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EFICACY OF ENDJULULU-KAPASSARINHO (*DATURA STRAMONIUM*) IN CONTROLLING *SPODOPTERA FRUGIPERDA* IN MAIZE (ZEA MAYS L.) IN VITRO[1]

EFICÁCIA DE ENDJULULU-KAPASSARINHO (*DATURA STRAMONIUM*) EM EL CONTROL DE *SPODOPTERA FRUGIPERDA* EN MAÍZ (ZEA MAYS L.) IN VITRO

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ABSTRACT: In order to control Spodoptera frugiperda in the maize crop in the laboratory, vegetative parts of the Edjululu-Kapassarinho plant were harvested, crushed and the concentrations formed: T0=0ml, T1=20ml, T2=40ml, T3=60ml, T4=80ml and T5=100ml. The caterpillars were collected and fasted for two hours before being placed in the treatment concentrations of each vegetative part for observation at times of 24, 48, 72, 96 and 120 hours respectively. The results showed that the fruit was the most active ingredient (Atropine, Hyoscyamine Scopolamine), followed by the stem, root and leaves, representing 60%, 27%, 24% and 13% respectively, with the leaves proving to be repellent to the caterpillars. Caterpillar mortality increased after 24 hours at all concentrations, showing 96% mortality with the stem-based extract, 98% with the leaf-based extract, 90% with the fruit-based extract and 79% with the root-based extract. In the statistical analysis observed at 5%, there was significant variation between treatments. In view of the results, the aqueous plant extract of the Endjululu-Kapassarinho plant (Datura Stramonium) proved to be effective in controlling the cartridge caterpillar in the maize crop in vitro.

Keywords: Bio-Extract. Datura Stramonium. Zea mays.

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RESUMEN: Para controlar Spodoptera frugiperda en el cultivo de maíz en el laboratorio, se cosecharon partes vegetativas de la planta Edjululu-Kapassarinho, se trituraron y se formaron las concentraciones: T0=0ml, T1=20ml, T2=40ml, T3=60ml, T4=80ml y T5=100ml. Las orugas se recogieron y ayunaron durante dos horas antes de colocarlas en las concentraciones de tratamiento de cada parte vegetativa para su observación a las 24, 48, 72, 96 y 120 horas respectivamente. Los resultados mostraron que el fruto era el ingrediente más activo (Atropina, Hiosciamina Escopolamina), seguido del tallo, la raíz y las hojas, que representaban el 60%, 27%, 24% y 13% respectivamente, resultando las hojas repelentes para las orugas. La mortalidad de las orugas aumentó tras 24 horas en todas las concentraciones, mostrando una mortalidad del 96% con el extracto a base de tallo, del 98% con el extracto a base de hojas, del 90% con el extracto a base de frutos y del 79% con el extracto a base de raíces. En el análisis estadístico observado al 5%, hubo una variación significativa entre los tratamientos. A la vista de los resultados, el extracto vegetal acuoso de la planta Endjululu-Kapassarinho (Datura Stramonium) demostró ser eficaz en el control de la oruga cartucho en el cultivo de maíz in vitro.

Palabras clave: Bioextracto. Datura Stramonium. Zea mays.

INTRODUCTION

Agriculture has been practiced by the Angolan population since ancient times, and there have always been problems due to the lack of technical information on pest management for most crops, the misinformation of technicians and farmers, the lack of agricultural policies centred on technical criteria, has resulted in low production, 40% of which is caused by the presence of pests, the efforts made to introduce chemicals to control these pests, which has caused environmental pollution, thus causing public health problems.

Many farmers are encouraged to abandon certain crops due to severe pest attacks, which require chemical control, although such chemicals are currently used with relative success in agriculture. The serious problems related to their use, which are widely known, have encouraged the development of alternative methods of control, as chemical insecticides represent very high costs in agricultural production, in addition to the social demand for pesticide-free products.

The management of this pest has been increasingly challenging for producers, causing serious problems for the crop, as control failures and environmental imbalance are factors that have potentiated the attack of these insect pests, making them resistant

to some insecticides and causing high population densities of insect pests in agricultural fields,

This study therefore set out to investigate an aqueous extract of Datura Stramonium (Endjululu-Kapassarinho) from the Solanaceae family with insecticidal properties for use as a bio-extract to control the Spodoptera Frugiperda caterpillar in maize.

MATERIALS AND METHODS

The trial was conducted in the Chemistry laboratory of the Instituto Superior Politécnico do Cuanza Sul (ISPCS), located in the municipality of Sumbe, province of Cuanza Sul, Angola, from January to June 2023. For the experiment, 30 plants averaging 1 metre in height were collected in the municipality of Cela in the province of Kwanza Sul, placed in a thermal box and transported on the same day to the place where the in vitro tests were carried out.

The harvested material was washed in a solution of distilled water (500 ml) for 6 minutes to reduce the possibility of fungal and bacterial contamination (Lovatto, Goetze & Thomé, 2004). A quantity of 100g was weighed out for each vegetative part, 750ml of distilled H_2O was added and each vegetative part was placed in a blender for three 15-second cycles. After grinding, the solutions were placed in a glass beaker with a graduation of up to 500 ml, strained to remove impurities, placed in a precipitation flask covered with a cork stopper, left to stand for 24 hours, resulting in the crude aqueous extract considered to be 100%.

For the laboratory test of Endjululu-kapassarinho (Datura Stramonium) extract doses, the extract rested for 24 hours, crude to a concentration of 100%, and from this crude product were diluted in different solutions of each vegetative part: T1 (20%±100ml), T2 (40%±100ml), T3 (60%±100ml), T4 (80%±100ml) and T5 (100%±100ml). For control T0 (0+%±100ml) only distilled water according to the methodology adapted from (Neto et al., 2019). For better handling, petri dishes were used for the 4 vegetative parts (Root, Stem, Leaves and Fruit). Six treatments were used for each vegetative part and three replicates for each treatment, with five caterpillars placed on each plate.

