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Research Article

Evaluation of the Bio-Insecticidal Effect of *Ricinus communis* (Malpighiales: Euphorbiaceae) on the Larvae of *Spodoptera frugiperda* (J. E. Smith, 1797) (Lepidoptera: Noctuidae)

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ABSTRACT

Since chemical insecticides favor the emergence of resistance and have disastrous consequences for the environment, we became interested in an alternative control method against Spodoptera frugiperda, more respectful for the environment. We therefore evaluated the effectiveness of the bio-insecticidal effects of plants extracts and oil of castor against the fall armyworm in the laboratory. The laboratory bioassays consisted of evaluating the toxicity of the castor plants extracts and oil by contact and ingestion on fourth instar larvae of Spodoptera frugiperda using a leaf dipping method. It emerges from this study that the mortality of the larvae treated with the bio-insecticide and the control solution varies significantly and that the mortality rate was 100% for dose 1; 85% for dose 2 and 70% for dose 3. The mortality rate for the control solution is 10%. These results testify to the good larvicidal activity of the organic insecticide based on oil, leaves and unripe seeds of castor bean on the fall armyworm.

Keywords: *Spodoptera frugiperda; Bio insecticide; Ricinus communis; Larvae.*

INTRODUCTION

Spodoptera frugiperda (J. E. Smith, 1797) (Lepidoptera: Noctuidae) also called fall armyworm is a pest native to the tropics and subtropics of the Americas (Prasanna et al., 2018). It first appeared in Africa in January 2016 where it causes considerable damage, especially in maize fields and to a lesser extent in sorghum and other crops (Goergen et al., 2016).

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It prefers maize but can feed on more than 80 plant species (FAO, 2017). According to the Center for Agriculture and Bioscience International (CABI), in the absence of adequate control methods, the fall armyworm can cause yield losses of 8.3 to 20.6 million tonnes per year, in just 12 of the African maize producing countries. In the conventional system, the control of this pest is most often carried out by chemical insecticides (LIMA et al., 2010). However, many of these insecticides are toxic to the natural enemies of *Spodoptera frugiperda* and other non-target insects, promote the development of resistance phenomena and have disastrous consequences for the environment (Silva et al., 2011). It is therefore important to find an alternative approach to the use of synthetic pesticides for the management of populations of this pest. Botanical insecticides have been shown to be effective against many crop pests in Africa (Tounou et al., 2011; Agboka et al., 2009; Faye, 2010; SANE et al., 2018; & Tamgno et al., 2014). Plant extracts with an insecticidal effect can therefore constitute an alternative means of control that respects the environment. Indeed, plant extracts are biodegradable and fertilizing (Faye, 2010). Thus, it seemed interesting to direct the present study on plant extracts including that of castor oil. Castor is a plant that grows in many agricultural ecosystems in Senegal. Bio insecticides based on plant extracts and castor oil emulsion have been shown to be effective against insects such as *Plutella xylostella* (Lepidoptera: Plutellidae) and on culicid mosquitoes (Tounou et al., 2011; & Aouinty et al., 2006). The objective of this work is to evaluate the insecticidal activity of extracts of leaves, unripe seed and castor oil emulsion on larvae of *Spodoptera frugiperda* under laboratory conditions.

MATERIALS AND METHODS

2.1. Plant material

The larvae are fed with corn leaves from our experimental perimeter located at the Plant Protection Directorate (DPV) of Dakar.

Castor leaves and seeds were collected from castor bean plants growing around the DPV. The oil was extracted cold in a specialized facility called Biosen.

2.2. Choice of larvae

The larvae of *Spodoptera frugiperda* are obtained from a colony maintained in culture in the entomology laboratory of the DPV, which was collected and originally identified on maize plants. The larvae were fed a natural diet consisting of corn husks. Toxicity tests were performed on fourth instar larvae.

