while mineral manure consists of urea. The

various fertilizers were spread manually and in a localized manner, according to the spots. We performed a Pre-irrigation before sowing.



Fig. 4 Experimental plot

**Assessment of *Spodoptera frugiperda* populations before treatments and evaluation of the effectiveness of insecticide treatments**

The density of the *Spodoptera frugiperda* population was measured before treatment by counting the larvae on 13 plants per elementary plot.

The damage assessment on maize plants was performed by counting healthy plants and plants damaged by *Spodoptera frugiperda* on a 5% sample of maize plants for each elementary plot.

Treatments were applied using a hand sprayer. One insecticide rate was applied twice during the corn cycle at 7-day intervals in a water volume of 500 L of water per hectare.

**Statistical analysis**

Before treatment, the level of infestation of the plots by *Spodoptera frugiperda* larvae was evaluated using an ANOVA with two classification criteria, namely treated plots and untreated plots. The efficacy of the geraniol solution used to control the fall armyworm was evaluated in the field by analyzing the effect of each treatment on the rate of corn infestation caused by the larvae of the pest.

**Results**

**Bio laboratory test**

There is a significant difference between the mortality of L3 larvae treated with the geraniol- solution and control larvae treated with distilled water ( $P < 0.014$ ). On the other hand, there is no significant difference between the mortality of L5 larvae fed with leaves treated with bio-insecticide and control L5 larvae after 24 hours and 72 hours of exposure. The

mortality rate of larvae exposed to the bio-insecticide changes over time (Fig.5 and 6). Whatever the larval stage, the highest mortality rate is obtained after 72 hours of exposure.

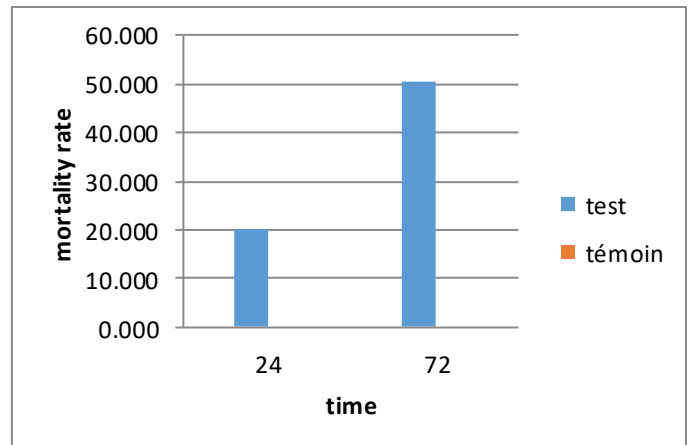


Fig. 5 Mortality of L3 larvae as a function of time

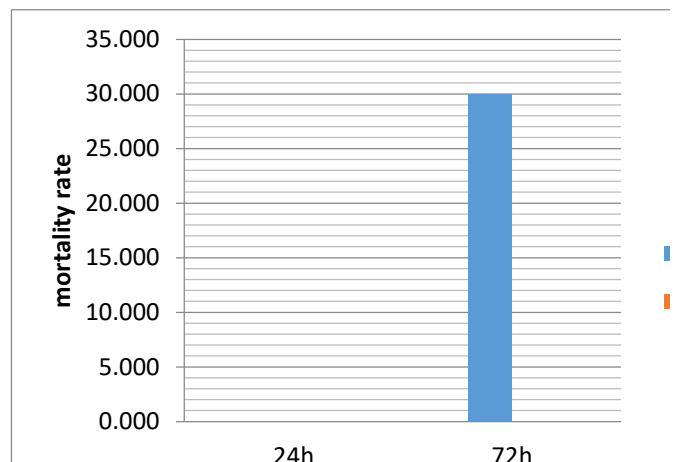


Fig. 6 Mortality of L5 larvae as a function of time

**Field trials**

The stage of phenological development of the corn plants during the first application of the bio-insecticide is that of 6 to 8 leaves. This first application of the bio-insecticides was therefore carried out at the phenological development stage when the maize plants are very vulnerable to attacks by *Spodoptera frugiperda* larvae (Malausa and Marival, 1981).

The rains that fell 3 days after the first application of the bio-insecticide may have influenced the effectiveness of the treatment.

**Evaluation of the populations of *Spodoptera frugiperda* before treatment and evaluation of the effectiveness of the bio-insecticide treatment**

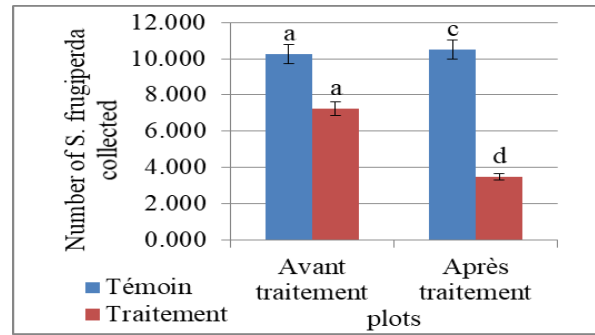
Before treatment, no significant difference was observed in the mean number of *Spodoptera frugiperda* larvae collected between the plots used as absolute control and those used for treatment ( $F = 4.59$ ;  $P = 0.07$ ).

