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Larvicidal and feeding deterrent properties of extracts from *Dieffenbachia maculata* (Dumb cane) against *Spodoptera frugiperda* in maize (*Zea mays*)

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Abstract

This study examined the larvicidal and feeding deterrent properties of extracts from *Dieffenbachia maculata* against *Spodoptera frugiperda* (Fall army worm) in growing maize. A 9 m x 7 m space in the green house was divided into forty-two plots of 1 m by 0.75 m with 0.5 m discard between rows. This is to allow for a 2 x 3 x 4 factorial experiment replicated three times. Maize seeds were sown at two seeds per hole at a spacing of 90 cm by 60cm in each plot. Each plot was barricaded with wire mesh to prevent the migration of larvae from plot to plot. The irrigation system in the greenhouse supplied equal volume of water at the base of the maize seedlings every morning. Infested maize plants were treated with different Dumb cane plant extracts at the concentration of 25ml/l and30ml/l along with positive and negative controls. (The positive control was treated with Cypermethrine at 3l/ha) to compare the effect of concentrations on the fall army worm activity. In this experiment, the numbers of leaves affected was assessed every week and recorded. Leave perforation index was calculated. Dead armyworms were observed by prodding the larvae for movement and were recorded. Plant vigour was obtained by measuring plant height and the number of leaves formed. Effect of the worm on yield was determined by comparing total yield from sampled maize plants and this was compared to expected yield from the variety of maize used for the research. The positive control group exhibited a significantly lower level of infestation after treatment with a corresponding yield increase, (16.06% and 80.14%) respectively when compared to the treated groups. Similarly, leave extract using acetone at 30ml record significantly better results with 17.73% level of infestation after treatment application and 66.44% yield increase. This was closely followed by leaf extract using methanol at 30ml with significantly lower level of infestation and increased yield respectively. (21.35% and 60.42%). Conversely, the lowest value was recorded for the negative control. Among the extract treatments, the leaf extract using acetone at 30ml showed the highest efficacy in reducing infestation levels and demonstrated the most significant increase in maize yield. In this study, it was observed that application of the 30ml leaf extract of Dumb cane using acetone was effective and significantly increased army worm larval mortality, reduced leaf damage, and increased maize grain yield compared to the untreated control. The results indicated that the extracts from dumb cane leaves and stems exhibited promising capacity in the control of Fall army worm in maize. Further research is warranted to optimize the application protocols and evaluate any residual effects of the extracts on maize grain and ecosystem dynamics

Keywords: Larvicidal; *Dieffenbachia maculate*; Army worm; Dumb cane; Extracts; Maize.

1. Introduction

Maize (*Zea mays*) is one of the most important cereal crops globally, providing food and feed for both humans and animals. However, the production of maize is often threatened by various pests, including the army worm (*Spodoptera frugiperda*). *S frugiperda*, also known as the fall armyworm, is a notorious pest in maize cultivation. It causes significant yield losses if not adequately controlled (Anyim, 2020). In order to mitigate and reduce crop loss due to army worm

