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EVALUATION OF THE INSECTICIDE ACTIVITY OF SODOM APPLE (*Calotropis procera*) AGAINST MAIZE WEEVILS (*Sitophilus zemais*) CAUSING DAMAGE ON STORE MAIZE

Abubakar, S., Zaharaddeen, S., Tijjani, A. and Aliyu, M.
Department of Crop Production, Faculty of Agriculture and Agricultural Technology,
Abubakar Tafawa Balewa University Bauchi PMB. 0248, Bauchi Nigeria
Corresponding Authors' E-mail: abubakarsamaila542@gmail.com **Tel.:** +2348068031134

ABSTRACT
Laboratory experiment was conducted to determine the insecticidal activity of leaves and stem bark powder of Sodom apple (*Calotropis procera*) and optimum concentration for the management of maize weevil (*Sitophilus zeamais*). Actellic dust was used a positive control and untreated maize seeds serving as negative control. The experiment was laid in Completely Randomized Design (CRD) comprising of Leaves powder (1 g, 3 g and 5 g), stem bark powder (1 g 3 g and 5 g), Actellic dust and control. These were applied to 100 g healthy maize seeds and repeated three times. Contact activity of the plant products were evaluated and data collected were subjected to analysis of variance (ANOVA) and means were separated using NDMRT at 1% and 5% probability level. The results showed that the application of 5 g/100g leaves significantly ($P \leq 0.05$) caused highest mortality of adult *S. zeamais* at 24 (2.33), 48 (2.66), 72 (2.33) and 96 (2.00) hours by contact toxicity comparable to other treated seeds. Similarly, maize seeds treated with 5 g /100 g of the leaves powder significantly ($P \leq 0.05$) decreased Oviposition (3.33), Adult emergence (3.00), Percentage grain damage (3.67%), Number of exit holes (3.33) and Weight loss (1.63%). Germination of the treated seeds was not affected negatively. The 5 g of leave of *C. procera* could be recommended as suitable alternatives to chemical pesticides to be used as contact protectants against *S. zeamais* on stored maize seeds.

Keywords: Atelic dust, *Calotropis procera*, Control, Leaves, *Sitophilus zeamais,* Stem bark.

INTRODUCTION
Maize (Zea mays **L.**), belonging to the family Poaceae or Gramineae, it is a grass related to rice, wheat, barley, and oat, ranking second in area cultivated and first in production and productivity in order of world grain production (Bhusal and Khanal, 2019). Maize is popularly known as queen of cereals, because of very high yield potential than any other cereals (Bhusal and Khanal, 2019). Maize serves as an important staple food for over 50 percent of the population in Africa (Food and Agriculture Organization [FAO], 2010). Insects are most often considered as the principal cause of maize grain losses. *Sitophilus zeamais* is the most important insect pest that attack maize from field to storage which results in decrease market value.

A number of management techniques have been adopted to control stored products insect pests. The synthetic insecticides are commonly used to control pests in general and stored product pests in particular. However, indiscriminate use of many synthetic insecticides is associated with manifold health and environmental problems, like development of resistance in insect pests, residues in food product, pest resurgence and effect on non-target organisms (Kumar *et al*., 2007). Poor resource farmers in developing countries use different plant materials to protect stored grains against pest infestation by mixing grains with protestants made up of plant products. This idea is supported with the fact that the use of naturally occurring plant materials to protect agricultural products against a variety of insect pests is an old-age practice in some parts of the world (Onolemhemhen *et al*., 2011).

Several classes of plant-derived chemicals can be classified in to: alkaloids, rotenoids, phenolic compounds, pyrethrins, oils, saponins, and some others. Some of them are already widely used, their activity have been tested against many insect pest. Although the acute toxicity of pure plant-derived substances or plant extracts may be many times lower than the toxicity of synthetic insecticides (Derbalah, 2012), their subacute toxicity, including repellency or antifeedant activity has been described (Regnault-Roger, 2012; and Said and Pashte, 2015).