The third instar caterpillars were added individually, using a brush, to each cell of the plate containing the pieces of leaves dipped in the solutions, and an evaluation of the concentrations of the extract of different plant parts of Datura Stramonium (Endjululu-Kapassarinho) on the mortality of the corn rootworm caterpillar was possible at 24, 48, 72, 96 and 120 hours respectively.

The nutritional assessment of the caterpillars was carried out by calculating the Body Mass Index to check the nutritional status of the caterpillars in the same observation period, in order to understand whether Datura Stramonium has a repellent function against the cartridge caterpillar. Heights were measured with a 50 cm ruler, weight was measured using an electronic scale, and mortality was assessed every 24 hours after the bio-extract was applied. It should be noted that this formula has been adapted, as it is commonly used in health to calculate the body mass index to analyses the level of malnutrition and obesity, but the author of this work proposes to the field of Agriculture mainly in Plant Protection to analyses the repellent effect of the caterpillar, to understand the mortality of the caterpillar, if the extract has a repellent effect, it is understood as the quotient of the averages of the sums of the weight of the caterpillars for each treatment plate and its repetitions with the unit of measurement in grams, over the averages of the heights of the caterpillars for the plates and their repetitions with the unit of measurement of centimeter's as illustrated,

$$\frac{\pm\Sigma\, Weight\ (g)}{\pm\Sigma\, Height\ (\mathrm{Cm})^2}$$

The results were subjected to analysis of variance (ANOVA) to check for possible differences between the treatments and Tukey's test was applied at a 5% probability level using the Sisvar 5.7 statistical programmer (Ferreira, 2010). The graphs were made using the Microsoft Excel programmer, version 2019.

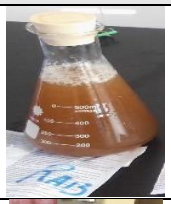
RESULTS

Evaluation of the degree of toxicity of the aqueous extract of the plant parts of Endjululu-Kapassarinho (Datura Stramonium).

From the aqueous extract of each plant part under study, the yield of the extract was assessed, where it was found that the aqueous extract of the root had a brownish color, the aqueous extract of the stem had a pale green color, the aqueous extract of the leaves

had a dark green color and the aqueous extract of the fruit had a deep brown color, as shown in Table 1.

Table 1 - Yields of crude extracts of *Datura Stramonium* (Endjululu-Kapassarinho), using the cold maceration process in distilled water solvent, in a ratio of 2:1 (w/v), from the different parts of the plant.

Plant structure	Syrup colour	Evidence	Material (g)	Income[1]	
				(ml)	%
Root	Chestnut		100	10	24
Stem	Pale green		100	10	27
Leaves	Dark green		100	10	13
Fruits	Loaded chestnut		100	10	60

Note: [1] obtained from the amount of vegetative material (g) ground in a blender

Table 1 shows the yields present in the quantity of aqueous extracts of *Datura Stramonium* obtained in the continuous quantitative variable of stramonine, which is the most abundant hallucinogen in the plant under study, which shows: for the roots it is 24%, the stem is 27%, the leaves are 13% and the fruit is 60%, and the color varies according to the vegetative part of the plant. It must be emphasized that these percentages of the yield from the vegetative part are very high, which is why they cause effects on the central nervous system, increasing the heart rate if consumed by humans.

Evaluation of the nutritional status of the caterpillars in the concentrations of methanolic extract of the different parts of Endjululu-Kapassarinho (Datura

Stramonium). The caterpillars (*Spodoptera frugiperda*) subjected to various concentrations were assessed for their nutritional status using the body mass index (BMI) as shown in Table 2.

Table 2 - Evaluation of the nutritional status of caterpillars subjected to concentrations of aqueous extract from the roots of Endjululu-Kapassarinho (Datura Stramonium).

Treatment	Weight (g)	±from the heights (cm²)	BMI	Body mass index (g/cm²) 24h		48h		72h		96h		120h	
				g	bmi	g	bmi	g	bmi	g	bmi	g	bmi
T_0	0,88	3	0,10	0,26	0,03	0,25	0,03	0,23	0,03	0,23	0,03	0,22	0,02
T_1	0,23	1,5	0,10	0,5	0,22	0,48	0,21	0,48	0,21	0,4	0,18	0,3	0,13
T_2	0,44	1,5	0,20	0,22	0,10	0,22	0,10	0,22	0,10	0,22	0,10	0,22	0,10
T_3	0,81	1,75	0,26	0,87	0,28	0,88	0,29	0,85	0,28	0,84	0,27	0,83	0,27
T_4	0,27	2,5	0,04	0,46	0,07	0,45	0,07	0,43	0,07	0,43	0,07	0,42	0,07
T_5	0,89	3,25	0,08	0,78	0,07	0,77	0,07	0,59	0,06	0,72	0,07	0,7	0,07
Total	**3,52**	**13,5**	**0,79**	**3,09**	**0,78**	**3,05**	**0,77**	**2,8**	**0,74**	**2,84**	**0,71**	**2,69**	**0,66**

Evaluation of the body mass index of the *Spodoptera frugiperda* caterpillars subjected to the aqueous extract of the roots, according to Table 2, shows that:

- For treatment To there was variation since the initial BMI was 0.10 g/cm², after 24h it dropped to 0.03 g/cm², maturing until 96h and a reduction and at 120h remaining at 0.02 g/cm².
- For treatment T1, the initial BMI was 0.10 g/cm², at 24 hours it increased to 0.22 g/cm², at 48 hours and 72 hours it fell by 2 grams, at 96 hours it fell by 3 grams and at 120 hours it fell by 5 grams, leaving a BMI of 0.13 g/cm².
- For T2, initially the BMI was 0.20 g/cm², at 24 hours the BMI dropped to 0.10 g/cm², and there was no variation at other times such as 48 hours, 72 hours, 96 hours and 120 hours.