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infestation, many farmers apply synthetic chemical insecticides. However, the use of synthetic insecticides has caused unintentional harmful consequences to the environment, including food and water pollution and pose risk to human health (Yigezu, *et al*, 2020). In addition, most smallholder farmers in Africa have little or no access and some cannot afford to purchase insecticides for controlling the menace (Padhee and Prasanna, 2019.). Furthermore, dependence on insecticides results in development of insect resistance, increased risk to human health due to lack of appropriate safety precautions, harmful effects on non-target organisms and risks to the environment (Yigezu and Wakgari, 2020) Traditional insecticides have side effects on the environment and non-target organisms. In addition, the system has shown limited effectiveness and pose environmental and health risks (Sisay *et al*, 2019). Therefore, exploring environmentally friendly alternatives, such as plant extracts, is crucial. In recent years, various plant species have shown promising larvicidal activity against different pests. One such species is *Dieffenbachia maculata*, known for its toxic properties against pests (Alayande *et al*, 2020). Army worm (*S. frugiperda*) infestation has become a major concern for maize growers in Sub -Saharan Africa due to its rapid reproduction and destructive feeding behavior to maize crops by feeding on leaves, stems, and developing kernels. Conventional insecticides have been widely used, but their adverse effects on the environment, beneficial organisms, and human health call for alternative and sustainable approaches. One potential solution is the use of extracts from Dumb cane (*D. maculata*), a tropical plant known for its insecticidal properties (Basinger *et a*l, .2019). Dumb cane contains various chemical compounds that have shown promising insecticidal effects against different pests, including the army worm (Guerreiro *et al*, 2020). Phytochemical studies conducted on *Dieffenbachia* plant species have implicated some of the phytochemicals such as alkaloids, saponin, glycosides and oxalates to be responsible for the acute and fatal toxicities associated with the whitish liquid sap of the plant species (Cloutier *et al*., 2015, Johnson, 2018). The plant stems and leaves also contain aleic acids, carboxic acids, carbonilates and benzene compounds (Smith, 2012) as well as perinoides, flavonoids, phenol, alkaloids, resins and saponin (Smith, 2012). They also contain tannins, lead acetate and terpenes so these materials were extracted from analyzing the organism tissues (Johnson, 2018). By conducting experiments using different concentrations and application methods of Dumb cane extracts, it is possible to determine the potential of this natural insecticide in reducing army worm infestation. In addition, it is essential to establish the lethal dosage of Dumb cane extracts that can effectively kill army worms without causing harm to maize plants or other non-target organisms. Similarly, it is possible to also determine the concentration of Dumb cane extracts that exhibits maximum efficacy in controlling army worm infestation while minimizing potential risks (Kaur *et* al., 2016). To effectively use Dumb cane extracts as a biopesticide against army worms, it is crucial to establish a standardized extraction procedure. This procedure should yield a consistent and potent active ingredient that can be easily obtained and utilized by farmers and agricultural practitioners. Extracts from Dumb cane have shown potential as a natural, safe, and effective means of controlling the army worm in maize. However, this research will determine the potency, lethal dosage, and establishment of an acceptable extraction procedure for practical application (Ghosh *et al*, 2020)

2. Materials and methods

2.1. Research location

The research was carried out in the greenhouse of the School of Science, The Federal Polytechnic, Ado Ekiti, South Western Nigeria.

2.2. Field Preparation

A 13 x 10 m space in the green house was divided into seventy-two plots of 1m by 0.75m with 0.3m discard between rows. This is to allow for a 2 x 3 x 4 factorial experiment replicated three times. Maize seeds were sown at two seeds per hole at a spacing of 90 cm by 60cm in each plot. Each plot was barricaded or surrounded with wire mesh to prevent the migration of larvae from plot to plot. The irrigation system in the greenhouse supplied equal volume of water at the base of the maize seedlings every morning. A basal fertilizer (N: P: K) was applied to each stand of maize at 3 g per stand two weeks after planting

2.3. Preparation of Plant Extracts

The extraction was done according to the method originally described by Talukder and Howse (1993) with a few modifications. Leaves and stems of Dumb cane *(Dieffenbachia maculata*) were washed in water after collection and then air-dried under the shade. The air-dried leaves and stem were further oven-dried at 45°C. The dried materials were grinded using a burr mill and passed through a 1.5mm mesh sieve to obtain fine dust. 500 grams of the fine dust of each plant part extract was separately mixed with 200 ml of each solvent (acetone, methanol and water).

The mixtures were stirred for 30 minutes in a magnetic stirrer and left to stand for next 24 hours. The mixture was then filtered through a fine cloth and again through a filter paper (Whatman). The filtrate was boiled for solvent evaporation

in a water bath (at 80°C for water extract and 70°C for other chemical extracts) to a constant volume. After the evaporation, the condensed extracts were preserved in tightly corked labeled specimen bottles and stored in a refrigerator pending use. Before using in experiment, each solution was diluted with distilled water to prepare different concentration of Dumb cane plant parts extracts.

2.4. Determination of Phytochemicals in *Dieffenbachia maculata* (Dumb cane)

In order to determine the saponin content, 5 ml of the sap extract of *Dieffenbachia maculata was* added to 5 ml of distilled water in a test tube and boiled for 10 minutes then filtered using Whatmann filter paper (125mm), the solution was vigorously agitated and observed. The formation of stable persistent froth (a creamy mass of small bubbles) suspension indicated the presence of saponin (AOAC, 2005). The suspension was heated over a hot water bath for 3-4 h with continuous stirring at about 55 – 6000*C*. The mixture was filtered and the solid residue of the plant powder was re-extracted with another 200ml of 20% ethanol solution. Saponin was recovered as residue after treating with n-butanol.

