Research Article
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Efficacy of Endjululu-Kapassarinho (*Datura Stramonium*) in controlling fall armyworm (*Spodoptera Frugiperda*) in corn (Zea mays L.)

Summary

The work aimed of analyzing the effectiveness of extracts obtained from the different plant parts of Endjululu-Kapassarinho (*Datura Stramonium*) in controlling the third instar cartridge caterpillar (*Spodoptera frugiperda*) in maize (Zea mays L.). Research into biological control methods is emerging as a prime alternative to bio-insecticides. This is a qualitative-quantitative trial, conducted in the Chemistry laboratory of the Instituto Superior Politécnico of Cuanza Sul and Instituto Técnico Agrário to Waku Kungo, from January to June 2023. For the study, vegetative parts of the Edjululu-Kapassarinho plant were collected, crushed and the concentrations formed: T0=0ml, T1=20ml, T2=40ml, T3=60ml, T4=80ml and T5=100ml. Using the zigzag routing method, the caterpillars were collected and then fasted for two hours before being placed in the treatment concentrations of each vegetative part for observation at 24, 48, 72, 96 and 120 hours respectively. Caterpillar mortality increased after 24 hours at all concentrations, showing 98% mortality with the leaf-based extract, 96% with the stem-based extract, 90% with the fruit-based extract and 79% with the root-based extract. In view of the results, the aqueous plant extracts of the Endjululu-Kapassarinho plant (*Datura Stramonium*) proved to be efficient in controlling the cartridge caterpillar, with the leaf-based extract, and is the effective extract for controlling the cartridge caterpillar in the maize crop, ecological, preserving the environment.

Keywords: ISPCS, bio-extract, concentration, datura stramonium

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Victorino Correia Kinhama,[1] Fernando Francisco de Sousa Neto[2]

[1]Master's student in Plant Protection at the Instituto Superior Politécnico do Cuanza Sul, Angola

[2]Professor of the Department of Scientific Research, IE and Postgraduate Studies at the Instituto Superior Politécnico do Cuanza Sul, Angola

Correspondence: Victorino Correia Kinhama, Master's student in Plant Protection at the Instituto Superior Politécnico do Cuanza Sul, Angola, Email vorenocorreia@gmail.com

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Introduction

Agriculture has been practiced by the Angolan population since ancient times, there have always been problems due to the lack of technical information on pest management for most crops, the lack of information from technicians and farmers, the lack of agricultural policies centered on criteria technicians, has resulted in low production, and that 40% of the losses are damages caused by the presence of pests, the efforts applied with the insertion of chemicals to control these pests, which have caused environmental pollution, thus bringing public health problems.

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

The Angolan government, concerned about the situation with the emergence of pests and pesticides, has always looked for alternative measures that achieve satisfactory results, introducing Law no. 5/21, 3 February, Plant Health Law, published in Diário da República Iª Série- no. 23 of Wednesday.

Plant extracts applied as insecticides are gaining ground, as products obtained from plants are renewable and degradable, in addition to reducing problems with the resistant population of pests, as their resistance is slow compared to these products.[1]

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 increased the attack of such insect pests, leaving it resistant to some insecticides and causing the occurrence of high population densities of insect pests in agricultural fields, thus leading to low crop yields even in corn (Zea mays L.) due to attack by the fall armyworm (*Spodoptra Frugiperda*).

In Angola, particularly in Cuanza Sul, corn is cultivated by small, medium and large producers, as it represents an important socioeconomic cereal for the people of Cuanza Sul. Scientific research shows that corn is part of the daily diet of approximately 90% of the population. According to IIA, (2005); Manuel, (2011) cited by Teixeira & Lima,[2] point out that the production of the Zea mays L. crop, in Angola, is limited by several factors, among them the key corn pest the caterpillar stands out. -cartridge (*Spodoptera Frugiperda*), as it is found in all stages and organs of the plant.

To mitigate the insufficiencies observed in the control of the pest in corn crops, alternative measures are necessary that achieve satisfactory results; for this, research into biological control methods appears as primary alternatives.[1]

With the current problem of the fall armyworm attack, in the production of corn crops, where more than 40% of production is destroyed in different regions, not only in Angola, Africa and throughout the world, large sums of values are used when purchasing chemical insecticides. With this, there is a need to prepare an aqueous extract of *Datura Stramonium* (Endjululu-Kapassarinho) and will it be known how effective it is in controlling the fall armyworm (*Spodoptera frugiperda*) in corn crops?

Therefore, the present work proposed the investigation of an aqueous extract of Endjululu-Kapassarinho (*Datura Stramonium*) from the solanaceous family with repellent or insecticidal properties for use as an insecticide in the control of the fall armyworm in corn (*Spodoptera Frugiperda*), which is the pest key to corn farming in Angola.

For the first time, it was seen that the extract of *Datura Stramonium* (Endjululu-Kapassarinho) is effective in controlling the fall armyworm (*Spidoptera frugiperda*) in corn (zea mays L.) crops, which will increase productivity, crop production and save large sums of money on purchasing chemicals.

General objective

To analyze the effectiveness of extracts obtained from different plant parts of Endjululu-Kapassarinho (*Datura Stramonium*), (Root, Stem, Leaves, fruit and flowers) in controlling the fall armyworm (*Spodoptera frugiperda*) of the third instar in the crop corn (Zea mays L.).

Materials and methods

Test location

The test is qualitative and quantitative in nature, conducted in the Chemistry laboratory of the Instituto Superior Politécnico do Cuanza Sul (ISPCS) and Instituto Técnico Agrario do Waku Kungo (ITAWK), located in the municipality of Sumbe and municipality of Cela, respectively, Province of Cuanza South, Angola, from January to June of 2023, following the stages of bibliographical research and methodology selection.

