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The Effect of *Aphthona whitfieldi* (Coleoptera: Chrysomelidae) Populations' Density on the Growth of *Jatropha curcas* in Burkina Faso

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Abstract

Aphthona whitfieldi Bryant (Coleoptera: Chrysomelidae) is a major insect pest of *Jatropha curcas* L. in Burkina Faso. This study aimed at evaluating the effect of the insect pest populations' density on the growth of the plant. To achieve this purpose, 90-day aged single plants were caged in a randomized complete block design experiment with 5 treatments and 5 replicates. The treatments consisted of increasing numbers of adults of *A. whitfieldi* used to infest the caged plants: T0 (0 adult = check), T1 (100 adults), T2 (200 adults), T3 (300 adults), T4 (400 adults). All caged plants were infested 21 days after transplantation and the evaluation started 14 days later one on every 2-week basis from September 18, 2014 to February 19, 2015. The growth parameters of the plant were assessed. The results showed that the intensity of damage caused by *A. whitfieldi* on the growth of young plants of *J. curcas* varied according to the treatment (*i.e.*, according to the number of adult individuals infesting the plant at the beginning). The higher the number, the heavier the level of damage caused by the pest. So, the growth of the *J. curcas* plant was inversely proportional to the number of *A. whitfieldi* infesting individuals. There was also a positive linear correlation between the defoliation rate and the height of the seedlings. The status of this insect pest was confirmed by the results of this study.

Keywords

Jatropha curcas, *Aphthona whitfieldi*, Growth, Impact, Burkina Faso

1. Introduction

Jatropha curcas is a shrub native to Central America. It is a multipurpose plant that is mainly used in Africa as a living fence to prevent animals from grazing. The plant is also used as fertilizer, chemical, soap production etc. [1]. Contrary to the general belief that the toxicity and insecticidal properties of the plant prevent the presence of pests, many insect pests have been observed on the shrub. The Aphthona flea beetle (Coleoptera: Chrysomelidae) has been identified as the main pest of *J. curcas* in various regions of Africa [2] [3] [4]. This pest can seriously reduce the growth of the plant [2] [3] [5] [6] [7].

In Burkina Faso, the species of Aphthona identified by [7] as the main pest of *J. curcas* is *Aphthona whitfieldi*. The insect feeds on the leaves of the shrub and can cause total defoliation in the case of severe attacks, which could influence the growth of the plant. The female adults lay their eggs in the soil where the larvae hatch and feed on the roots of the plant [8]. Adults feed only on the leaves.

The objective of this study was to assess the impact of *A. whitfieldi*'s attacks on the growth of *J. curcas*.

2. Material and Methods

2.1. Site of the Study

The study was conducted on the site of the company Fasobiocarburant SARL, located in the commune of Léo. Léo is the capital city of the province of Sissili, located in the southwest of Burkina Faso and 165 km from the capital city of the country, Ouagadougou. The geographical coordinates of the study site were: 11.10˚N and 02.10˚W.

2.2. Insects Used

The animals used were adult specimens of *A. whitfieldi* that were collected in the *J. curcas*' fields located in the commune of Léo.

2.3. Host Plant

We used 90-day old *J. curcas* seedlings acquired from the nursery of a grower in Kayéro (a village 15 km northwest of the city of Léo). Seedlings grown from the nursery were transplanted into 30 × 30 × 30 cm holes in 20 m × 20 m plots.

2.4. Experimental Design

The experimental design was a randomized complete block consisting of 5 treatments and 5 replications. The experimental unit was a seedling put in a cage measuring 1.5 m height by 1 m wide. A total of 25 seedlings were caged for this experiment. The treatments were as follows:

- T0 = 0 *A. whitfieldi* adult
- T1 = 100 *A. whitfieldi* adults
- T2 = 200 *A. whitfieldi* adults
- T3 = 300 *A. whitfieldi* adults
- T4 = 400 *A. whitfieldi* adults

Three weeks after the transplantation, all plants (except controls) were infested with adult of *A. whitfieldi* insects. All plants were infested on the same day. Two weeks after infestation, measurements of plant growth parameters began. Measurements were made using one meter-ribbon with respect to seedling height. The parameters that were assessed were:

- the diameter of the plant (using a measuring tape);
- the height of the seedling (considering the highest main axis);
- the presence or the absence of leaves;
- the number of primary branches (any branch at least 5 cm long when measured from the main axis was considered a primary branch).