- For T3, the initial BMI was 0.26 g/cm², and at other times such as 24h, 48h, 72h, 96h and 120h the BMI varied after rising and falling by around one gram.
- For T4, the initial BMI was 0.04 grams and at 24 hours it had risen to 0.07 g/cm², the same results being seen at subsequent times.
- For T5, the initial BMI was 0.08 g/cm², and after 24 hours it decreased to 0.07 g/cm², the same as in the subsequent times but with a slight variation in the order of 0.01g at 72 hours.

In view of these aspects, it is imperative to conclude that the aqueous extract of the roots of Endjululu-Kapassarinho does not have a repellent effect on the cartridge caterpillars (*Spodoptera frugiperda*) in maize, since their nutritional status did not vary significantly over the concentrations verified during the evaluation times.

Table 3 below shows the nutritional status of the caterpillars subjected to the concentrations of aqueous extract from the stem of Endjululu-Kapassarinho (*Datura Stramonium*).

Table 3- Evaluation of the nutritional status of caterpillars subjected to concentrations of aqueous extract of the stem of Endjululu-Kapassarinho (*Datura Stramonium*).

Treatment	Weight (g)	± from the heights (Cm²)	BMI	Body mass index g/cm²									
				24h		48h		72h		96h		120h	
				g	bmi	g	bmi	g	bmi	g	bmi	g	bmi
T_0	0,28	2,5	0,04	0,3	0,05	0,24	0,04	0,17	0,03	0,17	0,03	0,17	0,03
T_1	0,84	3	0,09	0,76	0,08	0,78	0,09	0,54	0,06	0,54	0,06	0,54	0,06
T_2	0,69	2,75	0,09	0,56	0,07	0,56	0,07	0,53	0,07	0,52	0,07	0,51	0,07
T_3	0,73	3	0,08	0,82	0,09	0,82	0,09	0,83	0,09	0,8	0,09	0,8	0,09
T_4	0,57	3,25	0,05	0,69	0,07	0,67	0,06	0,6	0,06	0,45	0,04	0,45	0,04
T_5	0,82	1,75	0,27	0,69	0,23	0,69	0,23	0,66	0,22	0,63	0,21	0,6	0,20
Total	**3,93**	**16,25**	**0,63**	**3,82**	**0,59**	**3,76**	**0,58**	**3,33**	**0,52**	**3,11**	**0,49**	**3,07**	**0,48**

Evaluation of the body mass index of Spodoptera frugiperda caterpillars subjected to the aqueous extract of the stem, according to Table 3, shows that:

- For treatment To, it has an initial BMI of 0.04 g/cm², after 24h it had a slight increase of 0.01 g, at 48h it dropped back to the initial grams, and at 72h there was again a reduction of 0.01g and it was maintained until 120h.

- For treatment T1, the initial BMI was 0.09 g/cm², at 24h it fell to 0.08 g/cm², at 48h there was an increase of 0.01g, which fell again at 96h and was maintained until 120h.
- For T2, the initial BMI was 0.09 g/cm², at 24 hours the BMI had dropped to 0.07 g/cm², the same as at the other testing times.
- For T3, the initial BMI was 0.08 g/cm², and at other times such as 24h, 48h, 72h, 96h and 120h the BMI rose to 0.09 g/cm².
- For T4, the initial BMI was 0.05 g/cm², and oscillations were seen rising and falling over time.
- For T5, the initial BMI was 0.27 g/cm², and at 24h and 48h it decreased to 0.23 g/cm², and at 72, 96 and 120h the BMI decreased by 0.2 and 0.1 respectively.

However, although studies need to be carried out on this subject, the T5 treatment so far has shown that with increasing time, the BMI dropped considerably, a fact that does not provide sufficient grounds for claiming that the aqueous extract of the stem of Endjululu-Kapassarinho exerts repellent effects against cartridge caterpillars (*Spodoptera frugiperda*) on maize.

Table 4 below shows the nutritional status of the caterpillars subjected to concentrations of aqueous extract from the leaves of Endjululu-Kapassarinho (*Datura Stramonium*).

Table 4 - Assessment of the nutritional status of caterpillars subjected to concentrations of aqueous extract of the leaves of Endjululu-Kapassarinho (*Datura Stramonium*).

Treatment	Weight (g)	± From the heigts (cm²)	Body mass index g/cm²									
			BMI	24h		48h		72h		96h		120h	
				g	bmi	g	bmi	g	bmi	g	bmi	g	bmi
T_0	0,26	2,5	0,04	0,26	0,04	0,16	0,03	0,13	0,02	0,13	0,02	0,13	0,02
T_1	0,29	2,25	0,06	0,28	0,06	0,23	0,05	0,13	0,03	0,11	0,02	0,1	0,02
T_2	0,3	2	0,08	0,3	0,08	0,24	0,06	0,17	0,04	0,16	0,04	0,15	0,04
T_3	0,49	2,25	0,10	0,44	0,09	0,41	0,08	0,33	0,07	0,27	0,05	0,22	0,04
T_4	0,25	1,5	0,11	0,29	0,13	0,34	0,15	0,31	0,14	0,31	0,14	0,3	0,13
T_5	0,99	1,25	0,63	0,99	0,63	0,98	0,63	0,93	0,60	0,89	0,57	0,86	0,55
Total	**2,31**	**11,75**	**0,84**	**2,56**	**1,02**	**2,36**	**0,99**	**2,00**	**0,89**	**1,87**	**0,84**	**1,76**	**0,81**