Endjululu-Kapassarinho (Datura Stramonium) collection site

As it is a spontaneously growing plant, it is almost always found in sewers, dumpsters and at the ends of roads and production fields. For the experiment, 30 plants with an average height of 1 meter were collected, in an empty plot of land close to road 120, in the vicinity of the Rosa Tchilepa hotel complex, to the south, to the west the homemade Chorisso Restaurant and to the east the military police unit of Demining as shown in Figure 1.

Figure 1 Collection site for Endjululu-Kapassarinho (Datura Stramonium) in the municipality of Cela. Source: Google Earth Pro (Android System).

Preparation of aqueous extract of Endjululu-Kapassarinho (Datura Stramonium)

The collected material was washed in a solution with distilled water (500 ml) for 6 minutes, to reduce the possibility of fungal and bacterial contamination.[3] With the clean material, the parts of the plants were separated and placed separately, an amount of 100g was weighed for each vegetative part, 750 ml of distilled H_2O was added, and placed in the blender in three cycles of 15 seconds for each vegetative part. After grinding, the solutions were placed in a glass beaker measuring up to 500 ml, strained to remove impurities, placed in a precipitation flask covered with a cork stopper, left to rest for 24 hours, resulting in the crude aqueous extract considered the 100% of the syrup as shown in Figure 2.

Figure 2 Aqueous extract of the vegetative parts of Endjululu-Kapassarinho (Datura Stramonium). Source: author (2023).

Place and method of collecting the Fall Armyworm in Corn (Spodoptera frugiperda)

The fall armyworm (*Spodoptera frugiperda*) was collected in a corn production area located in agroecological region 17, on the outskirts of the municipality of Cela, city of Waku-kungo which is positioned at the coordinates of 11° 33' 43" S 15 ° 28' 58" in the 2022/2023 agricultural season. To collect the caterpillar, the procedures used by Agropós, 2020 cited by Kinhama et al.,[4] were followed, which is random sampling in a Zig-Zague fashion in an area of 50/25, totaling 1250 square meters. *Spodoptera frugiperda* caterpillars from the 3rd instar were collected. After collection, they were kept without food for six hours, waiting for the biological tests to begin.[5]

They were transported to the laboratory in a 1000 ml plastic container, perforated on the sides for oxygen circulation, avoiding premature death of the caterpillars, at room temperature to the Biology laboratory of the Instituto Superior Politécnico do Cuanza Sul.

Dose formulation of the aqueous plant extract of Endjululu- Kapassarinho (Datura Stramonium)

For the laboratory test of doses of Endjululu-kapassarinho (*Datura Stramonium*) extract, the extract rested for 24 hours, crude at 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 the T0 control (0+%±100ml) only distilled water according to the methodology adapted from Neto et al.,[6] For better handling, petri dishes were used, with the 4 vegetative parts. Six treatments were used for each vegetative part and three replications for each treatment, making 18 plates for each solution, totaling 72 plates in total, containing 5 caterpillars in each disc, totaling 360 caterpillars.

Procedures for evaluated parameters

To determine the effectiveness of the different plant parts of Endjululu-Kapassarinho (*Datura Stramonium*) in controlling the fall armyworm, it was necessary to cut pieces of young corn leaves, collected in the same field where the Spodoptera fall armyworms were collected. frugiperda, in the same size (4x3cm), immersed for one minute in the concentrations of each vegetative part, following the same procedure for the control treatment. After dipping the

leaves in the solutions, they were placed in a petri dish, repeating daily until the end of the experiment. The 3rd instar caterpillars were added individually, with the help of a brush, to each cell of the plate containing the pieces of leaves dipped in the solutions. The plates with the bioassays were covered and kept in the laboratory at room temperature.

When evaluating the time in extract concentrations from different plant parts of Endjululu-Kapassarinho (*Datura Stramonium*) on fall armyworm mortality in corn, it was possible to reach 24, 48, 72, 96 and 120 hours respectively. At this point, the number of dead caterpillars was recorded after each treatment. Individuals who, when touched with the tip of a brush in the last abdominal segments, did not respond with coordinated movements, were considered dead caterpillars.

The frequency distributions of the grouped data of the vegetative parts of the Endjululu-kapassarinho (Datura Stramonium) plant in the control of the fall armyworm were made using the Sturges formula where the class number (K= 1+3, 33.log (N) where K is the class interval, N= is the total number of the experiment), total amplitude (At= Maximum value subtracting the minimum value) and interval amplitude (Ai= At/K). To form the table, the number of caterpillars used in each treatment of the vegetative part was entered, dead caterpillars in the treatment that showed greater effectiveness of the vegetative parts (fi), the relative frequency (fri), percentage relative frequency (fri%) were analyzed.) of these, the accumulated absolute frequency (faci) was obtained, also the relative accumulated frequency (fraci) and the relative cumulative percentage (fraci%) formula presented by Tomás,[7].

In 24 hours, treatment T5 had a higher mortality rate compared to treatment T4 and there was no mortality in other treatments such as T3, T2, T1 and T0 in this observed period.

At 48h, treatments T5 and T4 presented a higher mortality rate on an equal footing in relation to treatments T3, T2, T1 and T0, at the same time, Treatments T2 and T1 presented the same mortality rate in relation to treatments T3 and T0. control.

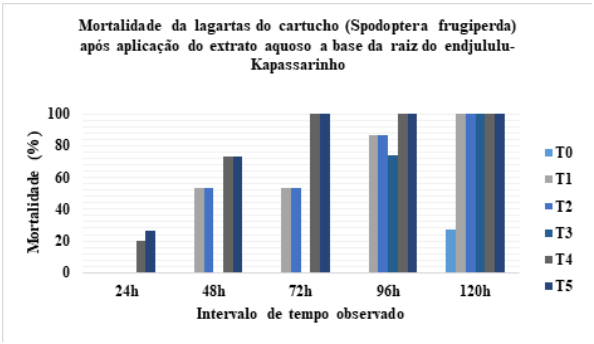
At 72h, treatments T5 and T4 had a higher mortality rate compared to treatments T2 and T1, and treatments T2 and T1 had a higher mortality rate than treatments T3 and T0.