Calotropis procera belongs to Asclepiadaceae family, which includes more than 280 genera and approximately 2,000 species (Sharma *et al*., 2016). In many countries *C. procera* leaves are used in folk medicine to reduce blood glucose in patients suffering from diabetes mellitus (Rahmatullah *et al*., 2009). Different parts of Calotropis are reported to have abundant phytochemical constituent as flavonoids, tannins, sterols, alkaloids, cardiac glycosides, sterols and tri-terpenes (Prabha *et al*., 2013). The plant latex of *C. procera* at the rates of 1.5mls and 2.0mls cause 100% mortality of adult *Callosobruchus maculatus* after 4 days (Prabha *et al*., 2013). According to Ogunleye and Omotoso (2011), *Jatropha curcas* offered 100% mortality of adult *S. zeamais* at the rates of 0.3mls and 0.4mls after 24 hours of application.

MATERIALS AND METHODS

The Study Area

The research was conducted at the Agronomy laboratory, Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi. The experiments was carried out under an ambient temperature of 28°C to 32°C and relative humidity of 55% to 75% for period of three months. Bauchi is located at 10° 74'E latitude and 9°47'E and situated at 690.3m above the sea level in savannah zone of Nigeria.

Collection and Preparation of Sodom apple (*Calotropis procera)*

The *Calotropis procera* leaves and branches were collected from the Calotropis trees in Bauchi metropolis. The leaves and branches was cut off and collected and dried under the shade dried for two weeks and it was grounded with pestle and mortal separately. The fine powder of each plant materials were separately kept on the leather until when needed.

Disinfestation of Maize Seeds

The maize seeds were manually sorted to remove broken seeds with holes and other foreign object using a mesh sieve to remove insects and remaining contaminants. The sorted seeds were fumigated with aluminium phosphide (Phostoxin tablets) at the rate of 0.2 g/kg for 72 hours under airtight conditions to exclude any possible infestation that may affect the seeds as described by Abdullahi (2012). After 72 hours, the fumigated maize seed was spread on a clean mat and covered with baft cloth to remove any residue and to avoid infestation. This was done for 48 hours.

Source and Rearing of Experimental Insects

A sample of maize weevil was collected from previously infested stored maize seeds obtained from Rail way market in Bauchi Local Government Area of Bauchi State, Nigeria. The insects were brought to the laboratory and kept at room temperature 28 $\pm$ 2 ^{0}C and relative humidity 70 $\pm$ 5%. About 15 kg of sound uninfected maize seeds was weight and transferred into an earthen clay pot. Thereafter, maize weevils were transferred into the earthen clay pot. The top of the earthen clay pot was covered with white muslin cloth, tightened firmly with a rubber band and *Sitophilus zeamais* were introduced to oviposit under crowded conditions in a light: dark regime of 12L:12D at room temperature and relative humidity for one week. After one (1) week, dead and live parent stocks were completely sieved out to await the emergence of F_1. The same procedure was used with F_1 generation to obtain F_2 generation used for the experiment.

Treatment and Experimental Design

The treatment consisted of leaves powder (1 g, 3 g and 5g), Stem bark powder of *C. procera* (1 g, 3 g and 5g), Actellic (Pirimiphos methyl) (positive control) and untreated maize seeds (negative control). These were applied to 100 g of clean uninfected maize seeds and repeated three (3) times. The experiment was laid out in completely Randomized Design (CRD) and means were separated using New Duncan Multiple Range Test (NDMRT).

Contact Toxicity

Five (5) pairs of laboratory reared F_2 generation of the maize seed weevils (*S. zeamais*) were introduced into the treated and untreated cowpea seeds already contained in plastic jars (measuring 4 x 6 x 8 cm). The open end of the plastic containers was covered with a fine muslin cloth and tied firmly with rubber band and kept at room temperature (29 – 32^{o}C) in the laboratory. Observation on insect mortality was recorded at 24 hours, 48 hours and 72 hours after exposure to the treatment for two (2) weeks according to (Liu and Ho, 1999).

Evaluation of Oviposition

Ten infested maize seeds were randomly selected from treated and untreated seed. Numbers of eggs were counted with the aid of magnifying hand lens and percentage oviposition deterrence was calculated using the formula as described by (Vanmathi *et al*., 2010).

$$\text{Percentage (\%) Deterrence} = \frac{Cs-Ct}{Cs} \text{ x } 100 \qquad \dots(1)$$

where;

Cs = number of eggs laid on control seed, Ct = Number of eggs laid on treated seed

Evaluation of Adult Emergence

All the plant powder was sieved and was subjected to incubation at room temperature in the dark for 2 weeks to monitor the emergence of adult weevil from the seeds. The number of adult weevils emerged by the weevil were recorded. The percentage adult emergence deterrence was calculated using the formula as described by (Vanmathi *et al*., 2010).

$$\text{Percentage (\%) Deterrence} = \frac{Ac-At}{Ac} \text{ x } 100 \qquad \dots(2)$$

where;

Ac = Number of adult emerged on control seed, At = Number of adult emerged on treated seed.