Evaluation of the body mass index of *Spodoptera frugiperda* caterpillars subjected to the aqueous extract of the leaves, as shown in Table 4, shows that:

- For treatment To there was variation since the initial BMI was 0.04 g/cm², the same verified at 24h, at 48h BMI of 0.03 g/cm², at 72, 96 and 120h BMI of 0.02 g/cm².
- Treatment T1 had an initial BMI of 0.06 g/cm², the same at 24h and at other times BMI decreased as time increased.
- For treatment T2, the initial BMI was 0.08 g/cm², the same as at 24 hours, at 48 hours the BMI dropped to 0.06 g/cm², while at 48, 72, 96 and 120 hours the BMI was 0.04 g/cm².
- For T3, the initial BMI is 0.10 g/cm², while at other times such as 24h, 48h, 72h, 96h and 120h the BMI drops by around 0.01gram.
- For T4, the initial BMI was 0. g/cm², until 48h the BMI went up by around 0.02g and remained there until 96h, while at 120h it dropped to 0.13 g/cm².
- For T5, the initial BMI was 0.63 g/cm², and at 24 and 48h it maintained the BMI initially verified, while until 120h it decreased on the scale of 0.03 to 0.02g.

Based on the nutritional assessment of the caterpillars subjected to the concentrations of the aqueous extract of the leaves of Endjululu-Kapassarinho, it is imperative to state that in all treatments there was a variation in the nutrition of the caterpillars losing weight, which affected their BMI.

Below is table 5, which shows the nutritional status of the caterpillars subjected to the concentrations of aqueous extract from the fruits of Endjululu-Kapassarinho (*Datura Stramonium*).

Table 5 - Assessment of the nutritional status of caterpillars subjected to concentrations of aqueous extract from the fruit of Endjululu-Kapassarinho (*Datura Stramonium*).

Treatment	Weight (g)	± from the heights (Cm²)	Body mass index g/cm²											
			BMI	24h		48h		72h		96h		120h	
				g	bmi	g	bmi	g	bmi	g	bmi	g	bmi
T_o	0,75	2,75	0,10	0,14	0,02	0,8	0,11	0,04	0,01	0,04	0,01	0,04	0,01
T_1	0,18	2,25	0,04	0,2	0,04	0,18	0,04	0,2	0,04	0,18	0,04	0,2	0,04

T_2	0,39	2,25	0,08	0,41	0,08	0,4	0,08	0,4	0,08	0,42	0,08	0,4	0,08
T_3	0,53	2,5	0,08	0,75	0,12	0,71	0,11	0,72	0,12	0,74	0,12	0,7	0,11
T_4	0,73	2,25	0,14	0,59	0,12	0,57	0,11	0,61	0,12	0,64	0,13	0,6	0,12
T_5	0,18	2,25	0,04	1,26	0,25	1,2	0,24	1,28	0,25	1,48	0,29	1,2	0,24
Total	**2,76**	**14,25**	**0,01**	**3,35**	**0,02**	**3,86**	**0,02**	**3,25**	**0,02**	**3,5**	**0,66**	**3,14**	**0,59**

Nutritional assessment using the body mass index of *Spodoptera frugiperda* caterpillars subjected to the aqueous extract of the fruit, as shown in Table 5, showed that:

- For treatment To, it has an initial BMI of 0.10 g/cm², after 24h it had a significant drop to 0.02 g/cm², at 48h the BMI increased significantly to 0.11 g/cm², and at 72, 96 and 120h it was around 0.01 g/cm².
- For treatment T1, the initial BMI was 0.04 g/cm²and there was no variation over time.
- For T2, the initial BMI was 0.08 g/cm², and there was no variation over time as the BMI remained the same as the T1 treatment.
- For T3, the initial BMI was 0.08 g/cm², and over other periods such as 24h, 48h, 72h, 96h and 120h the BMI fluctuated between 11 and 12 g/cm².
- For T4, the initial BMI was 0.14 g/cm², and there was an oscillation over time, going up and down between 11, 12 and 1312 g/cm².
- For T5, the initial BMI was 0.04 g/cm², and at 24, 48, 72, 96 and 120 hours, the BMI oscillated between 0.24, 0.25 and 0.29 g/cm².

For the aqueous extract of the fruits of Endjululu-Kapassarinho checked at various concentrations where the nutritional state of the caterpillars was assessed, it should be noted that there was a lot of variation, which leads to the conclusion that the aqueous extract of the fruits does not have repellent effects for the caterpillars of the cartridge beetle (*Spodoptera frugiperda*). This is because in T1 and T2, the body mass index remained at 0.04-0.08 g/cm² respectively. In T3, T4 and T5 the BMI fluctuated over time.

Mortality index of caterpillars (*spodoptera frugiperda*) subjected to concentrations of endjululu-kapassarinho (*datura stramonium*) roots at different residence times

Looking at graph 1, the mortality of the cartridge caterpillars (*Spodoptera frugiperda*) increased over time after the application of the aqueous extract of Endjululu-Kapassarinho.