Results and discussions

The evaluation of the effectiveness of Endjululu-Kapassarinho (*Datura Stramonium*) in controlling fall armyworm (*Spodoptera frugiperda*) in Corn (Zea Mays L.) was carried out using the vegetative parts of the plant to obtain probable data that, parts of the plant may be more effective in controlling fall armyworm.

Mortality rate of caterpillars (Spodoptera frugiperda) subjected to concentrations of Endjululu-Kapassarinho (Datura Stramonium) roots at different residence times.

Looking at Graph 1, the mortality of fall armyworms (*Spodoptera frugiperda*) increased over time after the application of the aqueous extract of Endjululu-Kapassarinho.



Graph 1 Efficacy of the Root-based aqueous extract in controlling the fall armyworm (*Spodoptera frugiperda).*

At 96h, treatments T5 and T4 had a higher death rate compared to treatments T2 and T1, while Treatment T3 had a lower mortality rate compared to the other treatments.

At 120h, treatments T5, T4, T3, T2 and T1 do not differ from each other and present higher mortality rates compared to treatment T0. From 48h onwards, treatments T5 and T4 did not differ between, yes, but they differed with other treatments T3, T2, T1 and T0 which represents control, the same observed at 72 and 96h. There is a positive linear correlation because as time increases, caterpillar mortality also increases at concentrations (Table 1).

Table 1 Frequency distribution of grouped caterpillar mortality data in the aqueous extract of the root of Endjululu-Kapassarinho (Datura Stramonium) in the control of fall armyworm

Designation	Times	fi (mortality)	fri	Fri%	faci	fraci	Fraci%
X1	24-36	7	0.1	10	7	0.1	10
X2	36-48	24	0.3	30	31	0.39	39
X3	48-60	0	0	0	31	0.39	39
X4	60-72	13	0.16	16	44	0.55	55
X5	72-84	0	0	0	44	0.55	55
X6	84-96	19	0.24	24	63	0.79	79
X7	96-108	0	0	0	63	0.79	79
X8	108-120	16	0.2	20	79	1	100
	Total	79	1	100			

X1 = 7: In the period of 24 to 36h verified death of 7 caterpillars in all treatments, which corresponds to a relative frequency of 0.1 and percentage of 10%, *f* (x1 = 24-36) = 7.

X2: In the range up to 48h has a 24-caterpillars mortality show in all treatments that correspond to a relative frequency of 0.30 and with a percentage of 30%, *f* (x2 = 36-48) = 24.

X3: In the 48–60H interval there was no death of the caterpillars in all treatments, it remaining 31 accumulated absolute frequency and 39% of the percentage accumulated relative frequency, *f* (x3 = 48-60) = 0.

Citation: Kinhama VC, Sousa Neto FF. Efficacy of Endjululu-Kapassarinho (Datura Stramonium) in controlling fall armyworm (Spodoptera Frugiperda) in corn (Zea mays L.). *MOJ Eco Environ Sci.* 2023;8(6):229–238. DOI: 10.15406/mojes.2023.08.00297

X4: At 60-72h interval has a 13-caterpillars show at all treatments with a relative frequency of 0.16 and a percentage of the accumulated relative frequency of 55%, *f* (x4 = 60-72) = 13.

X5: in the interval of 72-85h there were no deaths, *f* (x5=76-89)=0.

X6: In the interval of 86-96h, it presented a death in all 19 treatments that correspond to 0.24 relative frequency and a percentage 79 of accumulated relative frequency, *f* (x6 = 86-96) = 19.

X7: in the interval of 96-108h there was no death of the caterpillars in all treatments, *f* (x7=96-108)=0.

X8: At the time of 108-120 there was a 16-caterpillars mortality sample in all concentrations that correspond to 0.20 relative frequency and 79% accumulated relative frequency, *f* (x8 = 108-120) = 16.

Mortality rate of the caterpillar (Spodoptera frugiperda) subjected to concentrations based on extract from the stem of Endjululu-Kapassarinho (Datura Stramonium) at different time intervals.

From Graph 2, it shows a positive linear correlation after the mortality of fall armyworms (*Spodoptera frugiperda*) increase over time exposed in concentrations after application of the aqueous extract of Endjululu-Kapassarinho resulting in the following aspects:

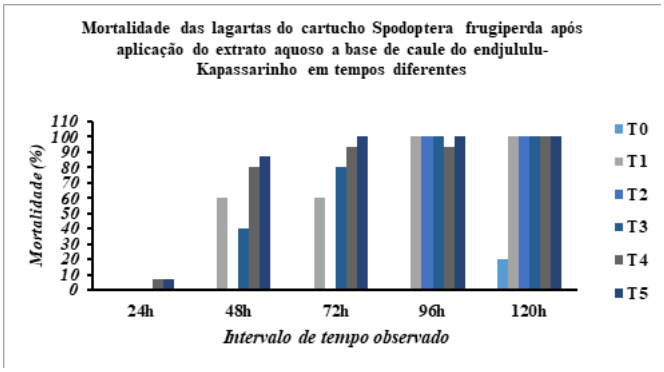
a) In 24 hours, the T4 treatment competes in the same proportion with the 100% pure T5 treatment, presenting a higher mortality rate compared to the other treatments (T3, T2, T1 and T0).

b) At 48 hours, treatment T5 has a higher mortality rate, differentiating itself from other treatments such as T4, T3, T2, T1 and T0. At the same observed time, the treatments differ in the following way (T4 >T1 >T3 >T2,T0).

c) At 72h, T5 treatments differ from T4 treatment, presenting a higher mortality rate, and T4 treatment presents a higher mortality rate than T3 treatment, T3 treatment differs from T1 treatment, and T1 treatment presents higher mortality than treatments T2 and T0 that there was no mortality in this observed period.

d) At 96h, treatments T5, T3, T2 and T1 do not differ from each other, but differ from treatment T4, which presented a lower mortality rate compared to treatments (T5, T3, T2, T1) and presents a higher mortality rate compared to treatment control (T0).

e) At 120h, treatments T5, T4, T3, T2 and T1 do not differ from each other and present higher mortality rates compared to treatment T0 (Table 2).



