Evaluation of the efficacy of castor oil as a biopesticide in the treatment of *Leucinodesorbitalis*GueneeL., a pest of eggplant (*Solanummelongena*)

ABSTRACT

LeucinodesorbonalisGuenéeL. *is a pest of Aubergine. It is currently managed using synthetic chemical pesticides. However, certain plants with insecticidal properties can be used to control Leucinodesorbonalis in aubergines. To study the effectiveness of the castor oil solution, a trial was carried out at the ISAV in Faranahfrom 08/05 to 20/08/2023. Castor oil was extracted using a press machine with a yield of 0.41 l/kg. Under field conditions, the study involved 80 aubergine plants. The parameters monitored were: incidence of attack, number of plants leafed out and productivity. The survival of Leucinodesorbonalis larvae after treatment was also estimated in vitro. The doses used were: D0 = 0 l/ha (control); D1 = 2.5 l/ha; D2 = 5 l/ha and D3 = 7.5 l/ha. The results showed that the incidence of attack after treatment was 68% for the control. However, this incidence was 10, 4 and 2% respectively for doses D1, D2 and D3. With regard to the number of plants thinned out, the rates were 68% for the control, 33% for D1, 17% for D2 and 8% for D3. Productivity was: 3.0 t/ha for the control; 5 t/ha for D1; 8 t/ha for D2 and 11.02 t/ha for D3. Survival of Leucinodesorbonalis larvae after application of the castor oil solution was 92%, 20%, 10% and 0% respectively for the D1, D2 and D3 controls. Analysis of the results shows that the 7.5 l/ha dose of castor oil is a good biopesticide for controlling Leucinodesorbonalis.*

Key words: Biopesticide, Castor oil, Leucinodesorbonalis, Aubergine.

1. INTRODUCTION

Aubergines (*Solanummalongena*) play an important role the human diet and make a significant contribution to family incomes in West Africa. [1]. This crop is grown for local consumption and for sale. [2]. Statistics for 2021 show that world aubergine production is around 54 million tonnes a year, of which 34.1 million tonnes are produced by China. In Africa, Egypt is the leading producer, with 1.4 million tonnes a year[3]. Aubergines can be eaten raw, cooked or fried with spices in stews[4]. Aubergine fruit contains fibre, potassium, vitamin C, B-6 and antioxidants that supports heart health[2]. In the Republic of Guinea, aubergine production is facing strong pressure from pests and climatic conditions (low rainfall), as well as poor soils that limits it productivity. These pressures reduce yield and markes it marketable [5], [6].

Among these pests, *Leucinodesorbonalis*L. is a devastating insect that causes enormous damage to aubergine crops[7]. The larvae pierce the flower buds (flower petals) and fruit, leaving open the possibility of secondary infection by fungi and bacteria. As a result, yields are reduced from 1.14 to 9 t/ha[8][9] ; [10]. To combat this pest, most market gardeners use chemical insecticides in their plots[11]. These chemical insecticides do not only make aubergine production unsustainable, but can also cause chronic and acute poisoning in humans. They can even cause disorders in human reproduction, gene mutation and carcinogenic effects. The rate of infestation of aubergine plants by *Leucinodesorbonalis* can reach 90% [4].

Traditionally, some growers have used indigenous knowledge based on both cultural practices and curative treatments. In these practices, the response test of five aubergine cultivars showed that LeucinodesorbonalisGuenee, under field conditions infests aubergine plants between 42.39 and 54.44%[12].

Controlling this pest is therefore a priority in the protection of aubergines. For chemical treatments, the survival rate of older larvae remains lower (10.12%) [13]. Similarly, the individual and combined use of buprofezin, emamectin benzoate, abamectin and spinosad reduced the average infestation percentage by 39.83% and generated a marketable fruit yield ranging from 6.05 to 9.94 t/ha[14] . Three applications of flubendiamide 39.35 SC, chlorantraniliprole 20 SC, Cypermethrin 25 EC, Spinosad 45 SC, indoxacarb 14.5 SC, fipronil 5 SC and imidacloprid 17.8 SL to control Leucinodesorbonalis stabilised the percentage of infestation between 2.98 and 11.59% [15]. The use of neem oil and garlic bulb extract kept the incidence of attack by *Leucinodesorbonalis* below 17%[4]. Similarly, the use of emamectin benzoate and buprofezin reduced the incidence of attack to 4% [5]Testing the combined effect of bird's eye chilli extract and spinosad resulted in a commercial aubergine yield of 10 t/ha [16]. Application of extracts of papaya leaves, Jatropha leaves, tamarind fruit, tulsi leaves, onion bulb and neem oil helped to maintain the Leucinodesorbonalis infestation threshold on aubergine plants at between 16.66 and 24.10%. These results made it possible to obtain yields ranging from 9.33 to 21.33 t/ha[17].