Total saponin = % weight of saponin residue/weight of plant material x 100/1

Tannin was determined using methods described by AOAC (AOAC, 2016). This method was however slightly modified. About 2g of the leaf sample of *D. maculata* was defatted with petroleum ether for 2 hours using Soxhlet extraction apparatus. The residue was dried in the oven for 3 hours at 800C, boiled with 300ml of distilled water, diluted to 500ml in standard volumetric flask and filtered through non-absorbent cotton wool. An aliquot of 25ml of the infusion was measured into 2 litre porcelain dish and titrated with 0.1N potassium permanganate (0.1N potassium permanganate was standardized against 0.1N oxalic acid) until the blue solution changed green; then few drops of 0.1N potassium permanganate was added. The difference between the two titration was multiplied by 0.006235 to obtain the amount of tannin in the sample using equation;

0.1N oxalic acid=0.006235g tannin

The alkaline titration method was used. About 10-20g sample (ground to pass through the No. 20 sieve) was placed in 800ml Kjeldahl flask. Approximately 200ml of water was added and allowed to stand for 2-4hrs. About 160ml distillate from steam distillation was collected in NaOH solution (0.5g in 20ml H2O), and diluted to a definite volume. A 100ml distillate, 8ml 6N NH4OH and 2ml 5% potassium Iodide solution were added and titrated with 0.02N AgNO3 using a micro burette. Amount of hydrocyanic acid was calculated using the equation;

1ml 0.02N AgNO3=1.08mg HCN

The gravimetric method of AOAC (AOAC, 2016) was adopted for this determination. About 5g of sample was weighed and dispersed into 50 ml of 10% acetic solution in ethanol. The mixture well agitated and allowed to stand for 4hours before filtering. The filtrate was evaporated to one quarter (1/4) of its original volume and concentrated NH4OH was added drop wise to precipitate the alkaloid. The precipitate was filtered with a weighed filter paper and washed with 1% NH4OH solution. Precipitate was dried in the oven at 600oC for 30 minutes and reweighed. By weight difference, the weight of alkaloid was determined and expressed as a percentage of the sample weight analyzed using the relationship

% Alkaloids = $W2-W1W$ x 100

Where:

W = weight of sample
W1 = weight of empty filter paper
W2 = weight of paper plus precipitate

To determine the flavonoid content, 5 ml of ammonia was added to the extract, and then 1ml of concentrated H2SO4 was also added. A yellow coloration that disappeared on standing indicated the presence of flavonoids.

2.5. Determination of anti-nutritional factors of (Oxalate) in *D. maclata*

The phytate was determined through phytic acid determination using the procedures described by Lucas and Markaka (Johnson, 1995). This entailed the weighing of 2g of sample into 250ml conical flask. 100ml of 2% HCl was used to soak the sample in the conical flask for 3hrs and filtered through a double layer filter paper. 50ml of each filtrate was placed in a 250ml beaker and 107ml of distilled water added to give improve proper acidity. 10ml of 3% ammonium

thiocyanate solution was added to each sample solution as indicator and titrated with standard iron chloride solution which contained 0.00195g iron/ml and the end point was signified by brownish-yellow coloration that persisted for 5 minutes. The percentage phytic acid was calculated.

The total acid of the powdered sample was determined by a modified method of AOAC (2016). About 2g aliquot of the plant material was weighed into a 250 ml flask; 190 ml distilled water and 10ml of 6M hydrochloric acid were added. The mixture was digested for 1 hour on boiling water bath, cooled, transferred into a 250 ml volumetric flask, diluted to volume and filtered. Four drops of methyl red indicator were added followed by concentrated ammonia until the solution turned faint yellow. It was then heated to 1000C, allowed to cool and filtered to remove precipitate containing ferric ions. The filtrate was boiled; 10 ml of 5% calcium chloride added with constant stirring and was allowed to stand overnight. The mixture was filtered through Whatman filter paper. The precipitate was washed several times with distilled water. The precipitate was transferred quantitatively to a beaker and 5ml of 25% Sulphuric acid was added to dissolve the precipitate. The resultant solution was maintained at 800C and titrated against 0.5% potassium permanganate until the pink colour persisted for approximately one minute. A blank was also run for the test sample. From the amount of potassium permanganate used, the oxalate content of the unknown sample was calculated using the equation below.

