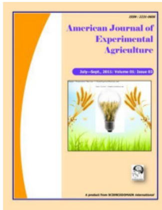

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Potentials of Two Indigenous Plants Powder for the Control of Stored Maize Weevil, *Sitophilus zeamais* (Motschulsky)

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Authors' contributions

This work was carried out in collaboration between all authors. Author EIO designed the study, wrote the protocol and wrote the first draft of the manuscript. Author IGU reviewed the experimental design and all drafts of the manuscript. Authors EEO and EJU managed the analyses of the study. Author SEU identified the plants. Authors JOO and ROA performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Potentials of two indigenous plants powder derived from *Acmella oleracea*, Linn and *Lantana camara*, Linn were evaluated in the laboratory at ambient temperature and relative humidity (28±20C; 75±5% RH) for the control of stored maize weevil, *Sitophilus zeamais* (Motsch). Powders obtained from air-dried flower heads of *A. oleracea* and leaves of *L. camara* were tested at 1, 3 and 5% (w/w) concentrations. Parameters assessed were effect of plant powders on weevil mortality (toxicity test), adult emergence (oviposition deterrence test) and germination (viability test) of seeds after storage. Results showed that the 3% and 5% plant powders significantly ($p<0.05$) increased weevils cumulative mortality and suppressed adult emergence compared to 1% powders and controls. The result also revealed that the efficacy of these plant powders on the weevils was dose-dependent with higher doses providing greater protection of the maize grains. Seeds viability test

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revealed that powder treatments had no deleterious effects on the germination potential of treated maize. The multiple insecticidal effects of these plant powders and their potential for local availability make them attractive candidates in upgrading traditional post-harvest protection practices. The outcome of this study is encouraging and a possible means of ensuring a steady supply of good quality maize grains.

Keywords: Zea mays; Sitophilus zeamais; plant materials; mortality.

1. INTRODUCTION

Maize, *Zea mays*, is one of the most valued cereal crops in the world and in Nigeria occupies the second position next to rice with an estimated annual production of 5.4 million metric tons from about 3.5 million hectares [1,2,3]. The popularity and high acceptability of maize have been based on their low cost and versatility in food preparation [4]. For most people in Africa, maize provides the staple food. It can be boiled fresh or dry and eaten alone or with other food items such as pea, coconut and groundnut. It can also be processed into starch or cooked into porridge, fried into pop corn or milled into flour and used for delicacies such as *Ogi* (pap) or *Agidi* [5,6].

There is however an increasing concern about the sustainability of large-scale maize production in Nigeria as a result of field to store insect pest infestation. One of the most incriminated insects is *Sitophilus zeamais* Motschulsky. The huge post-harvest losses and quality deterioration caused by this pest is a major obstacle to achieving food security in developing countries [7]. Varying estimates of losses caused by storage insect pests abound in literature. World post-harvest losses for all grains have been estimated at about 10% of the annual production, which in quantitative terms is over 100 million tons [8]. In Nigeria, weight loss and contamination of stored paddy rice caused by insect pests have been reported [9]. It has also been shown that the presence of *S. zeamais* in maize grains harvested led to a reduction in both weight and germination capacity of the grain [10].

The control of storage insects like *S. zeamais* has centered mainly on the use of chemical insecticides that are hampered by many attendant problems such as toxicity to human that consume the product, development of insect resistant strains and the cost of procurement [11,12]. These problems have therefore necessitated current research efforts to focus on stored products protection which includes the development of non-chemical technologies that eliminate the use of insecticides and have economic and health benefits for the applicators, consumers and environment [3]. The use of more natural and sustainable methods that can offer compatible control efficiency plus the benefit of reduced hazards to the environment is most favoured [13-15]. A lot of successes have been recorded in this area [16,17,10]. In this study various parts of two indigenous plant species reputed to have medicinal properties in Nigeria were prepared and tested as a potential insecticide against the weevil, *S. zeamais* (*Motsch*).

2. MATERIALS AND METHODS

2.1 Insect Culture

Cultures of the test insects, adult *S. zeamais*, were maintained in the laboratory at ambient temperature of 28±2ºC and relative humidity of 60±5% on a 12h:12h light: dark regime. The food medium (healthy and whole un-infested dry maize seeds) used for the insect culture as well as the bioassay was purchased from Watt Market, Calabar, and preserved in the refrigerator at -5ºC to disinfest the grains prior to the experiment. Fifty pairs each of 2-days old *S. zeamais* adult sexed following the methods of Halstead [18] and Haines [19] were introduced into thirty transparent mass culture plastic jars containing 200g of treated dry maize and left for 5 weeks. The plastic jars had their covers drilled with holes of diameter 9cm and then covered with nylon number 10 (sieve size 2mm). Freshly emerged adults sieved out of the jars using another nylon mesh were then used for the experiments.

