

Assessment of the Insecticidal Properties of  
Some Plant Extracts as Grain Protectants Against  
the Maize Weevil, *Sitophilus zeamais* Motschulsky

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#### ABSTRACT

Acetone extracts of ten plant materials namely, *Garcinia kola* Heckel, *Citrus frutescens* L., *C. sinensis* Osbeck, *C. parandis* Nacfr., *C. aurantifolia* Swing, *Aframomum melegueta* Schum, *Cymbopogon citratus* L., *Xylopiya aethiopica* Rich, *Allium cepa* L. and *Piper guineense* Schum and Thonn were evaluated for their insecticidal activity against the maize weevil, *Sitophilus zeamais* Motch. The results indicated that *C. frutescens*, *P. guineense* and *A. melegueta* effectively protected maize grains against weevil attack. All the three plant extracts exhibited fumigant mode of action since they each have a characteristic pungent smell. It appears *P. guineense* and *C. frutescens* acted mainly through the contact mode of action while *A. melegueta* needed to be absorbed through the cuticle or ingested before it can be effective. Only acetone-extracts of *A. cepa*, *C. citratus* and *C. aurantifolia* were the least effective of the plant materials tested while others were moderately effective. Based on weevil perforation index (WPI), the results of this investigation showed that all the plants tested had some insecticidal activity.

#### INTRODUCTION

The heavy post-harvest losses and quality deterioration caused by storage pests is a major problem facing agriculture in developing countries such as Nigeria. Dramatic successes recorded in the control of insect pests using synthetic insecticides are well known but it has a lot of shortcomings. The attendant problems of the orthodox insecticides such as high mammalian toxicity, high level of persistence in the environment, workers' safety and pest resistance (Sighamony et al. 1986) have necessitated the focussing of attention on alternative insect pest control methods. The use

of plant materials and their extracts, which are believed to be relatively safe and biodegradable, is one of such methods being explored. In the tropics, plant materials such as dried pepper and inert dusts have been in use as powders and admixtures for a long time to reduce post-harvest losses to stored grains and grain legumes.

Recently, attention has been given to the use of vegetable oils and plant extracts in the control of both field and storage insects (Ivbijaro, 1984; Ivbijaro et al., 1985; Odeyemi, 1991; Dike and Mbah, 1992; Shikaan and Uvah, 1992). Some degree of success has been recorded in most cases. For instance Osisioogu and Agbakwuru (1978) reported that the essential oil of *Dennetia tripetala* G. Baker was effective in the control of cowpea weevil, *Callosobruchus maculatus* F and the maize weevil, *Sitophilus zeamais* Mots. Oils of coconut, groundnut and African palm at dosage rates of 5 and 10 mls per kg were found to effectively control *S. Oryzae* L (Ivbijaro et al., 1985). These oils also significantly reduced oviposition and larval development (Ivbijaro et al., 1985). Su (1977) reported that an extract of black pepper, *Piper nigrum*, was highly toxic to the rice weevil, *S. Oryzae* L. while Sighamony et al (1986) also found that pepper extract protected wheat against *S. oryzae* and *Rhyzopertha dominica* F.

In this present study, the acetone extracts of some common Nigerian plants were compared for their relative effectiveness in the control of the maize weevil, *S. Zeamais*.

#### MATERIALS AND METHODS

*Sitophilus zeamais* adults used for this study were obtained from naturally infested stored maize collected from the store of the Teaching and Research Farm of the Federal University of Technology, Akure. From this stock new generations were reared on dry susceptible white maize in Kilner jars covered with muslin cloth.

The plant materials used were purchased from the local markets in Akure, Nigeria. The experimental plant parts used and other relevant information are presented in Table 1. Each of the plant materials was sun-dried and pulverized into fine powder. Ten grams of each pulverized plant material was weighed into a thimble and extracted with 250mls of acetone in a Soxhlet apparatus. The extraction was carried out for four hours. Thereafter, the thimble was removed from the unit and the acetone was recovered by re-distilling the content in the Soxhlet extractor. The resulting extract was air-dried in order to remove traces of the solvent. An aliquot (1.0g) of the extract was weighed into a container and dissolved in 10.0 ml of acetone in order to prepare a concentration 100mg/ml of the extract.