Evaluation of Percentage Seed Damage

Ten seeds were randomly selected from each treatment and observation on number of exit holes was carried out. Seeds containing three or more holes were considered as damaged seeds. Number of damaged and undamaged seeds were counted and recorded for each repetition percentage seed damage was evaluated using the formula which was described by (Awoke *et al*., 2014).

$$\text{Percentage (\%) Seed Damage} = \frac{G1}{G2} \text{ x } 100 \qquad \dots(3)$$

where;

G_1 = Number of seed with holes

G_2 = Number of seed without holes

Evaluation of Weight loss

At the end of the experiment, the insects and plant powders were sieve our and maize seeds reweight to obtain the weight loss and this was done using the formula which was described by (Awoke *et al*., 2014).

$$\text{Percentage (\%) Loss} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100 \qquad \dots(4)$$

Evaluation of Viability Test

Ten (10) uninfected seeds were randomly selected from each treatment to evaluate germination test. The seeds were arranged on a moisten Petri dishes, and seeds were subjected to germination for period of seven days after which the number of germinated seeds in each Petri-dishes was counted and recorded. The germination percentage (GP) was calculated using the formula as described by (Awoke *et al*., 2014).

$$GP = \frac{\text{Number of seed germinated}}{\text{Total number of seed planted}} \times 100 \qquad \ldots(5)$$

Data Collection and Analysis

Data were collected on Adult Mortality, Number of seed with holes, Number of eggs laid, Number of weevils that emerge, Number of germinated seed, Weight loss and Percentage grain damage. All data collected were subjected to statistical analysis of variance (ANOVA) using SPSS software (version) and New Duncan's Multiple Range Test (NDMRT) was used to separate the difference between treatment means.

RESULTS AND DISCUSSION

Table 1 show the effect of leaves and stem bark powder of *calotropis procera* on adult mortality of *Sitophilus zeamais*. The result revealed that all treated seeds were better than untreated seeds (control). The high concentration of *C. procera* leaves powder recorded, the highest the adult mortality of adult *S. zeamais* at 24 (2.33), 48 (2.66). 72 (2.33), and 96 (2.00) hours compared to other treated seeds.

Table 1: Mean Mortality of Adults *Sitophilus zeamais* exposed to Maize Seeds Treated with Different Concentration of Leaves and Stem Bark Powder of *Calotropis procera*

Stem Bark	**Conc. (g/100g seed)**	**24**	**48**	**72**	**96**	**168**	**336**
	3	0.67^{c}	1.00^{c}	1.33^{bc}	1.33^{bc}	1.33	1.00
	1	0.67^{c}	0.67^{d}	1.00^{c}	2.00^{a}	1.00	1.00
	3	0.67^{c}	1.00^{c}	1.33^{bc}	1.33^{bc}	1.33	1.00
	5	1.33^{b}	2.00^{b}	1.67^{b}	2.33^{a}	1.67	1.33
Leaves	1	0.67^{c}	0.33^{d}	1.00^{c}	1.00^{cd}	0.67	0.67
	3	1.33^{b}	1.33^{c}	1.67^{b}	1.33^{bc}	1.00	1.00
	5	2.33^{a}	2.66^{a}	2.33^{a}	2.00^{a}	1.00	0.00
Actellic dust	0.04%	2.67^{a}	2.33^{a}	2.33^{a}	2.33^{a}	0.00	0.00
Control (untreated)		0.00^{d}	0.00^{e}	0.00^{d}	0.67^{d}	0.33	0.67
LS		*	**	*	*	NS	NS
SE (+)		0.68	0.41	0.39	0.42	1.12	1.48

**Significant at 1%, and * at 5%; Means followed by the same letter are not significantly different ($P \leq 0.01$) from each other, using New Duncan's Multiple Range Test (NDMRT); LS = level of Significance; SE = Standard Error