The infestation rate before treatment for the control plots is 51.30% and that for the plots used for treatment is 42.34%. There is therefore no significant difference between the number of plants attacked by the larvae of *Spodoptera frugiperda* for the control plots and those planned for the treatment ( $F = 3.64$ ;  $P = 0.10$ ).

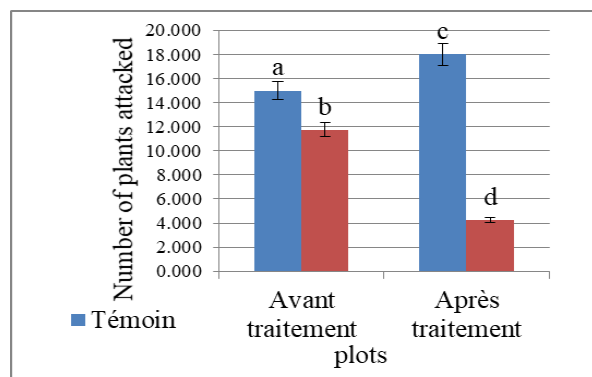
**Evaluation of the effectiveness of insecticide treatments**

The treatment had a significant effect on the corn infestation rate ( $F = 58.54$ ;  $P = 0.00$ ) and on the larval population ( $F = 98.00$ ;  $P < 0.0001$ ) (Fig.5 and 6). The infestations of *Spodoptera frugiperda* were very low on the treated plots compared to the untreated plots (control plots). Applications with the geraniol product resulted in a 38.5% reduction in the infestation rate of maize by *Spodoptera frugiperda* larvae following both treatments.

after 72 hours) was much higher than that observed in fifth instar (L5) larvae (50% mortality after 72 hours).



**Fig. 8 Number of *S. frugiperda* larvae collected before and after treatment**



**Fig. 7 Number of plants attacked by *S. frugiperda* before and after treatment**

The analysis of variance carried out on the level of infestations of the caterpillars revealed a very highly significant difference ( $P < 0.001$ ). The structuring of the means shows that the treatment was significantly different from the absolute control (Untreated) at the 5% level.

**Discussion**

**Bio laboratory test**

The results of laboratory tests demonstrate the effectiveness of the bio-insecticidal effect of geraniol to fight against the larvae of *Spodoptera frugiperda*. Almost 20% of third instar larvae placed on maize leaves treated with geraniol solution died after only 24 hours of exposure. The highest mortality rate of L3 larvae is recorded 72 hours after exposure of the larvae. Indeed, a rate of 50.6% of dead third instar larvae was recorded. This can be explained by the fact that the larvae, after ingestion of the product during the first hours of exposure, stop feeding and mortality occurs a few days later. This is the case of fifth instar larvae, of which the total mortality, which is 50% of exposed larvae, occurred 72 hours after exposure. The effectiveness of the bio-insecticidal effects of geraniol is therefore influenced by the age of the larvae. The mortality of young third instar (L3) larvae (80%

**Field test**

The analysis of variance carried out on the level of infestations of the caterpillars revealed a very highly significant difference ( $P < 0.001$ ). In general, the results of the field tests corroborate those of the laboratory tests. Treatment of the geraniol product on *Spodoptera frugiperda* larvae had a significant effect on the infestation rate of maize and the larval population. However, it should be noted that the effectiveness of field treatment may be limited by the feeding behavior of the larvae. Indeed, the larvae of *Spodoptera frugiperda* eat by sinking into the crown of the corn plant, which makes it difficult to reach them during treatment (Burtet et al., 2017). Geraniol is naturally present in many fruits, vegetables, spices, and essential oils. In addition to its pleasant smell, geraniol is known for its insecticidal and repellent properties and is used as a natural pest control agent with moderate toxicity (Chen et al, 2010). It has already shown its effectiveness as a repellent against ticks and mosquito or sandfly bites. The toxicity of geraniol against *Dermanyssus gallinae* has been proven in the laboratory with a mortality of 100% following a 24 hours exposure with a concentration of 0.5; 1 and 2% (corresponding approximately to concentrations of 0.02, 0.04 and 0.07 mg / cm<sup>2</sup>) (George, 2006).

Geraniol in aqueous solution acts on insects in two ways, regardless of the stage of metamorphosis (egg, larva, adult): by suffocation and by dehydration by acting on chitin (Penntybio, 2019). Geraniol could therefore constitute an alternative to chemical molecules in certain conventional treatments. Indeed, chemical molecules cause the significant accumulation of active materials in treated ecosystems as well as resistance problems in treated insects, unlike plant extracts which are biodegradable and fertilizing (Barbouche et al., 2001; Faye, 2010; Sinegre et al.,1977).

**Conclusion**

These results testify to the good larvicidal activity of the geraniol on the larvae of *Spodoptera frugiperda*. The results obtained show that there is a significant difference between

the mortality of L3 larvae treated with the geraniol solution and control larvae treated with distilled water ( $P < 0.014$ ). The treatment also had a significant effect on the corn infestation rate ( $F = 58.54$ ;  $P = 0.00$ ) and on the larval population ( $F = 98.00$ ;  $P < 0.0001$ ). Geraniol is therefore a promising bio-insecticide to fight against the larvae of *Spodoptera frugiperda*. However, it would be interesting to assess the impact of geraniol on the auxiliary entomofauna associated with *Spodoptera frugiperda* on maize.

### Conflict of Interest

The author hereby declares no conflict of interest.

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