Graph 2 Efficacy of aqueous extracts based on the stem in controlling the fall armyworm *Spodoptera frugiperda* at different time intervals.

Table 2 Frequency distribution of grouped data on caterpillar mortality in the aqueous extract at the base of the stem of the Endjululu-Kapassarinho (Datura Stramonium) plant in the control of fall armyworm

Designation	Times	fi (mortality)	fri	Fri%	faci	fraci	Fraci%
X1	24-36	1	0.01	1	1	0.01	1
X2	36-48	39	0.5	50	40	0.51	51
X3	48-60	0	0	0	40	0.51	51
X4	60-72	11	0.14	14	51	0.65	65
X5	72-84	0	0	0	51	0.61	61
X6	84-96	24	0.3	30	75	0.96	96
X7	96-108	0	0	0	75	0.96	96
X8	108-120	3	0.03	3	78	1	100
	Total	78	1	100			

X1 = 7: In the period of 24 to 36h verified death of a caterpillar in all treatments, which corresponds to a relative frequency of 0.01 and percentage of 1%, *f* (x1 = 24-36) = 1.

X2: At 36 to 48h interval has a mortality show of 39 caterpillars in all treatments that correspond to a relative frequency of 0.50 and with a percentage of 50% *f* (x2 = 36-48) = 39.

X3: In the 48–60H interval there was no death of the caterpillars in all treatments, it remaining 40 accumulated absolute frequency and 51% of the percentage accumulated relative frequency, *f* (x3 = 48-60) = 0.

X4: At 60-72h interval has a show of 11 katerprokes in all treatments with a relative frequency of 0.14 and one, percentage of the accumulated relative frequency of 65%, *f* (x4 = 60-72) = 11.

X5: In the interval of 72-84h there was no death, remaining with 51 of accumulated absolute frequency and 51% of accumulated relative frequency, *f* (x5 = 76-89) = 0.

X6: In the interval of 84-96h, it presented a death in all 24 caterpillars treatments that correspond to 0.30 of relative frequency and a percentage 96 of accumulated relative frequency. *f* (x6=84-96)=24.

X7: At 96-108 hours there was no death of caterpillars in all treatments, remaining with 75 accumulated absolute frequency and 96% percentage accumulated frequency, *f* (x7 = 96-108) = 0.

X8: In the interval of 108-120h, there was a mortality sample of 3 caterpillars in all concentrations that correspond to 0.03 relative frequency and 96% accumulated relative frequency *f* (x8 = 108-120) = 3.

Citation: Kinhama VC, Sousa Neto FF. Efficacy of Endjululu-Kapassarinho (Datura Stramonium) in controlling fall armyworm (Spodoptera Frugiperda) in corn (Zea mays L.). *MOJ Eco Environ Sci.* 2023;8(6):229–238. DOI: 10.15406/mojes.2023.08.00297

The frequency of the 36-48h time interval presents the highest absolute frequency of caterpillar mortality in different treatments with 96% dead caterpillars, results that are similar to the results of Wu et al., (2016) cited by Flores -Villegas et al.,[8] who found a mortality rate of 39%.

For Lima,[9] in studies with aqueous extract from the stem of *Datura Stramonium*, mortality was found to be 3.57±1.60 and in studies by Flores-Villegas et al.,[8] which obtained a mortality rate of around 30%, after 24 hours, which constitutes clear proof of the insecticidal potential of aqueous extracts of Edjululu-Kapassarinho (*Datura Stramonium*).

Mortality rate of the caterpillar (Spodoptera frugiperda) subjected to concentrations of Endjululu-Kapassarinho (Datura Stramonium) leaves at different time intervals

From the illustration in Graph 3, the mortality of fall armyworms (*Spodoptera frugiperda*) increased over time exposed in concentrations, after application of the aqueous extract of Endjululu-Kapassarinho, which demonstrates a positive linear correlation, resulting in the following aspects:

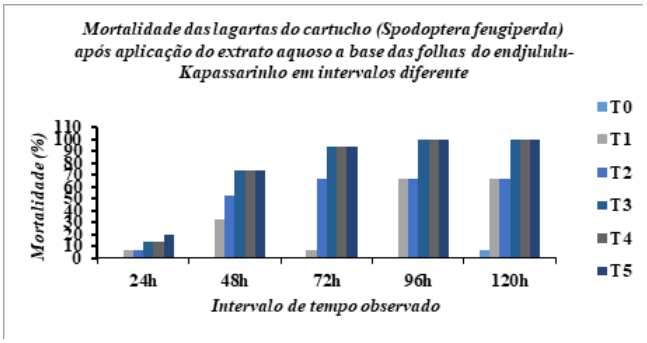
i. In 24 hours, treatments T5, T4, T3, T2 and T1 present mortality, but treatment T5 presents a higher mortality rate in relation to Treatment T4 and the same treatment (T4) does not differ in its results with treatment T3, both present the same mortality rate in relation to T2 and T1 treatments, which also do not differ from each other.

ii. At 48h, treatments T5, T4 and T3 present a higher mortality rate and do not differ from each other in their results, but they differ from treatments T2, T1 and T0, at the same time observed, Treatment T2 presented a higher mortality rate than T1 and T0 showed no mortality.

iii. At 72h, treatments T5 did not differ from Treatment T4, T3, T2, presenting higher mortality rates compared to Treatment T2 and T2 presented a higher mortality rate than treatment T1, treatment T0 did not present mortality at this time.

iv. At 96h, treatments T5, T4 and T3 do not differ, but they differ from treatments T2 and T1, which presented lower mortality rates compared to treatments (T5, T4 and T3).

v. At 120h, compared to observation in the previous hours, treatments T5, T4 and T3 do not differ from each other, but differ from treatments T2 and T1, which showed lower mortality rates compared to treatments (T5, T4 and T3) and treatments T2 and T1 presented higher mortality rates compared to the control T0 (Table 3).