The caged seedlings were watered every day until the end of the experiment. Each seedling received 5 l of water per day. The measurements were thus done from 18 September 2014 to 19 February 2015. There were 12 h light versus 12 h/darkness. No fertilizer was used (Picture 1).

2.5. Statistical Analysis

Data collected were processed using Genstat Discovery 3, version 12, and all figures were created using Excel 2010. Seedling height, number of branches, number of leaves, and defoliation rate were tested with the analysis of variance (ANOVA) using "treatment" and "date of observation" factors.

3. Results

Effect of *A. whitfieldi*'s populations' density on the growth of *J. curcas.*

3.1. Effect on the Height of *J. curcas*

The effect of *A. whitfieldi*'s attacks on the height of *J. curcas* is presented in Figure 1 and Figure 2. The average height of the plant regressed from the control to the treated plants. In Figure 1, the following was observed:

- For the control, the average plant height was 33.07 cm at the beginning, and at the end of the measurements, it was 43.87 cm (*i.e.*, an elongation of more than 10 cm);
- For plants infested with 100 insects (T1), the average plant height was 31.48

Picture 1. Partial view of the experimental design showing some of the cages used ⟷ = 1 m.

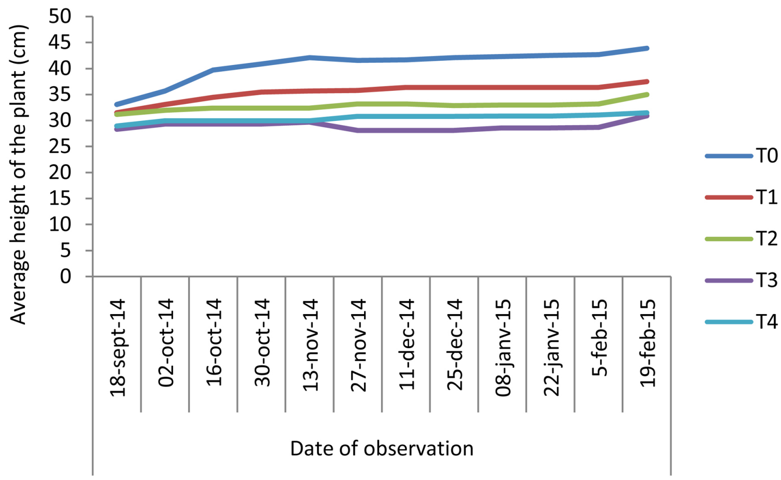

Figure 1. Evolution of the height of *J. curcas*' plant according to the number of *A. whitfieldi*'s adults used for infestation.

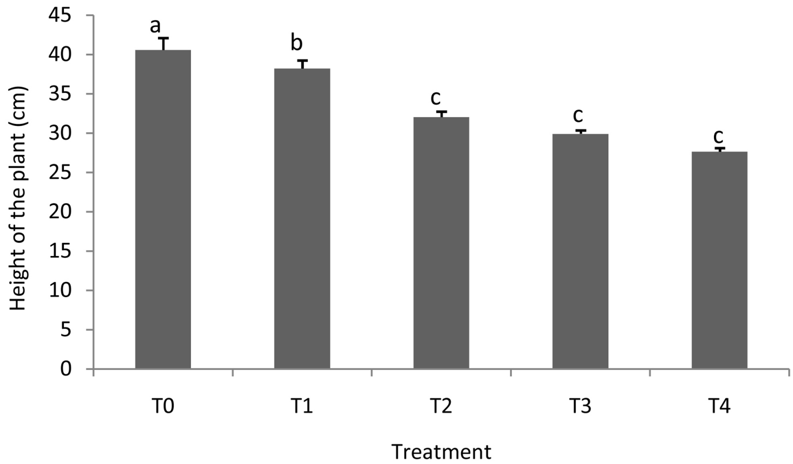

Figure 2. Average height of *J. curcas* according to the number of *A. whitfieldi*'s adults used for infestation.

cm at the beginning and 37.48 cm at the end of the experiment (an elongation of 6 cm);

- For plants infested with 200 individuals, the average plant heights at the beginning and at the end of the experiment were 31.17 cm and 34.97 cm, respectively (an elongation of less than 4 cm);
- Plants treated with 300 individuals of the insect pest (T3) and 400 individuals (T4) had starting heights of 28.32 cm and 28.96 cm, respectively, and at the end of the experiment, they had heights of 30.92 cm and 31.42 cm, respectively (a maximum elongation of 3 cm).