Castor oil is a common insecticide plant, easily accessible to most farmers. It contains over 87.7% ricin, making it an effective and efficient insecticide. [18]. The use of castor oil can therefore be an asset in the fight against *Leucinodesorbonalis*. Optimising the management of *Leucinodesorbonalis* through the use of pesticide plants are promising alternative for sustainable agriculture and reduces the health and environmental risks [19]. With this in mind, the following question was asked, which this article will attempt to answer: Can *Leucinodesorbonalis* L. be controlled by a castor oil solution?

To answer this question, the main objective set in this study is to assess the effectiveness of castor oil on *Leucinodesorbonalis* as pesticide. To achieve this objective the castor oil will be firstly extracted and secondly, that oil will be tested on *Leucinodesorbonalis*.

2. MATERIALS AND METHODS

2.1. Presentation of study areas and plant material

The Studywas conducted at the experimental station of the Agriculture Department of the Higher Institute of Agronomy and Veterinary of Faranah (10°03'10'' N, 10°44'38'' W), Republic of Guinea. The trial was conducted on ferralitic soil. Analysis were carried out according to the protocol given byauthor'sname[20].

The Barbentane variety of aubergine (*Solanummelongena*) was used as experimental material for the study.

2.2. Castor bean seeds collection and oil extraction

Castor bean seeds were obtained on the left coast of the Niger River in Faranah(10°02'12'' N, 10°44'27'' W) and at an altitude of 433 above sea level. Seeds were harvested when fruit maturity per inflorescence cluster was above 50%. The onset of ripening was observed on fruit spines by changing their colour from red to brown. Castor oil was extracted using a machine (Figure 1). A total of 24.5 kg of seeds were used to obtain 10 litres of castor oil, giving a yield of 0.41 l/kg.