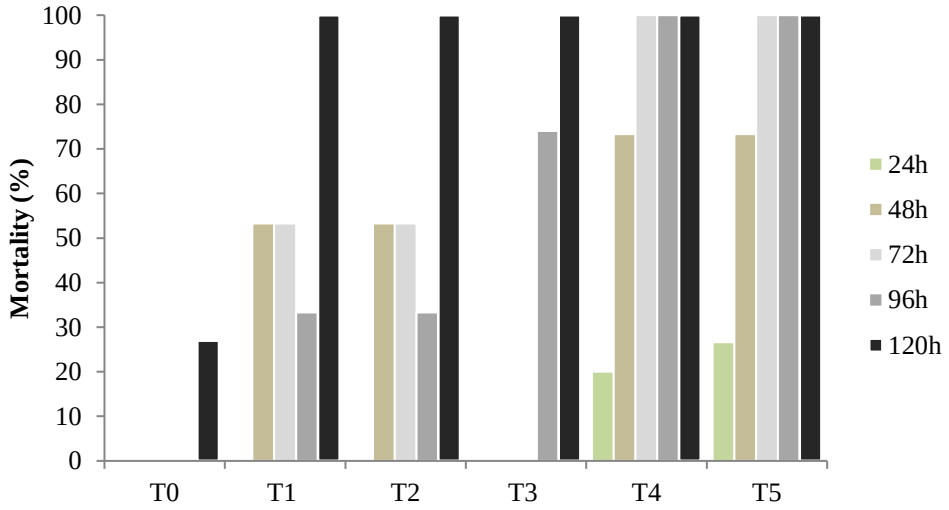
At 24 hours, treatment T5 showed a higher mortality rate than treatment T4 and there was no mortality in other treatments such as T3, T2, T1 and To during this period of time.

At 48 hours, treatments T5 and T4 had the highest mortality rate compared to treatments T3, T2, T1 and To, while treatments T2 and T1 had the same mortality rate compared to control treatments T3 and To.

At 72 hours, treatments T5 and T4 had a higher mortality rate than treatments T2 and T1, and treatments T2 and T1 had a higher mortality rate than treatments T3 and To.

At 96 hours, treatments T5 and T4 had a higher mortality rate than treatments T2 and T1, while treatment T3 had a lower mortality rate than the other treatments.

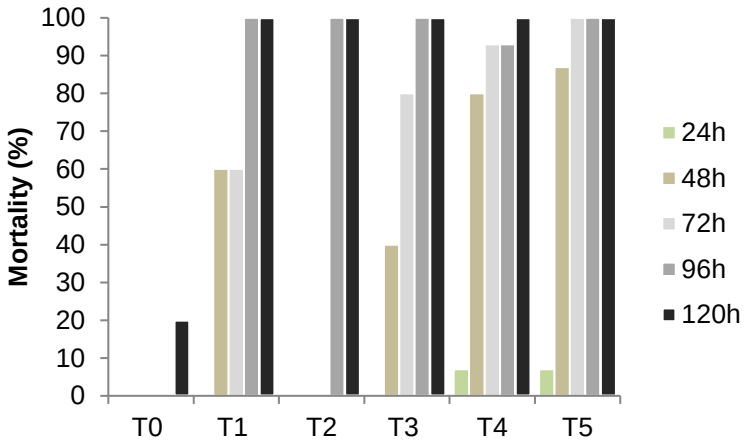
At 120 hours, treatments T5, T4, T3, T2 and T1 did not differ and showed higher mortality rates compared to treatment To. After 48 hours, treatments T5 and T4 did not differ from each other, but they did differ from other treatments T3, T2, T1 and To, which represents the control, and the same was true at 72 and 96 hours. There is a positive linear correlation because as time increases so does caterpillar mortality in the concentrations.



Graph 1 - Effectiveness of the aqueous extract based on the Root in controlling the cartridge caterpillar (*Spodoptera frugiperda*).

Graph 2 shows a positive linear correlation after the mortality of the cartridge caterpillars (*Spodoptera frugiperda*) increased over time exposed to the concentrations after the application of the aqueous extract of Endjululu-Kapassarinho, resulting in the following aspects:

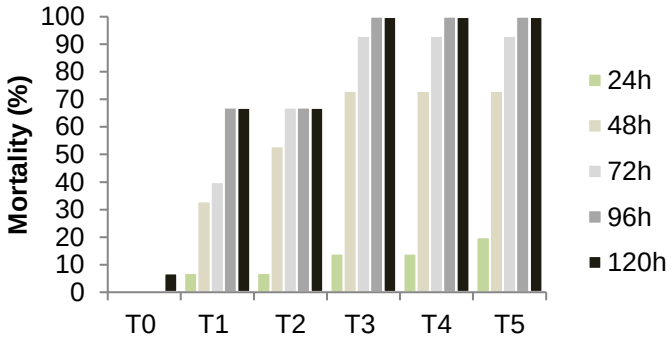
- At 24h the T4 treatment competes to the same extent as the 100% pure T5 treatment, showing higher mortality rates compared to the other treatments (T3, T2, T1 and To).
- At 48 hours, treatment T5 showed the highest mortality rate, differing from the other treatments such as T4, T3, T2, T1 and To. At the same time, the treatments differed from each other as follows (T4 >T1 >T3 >T2,To).
- At 72 hours, treatment T5 differed from treatment T4 in that it had a higher mortality rate and treatment T4 had a higher mortality rate than treatment T3, treatment T3 differed from treatment T1, and treatment T1 had a higher mortality rate than treatments T2 and To, which had no mortality during this period.
- At 96 hours, treatments T5, T3, T2 and T1 did not differ from each other, but they did differ from treatment T4, which had a lower mortality rate compared to the treatments (T5, T3, T2, T1) and a higher mortality rate compared to the control treatment (To).
- At 120 hours, treatments T5, T4, T3, T2 and T1 did not differ from each other and showed higher mortality rates compared to treatment To.



Graph 2 - Efficacy of the aqueous extract based on the stem in controlling the cartridge caterpillar Spodoptera frugiperda at different time intervals.