In general, the curves describe a small variation in the height of the seedlings. The results of the statistical analysis show a highly significant difference as a function of the treatment ($P < 0.0001$).

There was a positive linear correlation between the defoliation rate and the height of the seedlings. The higher the degree of defoliation, the lower the seedlings' height will be.

The bars represent the standard deviations (±SD), and the same letters above the vertical bars indicate homogeneous groups at the 5% threshold according to the Fischer LSD test.

The bars (Figure 2) represent the standard deviations (±SD), and the same letters (a, b and c) above the vertical bars indicate homogeneous groups at the 5% threshold according to the Fischer least significant difference (LSD) test. The defoliation rate of *J. curcas* was highly and positively correlated with the average height of the plant (Figure 3).

3.2. Effect on the Diameter of *J. curcas*

The effect of *A. whitfieldi*'s attacks on the diameter of *J. curcas* seedlings is shown in Figure 4 and Figure 5. The impact of insect attacks on diameter was

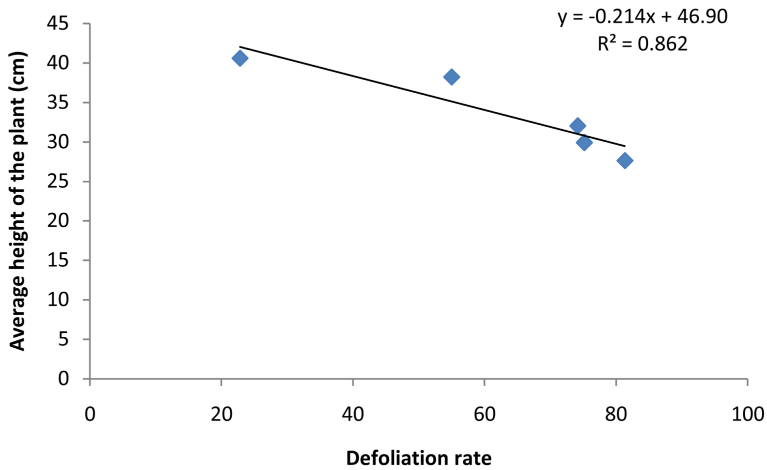

Figure 3. Linear regression between the rate of defoliation and the height of *J. curcas*' plant.

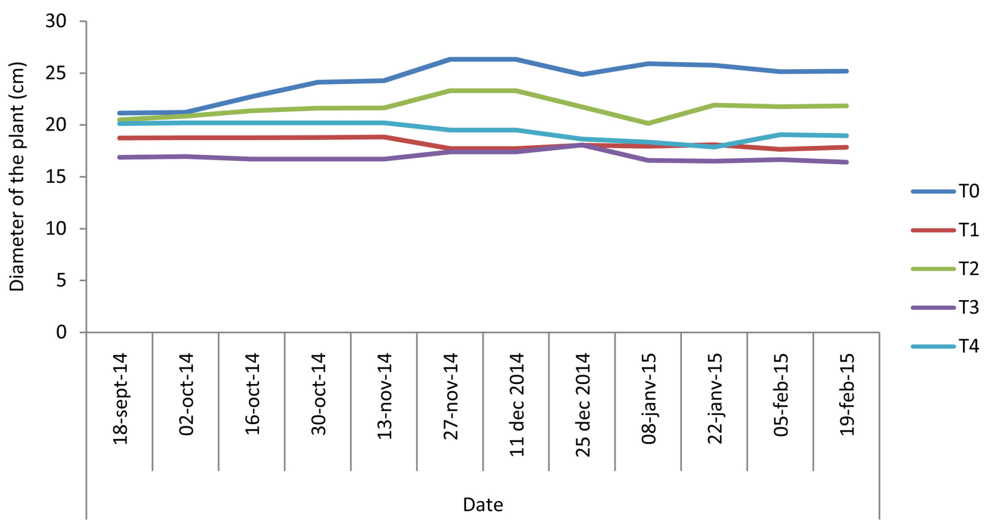

Figure 4. Evolution of the diameter of *J. curcas*' plant according to the number of *A. whitfieldi*'s adults used for infestation.