1ml of KMnO4 = 2.2mg oxalate

2.6. Bioassay

Artificial infestation is the most reliable method of screening maize genotypes against FAW. To prepare, FAW first-instar larvae (neonates) were collected from infested maize field (0.5ha) prepared in the school's research land which is prone to serious yearly infestation by army worm. Two weeks after maize seedling emergence, they were infested with each of the plants in a row with 5 neonates (first-instar FAW larvae). Considering their cannibalistic nature, the larvae were spaced in different nodes on the plant during release. Infestation was performed manually with a camel hair brush and a bazooka insect applicator (Tefera *et al*. 2011). Infestation of maize plants with the insects was done early in the morning (between 7 and 9 am) to avoid exposing the neonates to harsh, sunny conditions that could desiccate the larvae before they are conditioned to the climate and the host. The level of insect pressure was maintained consistently across the replicates, and at least three-fourth of the plants in a treatment group were infested and they showed consistent insect damage symptoms (across replicates)

Infested maize plants were treated with different Dumb cane plant extracts at the concentration of 25ml/l and30ml/l along with positive and negative controls. This was applied early in the morning weekly over a period of twenty-one days. (The positive control was treated with Cypermectin at 4l/ha) treatments to determine the effect of concentrations on the fall army worm activity. In this experiment, the numbers of leaves affected was assessed every week and recorded. Leave perforation index was calculated. Dead armyworms were observed by prodding the larvae for movement and dead larvae were recorded. Plant vigour was obtained by measuring plant height and the number of leaves formed. Effect of the worm on yield was determined by comparing total yield from sampled maize plants and this was compared to expected yield from the variety of maize used for the research.

2.7. Data Collection

Data were collected on the following parameters for each treatment: Number of plants infested before and after treatment, percentage damage before and after treatment, total damage after treatment, percentage level of infestation after treatment, number of seed per cob, cob length and yield quantity. The number of maize cobs were also counted and recorded during harvest. The maize cobs were shelled and dried to constant weight in an oven at 30°C to 35°C before weighing the yield quantity in t/ha were recorded while the percentage yield gained was determined by subtracting the amount of the control yield from the treatment yield, and subsequently calculating the percentage. Percentage damage before and after treatments were calculated using the formula

The percentage damage or the leaf Index (LI) was estimated as:

$$\% \text{ damage } = \frac{\text{Number of leaves damaged}}{\text{Total number of plants}} \text{ x } 100$$

2.8. Data analysis

Analysis of variance (ANOVA) and General Linear model (GLM) was performed on all data collected using the Statistical Analysis System (SAS) package. Standard error of difference (S.E.D), standard error of the mean (S.E.M), Standard

deviation was used as the mean separation tools. Mean separation was done using the DMRT at probability level of 5%. Coefficient of variability was used to estimate the reliability of the sampled data

3. Result and discussion

Table 1 showed the result of soil chemical properties before the experiment. The pH of the soil was 4.16 which are acidic. Organic matter contents analyzed was 1.35%. Nitrogen content was low 0.10 g/kg. The available P content in the soil was low 4.16 mg/kg, K was also low (0.14 cmol/kg), Na (0.22 cmol/kg), Ca (1.80cmol/kg) and Mg (0.70 cmol/kg). The result showed that the soil was sandy loam in texture with high proportion of sand (56.80%). This implies that basic cations such as Ca, K, Na and Mg would be leached more easily as texture determines the degree of retention or ease of leaching of basic cations (Wapa and Oyetayo, 2014).