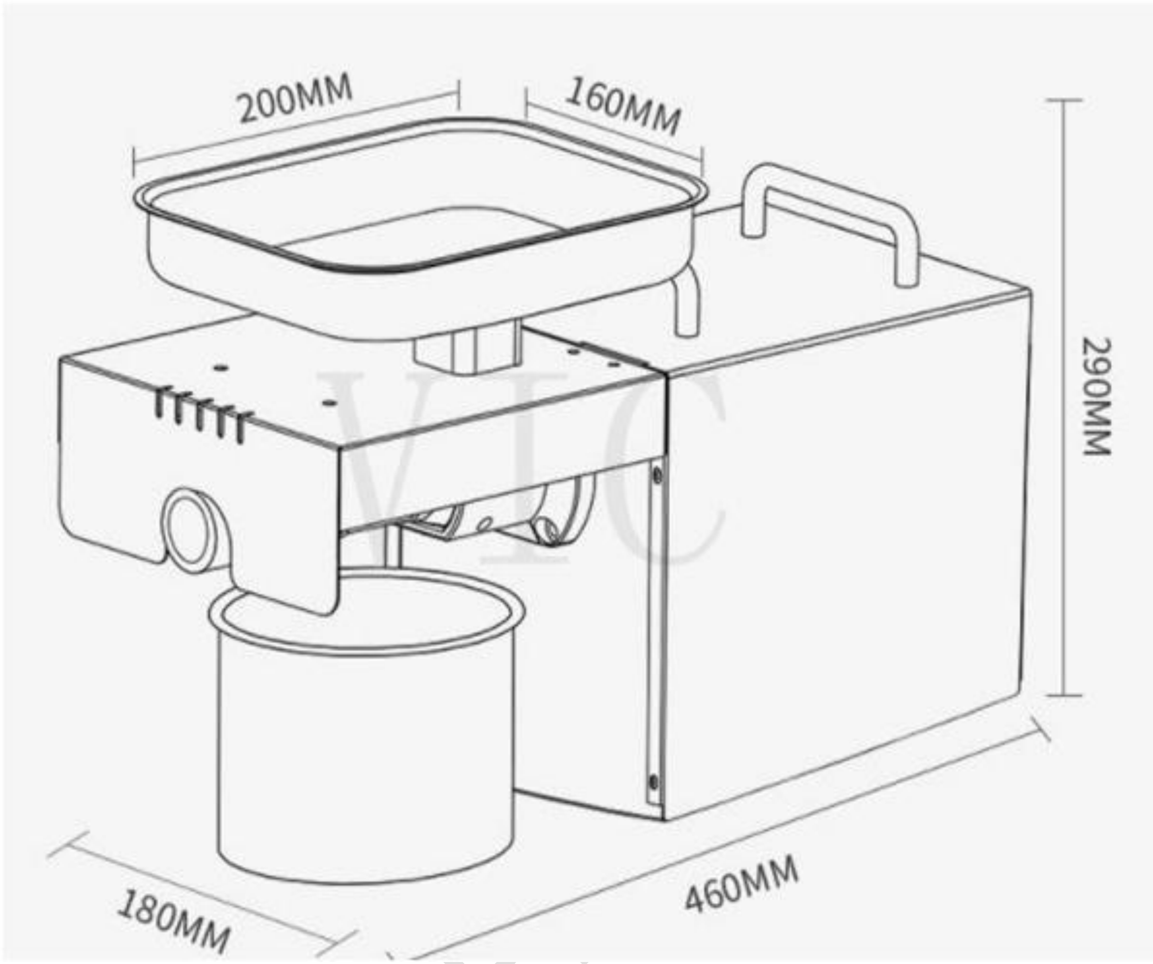

Figure 1: Characteristics of the small oil press (make: CIV and code: 8419409090)

2.3 Experimental set-ups and process

a. Testing castor oil solution on aubergine plants

The study was carried out in a completely randomised design with four doses repeated four times such that D0 = 0 l/ha (control), D1 = 2.5 l/ha; D2 = 5 l/ha and D3 = 7.5 l/ha. The formulations during application were: (0; 130.68; 131.76; 132.84 ml/plot) for D0, D1, D2 and D3 respectively.
A total of one hundred and ninety-two aubergine plants were transplanted onto plots measuring 3 m in length and 1.8 m in width. Data were collected for 105 days.

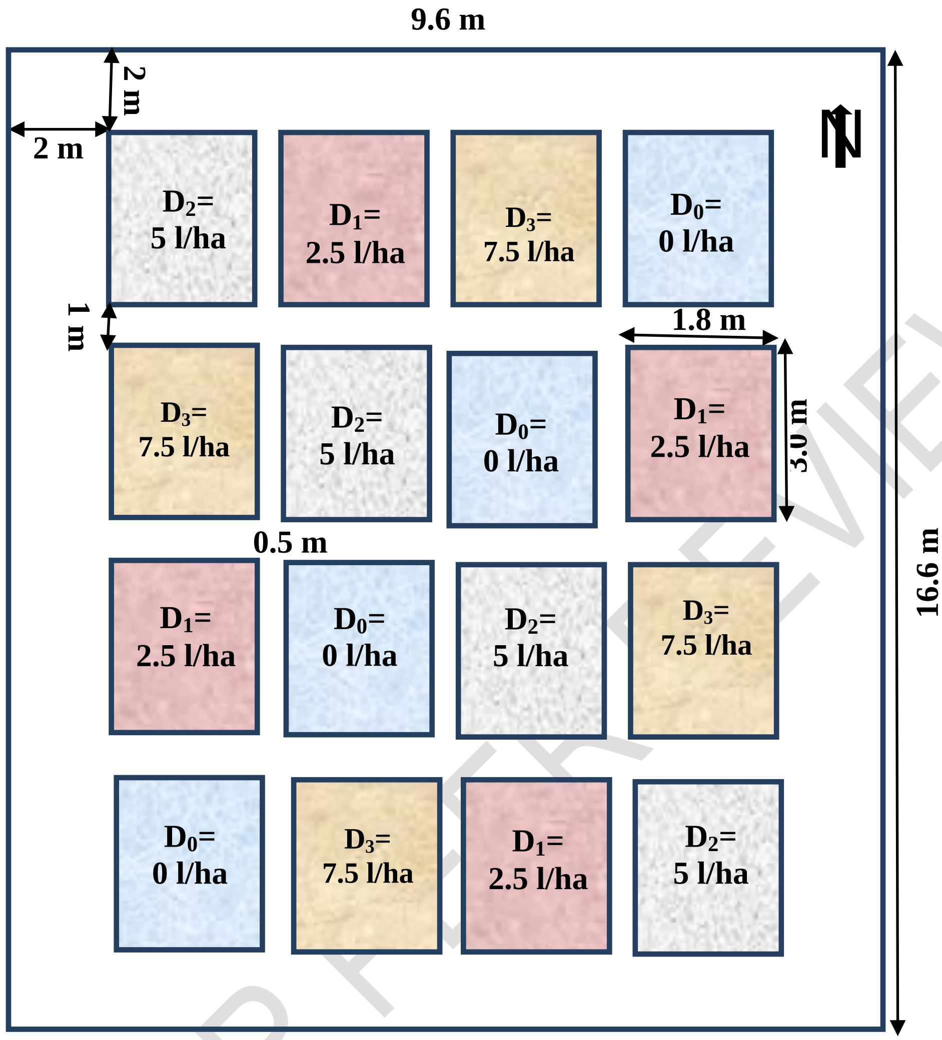

Figure 2: Experimental set-up for evaluating the oil solution in the field.