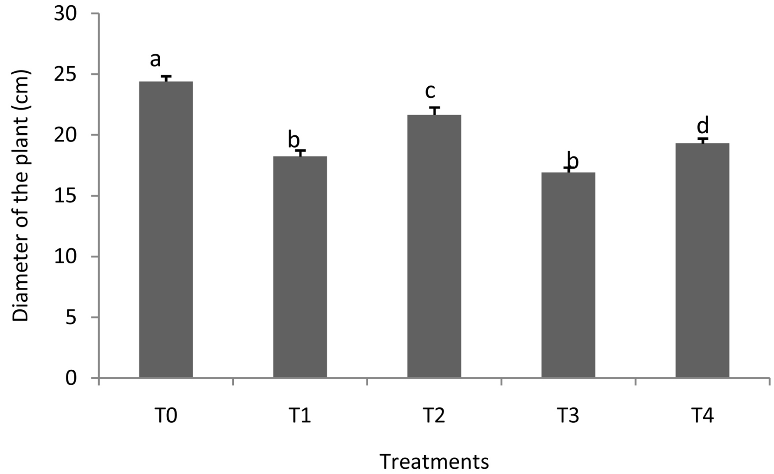

Figure 5. Average diameter of *J. curcas* according to the number of *A. whitfieldi*'s adults used for infestation.

more pronounced in treated plants (T1 = 18.24 ± 0.49 cm, T2 = 21.66 ± 0.94 cm, T3 = 16.92 ± 0.48 cm, T4 = 19.39 ± 0.83 cm, control = 24.4 ± 1.82 cm). The statistical analysis revealed very highly significant differences among the different treatments ($P < 0.0001$).

The bars represent the standard deviations (±SD), and the same letters above the vertical bars indicate homogeneous groups at the 5% threshold according to the Fischer least significant difference (LSD) test.

3.3. Effect on the Development of *J. curcas*' Branches

The production of branches varied according to the treatment (**Figure 6**). The lowest average numbers of branches were recorded in T2 (with less than one branch), followed by T0 (1.03 branches) and T4 (1.18 branches). The highest numbers of branches were recorded in T1 (3.34 branches) and T3 (2.11 branches).

The curves of evolution of the average number of branches of the seedlings evolved in a sawtooth pattern, which is stronger in T1 and T3 (**Figure 6**).

Statistical analysis of the number of branches of seedlings revealed highly significant differences among treatments ($P < 0.001$) (**Figure 7**).

The bars represent the standard deviations (±SD), and the same letters above the vertical bars indicate homogeneous groups at the 5% threshold according to the Fischer least significant difference (LSD) test.

3.4. Effect on the Number of Leaves of *J. curcas*

The curves of the evolution of the average number of leaves of *J. curcas* as a function of the treatment and the time show a tendency of falling and recovering leaf production for all the seedlings (**Figure 8** and **Figure 9**). At the beginning of the measurements, that is, in September 2014, almost all seedlings bore leaves.

During October 2014, the number of leaves of the seedlings of treatments 3

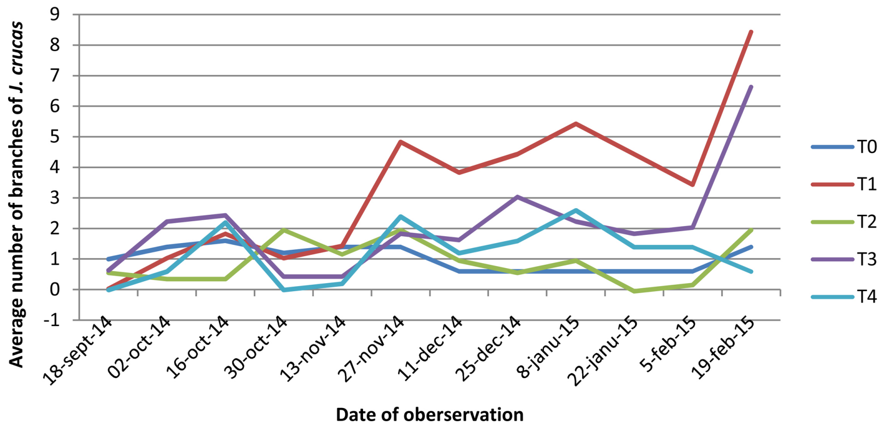

Figure 6. Evolution of the number of *J. curcas*' branches over time according to the initial number of *A. whitfieldi*'s adults used for infestation.

