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USO DA MANIPUEIRA NO MANEJO DA LAGARTA-DO-CARTUCHO REMANESCENTE DO MILHO TRANSGÊNICO

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RESUMO: A *Spodoptera frugiperda*, conhecida como lagarta-do-cartucho, é uma praga prejudicial ao milho no Brasil, sem nenhum método de controle, os danos podem resultar em até 35% de perdas na produtividade. Seu controle é desafiador, pois provoca danos desde a fase inicial até a reprodutiva da planta. O uso de inseticidas e transgênicos apresenta desafios, como a resistência da praga aos produtos aplicados e à tecnologia transgênica. O objetivo foi analisar o comportamento da *Spodoptera frugiperda* sob diferentes doses de manipueira (0%, 25%, 50%, 75% e 100%). As lagartas de diferentes fases eram coletadas em diferentes datas em um milharal no perímetro irrigado em Canindé de São Francisco, Sergipe, levadas para o laboratório de Fitossanidade do IFAL - *Campus* Piranhas, onde ocorria a aplicação dos tratamentos. Os dados foram submetidos à análise de variância e regressão logística e também polinomial. A maior mortalidade da praga ocorreu para a dose de 75% do resíduo (73% de mortes). Portanto, a manipueira mostrou-se eficiente como ferramenta no manejo da *S. frugiperda.*

Palavras-chaves: Bioinseticida, *Spodoptera frugiperda*, controle.

USE OF MANIPUEIRA IN THE MANAGEMENT OF ARMYWORM REMAINING FROM TRANSGENIC CORN

ABSTRACT: *Spodoptera frugiperda*, known as fall armyworm, is a pest that is harmful to corn in Brazil; without any control method, damage can result in up to 35% productivity losses. Its control is challenging, as it causes damage from the initial to the reproductive phase of the plant. The use of insecticides and transgenics presents challenges, such as the resistance of the pest to the products applied and to transgenic technology. The objective of this study was to analyze the behavior of *Spodoptera frugiperda* under different doses of cassava (0%, 25%, 50%, 75% and 100%). The caterpillars of different phases were collected on different dates in a cornfield in the irrigated perimeter in Canindé de São Francisco, Sergipe, taken to the Plant Health Laboratory of IFAL - Piranhas Campus, where the treatments were applied. The data were subjected to analysis of variance, logistic regression and polynomials. The highest mortality of the pest occurred at a dose of 75% residue (73% of deaths). Therefore, manipulators have proven to be efficient tools in the management of *S. frugiperda.*

Keywords: Bioinsecticide, *Spodoptera frugiperda*, control.

1 INTRODUCTION

Spodoptera frugiperda, popularly known as fall armyworm or armyworm, is the main pest of corn (*Zea mays* L.) and is highly important for pest management in Brazil, whether during the first or second harvest (Oliveira *et al.* 2023). The newly hatched caterpillars scrape the leaves without piercing the epidermis on the underside, causing the

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appearance of scraping symptoms, and then, these caterpillars lodge in the plant cartridge (Wordell Filho *et al*., 2016) but can also attack corn from seedlings after emergence to the grains of the cob in formation (Toscano *et al., 2010). Spodoptera frugiperda* pests are present throughout the year, causing damage to food crops and, as a consequence, economic losses (Paredas-Sánchez *et al*., 2021). Without any control method, damage can result in up to 35% losses in productivity (Spatt; Sturza; Dequech, 2011).

Manipueira is a yellowish liquid residue extracted from cassava (Manihot esculenta) to obtain flour or starch (Duarte *et al*., 2012). Manipueira contains a toxic cyanogenic glycoside called linamarin, from which hydrocyanic acid (HCN), which is highly volatile, is produced (Gonzaga *et al*., 2007). In nature, there are two types of cassava: the bitter type, which is used in the production of flour and has high concentrations of hydrocyanic acid (HCN) (above 100 mg HCN/kg fresh root without peel) (Chisté; Cohen, 2008). The sweet type, also known as cassava or macaxeira, has low concentrations of HCN (less than 50 mg HCN/kg fresh root without peel). (Chisté; Cohen, 2008)). Manipira is a toxic waste and can pose environmental risks if it is discarded "in natura" in the environment (Cereda, 2001). According to Costa *et al*. (2022), manipueira has shown promise as a nematicide, insecticide and fungicide because of the cyanogenic glycosides and free cyanide present.