As reported in Table 1, the higher mortality recorded on seeds treated with *C. procera* leaves could be as a result of higher phytocompounds in the leaves. This is in line with the a similar study conducted by Prabha *et al*. (2013) who reported *C. procera* to have abundant phytochemical constituent such as flavonoids, tannins, sterols, alkaloids, cardiac glycosides, sterols and tri-terpenes. Prabha *et al*. (2013) further stated that, the latex of *C. procera* at the rates of 1.5mls and 2.0mls evoked 100% mortality of adult *Callosobruchus maculatus* after 4

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days. Danjumma *et al*. (2009) also reported that 2.0 g of *N. tabacum* applied in 50 g of maize grains results 100.00% mortality of *S. zeamais.*

Table 2 showed the effect of leaves and stem bark powder of *C. procera* on oviposition and percentage oviposition deterrence on *S. zeamais.* The result show that the highest (53.00) number of eggs was recorded in untreated seed and the number is more than double to that recorded in all treated seeds. The lowest (3.33) number of eggs was recorded in seeds treated with higher concentration of leaves powder of *C. procera*. This could be attributed to higher mortality of adult *S. zemais* earlier recorded this finding agrees with that of Ibrahim *et al*. (2017) reported that the toxicity of *C. procera* was proportionally to the concentration and higher concentration has stronger effects against *C. maculatus*. He further stated that, the overall mean oviposition also increased with increase in time intervals after treatment, which revealed that the higher concentration have the lower oviposition than that of lower concentration. Suleiman and Suleiman (2014) also reported that leaf powders of *E. balsamifera* and *L. inermis* prevent *C. maculatus* from laying eggs. Umar (2008) also obtained similar results which showed that at the rate of 2.0g/ 20.0g seeds, the leaf powder of *J. curcas* reduced oviposition by 30% compared to other treatment, when he worked on the comparative potentials of leaf, bark and wood powders of *J. curcas* as protectants of stored cowpea against *C. maculatus*.

Table 2: Effect of *Calotropis Procera* Leaves and Stem Bark Powder on Number of Eggs and Percentage Oviposition Deterrence of *Sitophilus Zeamais* on Seeds Treated with Different Concentrations

Treatments	**Conc. (g/100g seed)**	**Oviposition**	**% Deterrence**
Leaves	**1**	10.00^{b}	81.13
	3	6.67^{c}	67.42
	5	5.67^{c}	89.30
Stem bark	1	11.33^{b}	78.62
	3	6.67^{c}	67.42
	5	3.33^{d}	93.72
Actellic	0.04	3.00^{d}	94.34
Control (untreated)		53.00^{a}	0.00
LS		**	
SE ($\pm$)		2.04	

**Significant at 1%; Means followed by the same letter are not significantly different ($P \leq 0.01$) from each other, using New Duncan's Multiple Range Test (NDMRT); LS = level of Significance; SE = Standard Error

Table 3 showed the effect of leaves and stem bark of *C. procera* on progeny emergence of adult *S. zeamais.* The result showed that the highest (51.00) number of progeny emergence was recorded in untreated compare to treated seeds and the progeny emergence was lower (3.00) in higher concentration of the plant leaves powder of the plant materials. Plants material presents several mode of action to various insects raging from repellent, anti-feedant and fumidant. Lower progeny of adult *S. zeamais* recorded in higher concentration could be attributed to high mortality of adult *S. zemais*. This could also be as a result of inability of the insect to properly oviposit due to the unpleasant oviposision condition. This is in conformity with those of Begum *et al*. (2011) who reported similar results on leaves of *C. procera* and *Annona squamosa* which he attributed the effect against the maggots of *Musca domestica* to mortality recorded. Ashamo *et al*. (2013) also reported attributed inability of the progeny to emerge could be due to the mortality of the insect larval which is caused by inability of the larval to fully cast off their exoskeleton which typically remained linked to the posterior part of their abdomen.