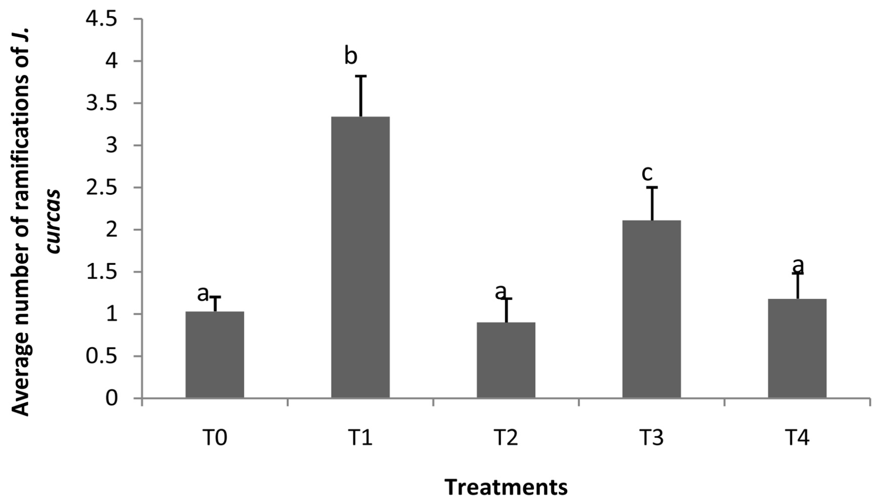

Figure 7. Average number of branches of *J. curcas* according to the number of *A. whitfieldi*'s adults used for infestation.

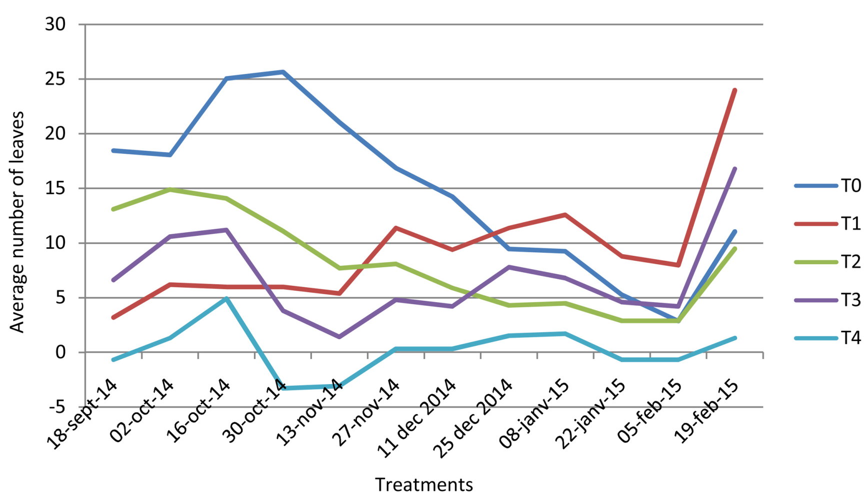

Figure 8. Evolution of the number of *J. curcas*' leaves over time according to the initial number of *A. whitfieldi*'s adults used for infestation.

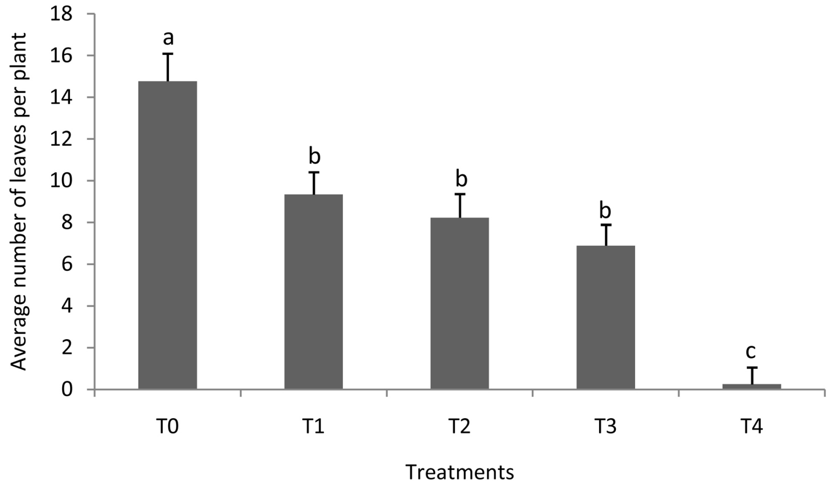

Figure 9. Average number of *J. curcas'* leaves according to the number of *A. whitfieldi*'s adults used for infestation.

and 4 fell sharply (**Picture 2**), and this trend continued until November of the same year before a saw-tooth recovery towards the end of the same year's month. However, this recovery was very low for the seedlings that underwent T4 treatment. For the control, declining leaf production rates began in late October 2014 and continued until early February 2015, when a recovery was observed.