2.2 Plant Material Collection and Preparation

Plant materials; flower heads of *Acmella oleracea* (*Asteraceae*) and leaves of *Lantana camara,* (*Verbenaceae*) were selected on the basis of their ethnomedical properties and endemicity. These were collected from fields in

Calabar (situated within Latitude 05º 08[1] North and Longitude 8º 14[1] East) and Ugep (situated within Latitude 05º 48[1] North and Longitude 05º 48[1] East) both in Cross River State of Nigeria, in December 2010. The plant parts were spread on the laboratory bench, to air-dry in a well ventilated area for two weeks; thereafter separately pulverized using a milling machine (All steel, 11.1cm diameter sample input, 17.8cm deep chamber diameter, Corona Mechanical Blender; Landers, Medellin-Colombia). A 63/75 micron sieve shaker was used to obtain powder size. Plant powders were kept in clean transparent containers and preserved in the refrigerator to maintain their efficacy.

2.3 Effect of Plant Powders on Weevil Mortality and Adult Emergence

Fifty grams (50g) of un-infested maize were weighed into 11.00 x 4.50 x 9.40cm^3 transparent test plastic containers for each replicate. Each container had cover with holes covered with nylon mesh to permit aeration and confinement of insects. In each of these containers were different doses of the plant powders 1, 3 and 5% while the control received no plant powder. Powders were applied by direct admixture to the maize grains calculated on the weight of plant material per weight of grain (w/w). Fifteen (15) pairs of 2 days old *S. zeamais* adults were introduced into each of the test plastic containers containing treatments and shaken thoroughly to ensure even distribution of the powders on the insects. Each treatment was replicated 4 times and laid out in a completely randomized design (CRD) on the laboratory bench for 6 days. A mortality count was done every 24 hours for 96 hours after treatment. Each time a count was made; dead individuals were discarded while live ones were returned to their respective treatments. After 6 days all live and dead insects were discarded and the maize seeds kept aside for F_1 progeny emergence.

Weevils emerging from each treatment five weeks after the withdrawal of both live and dead adult weevils from the mortality test were counted and recorded to give a measure of effects of powders on weevil reproduction (adult emergence test). Emerging insects were sieved off subsequently every day to prevent mating and subsequent oviposition by F_1 as mating in *S. zeamais* does not occur before weevils are 3 days old [20]. The effects of treatments on reproduction of insects were determined using the percentage reproductive potential deterrence formula:

% insect emergence (reproductive deterrence) =

$$\frac{\text{Number of adult emergence in Control} - \text{adult emergence in Treatment}}{\text{Number of adult emergence in Control}} \times 100$$

2.4 Viability Test

Viability test was carried out to assess the effects of the plant powders on post storage maize germination. Twenty (20) maize seeds were randomly selected from each replicate and soaked in water for about 30 minutes after which the grains were removed and put in labeled transparent plastic containers lined with cotton which were moistened daily with water and left near the window in the laboratory. Germination and viability were assessed after five days by calculating the mean number of seeds germinated out of the total mean number put in each plastic container.

$$\%\text{germination} = \frac{\text{Mean number of germinated grain}}{\text{Mean number of grains soaked in container}} \times 100$$

2.5 Data Analysis

All data were subjected to analysis of variance and where significant differences existed, treated means were compared using New Duncan's Multiple Range Test at 5% level of probability.

3. RESULTS

3.1 Weevil Mortality and Adult Emergence

The toxicity effects of applied powders of *A. oleracea* and *L. camara* on adult *S. zeamais* is presented in Table 1. The result showed that there were significant differences (p<0.05) in *S. zeamais* cumulative percentage mortality at 24, 48, 72 and 96 hours between concentrations 1, 3 and 5% of both powder treatments and control. Adult mortality significantly increased with increase in concentration and days of exposure. One day after exposure of *S. zeamais* adult to treated maize seeds, *A. oleracea* caused a weevil mortality of 70% as against 60% caused by *L. camara* at 5% concentration. Mortality at 96 hours showed that *A. oleracea* at all the concentration caused 100% insect kill, while *L. camara* recorded similar feat only at 5% dosage.

The number of F_1 adult *S. zeamais* that emerged from treated and untreated maize is represented in Table 2. The results show significant differences (p<0.05) among treatments and the control in the mean number of F_1 adult emergence, as emerged adults decreased with increased concentration of the powder.

3.1 Seed Viability at Post Storage Period

Table 3 shows the effect of plant powder on germinability of the seeds. Majority of the treated seeds and the control had viability, 52.50–85.00, indicating that the powders were not deleterious to germination.