Graph 3 shows that the mortality of the cartridge caterpillars (*Spodoptera frugiperda*) increased over the time exposed to the concentrations, after the application of the aqueous extract of Endjululu-Kapassarinho, which demonstrates a positive linear correlation, resulting in the following aspects:

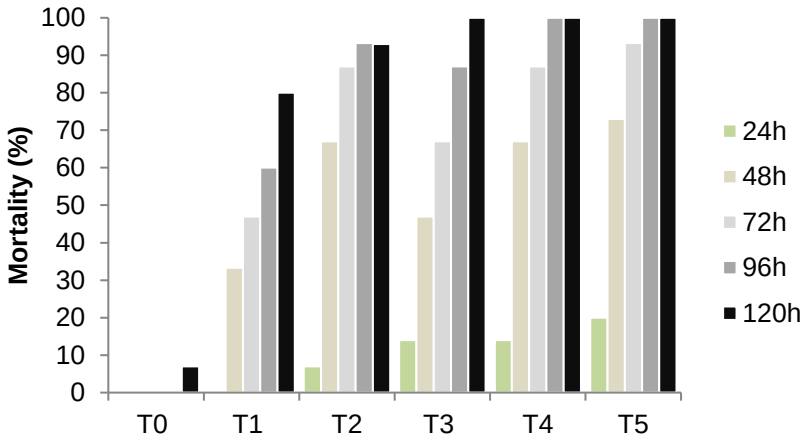
- At 24 hours, treatments T5, T4, T3, T2 and T1 showed mortality, but treatment T5 showed a higher mortality rate compared to treatment T4 and the same treatment (T4) did not differ in its results from treatment T3, both showing the same mortality rate compared to treatments T2 and T1, which also did not differ from each other.
- At 48 hours, treatments T5, T4 and T3 showed the highest mortality rates and did not differ from each other in their results, but they did differ from treatments T2, T1 and To. At the same time, treatment T2 showed a higher mortality rate than T1 and To showed no mortality.
- At 72 hours, treatments T5 did not differ from treatments T4, T3 and T2, showing higher mortality rates than treatments T2 and T2 showed a higher mortality rate than treatment T1, while treatment To showed no mortality during this period.
- At 96 hours, treatments T5, T4 and T3 did not differ from each other, but they did differ from treatments T2 and T1, which showed lower mortality rates compared to treatments (T5, T4 and T3).
- At 120 hours, compared to the observation in the previous hours, treatments T5, T4 and T3 did not differ from each other, but differed from treatments T2 and T1, which showed lower mortality rates compared to treatments (T5, T4 and T3) and treatments T2 and T1 showed higher mortality rates compared to the control To.



Graph 3 - Effectiveness of the aqueous leaf extract in controlling the cartridge caterpillar *Spodoptera frugiperda* at different time intervals.

Graph 4 shows the mortality of the cartridge caterpillars (*Spodoptera frugiperda*) as in all the experimental sub-treatments, increased over the time exposed to the concentrations, which shows a positive linear correlation, resulting in the following aspects:

- At 24 hours, treatments T5, T4, T3, T2 and T1 showed mortality, but treatment T5 showed a higher mortality rate compared to treatment T4 and the same treatment (T4) did not differ in its results from treatment T3, both showing the same mortality rate compared to treatment T2.
- At 48 hours, treatment T5 had a higher mortality rate than T4. At the same time point, T4 had the same mortality rate as T2, and both had a higher mortality rate than T3, T1 and To. T2 outperformed Treatment T3 in terms of caterpillar mortality and T3 showed a higher mortality rate than T1, while To showed no mortality; these results were verified again at 72 hours.
- At 96 hours, treatments T5 and T4 did not differ from each other, but they did differ from T3, T2 and T1. T2 had a higher mortality rate than T3 and T3 had a higher mortality rate than T1.
- At 120 hours, compared to the observations made in the previous hours, treatments T5, T4 and T3 did not differ from each other, but differed from treatments T2 and T1, which had lower mortality rates compared to treatments (T5, T4 and T3). Treatments T2 had a higher mortality rate than T1 and T1 had a higher mortality rate than the control.



Graph 4 - Effectiveness of fruit-based aqueous extracts in controlling the cartridge caterpillar (*Spodoptera frugiperda*).

STATISTICALLY ANALYZED RESULTS

The statistically analysed results on the mortality rate of the corn rootworm caterpillar (*Spodoptera frugiperda*), observed 24 hours after exposure to the different aqueous extracts of Endjululu-Kapassarinho (*Datura Stramonium*), showed that there were no statistically significant differences between the extracts used in the different concentrations, according to Tukey's test with a nominal value of 5% significance. On the other hand, it was also found that within the extracts used, they were statistically equal.

Table nº6- Analysis of variance of the extract within each concentration level over the 24-hour period.

FV		GL	SQ	QM	FC	Pr>Ec
EXTRACT	/To	3	0.000000	0.000000	0.000	1.0000
EXTRACT	/T1	3	100.000000	33.333333	0.310	0.8178
EXTRACT	/T2	3	133.333333	44.444444	0.414	0.7441
EXTRACT	/T3	3	533.333333	177.777778	1.655	0.1939
EXTRACT	/T4	3	633.333333	211.111111	1.966	0.1366
EXTRACT	/T5	3	633.333333	211.111111	1.966	0.1366
Error		36	3866.666667	107.407407		

Corn rootworm caterpillar mortality 48 hours after exposure to aqueous extracts of leaves, roots, stems and fruits of Endjululu-Kapassarinho (Datura Stramonium)

The results presented in Table 7 show that after 48% hours of applying the extracts to the corn rootworm caterpillars (*Spodoptera frugiperda*), there were no statistically significant differences in the percentage of caterpillar mortality between the different aqueous extracts (root, stem, leaf and fruit) and the concentrations used, according to the Tukey test at 5% significance.