b. In vitro test of the survival rate of *Leucinodesorbonalis*L. larvae

The protocol described by Abdul et al. (2021) was used [21]. The Leucinodesorbonalis larvae used in the experiment were obtained after rearing an adult female in a plastic container at a laboratory under ambient temperature of 26 ± 5°C and a relative humidity of 75 ± 3%. Aubergine leaves were used as the food source. Eggs were laid in batches in the container. After incubation, one hundred and sixty 12-days old L. orbonalis larvae were used for the survival test. The *L. orbonalis* larvae were divided into sixteen beakers at a rate of ten larvae per beaker. The beakers were covered with muslin cloth to prevent the larvae from escaping (Figure 3).

The experimental set-up used was a Randomised Complete Block (RCB) with four doses repeated four times. The treatments used were different doses of castor oil solution (0 ml; 0.125 ml; 0.25 ml; 0.375 ml oil/beaker). *Leucinodesorbonalis* larvae were distributed in sixteen beakers at a rate of ten larvae per beaker. The formulations applied were: 1.0 ml for the control; 1.125 ml for D_1; 1.25 ml for D_2 and 1.375 ml for D_3.

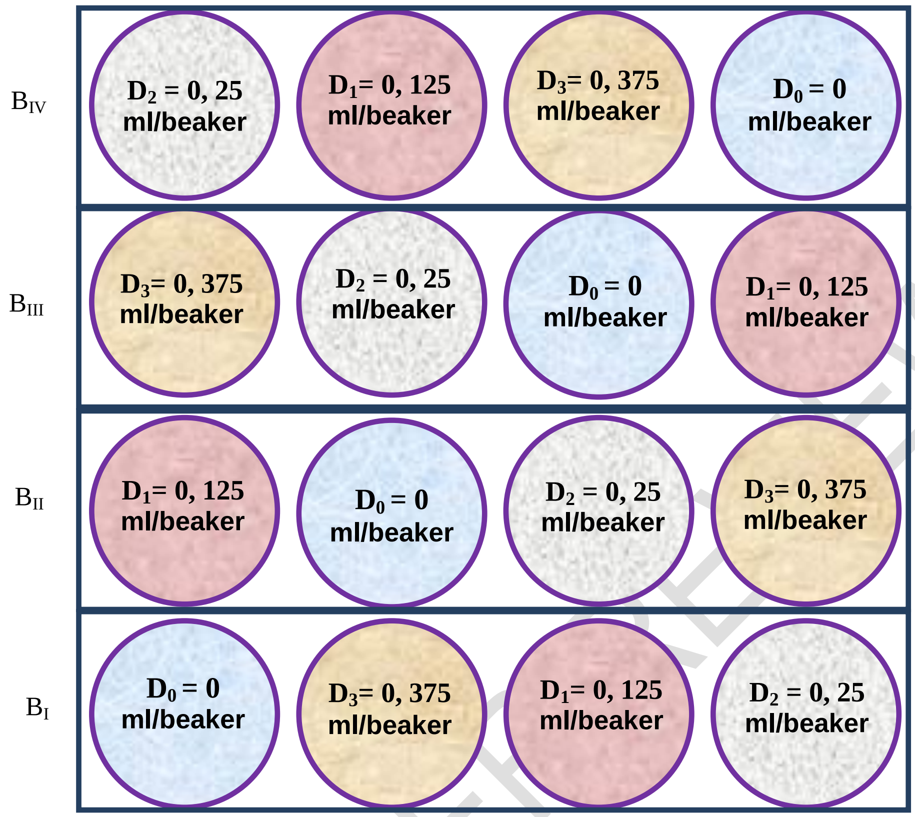

Figure 3: Device used to test the survival rate of L. orbonalis larvae in vitro.

2.4. Phenological observations

Phenological observations focused on recovery, branching, flowering, fruiting and ripening. Phenophase times were recorded until at least 50% of the plants in the elementary plot had completed the following phases[22].

