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Efficacy of *Anacardium occidentale* and *Cymbopogon citratus* as Biopesticides against Maize Weevils (*Sitophilus zeamais* Motsch.) on Stored Maize

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Authors' contributions

This work was carried out in collaboration between all authors. Author JAW designed and supervised the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author BBD carried out the experiment. Author OSE, VMV and RZ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An experiment on the insecticidal potency of *Anacardium occidentale* and *Cymbopogon citratus* against maize weevils (*Sitophilus zeamais* Motsch.) on stored maize was evaluated at 1.0g, 1.5g and 2.0g doses per 20g maize grain in 300ml rearing jars. Toxicity in terms of mortality, oviposition, F1 generation emergence, grain damage, and grain weight loss were all noted. Data collected was subjected to Analysis of Variance (ANOVA) using SPSS version 16.0 at 5% level of significance (P>0.05). When compared with the control (untreated maize), significant difference (P>0.05) in the potency of the biopesticides was observed in the parameters measured. *A. occidentale* performed significantly lower than *C. citratus* as it recorded higher (18.75±9.68) grain damage at 1.0g dose, as well as grain weight loss (0.58) at 1.0g and 1.5g treatment doses respectively. This suggests that although the plant products were tested to possess insecticidal potency against the maize

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weevils, *C. citratus* performed significantly (P>0.05) better than *A. occidentale* in the control of *S. zeamais* on stored maize. Hence, it could be used sustainably in the control of insect pests on stored products.

Keywords: Anacardium occidentale; biopesticide; *Cymbopogon citrates;* maize; *Sitophilus zeamais.*

1. INTRODUCTION

Maize (*Zea mays*) is a cereal crop widely cultivated in different parts of the world. Worldwide, about 785 million tons of maize is produced each year, with United States being the largest producer, accounting for about 42% of the overall production [1]. Maize is an important food crop in the tropics, subtropics and temperate regions where they are grown [2]. In Nigeria, and in Adamawa Sate, maize is one of the most important economic crops grown [3]. But unfortunately, maize production in most parts of Nigeria is restricted to only the rainy months of the year. This however necessitates the need to store the maize grains throughout the dry months of the year.

However, the storage of maize grains and its maximum utilization is seriously affected by the activities of pests [4]. The major insect pest is *Sitophilus zeamais* Motch. (Coleoptera: Curculionidae). To enhance productivity of maize in the field and reduced its loss in storage, the control of insect pests activities is needed, including the use of chemical insecticides. The use of insecticides is very effective and reliable, and can prevent loss of maize yield. They act quickly, making them suitable for use in emergency situations [2]. But unfortunately, the intensive use of insecticides has caused problems such as residual effect and the effect on non-target organisms. Hence, safe alternatives which are also effective, non-costly and biodegradable, are needed for the control of these pests against stored product pests, especially *S. zeamais* [5]. Farmers and researchers have been trying to control stored product pests like *S. zeamais* using plant products (biopesticide) which are readily available, cheap and environmentally friendly [6, 7].

Anacardium occidentale is an evergreen tree in the family Anacardiacea and has both medicinal and economic values [8]. *Cymbopogon citratus* is utilized for its numerous uses. It is used as fragrance, for perfume and also a source as vitamin A and E [9]. *Cymbopogon citratus* oil is used deodorants, waxes, polishes, detergent and insecticides [10].

In this study, the insecticidal potentials of leaf powders of *Anacardium occidentale* and *Cymbopogon citratus* were evaluated against the *S. zeamais* with a view of developing biopesticides against stored product pests.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in Mubi town of Adamawa state, Nigeria. Mubi is located between latitude 10º12N and longitude 13º10'E. The climate is tropical with average temperature of about 15-42ºC in dry season and relative humidity 10-45% [11].