Table 7 - Analysis of variance of the extract within each concentration level over 48 hours.

FV		GL	SQ	QM	FC	Pr>Ec
EXTRACT	/To	3	0.000000	0.000000	0.000	1.0000
EXTRACT	/T1	3	1700.000000	566.666667	1.654	0.1941
EXTRACT	/T2	3	1200.000000	400.000000	1.168	0.3356
EXTRACT	/T3	3	366.666667	122.222222	0.357	0.7845
EXTRACT	/T4	3	1200.000000	400.000000	1.168	0.3356
EXTRACT	/T5	3	400.000000	133.333333	0.389	0.7614
Error		36	12333.333333	342.592593		

Maize wireworm caterpillar mortality 72 hours after exposure to aqueous extracts of leaves, roots, stems and fruits of Endjululu-Kapassarinho (Datura Stramonium)

The results obtained on the percentage mortality of the corn rootworm caterpillars shown in Table 8, 72 hours after exposure to the aqueous extracts of the leaves, roots, stem and fruit of the Endjululu-Kapassarinho plant, show that there were no statistically significant differences between the aqueous extracts used and their respective concentrations, when Tukey's test was applied at 5% probability. **Table 8** - Analysis of variance of the extract within each concentration level over 72 hours.

FV		GL	SQ	QM	FC	Pr>Ec
EXTRACT	/To	3	0.000000	0.000000	0.000	1.0000
EXTRACT	/T1	3	366.666667	122.222222	0.363	0.7803
EXTRACT	/T2	3	1733.333333	577.777778	1.714	0.1814
EXTRACT	/T3	3	1966.666667	655.555556	1.945	0.1398
EXTRACT	/T4	3	1433.333333	477.777778	1.418	0.2535
EXTRACT	/T5	3	1166.666667	388.888889	1.154	0.3407
Error		36	12133.333333	337.037037		

Mortality of corn rootworm caterpillars 96 hours after exposure to aqueous extracts of leaves, roots, stems and fruits of Endjululu-Kapassarinho (Datura Stramonium)

After 96 hours of exposure to the different Endjululu-Kapassarinho extracts on the corn rootworm caterpillars, the results presented in Table 9 show that there were significant differences between the extracts used on the mortality rate of the corn rootworms, at concentrations of 20% and 60%, applying the Tukey test at 5% significance.

Table 9 - Analysis of variance of the extract within each concentration level over the 96-hour period.

FV		GL	SQ	QM	FC	Pr>Ec
EXTRACT	/To	3	0.000000	0.000000	0.000	1.0000
EXTRACT	/T1	3	3033.333333	1011.111111	3.269	0.0322
EXTRACT	/T2	3	666.666667	222.222222	0.719	0.5474
EXTRACT	/T3	3	5166.666667	1722.222222	5.569	0.0030
EXTRACT	/T4	3	400.000000	133.333333	0.431	0.7319
EXTRACT	/T5	3	1600.000000	533.333333	1.725	0.1793
Error		36	11133.333333	309.259259		

Mortality of the corn rootworm caterpillar 120 hours after exposure to aqueous extracts of the leaves, roots, stem and fruit of Endjululu-Kapassarinho (Datura Stramonium)

120 hours or even 5 days after applying the aqueous extracts of the leaves, roots, fruit and stem of the Endjululu-Kapassarinho (*Datura Stramonium*) plant to the corn rootworm caterpillars, it can be seen that there were no statistical differences between the extracts used either for each extract at the different concentrations used, according to Tukey's test, considering a 5% probability value.

Table 10 - Analysis of variance of the extract within each concentration level over 120 hours.

FV		GL	SQ	QM	FC	Pr>Ec
EXTRACT	/T0	3	900.000000	300.000000	0.723	0.5447
EXTRACT	/T1	3	2400.000000	800.000000	1.929	0.1424
EXTRACT	/T2	3	800.000000	266.666667	0.643	0.5925
EXTRACT	/T3	3	366.666667	122.222222	0.295	0.8291
EXTRACT	/T4	3	100.000000	33.333333	0.080	0.9705
EXTRACT	/T5	3	2500.000000	833.333333	2.009	0.1300
Error		36	14933.333333	414.814815		

The statistically analysed results indicate that the Endjululu-Kapassarinho (*Datura Stramonium*) showed a high mortality rate, in the different extracts of each plant part and in different concentrations, where T4 at all times of the aqueous extracts competed with T5, which is the pure concentration. These results are similar to those of Wu (2016), who obtained satisfactory mortality results after 24 hours of observation.

DISCUSSION

Granados-Echegoyn et al. (2016), in their study, the roots showed a higher content of active product compared to other parts of the Endjululu-Kapassarinho plant.

D'Ambrósio et al., (2017), say that the leaves of Endjululu-Kapassarinho contain 50% epoxy tropane alkaloids. Al-Snafi, (2017), says that the flowers of Endjululu-Kapassarinho contain 50% scopolamine and hyoscyamine (3%).

Lima, (2017) in his studies points out that in 100g of dried leaf material Datura Stramonium contained 16.83%, in the fruit in 100g of dried material he found 13.05% and in the stem in 85g of dried material he found 7.94% of the active product.

Flores-Villegas et al., (2019), in their studies found that the roots of Endjululu-Kapassarinho (*Datura Stramonium*) contained 9.7% of the yield, 5.7% in the stem and 7.1% in the leaves. Liu et al. (2020) state that the leaves of Datura Stramonium contain 20 to 60 per cent epoxy tropane alkaloids. The results are in agreement with Perez, Martinez, Hernandez and Rojas (1998), cited by Flores-Villegas et al., (2019), who stated that hyoscyamine has caused disorientation, dry mouth and throat, obstructed vision, hallucinations, dizziness and agitation and scopolamine produces delirium and death.