2.5. Evaluation of the incidence of *Leucinodesorbonalis* attack and the rate of plants stripped of leaves

Out of a total of 192 aubergine plants, 80 plants were sampled using the FAO W method (2019) [23]. Data on the incidence of attack and the rate of leaf removal were obtained by counting the number of plants showing symptoms of Leucinodes attack. The data were recorded during the flowering period (55 days after sowing) and ripening (88 days after sowing). The incidence of attack and the rate of stripped plants were calculated using the formula described by Oertel (2018) and Johnson et *al.* (2018) [24], [25].

$$\text{Incidence of attack} = \frac{\text{Number of plants attacked}}{\text{Total number of plants}} \times 100$$

$$\text{Rate of plants with leaves removed} = \frac{\text{Number of leaves attacked}}{\text{Total number of sheets}} \times 100$$

2.6. Evaluation of plant productivity

Productivity per hectare was determined by extrapolating the production of each elementary plot considered as a yield square. According to Tchegueni et al (2022) and Yeo et al (2022) [22], [26]. The following formula was used:

$$\text{Productivity (t/ha)} = \frac{\text{Weight of fruit harvested from useful plants (Kg)}}{\text{Area occupied by these plants } (m^2)} \times \frac{10\ 000\ m^2}{1000}$$

2.7 Survival rate of *Leucinodesorbonalis* larvae

Data on the survival rate of *Leucinodesorbonalis* larvae were obtained by counting the number of dead larvae in the beakers after application of the castor oil solution. The data were recorded over a 24-hour period and the survival rate was calculated using the formula of Ojuu et *al.* (2023) [27].

$$\text{Survival rate} = \frac{\text{Number of dead Leucinodes orbonalis larvae}}{\text{Total number of Leucinodes orbonalis larvae}} \times 100$$

2.8. Data analysis

Data were collected and entered using Microsoft Excel 2021 spreadsheet software. SPSS 22 Windows software was used for statistical analysis of the data. Origin Pro 9.0 software was used to generate the graphs.

3. RESULTS AND DISCUSSION

3.1 Results

Physico-chemical characteristics of the soil

Table 1 shows the various results obtained on the physico-chemical characteristics of the soil. The granulometric analyses show the following characteristics: sand (63.62%), silt (8%), clay (18%). According to the FAO textural triangle, the soil has a sandy-loam texture. The soil has an acid pH (5.6), a low content of major assimilable nutrients (N: 2.00 mg kg-1; P_2O_5: 14.66 mg kg-1 and K_2O: 99.83 ppm) and an organic matter content of 0.84%.

Table 1: Soil analyses according to the Rostaee (2021) et Yeo (2022) [21], [22].

Details	Value
Sand (%)	63.62
Silt (%)	8.00
Clay (%)	18.00
Texture	Silty-sandy
Bulk density (g cm^{-3})	1.43
Real density (g cm^{-3})	2.14
pH (water)	5.60
Organic matter (%)	0.84
Assimilable nitrogen (mg kg^{-1})	2.00
Details	14.66
Sand (%)	99.828

Meteorological data recorded during the trial period

Table 2 shows the results of the meteorological data recorded during the trial period. The mean temperature was 26.57°C, total rainfall 104.10 mm, mean relative humidity 80.88% and mean wind speed 1.99 m. $s^{-1.}$

Table 2: Meteorological data recorded during the trial (May - August 2023)

Details	Value	Methods
Average temperature (°C)	26.57	According to the method described by Vanlande (1995) [28]
Relative humidity (%)	80.88	
Total rainfall (mm)	1042.10	
Wind speed (m s^{-1})	1.99	

Source: ISAV agro-meteorological station (2023)

Phenological observations

The results of the phenological observations obtained during the vegetative cycle (Table 4) show that the duration of recovery, branching and flowering were uniform for all the treatments, respectively 1, 5 and 8 days after sowing. On the other hand, D0 showed a demarcation for the duration of fruiting (12 days) and ripening (7 days). However, the duration for doses D1, D2 and D3 was uniform, with 6 days for fruiting and 4 days for ripening. This demarcation in fruiting and ripening can be explained by the fact that the control plants were heavily attacked by *Leucinodesorbonalis* (Table 3).