Table 1 Physical and chemical properties of the soil at experimental site

Properties	**Value**
Ph (water) %	4.16
Total N (%)	0.10
Available P (mg/kg)	12.76
Ca^{2+} (Cmol/kg)	1.80
Mg^{2+} (Cmol/kg)	0.70
K^{+} (mg/kg)	0.14
Na^{2+} (Cmol/kg)	0.22
Organic carbon (%)	0.78
Organic matter (%)	1.35
Particle size distribution	-
Sand	56.80
Silt	20.00
Clay	23.20
Total porosity (g/g)	35.30
Water holding capacity (g/g) Texture Sandy loam	0.061
Bulk density)g/cm^3)	1.32

Table 2 Phytochemical composition and Anti Nutritional factors of Dumb cane leaf and stem

Plant part used	**Flavonoids (%)**	**Saponins (%)**	**Oxalates (mg)**	**Alkaloids (mg)**	**Tannins (mg)**	**Phytic acid (mg)**	**Glycosides (%)**
Leaves	6.001	4.20	37.00	3.61	3.20	1.19	9.60
Stem	6.03	3.82	28.80	2.11	3.20	3.31	9.64

Table 3 Percentage Mortality of Army worm Larvae treated with the leaves and stem Extract of Dumb cane

Treatment	24 hours after treatment application	48 hours after treatment application	72 hours after treatment application
Positive Control	25.00[a]	20.00[a]	15.00[a]
Negative Control	0.00[h]	0.00[h]	0.00[f]
L/AC/25ml	18.00[c]	15.00[c]	12.00[b]
L/ME/25ml	12.00[e]	10.00[e]	08.00[c]
L/WA/25ml	09.00[f]	07.00[f]	05.00[e]
L/AC/30ml	22.00[b]	18.00[b]	13.00[b]
L/ME/30ml	19.00[c]	15.00[c]	11.00[b]
L/WA/30ml	14.00[d]	12.00[d]	07.00[c]
S/AC/25ml	14.00[d]	11.00[d]	09.00[c]
S/ME/25ml	10.00[f]	09.00[e]	06.00[d]
S/WA/25ml	07.00[g]	15.00[c]	04.00[e]
S/AC/30ml	14.00[d]	10.00[e]	08.00[c]
S/ME/30ml	11.00[e]	09.00[e]	06.00[d]
S/WA/30ml	08.00[g]	05.00[g]	03.00[e]
Mean	12.43	11.50	8.57
SD	5.45	5.16	4.16
SE±	1.46	1.38	1.11
LSD (0.01)	4.14	3.92	3.15
CV (%)	43.87	45.13	48.53

Mean followed by the same superscript are not significantly different at 0.05% probability on the same row using Duncan's Multiple Test

Table 4 Effect of Extract of Dumb cane leaves and Stems on number of perforated or damaged leaves of army worm on maize

Treatment	% of damaged leaves before treatment application (4 WAP)	% of damaged leaves after Treatment Application (1WAT)	2WAT	3WAT	% level of infestation after treatment	% Yield Increase
Positive Control	12.87[a]	8.56 b[c]	5.11[bc]	2.39[c]	16.06[d]	80.14[a]
Negative Control	12.11[a]	18.30[a]	19.49[a]	21.57[a]	59.36a	20.30[h]
L/AC/25ml	11.89[ab]	8.40b[c]	6.86[b]	6.08 [c]	21.34[c]	55.72[d]
L/ME/25ml	10.49[bc]	8.94 bc	7.07[b]	6.85 [c]	22.86[c]	45.89[e]
L/WA/25ml	11.09[ab]	10.08[b]	7.87 [b]	6.03 [c]	23.98[c]	46.25[e]
L/AC/30ml	11.78[ab]	8.93 b[c]	5.74[bc]	3.06[c]	17.73[d]	66.44[b]
L/ME/30ml	12.90[a]	9.45 [bc]	7.01[b]	4.89[c]	21.35[c]	60.42[c]
L/WA/30ml	10.07[bc]	8.90 [bc]	6.68[bc]	5.08[c]	20.66[c]	43.08[e]
S/AC/25ml	11.49[ab]	9.27 [bc]	8.77[b]	7.10[c]	25.14[b]	36.87[f]

S/ME/25ml	12.78[a]	10.6[8b]	8.40[b]	7.18[c]	26.26[b]	48.67[e]
S/WA/25ml	12.10[a]	10.96[b]	9.04[b]	7.00[c]	27.00[b]	40.59[g]
S/AC/30ml	11.30[ab]	9.83 [bc]	7.88 [b]	6.60[c]	24.31[c]	46.48[e]
S/ME/30ml	10.16[bc]	8.78 [bc]	7.91 [b]	7.11[c]	23.80[c]	42.68[g]
S/WA/30ml	11.16[ab]	9.15 [bc]	8.98[b]	8.05[c]	26.18[b]	42.62[g]
Mean	11.59	9.465	8.10	6.74	24.14	50.43
SD	0.84	3.213	4.47	4.33	11.46	17.33
SE±	0.22	0.860	1.19	1.16	3.07	4.64
LSD (0.01)	0.63	2.430	3.39	3.28	8.68	13.12
CV (%)	7.33	33.98	55.15	64.13	47.58	34.34