2.3. Preparation of aqueous extracts

The fresh leaves and green fruits of Ricinus communis are harvested and then washed with distilled water. Then the leaves are crushed, and the seeds crushed. 110g of crushed leaves and 180g of crushed green fruits are mixed with 125 ml of R. communis oil. The whole (leaves, fruits and oil) is diluted in 1 liter of water previously brought to the boil, then cooled. The mixture is then stirred well, covered and left to stand for 10 days then filtered. The solution obtained (Dose 1) is diluted twice in order to obtain two other solutions (Dose 2 and Dose 3):

- A solution with 50% of dose 1 and 50% distilled water;
- And a solution with 25% of dose 1 and 75% distilled water.

These 3 solutions (dose 1, dose 2 and Dose 3) were used for the treatment of larvae. As a control solution we used distilled water.

2.4. Toxicity tests

The laboratory bioassays consisted of evaluating the toxicity bio-insecticidal effects of plants extracts and oil of castor by contact and ingestion on fourth instar larvae of *Spodoptera frugiperda* using a leaf dipping method similar to that of Deland et al. (2014). The maize leaves are first rinsed with distilled water, then soaked in a solution of 150 ml of bio-insecticide for each of the three doses and placed in individual larval rearing boxes.

For the control solution, the corn husks are soaked in 150 ml of distilled water. After the leaves are soaked, excess water (or solution) is removed by placing the leaves for 5 minutes on blotting paper. One larva of Spodoptera frugiperda is introduced per breeding box. Larval mortalities are recorded every 24 hours.

The mortality rate is calculated by the following formula:

MT = Number of Dead larvae / Total number of larvae × 100

2.5. Analysis of the results

Analysis of the results is performed by R software for testing the normality and independence of the data (Shapiro & Wilk, 1965); for checking the equality or homogeneity of variances (Bartlett test) and for structuring the means of larval mortality according to the different doses used for the treatment of larvae.

XLSTAT 2019 software was used to determine larval mortality as a function of doses and the evolution of mortality as a function of time.

RESULTS

Analysis of the results by ANOVA shows that there is a significant difference in the mortality of larvae treated with the 3 doses of the bio-insecticidal of plants extracts and oil of castor and distilled water ($F = 3.875$; $P < 0.0103$). The mean structuring test yielded 3 statistically different dose groups (Figure 21). At the end of the experiment, the mortality of the larvae treated with the bio-insecticide was 100% for solution 1; 85% for solution 2 and 70% for solution 3 (figure 1). The mortality of the control larvae is very low (10%) in comparison with the treated larvae. The last mortalities occurred 9 days after the start of the experiment for dose 1 and 11 days for doses 2 and 3 (Figure 2).