Graph 3 Efficacy of aqueous leaf extracts in controlling the fall armyworm *Spodoptera frugiperda* at different time intervals.

Table 3 Frequency distribution of grouped data on caterpillar mortality in the aqueous extract of the leaves of the Endjululu-Kapassarinho plant (Datura Stramonium) in the control of fall armyworm

Designation	Times	fi (mortality)	fri	Fri%	faci	fraci	Fraci%
X1	24-36	9	0.13	13	9	0.13	13
X2	36-48	37	0.56	56	46	0.7	70
X3	48-60	0	0	0	46	0.7	70
X4	60-72	13	0.2	20	59	0.9	90
X5	72-84	0	0	0	59	0.9	90
X6	84-96	6	0.1	10	65	0.98	98
X7	96-108	0	0	0	65	0.98	98
X8	108-120	1	0.01	1	66	1	100
	Total	66	1	100			

X1: In the 24 to 36h time interval verified death of 9 caterpillars in all treatments, which corresponds to a relative frequency of 0.13 and percentage of 13%, *f* (x1 = 24-36) = 9.

X2: In the range up to 48h has a mortality show of 37 caterpillars in all treatments that respond to a relative frequency of 0.56 and with a percentage of 70% *f* (x2 = 36-48) = 37.

X3: At the time of 48–60h there was no death of caterpillars in all treatments, it remaining with 46 accumulated absolute frequency and 70% of the percentage accumulated relative frequency, *f* (x3 = 48-60) = 0.

X4: At 60-72h interval has a 13-caterpillars show on all treatments with a relative frequency of 0.20 and one, percentage of accumulated relative frequency of 90%, *f* (x4 = 60-72) = 13.

X5: In the interval of 72-84h there was no death, remaining with 59 accumulated absolute frequency and 90% accumulated relative frequency, *f* (x5 = 72-84) = 0.

X6: In the interval of 84-96h, it presented a death at all 6 treatments that correspond to 0.01 relative frequency and a percentage 98 of accumulated relative frequency. *f* (x6=84-96)=6.

X7: In the interval of 96-108h there was no death of caterpillars in all treatments, remaining with 65 accumulated absolute frequency and 98% of percentage accumulated frequency, *f* (x7 = 96-108) = 0.

X8: At the time of 108-120h there was a mortality sample of a caterpillar in all concentrations that correspond to 0.01 relative frequency and 98% accumulated relative frequency *f* (x8 = 108-120) = 1.

Citation: Kinhama VC, Sousa Neto FF. Efficacy of Endjululu-Kapassarinho (Datura Stramonium) in controlling fall armyworm (Spodoptera Frugiperda) in corn (Zea mays L.). *MOJ Eco Environ Sci.* 2023;8(6):229–238. DOI: 10.15406/mojes.2023.08.00297

At frequencies between 37 and 50 hours, it has the highest mortality rate at 37%, resulting in a total of 66 dead caterpillars in the aqueous extract of the leaves. Given these facts, *Datura Stramonium* leaves are effective in controlling fall armyworm (*Spodoptera frugiperda*), the same was verified in studies by Lima,[9] where *Datura Stramonium* was effective in controlling caterpillars after 4 verification days. The same author, in his studies, saw that *Datura Stramonium* leaves caused a higher mortality rate of 20.24%.

For Granados-Echegoyn et al.,[10] in their studies, they found that extracts from *Datura stramonium* leaves caused the death of caterpillars in the order of 16%, results that differ from the present study, as the mortality rate found is of 98%.

Srivastava et al.,[11] point out that the aqueous extract of Endjululu-Kapassarinho proved to be excellent and effective as a bio-insecticide when used in the form of an aqueous extract, the leaves showed better effectiveness, followed by the stem and root, while However, for the results of the present work, the leaves come second after the stem, before the roots and long before the fruits.

Mortality rate of the caterpillar (Spodoptera frugiperda) subjected to concentrations based on the aqueous extract of the fruits of the Endjululu-Kapassarinho plant (Datura Stramonium) at different time intervals.

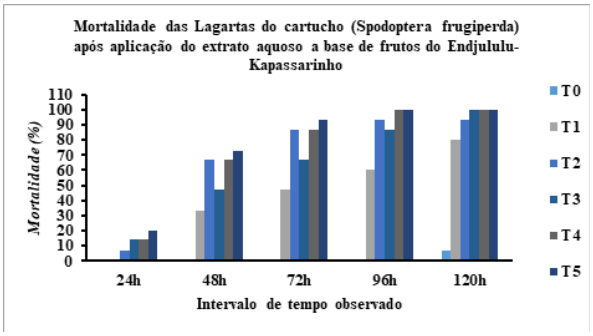
Graph 4 shows the mortality of fall armyworms (*Spodoptera frugiperda*) as in all experimental substrates, an increase over time exposed in concentrations, which demonstrates a positive linear correlation, resulting in the following aspects:

a) In 24 hours, treatments T5, T4, T3, T2 and T1 present mortality, but treatment T5 presents a higher mortality rate in relation to Treatment T4 and the same treatment (T4) does not differ in its results with treatment T3, both present the same mortality rate in relation to T2 treatment.