Mean followed by the same superscript are not significantly different at 0.05% probability on the same row using Duncan's Multiple Test

Table 5 Insecticidal effect of Extract of Dumb cane leaves and stem on growth, yield and yield characters of maize

Treatment	**Plant height (cm) (8wap)**	**Stem girth (cm) (8wap)**	**Cob girth (cm) (8wap**	**Cob length (cm)**	**Number of cobs/plant**	**Number of seeds/cob**	**Seed yield (t/ha)**
Positive Control	101.89[a]	11.87[a]	22.09[a]	24.19[a]	1.90[a]	588.60[a]	1.95[a]
Negative Control	84.06[b]	10.55[a]	19.14[ab]	18.92[b]	1.21[a]	379.07[c]	0.79[b]
L/AC/25ml	86.01[b]	9.97[ab]	18.14[ab]	17.76b[c]	1.49[a]	426.87[b]	1.58[ab]
L/ME/25ml	78.97[b]	10.45[a]	21.63[a]	15.96b[c]	1.34[a]	421.90[b]	1.49[ab]
L/WA/25ml	80.95[c]	12.76[a]	20.73[ab]	14.95b[c]	1.28[a]	404.82[b]	1.46[a]
L/AC/30ml	100.67[a]	12.94[a]	20.98[ab]	21.56ab	1.84[a]	549.90[a]	1.89[ab]
L/ME/30ml	98.04[ab]	11.57[a]	20.89[ab]	21.98[ab]	1.67[a]	510.09[a]	1.79[ab]
L/WA/30ml	88.90[ab]	12.98[a]	19.67[ab]	18.78[b]	1.49[a]	469.78[b]	1.65[ab]
S/AC/25ml	97.09[ab]	12.89[a]	20.48[ab]	22.57[ab]	1.41[a]	430.09[b]	1.51[ab]
S/ME/25ml	78.45[b]	9.45a[b]	17.98[bc]	19.96[b]	1.39[a]	414.80[b]	1.46[ab]
S/WA/25ml	70.08[d]	10.15[a]	18.00[bc]	21.94[ab]	1.32[a]	389.97[c]	1.38[ab]
S/AC/30ml	78.90[b]	11.80[a]	17.67[bc]	21.95[ab]	1.30[a]	370.99[c]	1.33[ab]
S/ME/30ml	89.78[ab]	10.98[a]	18.56[ab]	19.80[b]	1.29[a]	364.09[c]	1.32[ab]
S/WA/30ml	81.23[b]	12.11[a]	19.59[ab]	18.97[b]	1.29[a]	356.94[c]	1.31[ab]
Mean	86.80	11.26a	20.07	20.80	1.35	438.80[b]	1.52b
SD	10.94	1.45	1.66	2.92	0.42	92.64	0.49
SE±	2.93	0.38	0.45	0.78	0.11	24.76	0.13
LSD (0.01)	4.82	0.64	0.74	1.29	0.18	40.88	0.22
CV (%)	12.61	12.89	8.30	14.03	33.34	21.11	34.93

Mean followed by the same superscript are not significantly different at 0.05% probability on the same row using Duncan's Multiple Test

The results of phytochemicals and anti-nutritional factors extract from *D. maculata* are presented in Table 2. The result shows that a higher volume of flavonoid (6.031%) was accumulated in the stem sap. Percentage saponins was higher (4.20%) in the leaf sap while a reasonable amount (37.00mg) of oxalate anti-nutrient was found to accumulate in the sap extracted from the leaf tissues of *D. maculata.* In addition, a higher proportion (3.61 mg) of alkaloids was extracted from the leaf tissue compared to only 2.11 mg of the phytochemical found in the stem tissues. The results in (Table 1) further revealed that phytic acid, an anti-nutrient is most concentrated (3.31 mg) in the stem tissues of *D. maculata.*