Table 3: Descriptive statistics for the duration of the various phenophases

Castor oil solution	Takeover			Branching			Flowering			Fructification			Maturation			Vegetative cycle
	D	F	d	D	F	d	D	F	d	D	F	d	D	F	d	
D_0	4	4	1	32	36	5	40	47	8	83	95	12	98	105	7	105
D_1	4	4	1	32	36	5	40	47	8	83	88	6	95	98	4	98
D_2	4	4	1	32	36	5	40	47	8	83	88	6	95	98	4	98
D_3	4	4	1	32	36	5	40	47	8	83	88	6	95	98	4	98

Analysis of variance of the parameters studied

Analysis of variance showed that all treatments had a significant effect on *Leucinodesorbonalis* (P <0.05) except for the incidence of attack before application of the castor oil solution under field conditions (P <0.05). The evaluation of the survival rate of *Leucinodesorbonalis* larvae during the in vitro experiment was highly significant (P <0.01). A comparison of the averages of the following parameters: incidence of Leucinodes attack before and after application of the castor oil solution, the effect of this solution on plant thinning, aubergine productivity and on *Leucinodesorbonalis* larvae are shown in Figures 4, 5 and 6.

Table 4: Summary of analysis of variance

		Sum of squares	ddl	Medium square	F	Sig.
Incidence of attack by *Leucinodesorbonalis* before treatment	Intergroups	249.00	3	83.00	.00	.245
	Intragroup	1431.00	12	119.00		
	Total	1681.00	15			
Incidence of *Leucinodesorbonalis* attack after treatment	Intergroups	12159.00	3	4053.00	76.00	.000
	Intragroup	637.00	12	53.00		
	Total	12797.00	15			
Number of plants thinned	Intergroups	111.00	3	37.00	42.00	.000

out during the cycle	Intragroup	10.00	12	.00		
	Total	122.00	15			
Productivity of post-harvest treatments	Intergroups	130.00	3	43.00	9.00	.002
	Intragroup	56.00	12	4/00		
	Total	187.02	15			
Survival rate of *Leucinodesorbonalis*	Intergroups	21218.00	3	7072.00	125.0	.000
	Intragroup	675.00	12	56.00		
	Total	21893.00	15			

Incidence of Leucinodes attack before and after application of the castor oil solution.

Analysis of the results shows that the incidence of attack on aubergine plants by treatment varied. We noted 39% for D0 (control) and D1, 35% for D2 and 46% for D3. After application, the incidence of attack was 68% for D0 (control), 10% for D1, 4% for D2 and 2% for D3. The reduction in the incidence of attack after application was proportional to the increase in the dose of castor oil solution (Figure 4).

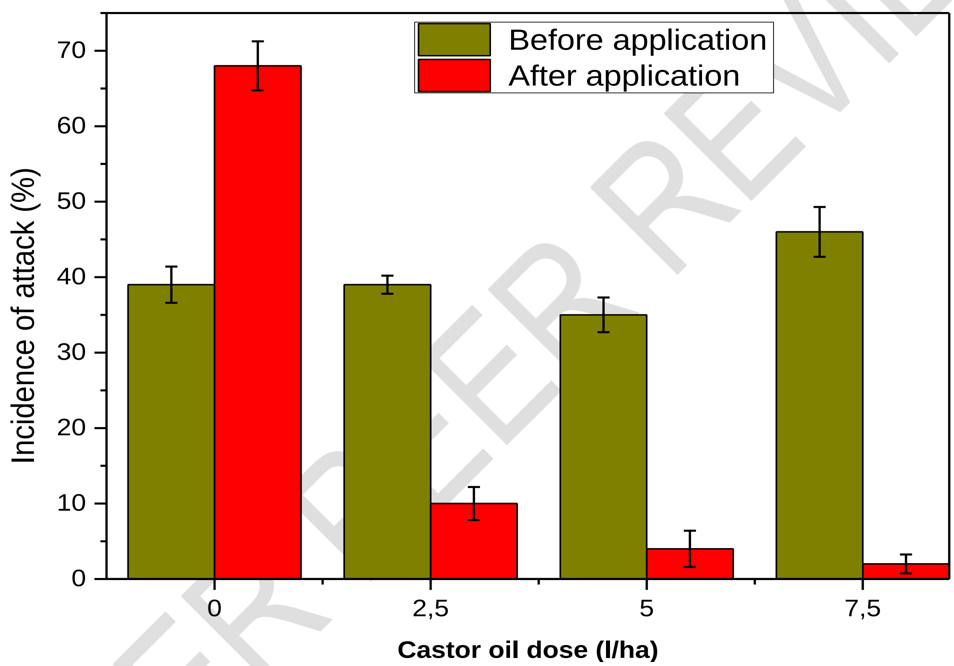

Figure 4: Effect of castor oil solution on incidence of attack (%)

Effect of castor oil solution on plant stripping and aubergine productivity.

The effect of the doses of castor oil solution was highly significant (P <0.001). Analysis of Figure 2 shows that the number of plants with leaves removed was 67, 33, 25 and 8% respectively for D0, D1, D2 and D3.