b) At 48 hours, T5 treatment has a higher mortality rate compared to T4. At the same time observed, T4 has the same mortality rate as T2, both have a higher mortality rate than T3, T1 and T0. T2 surpassed Treatment T3 in terms of caterpillar mortality and T3 presented a higher mortality rate compared to T1, while T0 presented no mortality. These results were verified other times at 72h.

c) At 96h, treatments T5 and T4 do not differ from each other, but they do differ from treatments T3, T2 and T1. T2 has a higher mortality rate than T3 and T3 has a higher mortality rate than T1.

d) At 120h, compared to observation in the previous hours, treatments T5, T4 and T3 do not differ from each other, but differ from treatments T2 and T1, which presented lower mortality rates compared to treatments (T5, T4 and T3) and treatments T2 has a higher mortality rate compared to T1 and in turn T1 has higher mortality than the control (Table 4).



Graph 4 Efficacy of fruit-based aqueous extracts in controlling fall armyworm (Spodoptera frugiperda).

Table 4 Frequency distribution of grouped data on caterpillar mortality in the aqueous extract based on the fruits of the Endjululu-Kapassarinho plant (Datura Stramonium) in the control of fall armyworm

Designation	Time	fi (mortality)	fri	Fri%	faci	fraci	Fraci%
X1	24-36	8	0.11	11	8	0.11	11
X2	36-48	34	0.47	47	42	0.58	58
X3	48-60	0	0	0	42	0.58	58
X4	60-72	14	0.2	20	56	0.77	77
X5	72-84	0	0	0	56	0.77	77
X6	84-96	9	0.12	12	65	0.9	90
X7	96-108	0	0	0	65	0.9	90
X8	108-120	7	0.1	10	72	1	100
	Total	72	1	100			

X1: In the 24 to 36h time interval verified death of 8 caterpillars in all treatments, which corresponds to a relative frequency of 0.11 and percentage of 11%, *f* (x1 = 24-36) = 8.

X2: In the range between 36-48h has a mortality show of 34 caterpillars in all treatments that correspond to a relative frequency of 0.47 and with a percentage of 47%, *f* (x2 = 36-48) = 34.

X3: In the interval between 48–60h there was no death of the caterpillars in all treatments, it remaining with 42 accumulated absolute frequency and 58% of the percentage accumulated relative frequency, *f* (x3 = 48-60) = 0.

X4: In the interval between 60-72h it has a 14-caterpillars show in all treatments with a relative frequency of 0.20 and one, percentage of accumulated relative frequency of 77%, *f* (x4 = 60-72) = 14.

X5: In the interval between 72-84h there was no death, remaining with 56 accumulated absolute frequency and 77% accumulated relative frequency, *f* (x5 = 72-84) = 0.

X6: In the interval between 84-96h, it presented a death in all 9 caterpillars treatments that correspond to 0.12 relative frequency and a percentage 90 of accumulated relative frequency, *f* (x6 = 84-96) = 9.

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X7: In the interval between 96-108h there was no death of caterpillars in all treatments, remaining with 65 accumulated absolute frequency and 90% of percentage accumulated frequency, *f* (x7 = 102-115) = 0.

X8: In the interval between 108-120 there was a 7-caterpillars mortality sample in all concentrations that correspond to 0.1 relative frequency and 90% accumulated relative frequency, *f* (x8 = 108-120) = 7.

The frequency, with the interval of 36-48h, presented the highest mortality rate with 34%, totaling a total of 72 dead caterpillars for the aqueous extract of the fruits.

Lima,[9] in his study, found that the fruits of *Datura Stramonium* caused caterpillar death in the order of 4.76±2.38%.

Trancã et al.,[12] point out that plant extracts have been used successfully against pests/caterpillars in forestry, cotton pathogens and domestic worms, such as fleas and have also been used successfully against insects in wheat and corn in warehouses.

Teixeira, & Lima,[2] emphasize that studies on *Datura Stramonium* should be studied more and more as its aqueous extracts are useful for controlling root nematodes, Meloidogyne Javanica and other pests, due to their active potential.

Results statistically analyzed

Maize fall armyworm mortality 24 hours after exposure to aqueous extracts of leaves, roots, stem and fruits of Endjululu-kapassarinho (*Datura Stramonium*)

The statistically analyzed results (Table 5) on the mortality rate of the corn armyworm (*Spodoptera frugiperda*), observed 24 hours after exposure to different aqueous extracts of Endjululu-kapassarinhos (*Datura Stramonium*), showed there are no statistically significant differences between the extracts used in different concentrations, this is according to the Tukey 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. However, it is worth emphasizing that there were statistically differences in the aqueous root extract, where the concentration of T5=100mL, followed by the concentration T4=80mL, according to the Tukey test with the nominal value of 5% probability.

Table 5 Mortality rate of the corn armyworm (Spodoptera frugiperda), 24 hours after exposure to different aqueous extracts of roots, leaves, fruit and stem of Endjululu-Kapassarinho (Datura Stramonium)

Treatments	Concentration ml/l	Root extract (%)	Stem extract (%)	Leaf extract (%)	Fruit extract (%)
T0	0	0 ab	0 ab	0 ab	0 ab
T1	20	0 ab	0 ab	7 Aa	0 ab
T2	40	0 ab	0 ab	7 Aa	7 Aa
T3	60	0 ab	0 ab	13 ba	13 ba
T4	80	20 bc	0 ab	13 ba	13 ba
T5	100	27 aa	7 Aa	20 bc	20 bc

Means followed by the same letter in the same group in each column do not differ significantly from each other using the Tukey test, considering the nominal significance value of 5% probability.