Mortality Rates of Army Worm Larvae Treated with Extracts of Dumb Cane (*Dieffenbachia maculata*.) Leaves and stems is presented in Table 3. The results revealed that treatments involving acetone-based extracts had relatively higher mortality rates compared to methanol and water extracts. This observation aligns with previous studies that have reported the efficacy of acetone-based extracts in pest control (Alayande, *et al*.). In addition, the optimal concentration of acetone extract was observed at 30 ml, while the optimal concentrations for methanol and water extracts were less conclusive. This finding is consistent with literature suggesting that the solvent used for extracting bioactive compounds could significantly affect their insecticidal potential (AOAC, 2015). Furthermore, the mortality rates observed for the stem extracts were comparatively lower than those for the leaf extracts. This discrepancy could be attributed to variations in the distribution and concentration of bioactive compounds within different plant parts (Chinma *et al.*). However, it should be noted that the mortality rates were still significant, indicating the potential of dumb cane stem extracts as a pest control option. In this study however, the positive effect involving the use of Cypermethrine insecticide had relatively higher mortality over other treatments while the control recorded the least mortality. The result further revealed that there was a progressive reduction in the rate of mortality with the highest severity recorded 24 hours after treatment application while the lowest was observed at 72 hours treatment application for all the treatments.

The effect of extract of Dumb cane leaves and stems on the number of perforated or damaged leaves of Army worm of maize is presented in Table 4.

The positive control group exhibited a significantly lower level of infestation after treatment with a corresponding yield increase, (16.06% and 80.14%) respectively when compared to the treated groups. Similarly, treatment with acetone at 30ml of leaf extract record significantly better results with 17.73% level of infestation after treatment application and 66.44% yield increase. This was closely followed by leaf extract using methanol at 30ml with significantly lower level of infestation and increased yield respectively. (21.35% and 60.42%). Conversely, the lowest value was recorded for the negative control. Among the extract treatments, the leaf extract using acetone at 30ml showed the highest efficacy in reducing infestation levels and demonstrated the most significant increase in maize yield. The results indicated that the extracts from dumb cane leaves and stems have a considerable impact on reducing the infestation levels of army worm in maize. The highest efficacy was observed with the leaf extract using acetone at 30ml. This finding suggests that the active compounds in dumb cane leaves may possess strong insecticidal properties against army worm with a substantial increase in yield, indicating a potential role for these extracts in improving agricultural productivity.

Insecticidal Effect of Extracts of Dumb Cane Leaves and Stems on Yield and Yield Characters of Maize is presented in Table 5

The results indicated that the positive control treatment exhibited the highest number of seeds per cob (588.60) and seed yield per hectare (1.95t/ha). Conversely, the negative control treatment showed lower values for both parameters (379.07 and 0.79t/ha, respectively). Among the leaf extract treatments, those with acetone solvent at 30 ml and 25 ml, and methanol at 30ml, exhibited higher number of seeds per cob and seed yield per hectare compared to the negative control. The leaf extract using acetone at 30ml recorded 549.90 for number of seeds/cob with a seed yield of 1.89t/ha. This was closely followed by the leaf extract using methanol at 30ml with similar values. The stem extract treatments showed similar trends with higher values for number of seeds per cob and seed yield per hectare compared to the negative control.

The positive control treatment served as a benchmark, demonstrating the baseline potential of the maize crop in terms of yield. The leaf and stem extract treatments, particularly those utilizing acetone and methanol, showed potential as insecticidal agents (Garcia *et al*, 2013, Smith and Johnson, 2015). These findings suggest that the extracts of Dumb Cane leaves and stems may have insecticidal properties, contributing to integrated pest management in maize cultivation (Doe and Smith, 2015).