4. DISCUSSION

This present study has revealed that powders obtained from various parts of two indigenous plant species reputed to have medicinal properties have insecticidal activity against *S. zeamais*. *A. oleracea and L. camara* powder applications resulted in high mortality of the weevils, with higher doses of plant substances providing greater protection. This observation confirms the views of Hind and Biggs [21] and Mulunga, et al. [22], who separately found these plant substances to have high toxic effect on the feeding and survival of different pest species including mosquitoes. The ability of the plant powders to bring about significant ($p<0.05$) insect mortality indicated the powders have contact toxicity. This is in support of Ramsewak, et al. [23], who reported that *A. oleracea* is highly toxic and may act as antifeedants to insects thereby leading to starvation and subsequent death. The application of *A. oleracea and L. camara* to stored maize also resulted in significantly fewer emerging adults. This observation may be due to contact action resulting in partial or complete failure of embryonic development. This view is in agreement with the findings of Tapondjou, et al. [24] and Ukeh, et al. [10], who reported that reproductive inhibition could be due to powders having toxic effects on the larvae hatching from eggs laid on grains and subsequently resulting in reduced progeny emergence.

Table 1. Toxicity effect of plant powders on adult mortality (±SE) of *S. zeamais* (h)

Plant	Conc.(%w/w)	24	48	72	96
A. oleracea	1.0	28.33±0.64c	61.67±1.19c	85.00±1.19b	100.00±0.00a
	3.0	60.00±0.91a	86.67±0.91ab	97.50±0.25ab	100.00±0.00a
	5.0	70.00±0.91a	91.67±0.50a	100.00±0.00a	100.00±0.00a
L. camara	1.0	17.50±0.63d	37.50±1.32e	64.17±0.85c	82.50±1.32c
	3.0	40.00±1.58b	67.50±2.29c	85.83±2.36ab	95.00±0.87ab
	5.0	60.00±1.63a	86.67±2.16ab	95.83±0.63ab	100.00±0.00a
Control	0.0	0.00±0.00e	1.76±0.50f	4.17±0.48d	10.00±0.41d

Each value is the mean of 4 replicates. Means within column followed by same letter are not significantly different (p>0.05) from each other using Duncan New Multiple Range Test (DNMRT)

Table 2. Emergence of adult *S. zeamais* and percentage of reproductive deterrence

Treatments potential	Conc.(%w/w)	Mean adult emergence	Reproductive potential deterrence (%)
A. oleracea	1.0	11.05±0.50d	39.62
	3.0	4.18±0.29h	77.16
	5.0	2.35±0.12i	87.16
L. camara	1.0	16.58±0.47b	9.40
	3.0	9.66±0.45e	47.21
	5.0	5.22±0.26g	71.148
Control	0.0	18.30±0.03a	0.00

Means followed by the same letter(s) are not significantly different (p>0.05) from each other, using Duncan New Multiple Range Test (DNMRT)

Table 3. Effect of plant powders on germination of maize

Plant powders source	Concentration (%)	Germination (%)
A. oleracea	1	77.50
L. camara	1	65.00
A. oleracea	3	82.50
L. camara	3	70.00
A. oleracea	5	85.00
L. camara	5	82.50
Control (untreated)		52.50

Plants have evolved elaborate chemical defenses against pest attack and these chemicals have been exploited since ancient times. The plants used in this work are reputed in the treatment of various ailments. *A. oleracea* leaf when chewed causes numbing of the mouth; and is widely used to treat toothache and throat infections, while *L. camara* extracts exhibit antimicrobial, fungicidal and nematicidal activity [25]. Perhaps the same or some of the active compounds which served as human medicine may also be responsible for the insecticidal action. More so, insecticidal property of any plant material would depend on the active constituent of the plant materials [4]. *A. oleracea* and *L. camara* contain phytochemicals such as alkaloids, flavonoids, tannins, etc, in varying proportions. These phytochemicals have been reported to inhibit oxidative phosphorylation and fish oxygen consumption [26]. It is therefore not too surprising that both experimented plants demonstrated such significant insecticidal activity even at low concentrations.

Viability test showed that application of the powdery plant treatments had no deleterious effect on the germination of maize seeds at the post storage period. This indicated that the germination of the seeds was not significantly affected by the different plant parts used as protectants against the weevils, and germination took place in most of the treated seeds at the successive recorded days. The result corroborates earlier work by Oparaeke and Dike who observed that there was no adverse effect on the germination of maize seeds treated with different concentration of plant powders [27]. Similarly, Ukeh, et al. reported that maize seeds treated with different concentrations of powdered *Piper guineense* did not affect the viability of the seeds [10]. This study has therefore identified *S. zeamais* economic role as a serious threat to maize production in Nigeria. The plant powders used in this study to control these weevils are harmless to mammals at least at the dosage being reported and so efforts should be intensified towards their cultivation, packaging and application on a large scale as botanical insecticides.

5. CONCLUSION

The study demonstrated the effectiveness of plants powder derived from *Acmella oleracea* and *Lantana camara*, for the control of maize storage weevil, *S. zeamais*. Mortality at 96 hours showed that *A. oleracea* at the concentrations of 1 – 5% caused 100% insect kill, while *L. camara* recorded similar feat only at 5% dosage. Test results also proved that plant powders had no effect on the viability of maize seed. These findings indicate that the plant powders could serve as a better alternative to synthetic insecticides for the control of this pest.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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