Maize fall armyworm mortality 48h after exposure to aqueous extracts of leaves, roots, stem and fruits of Endjululu-kapassarinho (*Datura Stramonium*)

The results presented in Table 6 show that after 48% hours of application of the extracts on corn armyworms (*Spodoptera frugiperda*), there were no statistically significant differences in the percentage of mortality of the caterpillars between the different aqueous extracts (from root, stem, leaves and fruit) and the concentrations used, using the Tukey test at 5% significance. However, there were statistical differences for the stem extract, with the concentration T5=100mL being statistically higher, followed by the concentration T4=80mL and with lower mortality values the concentrations 60mL, 40mL and 20mL respectively.

Table 6 Mortality rate of the corn armyworm (Spodoptera frugiperda), 48 hours after exposure to different aqueous extracts of roots, leaves, fruit and stem of Endjulu-Kapassarinho (Datura Stramonium)

Treatments	mL concentration (%)	Root extract (%)	Stem extract (%)	Leaf extract (%)	Fruit extract (%)
T0	0	0 Ab	0 Ab	0 Ab	0 Ab
T1	20	53 Aa	60 Tab	33 ac	33 ac
T2	40	47 Aa	40Ac	67 Tab	47 Aa
T3	60	53 Aa	60 Tab	53 Aa	67 Tab
T4	80	73 Aa	80 Ada	73 Aa	53 Aa
T5	100	73 Aa	87 Ada	73 Aa	73 Aa

On the other hand, the leaf extract also showed significant statistical differences, where the concentrations of T5=100mL, T4=80mL, T3=60 and T2=40mL were statistically equal and higher than the concentration T1=20mL. Similar behavior occurred with the fruit extract, applying the Tukey test at 5% significance. As for the root extract, the different concentrations used did not differ from each other, that is, they were statistically equal, however it is worth noting that even though there were no statistical differences, the 100% and 80% concentrations were numerically higher than the others.

A. Means followed by the same capital letter, in the line, do not differ from each other using the Tukey test, considering the nominal significance value of 5%

B. Means followed by the same lowercase letter, in the column, do not differ from each other using the Tukey test with a nominal value of 5% probability.

Maize fall armyworm mortality 72h after exposure to aqueous extracts of leaves, roots, stem and fruits of Endjululu-kapassarinho (*Datura Stramonium*)

The results obtained on the percentage of mortality of corn fall armyworms presented in Table 7, in 72 hours after exposure to aqueous extracts of leaves, roots, stem and fruits of the Endjululu-kapassarinho plant, the results show no there are statistically significant differences between the aqueous extracts used and their respective concentrations, when applying the Tukey test at 5% probability.

Table 7 Mortality rate of the corn armyworm (Spodoptera frugiperda), 72 hours after exposure to different aqueous extracts of roots, leaves, fruit and stem of Endjulu-Kapassarinho (Datura Stramonium)

Treatments	Concentration ml/l (%)	Root extract (%)	Stem extract (%)	Extract leaves (%)	Fruit extract (%)
T0	0	0 Ac	0 Ac	0 Ac	0 Ac
T1	20	53 Ab	60Ad	47ba	47ba
T2	40	53 Ab	73 At	67 Al	87 Tab
T3	60	53 Ab	80 AA	87 Tab	67 Al
T4	80	100 AA	100 AA	93 Aa	73 At
T5	100	87 Tab	100 AA	73 At	93 Aa

On the other hand, within each extract, there are no statistical differences in the different concentrations used for the stem extract, but it is worth highlighting that even with statistically equal mortality rates, concentrations T5=100mL, T4=8mL and T3= 60mL were numerically higher than the concentrations T2=40mL and T1=20mL, respectively.

For the root extract, there were statistically significant differences, with a higher percentage being observed in the T4 and T5 concentrations, while the T1, T2 and T3 concentrations were statistically equal and lower in the mortality rate. It was also found that there were statistical differences in the leaf extract, where the T4 concentration and the T3 3 T5 concentrations were statistically equal and with a lower mortality rate than the T1 concentration. The fruit extract also presented statistically significant differences, with a higher death rate of caterpillars being observed in the T5 concentration, followed by the T2, T3 and T4 concentrations, which were statistically equal and the T1 concentration was lower among the treatments.

Means followed by the same capital letter, in the line, do not differ from each other using the Tukey test, considering the nominal significance value of 5%; 2 – Means followed by the same lowercase letter, in the column, do not differ from each other using the Tukey test with a nominal value of 5% probability.

Maize fall armyworm mortality 96h after exposure to aqueous extracts of leaves, roots, stem and fruits of Edjululu-kapassarinho (*Datura Stramonium*)

After 96 hours of exposure of different kapassarinho extracts on corn fall armyworms, the results presented in Table 8 show that there were significant differences between the extracts used on the mortality rate of fall armyworms, at concentrations 20 % and 60%, applying the Tukey test at 5% significance. However, for the 20% concentration, a higher percentage of mortality was observed in the stem extract, followed by the root extract and with lower values in the leaf and fruit extracts when using the same concentration.

Table 8 Mortality rate of the corn armyworm (Spodoptera frugiperda), 96 hours after exposure to different aqueous extracts of roots, leaves, fruit and stem of Endjulu-Kapassarinho (Datura Stramonium)

Treatments	Concentration ml/l (%)	Root extract (%)	Stem extract (%)	Leaf extract (%)	Fruit extract (%)
T0	0	0 Ac	0 Ac	0 Ac	0 Ac
T1	20	87 Tab	100 AA	66 Ann	60 years
T2	40	87 Tab	100 AA	80 AD	93 D a
T3	60	47 BB	100 AA	93 Da	87 Tab
T4	80	100 AA	100 AA	100 AA	87 Tab
T5	100	100 AA	100 AA	73 A to	100 AA

For the 60% concentration, there was also a higher percentage of 100% mortality for the stem extract, followed by the leaf and fruit extract, while the root extract when applied at the same concentration showed lower mortality than the others. On the other hand, at concentrations 40%, 80% and 100% they do not differ from each other using the Tukey test with a nominal value of 5% probability. When observed for each extract, it is noted that statistically significant differences occurred for the root extract, in which concentrations of 80% and 100% were statistically equal and higher, followed by concentrations of 20% and 40%, and with a lower value. of the others, the concentration was 60%, when the Tukey test was applied at 5% significance.