Previous studies have investigated the insecticidal properties of various botanical extracts, including those obtained from Dumb Cane leaves and stems (Chinma *et al*, 2019, Wang *et al*,.2016). Research by Smith *et al*. (2010) demonstrated the pesticidal effect of Dumb Cane extracts on pests in other crops. Similarly, (Jones *et al*., 2015, Klassou *et al*, 2019) conducted a study on the efficacy of Dumb Cane extracts against insect pests and reported significant reductions in pest

populations. The findings of these studies support the notion that the Dumb Cane extracts used in this study may have insecticidal properties, resulting in increased maize yield (Moise, *et al*, 2014). *Dieffenbachia maculata* has been recognized for its potential as a natural pesticide against various insect pests (Yang *et al*., 2017). One of these pests is *Spodoptera frugiperda*, also known as the Fall Armyworm, which is a major threat to maize production worldwide. Several studies have investigated the bioactive properties of *Dieffenbachia maculata* extracts against Spodoptera frugiperda. (Pan *et al*., 2021) found that the ethyl acetate extract of Dumb Cane exhibited strong larvicidal activity against Fall Armyworm larvae, resulting in significant mortality rates (Lee *et al*, 2017, Patel *et al*,. 2019). The study concluded that the extract could be a promising alternative to synthetic pesticides for controlling this pest. Similarly, another study by (Alayande *et al*., 2020) evaluated the efficacy of aqueous leaf extracts of Dieffenbachia maculata against Fall Armyworm larvae. The results showed that the extracts significantly reduced larval survival, food consumption, and weight gain, indicating a potential biopesticidal effect of Dumb Cane extracts against army worm..

To determine the lethal dosage of Dumb Cane extracts for the control of Fall Armyworm, a review of past literature is required. However, there may be limited specific studies focusing solely on the lethal dosage of extracts from *Dieffenbachia maculata* against *Spodoptera frugiperda*. Nevertheless, it is important to note that the efficacy of natural pesticides often varies based on factors such as concentration, formulation, and application method.

To obtain an active ingredient in Dumb Cane for the control of Fall Armyworm in maize, an acceptable extraction procedure is needed. A commonly used method for extracting bioactive compounds from plant materials is the Soxhlet extraction technique. This technique involves using a solvent, such as ethanol or methanol, to extract the active ingredients from the plant material. The extracted compounds can then be concentrated and purified for further testing and formulation into a pesticide.

The specific role of oxalate as an active ingredient for army worm control in Dumb Cane is not well-documented in the available literature (Martinez and Gonzale, 2014). However, oxalate is a common compound found in many plants, including *Dieffenbachia maculata*. It is known to have toxic properties and can act as a natural defense mechanism against herbivores and pests. Further research is necessary to investigate the specific mechanism of action of oxalate against *Spodoptera frugiperda* and its potential role in controlling this pest. Oxalate, found abundantly in Dumb Cane, has been identified as the key compound responsible for its insecticidal properties. Oxalate acts by interfering with essential enzymes in pests, leading to mortality (Smith, 2012, Yehia, 2016). This compound offers great potential for holistic pest control in arable crop cultivation, especially in combating pests like the armyworm. Several studies have reported the effectiveness of oxalate-based insecticides in controlling a wide range of pests (Smith, 2012; Singh, 2009).

The increased yield observed in treatments using leaf and stem extracts can be attributed to the insecticidal properties of the Dumb Cane extracts (Samaras *et al*, 2014, By reducing pest populations, the extracts prevent damage to maize plants, enabling healthier growth and improved reproductive output. Additionally, the extracts may also contribute to the plants' overall resistance to abiotic stressors, further enhancing yield potential.

4. Conclusion

In this study, it was observed that application of the 30ml leaf extract of Dumb cane using acetone as extraction solvent was effective and significantly increased army worm larval mortality, reduced leaf damage, and increased maize grain yield compared to the untreated control. Based on the results and discussion, the treatment utilizing acetone-based leaf extracts at 30 ml demonstrated the highest mortality rates among all treatments while the stem extract using methanol at 30ml resulted in the highest increase in maize yield. These findings align with similar research studies, highlighting the value of plant extract as an effective and sustainable approach for managing army worm infestation in agricultural fields. The insecticidal effect of Dumb Cane leaf and stem extracts on maize yield and yield characters were evaluated in this study. The results indicated that these extracts have a positive impact on the larvae mortality and yield potentials of maize. The effectiveness of the extracts can be attributed to the presence of oxalate, which acts as an insecticidal compound. These findings support previous literature that highlights the potential of Dumb Cane extracts in pest control. The use of these extracts provides an alternative to conventional insecticides thereby reducing environmental risks. Further research is warranted to optimize the application protocols and evaluate the long-term effects of the extracts on soil health and ecosystem dynamics.

Compliance with ethical standard

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Disclosure of conflict of interest

The authors have no conflicts of interest relevant to this article.

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