Bacillus thuringiensis (Bt) is a gram-positive bacterium that can be characterized by its ability to form protein crystals during the stationary and/or sporulation phase (Carniro *et al*., 2009), which has recently lost its effectiveness cycle after the cycle of cultivation, in which the caterpillar has become resistant to the technology in question, which can develop and reproduce in the location, promoting considerable attacks. The first case of insect resistance to the Bt protein was reported in 1985 (Macgaughey, 1895). Insect resistance to insecticide toxins is a preadaptive issue, and the assessment of its potential risk of evolution requires knowledge of the inheritance pattern of this characteristic (Horta *et al*., 2017). Cassava can be used as an alternative for the control of *Spodoptera frugiperda* (Silva; Souza; Oliveira, 2018) since it has insecticidal properties. In this sense, the objective was to test the effects of doses of cassava on the fall armyworm and observe its mortality.

2 MATERIALS AND METHODS

The caterpillars were collected from a plot in the California Irrigated Perimeter in the municipality of Canindé de São Francisco, Sergipe, in November, December 2023 and March 2024 and were then taken to the phytosanitary laboratory at IFAL-Campus Piranhas, where they were subjected to treatments.

The cassava starch was collected from a flour mill and stored in PET bottles (covered with aluminum foil to prevent oxidation of the residue). The byproduct was kept at a temperature of 18 °C in a conventional refrigerator and prepared by diluting the residue to different concentrations: 0% (water), 25%, 50%, 75% and 100% in 1.0 L of water. The pH of the raw cassava starch was 6.01, and its electrical conductivity was 5.442 ms/cm¬-1.

The first batch of corn where the caterpillars were collected was the hybrid “KWS 7510 vip 3” and “BM 3066 pro 2”, and in the second batch, the corn variety was “Feroz” 4 rows and “7510 kws vip 3” 2 rows. Five collections were carried out on the following dates: 11/01/2023, 11/16/2023, 12/08/2023, 12/07/2023 and 03/07/2024, and the following day, they were exposed to the treatments. Entomological tweezers were used to collect the larvae, which were then stored in transparent pots with perforated lids. To feed the caterpillars in the laboratory, green corn grains and corn straw were offered daily.

In the laboratory, mortality and feeding tests were carried out, where the caterpillars were exposed to the cassava extract, and mortality was verified over a period of 7 days. For the application of the cassava extract, 0.5 ml of the solution was sprayed. Two caterpillars were used per repetition in the 4th stage (8 to 10 mm), 5 caterpillars were used in the 5th stage (15 to 20 mm long), and 4 caterpillars were used

in the 6th stage of life (20 to 30 mm long). Each treatment was repeated 5 times. A millimeter ruler was used to measure the caterpillars.

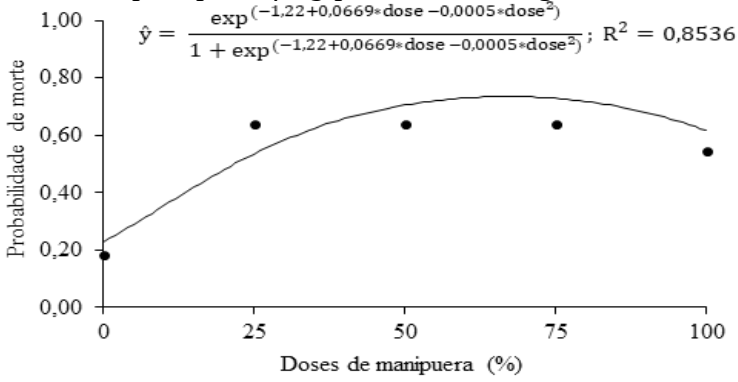
The data were subjected to analysis of variance via the F test ($p \leq 0.01$) and the quadratic logistic mathematical model, and the R program version 4.4 was used to analyze the data. The results are presented in graphs and tables.