In terms of productivity, the control gave a yield of 3.0 t/ha. However, when the treatment was increased to 2.5 l/ha, 5 l/ha and 7.5 l/ha, yields increased by 5, 8.25 and 11.02 t/ha respectively (Figure 5).

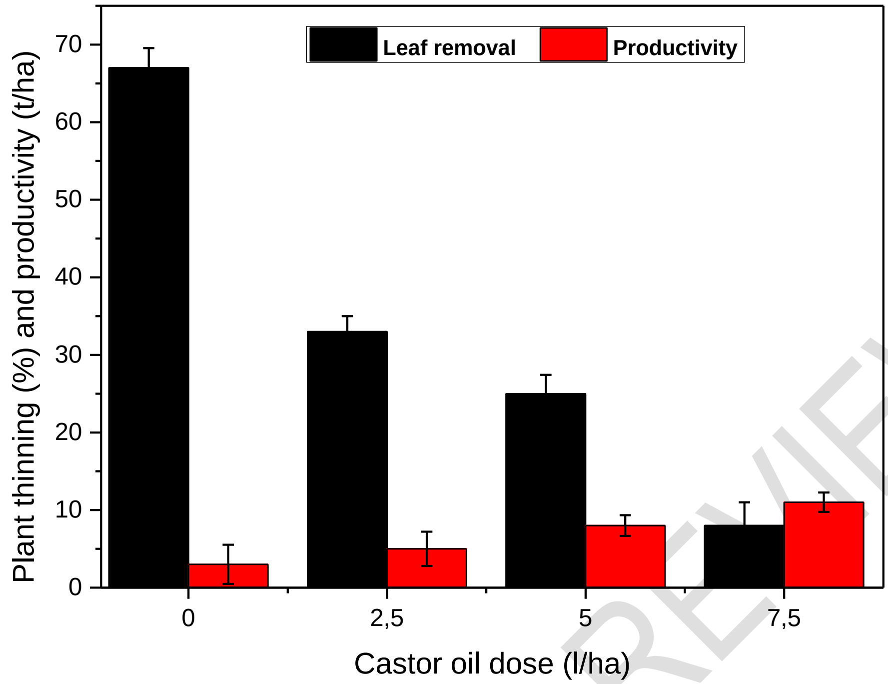

Figure 5: Plant productivity as a function of treatment dose

Effect of castor oil solution on Leucinodesorbonalis larvae.

The influence of castor oil doses on the survival rate of Leucinodesorbonalis larvae is shown in Figure 6. Analysis of this figure shows that the survival rate of larvae after in vitro testing of the castor oil solution was 92% for D0 (control), 20% for D1, 10% for D2 and 0% for D3. The downward trend in survival rate correlated with the dose of castor oil solution (Figure 6).

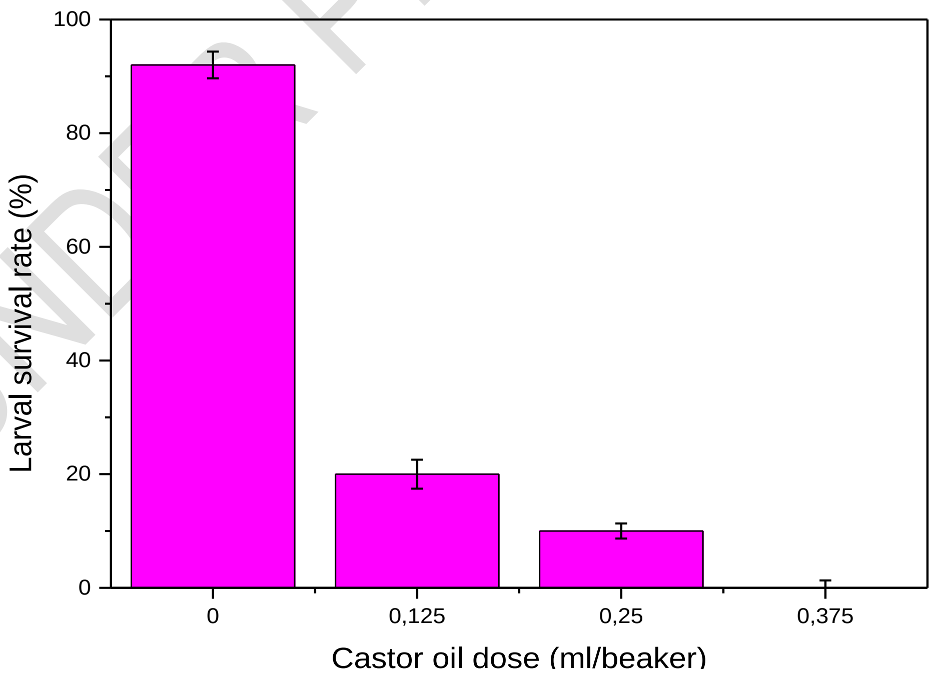

Figure 6: Effect of castor oil solution doses on the survival of L. orbonalis larvae