However, in general, histogram analysis showed that the heaviest leaf loss was recorded in T4 (an average of less than one leaf per seedling, whereas at the beginning the average was 15 leaves per seedling).

The bars represent the standard deviations (±SD), and the same letters above the vertical bars indicate homogeneous groups at the 5% threshold according to the Fischer LSD test (**Figure 9**).

There was a positive linear correlation (**Figure 10**) between the number of *A. whitfieldi* introduced into each cage and the defoliation rate observed on each seedling (R2 = 0.826). The higher the number of insects, the heavier the loss of leaves will be.

4. Discussion

Our observations show that the intensity of damage caused by *A. whitfieldi* on the growth of young plants of *J. curcas* varied according to the treatment (*i.e.*, according to the number of adult individuals infesting the plant at the beginning). The higher the number, the heavier the level of damage caused by the pest will be.

The growth of the *J. curcas* plant was inversely proportional to the number of *A. whitfieldi* infesting individuals. To grow, plants need oxygen and light in addition to water and nutrients. The only parts of the plant that can provide oxygen and light are the leaves. Thanks to the leaves, the plant continues its photosynthetic activity, which allows it to grow. However, in this study, the infested plants lost their leaves, which compromised their ability to grow in height. Despite

Picture 2. Defoliation of *J. curcas* due to the attacks of *A. whitfieldi*. First line from left to the right: T0, T1 and T2. Second line from left to the right: T3 and T4. ⟷ =0.75 m.

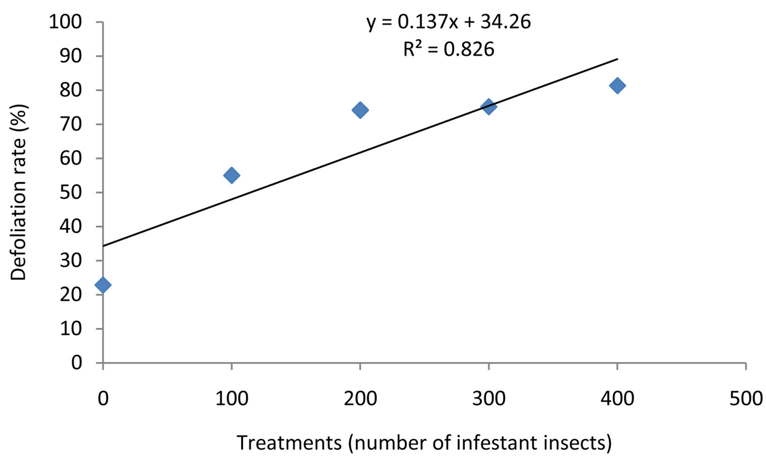

Figure 10. Linear regression between the rate of defoliation and the number of insects used for infestation.

the toxicity of the plant, which should give it some resistance to pests, it could not escape the attacks of *A. whitfieldi*. This indicates that there is a certain evolutionary link between this insect pest and its host plant, which has allowed the pest to bypass this toxicity. Our observation is in line with the results of the study on the "resistance of plants against herbivores" reported by [9]. According to this author, plants develop several types of defenses (structural, chemical, indirect defense, etc.) that allow them to escape the attacks of herbivores; however, there are cases in which these herbivores adapt to these defenses over time. This author described this relationship as coevolution. The results of this study thus appear to indicate a coevolution between *J. curcas* and *A. whitfieldi*.

Author [10] reported that some flea beetles, such as *Phyllotreta* sp., are responsible for small rounded perforations on the leaves of cruciferous plants, so that the plants, even very developed ones, are stunted in their growth and eventually die. According to the same author, *Aphthona euphorbiae* destroys the vegetative point of flaxseed and thus stops vegetative growth (*i.e.*, the branching) of the plants.

Authors [11] reported, in a study conducted in the DR Congo, that *Aphthona* sp. causes total defoliation of *J. curcas* plants if they are not treated with an insecticide. This defoliation had a negative impact on the growth in height, thickness, and number of branches of *J. curcas* plants.

According to [12], some beetles, such as weevils, feed on the leaves of some plants, causing wilting and eventually the death of the plants. These beetles also often cause stunting and deformation of plants.

The results of this study confirmed the adverse impact that *A. whithfieldi* has on *J. curcas*. When the number of infested beetles was higher than 200, the plant could suffer total defoliation and the reduction in the development of branches. The assessment of yield loss due to this insect pest is necessary to have a more comprehensive picture of this issue.

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