Ferreira & Furlanetto, (2018), reported the percentage of atropine and scopolamine in different stages of development and parts of Stramonium, the study suggested that the root contained lower levels of scopolamine than atropine and the same goes for the stem. The stem had almost three times more atropine than scopolamine, while the leaves and seeds had higher levels of scopolamine than atropine.

Srivastava et al., (2023), point out that the whole plant contains 26% alkaloids and the seeds contain 25% fatty oil, the stem contains more alkaloids at 30 to 40% volumetrically than even the seed, while the seeds contain more alkaloids than the leaves (21 to 23% in dry leaves and 27% for green leaves). However, the results of this study show that the fruits have the highest active principles with 60 per cent, followed by the stem with 27 per cent, the roots come third with 24 per cent and the leaves showed the lowest yields with 13 per cent.

Gobbo-Neto and Lopes (2007) cited by Lima (2017) emphasize that the time of collection of the species for the study of extract yield is a factor of major importance, because the quantity and nature of the chemical constituents are not constant throughout the year, associating these factors, plant age, plant development, structure, temperature, water availability, ultraviolet radiation and nutrient availability, however the yield of the extraction of the active principle from a plant can be influenced by various environmental factors that affect the accumulation of secondary compounds (Yang et al., 2019).

Tijani et al., (2012), says that although the plant contains active products, the seeds mixed with sorghum flour are used as a poisonous bait to control rats and rodents in open fields and warehouses.

The results found are supported by Sefton (2012), who says that there is a high degree of toxicity of this plant of Endjululu- Kapassarinho (*Datura Stramonium*) in all its vegetative parts, so the use of this plant causes dryness in the mouth, decreased secretions, redness and dryness of the skin, hyperthermia, difficulty in urination, hallucinations, retention of urine. Teixeira & Lima, (2020), say that this plant has concentrations of atropine, hyoscyamine and some alkaloids.

Bezerra et al., (2021) and Srivastava et al., (2023), who say that reports coming from Tanzania, an extract made from this species, but taken from the root, has been tried in domestic spraying to repel snakes and scare them away from houses, which indicates that extracts of this plant have been used in experiments to verify their degree of repellency, the same verified in the present study.

The results of the present study are in line with Lima (2017), who in his tests on the leaves of Datura Stramonium found that the aqueous extract of the leaves of Datura Stramonium provided the lowest weights in the larvae of *Spodoptera frugiperda* in the order of 1.86 mg, after Sefton, (2012) says that the use of Datura Stramonium as a pesticide and repellent is widespread in many countries. It has been used to repel rats from domestic pantries, for rodents in stables and corrals, and in the case of orchards it is already possible to grow it on a large scale to keep rats and other rodents out of the orchard.

D'Ambrósio et al. (2017) say that Datura Stramonium is used to repel moles, crop ants, aphids and whitefly in watermelon cultivation by boiling the root. Ferreira & Furlanetto (2018) say that in some European countries the juice of the leaves is given with hot milk to ward off intestinal worms, specifically tapeworms.

However, given these aspects and the verification of the leaves placed on the plates where the caterpillars were placed, there were few leaves consumed by the caterpillars, which leads us to affirm that the leaves exert repellent effects on the cartridge caterpillars (*Spodoptera frugiperda*) in maize, since their nutritional status varied significantly over the concentrations verified over the evaluation times.

Granados-Echegoyn et al. (2016) state that the susceptibility was manifested after 24 hours, when a significant increase was observed, which shows the insecticidal potential of the aqueous extracts of Endjululu-Kapassarinho (Datura Stramonium), results that are in line with those observed in the present study.

(2019), on the Efficiency of the plant extract of *Datura stramonium* L. as an insecticide for the control of the sierra fly, states that in the structures analyzed it contained tropine alkaloids and the toxicity is due to the fact that the alkaloids contain a methylated nitrogen atom (N-CH3), which makes this plant to be considered a potential organic insecticide.

In general, the mortality of the caterpillars in each vegetative part observed at each time was positively related to the concentrations applied, since they caused significant mortality when Tukey's tests were applied at a 5% probability level on the caterpillars of the maize leafhopper (*Spodoptera Frugiperda*). However, it can be said that the use of Endjululu-kapassarinho (*Datura Stramonium*) plant extract can be an alternative for controlling *Spodoptera frugiperda*, as well as being efficient in the first application, it has continued to prove itself as a valuable insecticide to use.

CONCLUSIONS

In view of the results presented in this research, which is by the way the first in the province of Kwanza-Sul and in Angola in general to be used to control the caterpillars of the maize cartridge, interesting conclusions were drawn as shown:

The yield of crude extract of Endjululu-Kapassarinho, by means of the cold maceration process in distilled water solvent, in the proportion of 2:1 (w/v), of the different parts of the plant showed that the fruit had the highest active principles (Atropine, Hyoscyamine scopolamine) with 60%, followed by the stem with 27%, the roots came third with 24% and the leaves showed the lowest yields with 13%. These alkaloids act directly on the central nervous system of the insect as observed in this study.

The mortality of the caterpillars (*Spodoptera frugiperda*) varied between the concentrations of the vegetative parts of Endjululu-Kapassarinho, increasing over time. Increasing doses of the treatment concentrations and time resulted in higher mortality and reduced significant differences between treatments.

The aqueous plant extract based on the Endjululu-Kapassarinho plant (Datura Stramonium) proved to be effective in controlling the caterpillar on maize after 24 hours. The aqueous extract of Endjululu-Kapassarinho (Datura Stramonium) is an

effective bioinsecticide for controlling the cartridge caterpillar in maize and could be an ecological alternative for controlling *Spodoptera frugiperda* caterpillars.

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