2.2 Collection of Materials

Samples of lemon grass (*Cymbopogon citratus*) and cashew leaves (*Anacardium occidentale*) were obtained around the Botanical Garden, Adamawa State University, Mubi. They were cupboard-dried at room temperature in the laboratory of Biological Science, Adamawa University for four days and were subsequently pulverized into fine powder using electric blender. Synthetic chemical (Rambo-permethrin 0.60%) was obtained in an agro-chemical store in Mubi market and was used as the positive control. Clean maize cobs was also obtained from a farmer in Mubi and shelled to obtain the grains.

2.3 Insect Culture

Parent stock of *S. zeamais* was obtained from infested maize grains obtained from a store in Mubi. The adult weevils obtained from the parent stock were transferred onto a clean maize grain in 500cm^3 rearing jar which was allowed to stand for 48 hours. Thereafter, the insects were discarded and the exposed maize was maintained under laboratory conditions for adult emergence of *S. zeamais* [12]. This helped in raising *S. zeamais* adults of the same size and age that were used to carry out the experiment.

2.4 Experimental Setup

Before the experiment was set up, the maize grains were oven-dried to a constant weight in an oven at 40-45ºC for two hours and were later air-dried in the laboratory to prevent moldiness for about an hour [12, 13]. 20g of the maize grains were placed in each of the treatment cups. Three treatment doses of 1.0g, 2.0g and 3.0g were constituted and replicated 4 times. These were added individually to the 20g of maize grains in the treatment jars and mixed thoroughly to ensure a uniform coating of the grain by the treatment samples. Thereafter, 10 newly emerged adult *S. zeamais* obtained from the cultured jar were introduced into the experimental jars at the same time. The content of the jars were covered with muslin clothes with the aid of a rubber band to prevent the insects from escaping and also to allow for ventilation.

2.5 Data Collection

2.5.1 Mortality

Mortality count was recorded at 24 hours post exposure intervals of four days. The content of each experimental jar was emptied gently on a silver tray in the laboratory. Using a broom stick, the insects were touched one after the other. The inability of any of the insects to respond to one touch indicated a death individual. The dead insects were subsequently removed and the remaining contents and the live insects were put back in the jar.

2.5.2 Oviposition

Oviposition was determined using the acid fuchsin staining method. 10 grains of maize from each jar was randomly picked on the 10th day, immersed in warm water for two to three minutes, drained and subsequently put in 0.5% acid fuchsin stain for two to five minutes. The grains were rinsed in water and were determined for cherry red gelatinous egg plugs. The number of egg plug noticed on the 10 grains was extrapolated for the entire jar using an average number of 82 grains per jar [14].

$$Oviposition = \frac{Average\ number\ of\ maize\ grain\ x\ Number\ of\ eggs\ laid}{Number\ of\ maize\ grain\ picked\ randomly}$$

2.5.3 F1 generation emergence

The F1 progeny emergence was observed within 4-5weeks after exposure to treatments in the course of the experiment. The newly emerged adult *S. zeamais* was counted and recorded.

2.5.4 Grain damage

Ten maize grains were selected randomly from each plastic jar and were noted for grain damage. Maize grains observed with holes, cracks and any form of abrasion were considered as damaged grains. The number of damages was noted on 10 randomly selected maize grains, and was extrapolated for the entire jar using an average number of 82 grains per jar.

2.5.5 Weight loss

The weight of the maize grain in each experimental jar was initially noted using a weighing balance prior to the experimental setup. Thereafter, the final weight of the grain was also noted after the experiment. Therefore, weight loss was determined by subtracting the final weight from the initial weight, as shown in the formula below:

Weight loss= initial weight – final weight

2.5.6 Data analysis

Data collected were subjected to Analysis of Variance (ANOVA), and the means were separated at P>0.05 level of probability using Least Significant Difference (LSD).