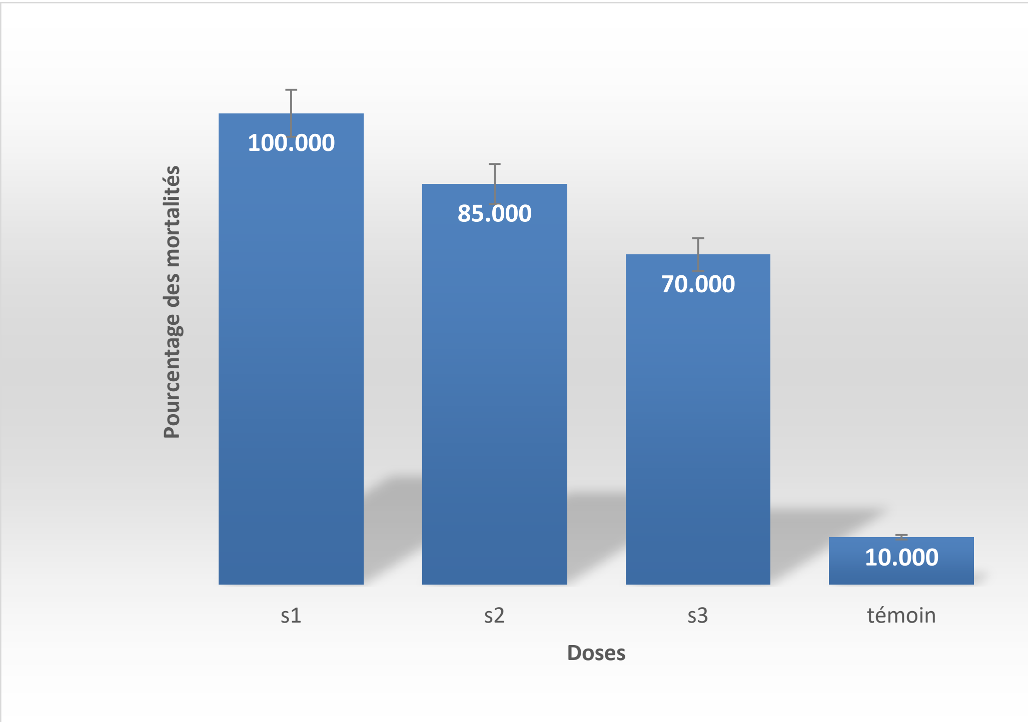

Figure 1: Mortality of larvae according to dose

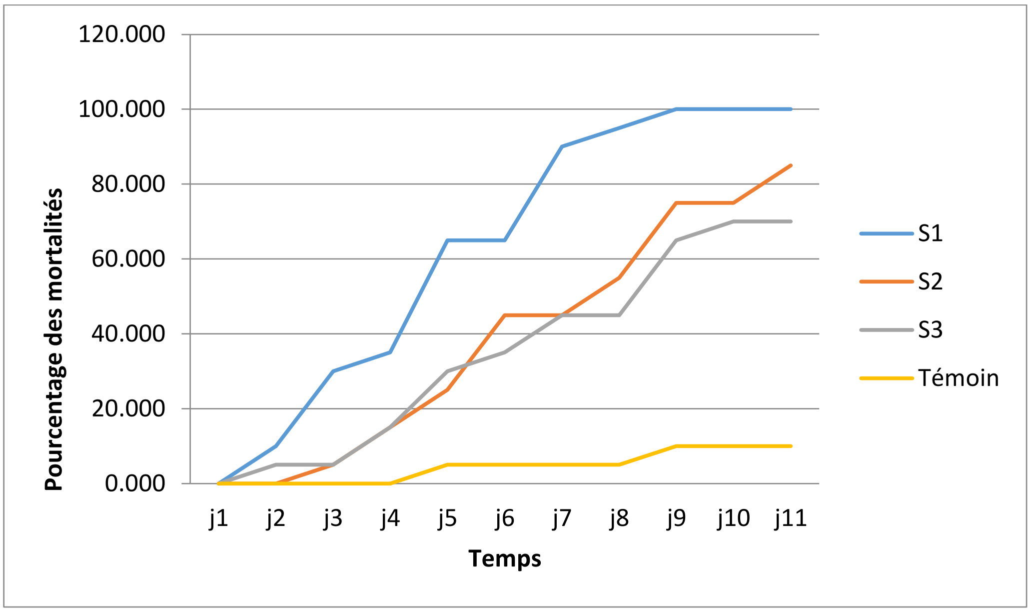

Figure 2: Evolution of mortalities over time

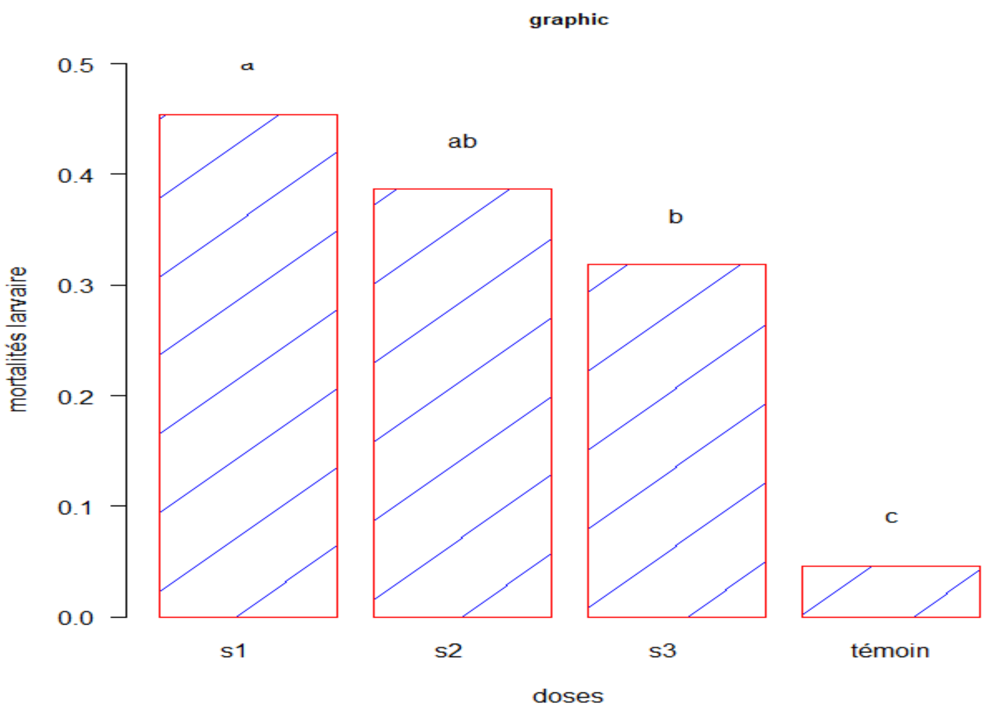

Figure 3: Structuring of the larval mortality averages as a function of the different doses used for the treatment of the larvae

DISCUSSION

The results of the present study show that the bioinsecticide based on oil, immature seeds and castor leaves can be very toxic to the larvae of *Spodoptera frugiperda* by contact and ingestion. The larvicidal effect of castor oil has been demonstrated by numerous authors (Ramos-López et al., 2010; Tounou et al., 2011; & Aouinty et al., 2006). In addition to its larvicidal effect, castor oil can act as a growth inhibitor (Ramos-López et al., 2010). This may explain the relatively long time (see figure 22) that the larvae take before dying. In fact, after ingestion of the treated leaves, the larvae almost stop feeding and if we add to this the inhibitory effect of the castor oil plant, this may be the cause of the relatively long time it takes for the larvae to die. The plant, the castor bean, is a shrub native to Africa and Asia, and is now found in temperate and subtropical regions (Spivak et al., 2005). The toxicity of the castor plant is linked to ricin, a water-soluble toxin naturally produced mainly by seeds (Winder, 2008). The seeds are therefore the primary source of castor oil toxicity, but other parts of the plant such as the leaves are also toxic ((Tounou et al., 2011); (Aouinty et al., 2006); (Tokarnia et al., 2012). Ricin is a type II ribosome-inactivating protein that consists of two polypeptide chains linked by a disulfide bridge that