Table 3: Effect of *Calotropis procera* Leaves and Stem Bark Powder on Adult emergence and Percentage Emergence Deterrence of *Sitophilus zeamais* on Treated and Untreated Maize Seeds

Treatments	Conc. (g/100g seed)	Number: adult emerge	% Deterrence
Leaves	**1**	12.33[b]	76.74
	3	7.33[c]	86.17
	5	7.00[c]	86.79
Stem bark	1	11.67[b]	77.98
	3	10.67[b]	79.87
	5	3.00[d]	93.08
Actellic	0.04%	2.33[d]	93.72
Control (untreated)		51.00[a]	0.00
LS		**	
SE (+)		1.97	

**significant at 1%; Means followed by the same letter are not significantly different ($P \leq 0.01$) from each other, using New Duncan's Multiple Range Test (NDMRT); LS = level of Significance; SE = Standard Error

Table 4 showed the effect of leaves and stem bark of *C. procera* on percentage grain damage and number of exit holes. The result showed that, the highest (56.67%) percentage seed damage and number of exit holes (58.00) was recorded in untreated seeds. Seeds treated with the higher concentration of leaves powder recorded the lowest (3.67%) percentage seed damage and number of exit holes (3.33). The toxicity of the plant powder might be the possible reasons of reducing percentage seed damage and number of exit holes. This is in line with the finding of Bakavathiappan *et al*. (2012) who earlier reported that the antifeedant activity was directly proportional to the concentration of the extract. This finding also agreed with the work of Udo (2011) who found that the extract of *Z. zanthoxyloides* was effective in reducing the adult emergence of *C. maculatus*.

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Table 4: Effect of *Calotropis procera* Leaves and Stem barks Powder on Percentage Grain Damage and Number of Exit Holes of on treated and untreated Maize Seed after Exposure to the Treatments

Treatment	Conc.(g/100g seed)	% Grain damage	Number of Exit hole
Leaves	1	9.33^{c}	10.00^{b}
	3	6.00^{d}	6.67^{c}
	5	6.00^{d}	5.67^{c}
Stem bark	1	11.67^{b}	12.33^{b}
	3	7.67^{d}	6.67^{c}
	5	3.67^{e}	3.33^{d}
Actellic	0.04%	3.33^{e}	3.00^{d}
Control		56.67^{a}	58.00^{a}
LS		**	**
S (+)		1.99	2.04

**significant at 1%; Means followed by the same letter are not significantly different (P≤0.01) from each other, using New Duncan's Multiple Range Test (NDMRT); LS = level of Significance; SE = Standard Error

Table 5 showed the effect of leaves and stem bark of *C. procera* on grain weight loss and germination. The result showed that untreated seeds recorded the highest (13.77%) weight loss compare to other treated seeds. However, seeds treated with the higher concentration of leaves powder (5 g/100 g seeds) recorded the lowest weight loss. Lower weight loss recorded in seeds treated with leaves of *C. procera* could be attributed to mortality recorded earlier and toxicity of the plant powder that deter insect from feeding. This supports the findings of Wahedi *et al*. (2013) who found that seeds treated with Neem seed extract significantly prevented emergence of F1 adults of C. *maculatus* and subsequent weight loss done due to pest.

Table 5: Effect of *Calotropis procera* leaves and Stem ark Powder on Percentage Weight Loss and Percentage Germination after Exposure to the Treatments

Treatment	Conc. (g/100g seed)	% Grain weight loss	% Seed germination
Leaves	1	4.73^{b}	96.33
	3	3.80^{c}	100.00
	5	1.90^{d}	100.00
Stem bark	1	4.37^{b}	95.33
	3	3.00^{d}	96.66
	5	1.63^{e}	100.00
Actellic	0.04%	1.40^{e}	100.00
Control (untreated)		13.77^{a}	96.67
LS		**	NS
SE (+)		0.67	5.24

**significant at 1%; Means followed by the same letter are not significantly different (P≤0.01) from each other, using New Duncan's Multiple Range Test (NDMRT); LS = level of Significance; SE = Standard Error

As reported in Table 5, there is no significant difference between untreated and treated seeds. The finding of this study is in line with Ibrahim *et al*. (2017) who reported that, that there was no significant difference among the treatment compared to the control sample throughout the sampling period. This means that seeds treated with *C. procera* have no negative effect against germination of the cowpea seeds.

CONCLUSION AND RECOMMENDATION

All tested plant part in this study clearly demonstrated contact toxicity against *S. zeamais* compare to untreated seeds. The higher concentration of leaves powder of *C. procera* significantly (P≤0.05) provided the highest results in all the parameters observed and could be recommended to farmers as a suitable alternative to chemical pesticide.

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