3. RESULTS

Table 1 shows the toxicity effect of treatments (*C. citratus* and *A. occidentale*) in terms of mortality of *S. zeamais* reared on maize grain. Overall, the mortality counts on various treatments and the control (untreated) experiment were significantly different (P>0.05). Although the mortality was spread across the four days of exposure in all the treated jars, there was no mortality recorded in the control experiment throughout the exposure period. At the end of the four days of exposures, there was a significant difference (P>0.05) in the mortality recorded across the treatments and the control. Among the plant treatments, *A. occidentale* appeared to have recorded a significant higher mortality than the *C. citratus* (Table 1).

Table 2 shows effect of the plant treatments in suppressing egg laying and adult F1 progeny emergence of *S. zeamais*. The results revealed that there was a significant difference (P>0.05) in both the egg laying and the number of F1 generation emergence between the treatments and control (untreated) experiment. The treatments significantly (P>0.05) reduced the number of eggs laid by the adult *S. zeamais* and the number of adult emergence. The number eggs laid was significantly (P>0.05) lower in grains treated with *A. occidentale* (12.30) at 1.0g dose, while the highest (18.45) was recorded in *C. citratus* at 1.0g dose and *A. occidentale* at 1.5g dose respectively. As expected, the synthetic insecticide (Rambo-permethrin 0.60%) significantly (P>0.05) reduced the number of eggs laid to as low as 2.05 in 1.0g and 2.0g treatment dose, and no adult emerged (0.00) for F1 generation.

The effect of treatments in the protection of maize grain from damage and weight loss as a result of *S. zeamais* activities is shown in Table 3. There was a significant difference (P>0.05) in grain damage and subsequent weight loss by the maize grains as a result of the insect activities, when compared with the control (untreated) experiment. Here, the grains treated with *A. occidentale* significantly (P>0.05) recorded higher damages (18.75±9.68) at 1.0g dose. The subsequent weight loss recorded was a clear reflection of the result on grain damage, as maize treated with *A. occidentale* significantly (P>0.05) recorded higher (0.58) at 1.0g and 1.5g treatment doses respectively. As expected, the synthetic insecticide (Rambo) at all treatment doses significantly reduced grain damage as well as the subsequent weight loss by the grains.

4. DISCUSSION

In this study, two different samples of biopesticides (*Cymbopogon citratus* and *Anacardium occidentale*) were tested for the insecticidal activities on maize weevils

Table 1. Mortality of *Sitophilus zeamais* reared on maize grain

Treatment	Dose (g)	Days of exposure (Mean±SD)				Total
		1	2	3	4	
Control	0.00	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
C. citrates	1.0	0.00±0.82^{a}	1.00±0.82^{b}	0.25±0.50^{a}	0.00±0.00^{a}	1.25±1.26^{ab}
	1.5	0.00±0.00^{a}	0.25±0.50^{ab}	0.00±0.00^{a}	0.00±0.00^{a}	0.25±0.50^{a}
	2.0	1.00±1.15^{a}	0.25±0.50^{ab}	0.50±1.00^{a}	0.00±0.00^{a}	1.75±1.71^{ab}
A. occidentale	1.0	1.00±1.15^{a}	0.00±0.00^{a}	0.50±0.58^{b}	0.00±0.00^{a}	1.50±1.29^{ab}
	1.5	1.00±2.00^{a}	0.25±0.50^{a}	0.00±0.00^{a}	0.50±1.00^{a}	1.75±2.06^{ab}
	2.0	0.25±0.50^{a}	0.75±0.96^{a}	0.00±0.00^{a}	0.25±0.50^{a}	1.25±0.50^{ab}
Rambo	1.0	3.50±0.58^{b}	4.25±1.26^{b}	2.00±0.82^{b}	0.25±0.50^{a}	10.00±0.00^{c}
	1.5	2.50±1.00^{ab}	6.00±1.83^{b}	1.25±0.96^{b}	0.25±0.50^{a}	10.00±0.00^{c}
	2.0	4.00±3.39^{b}	4.75±2.63^{b}	1.00±0.82^{ab}	0.25±0.50^{a}	10.00±0.00^{c}

Values are means of four replicates. Means carrying the same superscript alphabet along the columns are not significantly different (P>0.05)