The maize grains used were disinfested by putting them in a deep-freezer for 72 hours and later air-dried for 2-3 hrs in the laboratory in order to prevent mouldiness. The maize grains (10g) were weighed into 100ml volume conical flask and 1.0ml of the extract was added. The extract and the grains were thoroughly mixed with the aid of a glass rod and agitated manually for about three minutes in order to ensure uniform coating and then dried for 1 hr prior to the introduction of the maize weevil. Pure acetone (1.0ml) was used for the control. Each treatment was replicated four times. Twenty teneral adults of *S. Zeamais* were put in each conical flask containing maize grain already pre-treated with the plant extract or acetone. The flasks were covered with muslin cloth held firmly with a rubber band so as to prevent the escape of the weevil and at the same time ensure adequate aeration. Mortality count of the weevils was carried out at 3, 7, 21 and 28 days post-treatment. Damage by the weevils to the maize grains was assessed at 95 days after treatment by counting the number of insect-damaged kernels in the control and treatments. Weevil perforation index (WPI) was adopted for the analysis of damage using the method of Fatope et al. (1995). The weevil perforation index is defined as follows:

Weevil perforation Index (WPI) =

$$\frac{\% \text{ treated maize grains perforated} \times 100}{\% \text{ control maize grains perforated}}$$

Weevil perforation index value exceeding 50 is regarded as enhancement of infestation by the weevil or negative protectant ability of the plant material tested.

**Table 1: Plants evaluated for insecticidal activity**

Scientific name	Common name	Family	Parts used
1. <i>Garcinia kola</i>	Bitter kola	Clusiaceae	Seeds
2. <i>Citrus parandis</i>	Grape	Pintaceae	Peels
3. <i>Citrus aurantifolia</i>	Lime	Rutaceae	Peels
4. <i>Citrus sinensis</i>	Orange	Rutaceae	Peels
5. <i>Caspsicum frutescens</i>	Pepper	Soloanaceae	Fruits
6. <i>Xylophia aethiopica</i>	Pepper	Annonnceae	Fruits
7. <i>Cymbopogon citratus</i>	Lemon grass	Poaceae	Leaves
8. <i>Allium cepa</i>	Onion	Amaryllidaceae	Leaves
9. <i>Afromomum melegueta</i>	Alligator Pepper	Zingiberaceae	Seeds
10. <i>Piper guineense</i>	Black pepper	Piperaceae	Seeds

## RESULTS

The effects of various plant extracts on mortality of the maize weevil at different periods after treatment are presented in Table 2. In each treatment, the mortality of *S. zeamais* increased gradually with time of exposure. Acetone extracts of *Caspsicum frutescens* and *Piper guineense* caused 97.5 and 100% mortality, respectively three days after treatment. Their effect was significantly better than any of the other treatments.

At seven days after-treatment, the extracts of *C. frutescens* and *P. guineense* gave 100% mortality but their effect was not significantly different from those of *Afromomum melegueta*, *Garcinia kola*, *Citrus sinensis*, *C. aurantifolia*, *Xylopia aethiopica*, *Cymbopogon citratus* and *Allium cepa*. Only extracts of *C. frutescens*, *P. guineense* and *A. melegueta* performed significantly better than the control (Table 2).

At 21 days post treatment, extracts of *A. cepa* ( $38.75 \pm 1.77$ ) *Cymbopogon citratus* ( $28.75 \pm 5.42$ ) and *C. aurantifolia* ( $26.25 \pm 2.08$ ) were ineffective in the control of the weevils since the mortality recorded for each extract was not significantly different from the control. A similar trend was obtained at 28 days post treatment except for *A. cepa* ( $48.75ab \pm 2.73$ ) that was significantly different from the control ( $15.00 \pm 2.50$ ).

The damage inflicted on maize grains by *Sitophilus* was assessed 95 days after treatment and the result obtained is shown in Table 3. While the control recorded the highest level of damage, seeds treated with extracts of *C. frutescens* and *P. guineense* were not damaged.

Table 2: Mean percentage mortality of *Sitophilus zeamais* Mots. treated with various plant extracts after 3, 7, 21 and 28 days post treatment

Name of plant	Days	Post - treatment		
	3	7	21	28
<i>Garcinia kola</i>	10.00a±2.50	47.50ab±6.73	55.00ab±5.86	62.50ab±6.73
<i>Citrus parandis</i>	16.25a±2.08	28.75a ±2.73	42.50ab±7.40	61.25ab±8.26
<i>Citrus aurantifolia</i>	2.50a±1.25	13.75ab±3.25	26.25a ±2.08	30.00a ±3.06
<i>Citrus sinensis</i>	31.25a±4.80	58.75ab±4.80	63.75ab±4.80	70.00b ±4.68
<i>Caspsicum frutescens</i>	97.50b±2.17	100.00b±0.00	100.00b±0.00	100.00b±0.00
<i>Xylophia aethiopica</i>	20.50a±3.25	21.25ab±2.08	28.75ab±5.42	30.00a±5.73
<i>Allium cepa</i>	15.00a±4.68	23.75ab±2.08	38.75a ±1.77	48.75ab±2.73
<i>Afromomum melegueta</i>	31.25a±8.36	68.75b ±7.78	85.00b ±8.29	100.00b±0.00
<i>Piper guineense</i>	100.00b±0.00	100.00b±0.00	100.00b±0.00	100.00b±0.00
Control	5.00a±1.77	10.00a ±3.06	15.00a ±3.96	15.00a ±2.50

\* Figures in the same column followed by the same letter are not significantly different at 5% confidence limit using Duncan's multiple range test.