must be linked to cause toxicity (Spivak et al., 2005). The A chain contains toxic substances because it prevents the synthesis of proteins in the recipient organism, and the B chain has the ability to fix the toxin on the cell walls of the same recipient organism. Through this process, ricin therefore causes cell death (Élie, 2004); (Parikh et al., 2000). Based on recent studies, we can say that castor-based bioinsecticide is a potent larvicide. Thus, Tounou et al. (2011) were able to obtain a 100% mortality by contact and ingestion of third instar *Plutella xylostella* larvae of castor oil emulsion and 67.49 and 70.86% still by contact and ingestion of aqueous extracts of the castor plant. Moreover, Aouinty et al. (2006) have shown that castor oil is more effective on the youngest larval stages of Culicidae mosquitoes. In conclusion, we can say that these results testify to a good larvicidal activity of the bio-insecticidal of plants extracts and oil of castor.

CONCLUSION

These results testify to the good larvicidal activity of the bio-insecticide based on leaves, immature seeds and castor oil on the larvae of Spodoptera frugiperda. Analysis of the results obtained shows that there is a significant difference between the mortality of larvae fed with leaves treated with bio-insecticide and those fed with leaves treated with the control solution. The best results were obtained with dose 1 with a mortality rate of 100% followed by dose 2 (85%) and dose 3 (70%). Castor is therefore a promising bio-insecticide to fight against the larvae of *Spodoptera frugiperda*. However, it would be interesting to see its effects on larvae of younger larval stages.

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