Table 2. Oviposition and F1 progeny emergence of *S. zeamais* reared on maize grain

Treatment	Dose (g)	Parameters (Mean±SD)	
		Number of eggs laid	F1 generation Emerged
Control	0.0	36.9±10.59^{c}	4.50±1.29^{c}
C. citrates	1.0	18.45±14.00^{b}	1.50±0.58^{b}
	1.5	16.40±20.00^{b}	2.00±2.16^{b}
	2.0	18.45±12.30^{b}	2.50±1.29^{b}
A. occidentale	1.0	12.30±19.52^{ab}	2.25±1.26^{b}
	1.5	18.45±21.57^{b}	1.75±2.87^{b}
	2.0	20.50±4.74^{b}	2.50±2.52^{b}
Rambo	1.0	2.05±4.10^{a}	0.00±0.00^{a}
	1.5	6.15±7.85^{a}	0.00±0.00^{a}
	2.0	2.05±4.10^{a}	0.00±0.00^{a}

Values are means of four replicates. Means carrying similar alphabets along the columns are not significantly different (P>0.05)

Table 3. Damages and weight loss of maize grain

Treatment	Dose (g)	Parameters (Mean±SD)	
		Grain Damage	Weight Loss (g)
Control	0.0	22.50±13.69^{b}	1.00±0.18^{b}
C. citrates	1.0	15.00±6.12^{ab}	0.28±0.22^{a}
	1.5	11.25±4.33^{ab}	0.45±0.25^{a}
	2.0	11.25±4.33^{ab}	0.23±0.13^{a}
A. occidentale	1.0	18.75±9.68^{b}	0.58±0.26^{a}
	1.5	13.12±3.75^{ab}	0.58±0.33^{a}
	2.0	13.12±7.18^{ab}	0.55±0.13^{a}
Rambo	1.0	7.50±6.12^{a}	0.33±0.10^{a}
	1.5	5.62±7.18^{a}	0.30±0.16^{a}
	2.0	7.50±6.12^{a}	0.25±0.17^{a}

Values are means of four replicates. Means carrying the same superscript alphabets along the columns are not significantly different (P>0.05)

(*Sitophilus zeamais*). All the treatments caused a significant mortality of adult *S. zeamais* than the control (untreated), where no mortality was recorded throughout the four days of exposure, confirming the effectiveness of the plant products (biopesticides) on *S. zeamais*. The order of their efficacy is: Rambo>*A. occidentale*>*C. citratus*. The results of this study corroborate with the findings of Dike and Mbah [15] where lemon grass products significantly protected cowpea grains in storage from insect infestation. The powder of *A. occidentale* has been reported as protectant against different storage insect pests [16]. In a similar study on the efficacy of plant products on stored maize, Wahedi [7] reported the insecticidal effect of neem seed powder on adult *S. zeamais* reared on maize grains in Mubi.

The biopesticides were able to reduce F1 emergence of *S. zeamais* on maize grain significantly (P>0.05). *C. citratus* and *A. occidentale* showed some insecticidal activities by reducing the number of eggs laid as well as F1 adult emergence, when compared with the control (untreated) experiment. This further confirms the insecticidal properties in the plant products. This agrees with the study conducted by Mba and Okoronkwo [2] and Wahedi [7] who reported the efficacy of plant products in reducing egg laying as well as F1 progeny emergence of *S. zeamais*.

Similar result was reported in the grain damage and weight loss. The treatments showed some insecticidal activities by significantly protecting the maize grains from damages and subsequent weight loss possibly as a result of the activities of *S. zeamais*. This also agrees with the study performed by Wakole [17] and Wahedi [7], who reported plant products effectively protected maize grain from damage as well as weight loss.

5. CONCLUSION

In conclusion, the overall results have confirmed the effectiveness of *A. occidentale* and *C. citratus* as biopesticides for the control of adult *S. zeamais*. *A. occidentale* performed significantly better than *C. citratus* based on the various parameters tested.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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