**Table 3: Damage by *Sitophilus zeamais* Mots. to treated maize grains after 95 days post treatment**

	Total No. of seeds	No. Of seeds damaged	No of undamaged Seeds	% seed damage	*WPI
<i>Garcinia kola</i>	159	108	51	67.92	43.77
<i>Citrus parandis</i>	159	112	47	70.44	44.66
<i>Citrus sinensis</i>	164	107	57	65.24	42.77
<i>Caspsicum frutescens</i>	167	0	167	0.00	0.00
<i>Xylopi aethiopica</i>	159	98	61	61	41.14
<i>Cymbopogon citratus</i>	162	121	41	75.69	46.45
<i>Allium cepa</i>	157	114	43	72.61	45.42
<i>Afromomum melegueta</i>	163	96	67	58.89	40.29
<i>Piper guineense</i>	160	0	160	0.00	0.00
Control (Acetone)	165	144	21	87.27	50

\* Weevil Perforation Index (WPI). Value lower than 50 is an index of positive protectant effect while WPI greater than 50 is an index of negative protectant ability.

#### DISCUSSION

The extracts of *P. guineense* and *C. frutescens* were found to be the most effective against the maize weevils, *S. zeamais*, on the 3rd day after treatment. The observed mortality is probably due to

the pungency of the extract in the case of *P. guineense* while in the case of *C. frutescens*, it could be due to its pepperish and pungent nature. Apparently the extracts of these plants acted mainly through fumigant and contact modes of action which are similar to those of synthetic organochlorines and organophosphates. Su (1977) advanced similar reason for the effect of black pepper, *P. nigrum* L. on the cowpea weevil *Callosobruchus maculatus* F. This observation also tallies with the findings of Olaifa et al. (1987) who reported that the essential oil of *P. guineense* showed acute toxicity against four field insect pests and thus exhibiting properties similar to any of the chlorinated hydrocarbons. Lale (1992) also reported that oil extract of *P. guineense* was extremely toxic to adult *S. zeamais* compared to oils of *Denneria tripetala* and *A. melegueta*.

*Afromomum melegueta* caused total mortality of the weevils in 28 days after treatment which showed that the insecticidal strength of the extract increased with the length of storage. Similar trend was obtained for the extract of *Xylopiya aethiopica*. Pulverized powders of *A. melegueta* had been shown to offer adequate protection for stored maize against *S. zeamais* by Lale (1992). The mode of action of these plant extracts could be attributed to stomach poison since the weevils are known to feed directly on the maize kernel. Analogous mode of action could be responsible for the effects of the extracts of *G. kola*, *C. parandis*, *C. sinensis* and *A. cepa* on the maize weevil even though they are not as effective. Natural embelin has also been reported to exhibit similar mode of action against storage pests (Chander and Ahmed, 1985, 1987). Volatile oils of these plants may also exert their toxic effect by disrupting normal respiratory activities of the weevils and thus resulting in suffocation and subsequent death.

The toxicity of some of the plant extracts used for the control of the weevils did not persist indefinitely. Some of the extracts lost their effectiveness within 95 days of treatment (Table 3). Despite 100% mortality recorded for *A. melegueta* extract after 28 days post treatment, the percentage damage on maize grains was still high. This may be due to some of the weevil eggs successfully hatching and developing after the effectiveness of the extract had been lost so that the emergent adults were able to continue the destructive activities of the weevil in the grains. This clearly showed that *A. melegueta* was not able to inhibit oviposition and development of *S. zeamais*. It was however effective as an adulticide. The result of this study also confirms the effectiveness of the use of pulverized powders of *A. melegueta* and *A. melegueta* are recommended for house hold to small scale storgae of maize because the materials are readily available and affordable. In addition, the plant materials are edible since they are used either as ingredients for soup or medicinal preparations. It is also evident from this study that all the plant materials

tested have the potential of being used as a botanical insecticide especially when weevil perforation index is taken into consideration. Higher concentrations of the extracts could be more effective since it is expected to contain higher active ingredients. Further research still needs to be carried out on these plant extracts since their potential appears great. The extracts also need to be screened against field and other storage insect pests so as to determine their spectrum of activity.

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