1-Averages followed by the same capital letter, in the line, do not differ from each other using the Tukey test, considering the nominal significance value of 5%; 2 – Means followed by the same lowercase letter, in the column, do not differ from each other using the Tukey test with a nominal value of 5% probability.

Maize fall armyworm mortality 120h after exposure to aqueous extracts of leaves, roots, stem and fruits of Endjululu-apassarinho (*Datura Stramonium*)

After 120 hours after application of aqueous extracts of leaves, roots, fruit and stem of the Endjululu-kapssarinho plant (*Datura Stramonium*) on corn fall armyworms, it was noted that there were no statistical differences between the extracts used for each extract. in the different concentrations used (Table 9).

Table 9 Mortality rate of the corn armyworm (Spodoptera frugiperda), 120 hours after exposure to different aqueous extracts of roots, leaves, fruit and stem of Endjulu-Kapassarinho (Datura Stramonium)

Treatments	Concentration ml/l (%)	Root extract (%)	Stem extract (%)	Extract leaves (%)	Fruit extract (%)
T0	0	27 Ab	20 Ab	7 Ab	7 Ab
T1	20	100 AA	100 AA	67 Ad	80 Ac
T2	40	100 AA	100 AA	80 Ac	93 Aa
T3	60	87 Aa	100 AA	93 Aa	100 AA
T4	80	100 AA	100 AA	100 AA	93 Aa
T5	100	100 AA	100 AA	67 Ad	100 AA

Means followed by the same capital letter, in the line, do not differ from each other using the Tukey test, considering the nominal significance value of 5%; 2 - Means followed by the same lowercase letter, in the column, do not differ from each other using the Tukey test with a nominal value of 5% probability.

The statistically analyzed results indicate that Endjululu-kapassarinho (*Datura Stramonium*) presented a high mortality rate, in the different extracts of each part of the plant and in different concentrations, where the T4 at all times in the aqueous extracts competed with the T5 concentration that It's pure. Results similar to those of Wu (2016) cited by Flores-Villegas et al.,[8] who obtained satisfactory results in mortality just after 24 hours of observation, the same was observed in the studies by Granados-Echegoyn et al.,[10] that susceptibility manifested itself after 24 hours, when a significant increase was observed, which highlights the insecticidal potential of aqueous extracts of Endjululu-kapassarinho (*Datura Stramonium*).

According to the studies by Flores-Villegas et al.,[8] on the Efficiency of the plant extract of *Datura stramonium* L. as an insecticide for the control of sawflies, it states that the structures analyzed contained tropine alkaloids and the toxicity is due the fact that alkaloids contain a methylated nitrogen atom (N-CH_3), which makes this plant considered a potential organic insecticide.

In general, the mortality of the caterpillars in each vegetative part observed at each time, these are positively related to the applied concentrations, as they caused a significant mortality when Tukey tests were applied at the level of 5% probability in the caterpillars. -corn shell (*Spodoptera Frugiperda*). However, it can be stated that the use of Endjululu-kapassarinho (*Datura Stramonium*) plant extract can be an alternative for controlling Spodoptera frugiperda, in addition to being efficient in the first application, it continues to prove to be a valuable insecticide to be used.

Conclusion

In view of the results presented in this investigation, which is the first in the province of Cuanza Sul and in Angola in general, the use of corn armyworms to control fall armyworms, where interesting conclusions were drawn such as:

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

The experiment showed that Endjululu-Kapassarinho (*Datura Stramonium*) was effective in controlling fall armyworm in corn, after demonstrating that in the aqueous extract at the base of the leaves there was 98%, followed by the stem with 96% mortality, 90% of mortality in the aqueous extract based on the fruits and 79% mortality in the aqueous extract based on the roots. Mortality percentages increased after 24 hours in all concentrations, regardless of the control treatment.

Doses of concentrations of 80 mL of extracts from the root, stem, leaves and fruits were the ones that proved to be most efficient in the mortality of fall armyworms (*Spodoptera frugiperda*) competing over the times observed with the pure concentration of 100%. In general, regarding the mortality of caterpillars in each vegetative part analyzed, they are positively related to the concentrations applied, this is because they caused significant mortality.

The aqueous vegetable extract based on the Endjululu-Kapassarinho (*Datura Stramonium*) plant proved to be efficient in controlling the caterpillar in corn after 24 hours. The aqueous extract of Endjululu-Kapassarinho (*Datura Stramonium*) is an effective biological insecticide for controlling fall armyworm in corn, which can be an ecological alternative for controlling *Spodoptera frugiperda* caterpillars.

Recommendations

To the scientific community to continue testing this plant, which showed high percentages of Atropine, Hyoscyamine Scopolamine in the order of 60, 27, 24 and 13% respectively in this order, to find out if Endjululu can be efficient in controlling other pests in crops of interest in the country.

Researchers should follow up on this work with possible open field tests on corn crops to control fall armyworm (*Spodoptera frugiperda*).

To the Ministry of Health to pay attention to this plant after its use by young Angolans has caused drastic and worrying consequences for public health.

There must be legislation for certain plants with certain toxicity, such as Endjululu-Kapassarinho, to be used only as insecticides or other pharmacological tests and not for drug consumption.

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Conflicts of interest

The author declares that there is no conflicts of interest.

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