3.2. DISCUSSION

The experiment was conducted to assess the effect of castor oil doses on *Leucinodesorbonalis* L. On day 35, after transplantation, the presence of *Leucinodesorbonalis* L. was noted as reported by Tarnagda et *al.* (2017) [7] which states that Leucinodes infestation of aubergine fields occurs at all stages of development. In terms of productivity, D0 (control) gave 3 t/ha, while D1, D2 and D3 gave 5, 8 and 11.02 t/ha respectively. These results are in line with those obtained by Djagni et Fokl (2019)[5]who describe that experimentation with several biopesticides on *Leucinodesorbonalis* L. resulted in production yields between 3 t/ha and 14 t/ha.These results are also similar to those reported by Islam et *al.* (2016) [14], which show that the individual and combined use of buprofezin, emamectin benzoate, abamectin andspinosad generated a marketable fruit yield of 6.05 to 9.94 t/ha. They corroborate with that obtained by Silvosa et al. (2012) [16],according to which the test of the combined effect of bird's-foot pepper extract and spinosad made it possible to obtain a commercial aubergine yield of 10 t/ha.

The doses of castor oil tested in the trial proved effective in controlling *Leucinodesorbonalis* L. both under field conditions and in the in vitro test at the larval stage. The incidence of plant attack by Leucinodes before application of the castor oil solution was generally high for all treatments (39 to 46%). This incidence corroborates the idea of d'Owen et al.(2023)[4]which indicate that the incidence of attack on aubergine plants by Leucinodesorbonalis L. varies from 20 to 90 %. These values are lower than those given by [Article 10] which describes an infestation of 42.39 to 54.44% under field conditions. Application of castor oil reduced infestation by 10% for D1, 4% for D2 and 2% for D3. However, it should be noted that infestation increased by 68% for the control. These values are lower than those given by Tarnagda et al (2017) [7]who reported that the use of garlic extract on aubergine reduced the incidence of Leucinodes attack between 17.07 and 25.60%. Similarly, the use of neem oil enabled Owen et al (2023) [4]to reduce this attack threshold by between 3 and 5%.These rates are close to those given byKushwaha et *al.*(2016)[15].They state that three applications of flubendiamide 39.35 SC, chlorantraniliprole 20 SC, cypermethrin 25 EC, Spinosad 45 SC, indoxacarb 14.5 SC, fipronil 5 SC and imidacloprid 17.8 SL in the control of Leucinodesorbonalis stabilised the percentage of infestation between 2.98 and 11.59%. These results confirm the idea given by Kassi et *al.* (2019) [12]according to which, the combination of several extracts (papaya leaves, Jatropha leaves, tamarind fruit, tulsi leaves, onion bulb) and neem oil in the control of Leucinodesorbonalis on aubergine plants made it possible to maintain the threshold between 16.66 and 24.10%.Evaluation of the survival rate of *Leucinodesorbonalis* larvae after the in vitro test gave rates ranging from 0 to 92%. These rates are close to those obtained by Djagni and Fok (2010) [5]who stated that the rate of Leucinodesorbonalis after a biopesticide test varied from 55.56 to 83.70%.

However, those obtained by Hung et *al.* (2020) [13], which amounted to just 89.88% survival after a survival test of aged Leucinodesorbonalis larvae in the biological characterisation study, are included in the range obtained.

4. CONCLUSION

Climatic conditions were generally favourable for aubergine cultivation and for the proliferation of the pest *Leucinodesorbonalis* during the study period. The use of the doses of castor oil solution in the present study demonstrated its biopesticidal efficacy in the management of *Leucinodesorbonalis* in aubergine crops. The incidence of attack after application was 68% for D0; 10, 4 and 2% for D1, D2 and D3 respectively. The survival rate of *Leucinodesorbonalis* larvae after in vitro testing of the different doses of castor oil solution was 92% for D0 (control). The use of this castor oil had an impact on plant leaf removal. In terms of productivity, the use of castor oil influenced productivity. Castor oil could therefore be used to control *Leucinodesorbonalis* L without resorting to synthetic chemical insecticides.

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