3 RESULTS AND DISCUSSION

The data were adjusted to the quadratic logistic mathematical model, with the variable considered to be $p \leq 0.10$. In the mortality test, a logistic regression was adjusted, considering the data with a binomial distribution, i.e., the caterpillar is either alive or dead. In the feeding test, there was no effect of the dose and no regression adjustment as a function of the dose; therefore, total consumption and consumption per caterpillar were considered.

The probability of caterpillar death was determined on the basis of the mortality of caterpillars in different concentrations of cassava, and the results are shown in Figure 1.

Figure 1. Probability of death of *Spodoptera frugiperda*, according to each dose of cassava.



Source: personal archive (2024).

The probability of death is low for the first dose, which is composed of water. At a dose of 25%, this probability doubles, with small increases occurring from then on at doses of 50% and 75%, with the probability of death above 60%. It then begins to decrease at very high doses. This decrease occurred because when cassava is diluted in water, it becomes more poisonous than when it is pure (Sebrae, 2015). This result is strongly related to the fact that cyanide dissociates in the presence of water, releasing HCN. The R^2 value of 0.8536 indicates that the logistic model explains approximately 85.36% of the variation in the data, which suggests a good fit of the mathematical model.

The mortality of *Spodoptera frugiperda* treated with different doses of cassava starch within each stage of life can be seen in Table 1 below.

Table 1. Percentages of deaths of *S. frugiperda* subjected to different doses of Manipira in each phase.

	STADIUM			
Treatments	**4th**	**5th**	**6th**	**Grand total**
0% (water)	0.00	0.20	0.25	0.18
25%	0.00	0.80	0.75	0.64
50%	0.50	0.60	0.75	0.64
75%	0.50	0.80	0.50	0.64
100%	0.50	0.60	0.50	0.55
Grand total	0.30	0.60	0.55	0.53

Source: personal archive (2024).

There was a mortality rate of 18% for the caterpillars subjected to spraying with water, a mortality rate caused by factors in the laboratory environment. Pure cassava caused 55% mortality, and when subjected to 25%, 50% and 75% cassava residue, 64% of the population died, possibly because dilution in water made it more poisonous (SEBRAE, 2015).

Caterpillars in the 5th and 6th stages were more sensitive when exposed to different doses of cassava. Individuals in the 4th stage were more resistant to the application of the residue but still controlled half of the population exposed to the different doses (50, 75 and 100%). The choice of the most efficient dose should consider the risk of burning corn leaves. Silva, Souza and Oliveira (2018) reported that high concentrations of cassava cause the burning of corn leaves, resulting in large reductions in leaf area and in the photosynthetic process.

The estimated mortality rates of *S. frugiperda* subjected to different concentrations of cassava are shown in Table 2 below.

Table 2. Estimated mortality according to each dose of cassava.

Dose	**I estimated**
0	0.23
25	0.53
50	0.71
75	0.73
100	0.62

Source: personal archive (2024).

All the cassava residue concentrations resulted in more than 50% mortality of the caterpillars. The 75% cassava solution was the most effective, with 73% mortality, but it can burn corn leaves because of its high HCN and other salt contents. In this situation, the cassava solution was applied directly to the caterpillars, which ensures total contact of the pest with the solution and thus allows for high application efficiency. However, in the field, uneven distribution and abiotic factors can reduce the effectiveness of the cassava solution, since the pest lodges in the corn cassava, a place that is difficult to access.

4 CONCLUSIONS

Cassava starch has been shown to be effective in controlling *S. frugiperda* in transgenic corn under laboratory conditions and may be an important tool in pest management.

Cassava starch doses equal to or greater than 25% cause mortality of fall armyworms in more than 50% of the population, especially in the last instars. The best stage for applying cassava starch is the 5th stage of the pest. The feeding of the caterpillars was not affected by the cassava byproduct.

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