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Toxicity of Powders from Indigenous Plants Against *Sitophilus zeamais* Motsch on Stored Maize Grains

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Abstract: An admixture of powders from *Erythrophleum guineense* (stem bark and leaf), *Aloe vera* (leaf) and *Dacryodes edulis* (seed) were separately treated at three different rates (0, 10 and 20% w/w) on stored maize grains and tested against the maize weevil, *Sitophilus zeamais* Motsch under laboratory conditions for three months. Pirimiphos methyl (2% dust) used as synthetic insecticide check was applied at 0, 1 and 2% (w/w). Some parameters considered included, mortality (at 24, 48, 72 and 96 h), progeny development (F1 and F2) and grain damage. The results showed that *E. guineense* stem-bark and *A. vera* leaf powders applied at 20% (w/w) were more toxic to *S. zeamais* and could suppress progeny development of the weevil as well as protect maize grains from pest damage compared to *D. edulis* seed powder and the untreated check. Pirimiphos methyl caused more weevil mortality ($p<0.05$) within 72 h, considerably suppressed progeny development and reduced grain damage compared to plant powders but its values on the last two parameters were not statistically superior to *E. guineense* stem bark powder. This technology is simple, cheap, readily available, non toxic to mammals and environmentally friendly. *E. guineense* plant could add to the lexicon of plant materials known to possess insecticidal attributes for integrated pest management for small-scale rural grain storage programmes in developing countries.

Key words: IPM, *Erythrophleum guineense*, *Aloe vera*, *Dacryodes edulis*, *Sitophilus zeamais*, maize

Introduction

Maize, *Zea mays* L. (Graminae) is an important food crop widely grown in both temperate and tropical countries. In Nigeria, its production estimated at 5.4 million metric tonnes from about 3.5 million hectares cuts across the different ecological zones ranging from the rain forest belt in the south to the northern Guinea savanna. Maize contains 80% starch, 13% water, 10% protein, 4% oil, 2% sugar and 3% fibre. Yellow maize in addition contains appreciable quantities of vitamin A (Purseglove, 1974). Maize is used for food, feed, starch and other industrial products. In spite of the increasing hectarages devoted to maize production, its yield continues to decline due to pests' pressure.

In the store, maize is infested by *S. zeamais* Motsch, *S. oryzae* L., *S. granarium* L., *Sitotroga cereallela* Oliv. (Angoumois grain moth), *Trogoderma granarium* Everts, *Oryzaephilus surinamensis* L. and others. However, the most important economic pests of stored maize in Nigeria are *S. zeamais* and *S. cereallela* (Giles and Ashmani, 1971; Nwanna, 1993). Over 96 million metric tonnes of maize grains are destroyed annually all over the world by *Sitophilus* spp. (FAO, 1961).

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Both larvae and adults feed on the grains in the store and reduce them to powdery form and taint the grains with their frass. Infested grains are often susceptible to caking and mouldiness, which reduce their market value (Ofuya and Lale, 2001).

Some measures have been taken to protect stored maize from pest infestation such as preventive (seed sanitation, insect resistant varieties, solar disinfestations, weather-proof storage bins, removal of corn stubbles and residues) and therapeutic (use of pesticides, biological control agents, etc.). However, none of these measures except pesticide application have impacted so much on farmers' efforts to control stored product pests. Pesticide (fumigants, dusts and liquid) use in storage is effective, has long shelf life, easy to transport and store (Ofuya and Lale, 2001). For instance, Fenitrothion and pirimiphos methyl (2 ppm each), melithion (3 ppm), Tetrachlororimphos (4.5 ppm) and Bodfenphos (6 ppm) gave 100% mortality of *S. zeamais* in 48 h, protected maize grains for over seven months with damage reduced to less than 5% (Hindmarsh and McDonald, 1980). In spite of the advantages of synthetic insecticides in the control of stored product pests, these products still constitute an enormous problem such as high mammalian toxicity, insect resistance/resurgence and high cost of importation, unavailability at critical period and environmental pollution.

Alternatives to synthetic insecticides have been screened over the past two decades and many more are being assessed for their efficacy to control many pests of crops (Golob and Webley, 1980; Don Pedro, 1985; Lale, 2002). Seed powder and oil of black pepper (*Piper nigrum*, L., *E. guineense, E. umbellatum, Capsicum frutescens* L. can cause adverse effect on the biology of *S. zeamais* and high mortality (Ivbijaro and Agbaje, 1986; Lale, 1996). The essential oil of *Xylopia aethiopica* (Dunal) A. Rich applied at 0.3 mL/100 g seed and powder at 1.5 mL/250 g seed reduced the emergence of F1 adult of *S. zeamais* and achieved 30% mortality of the weevil in 24 h. (Okonkwo and Okoye, 1996). Similarly, *P. guineense* oil applied at 0.3 mL/100 g seed caused 100% mortality of *S. zeamais* in 24 h, suppressed emergence of F1 progeny and gave protection to stored maize grains for 4 months (Okonkwo and Okoye, 1996).

Limited information is available on the use of *E. guineense*, *Dacryodes edulis* L. and *Aloe vera* for the protection of stored products. The present study was conducted in the Storage Entomology Laboratory Section of the Department of Crop Protection, Ahmadu Bello University, Zaria, Nigeria to ascertain the efficacy of new candidate botanical landraces growing in the northern Guinea savanna and rain forest belt of Nigeria for protection of stored products.

Materials and Methods

Maize grains (var. TZESR-W) weighing six kilograms were purchased from the National Seed Service, Zaria and fumigated with one tablet of phostoxin for seven days to disinfest the seeds of insect pests and their eggs. Prior to fumigation, 250 g maize grains were weighed in three places into kilner jars and large numbers of unsexed *S. zeamais* obtained from cultures in the Storage Entomology Laboratory of Crop Protection Department were introduced into the jars to raise fresh cultures for the bioassay. Plant materials used in the trial included fresh leaves of *A. vera*, seeds of *D. edulis* and stem bark/leaves of *E. guineense*. These were cleared of foreign debris and shade dried for three days before oven drying at 80°C for 24 h to stabilize their moisture contents. The oven-dried materials were separately pounded into powder in a wooden mortar with pestle. The powders were sieved using 0.5 mm diameter wire mesh to obtain fine powders, which were kept in air-tight polythene bags and stored in a refrigerator at 4°C prior to use. Plant powders were added separately at dosage rates of 10 g and 20 g per 100 g seed (w/w) in each kilner jar and shaken manually to obtain a good admixture. Pirimiphos methyl (2% dust) used as a synthetic insecticide check was applied at the rate of 1% and 2% (w/w). The powders and pirimiphos methyl dust were allowed to settle down for 10 min before introducing 10 pairs of freshly emerged adult *S. zeamais* to each jar, which were covered with muslin cloth at fluctuating room temperatures of 32±1.5°C with 70±3% r.h. There was an untreated check and all treatments were replicated three times and layed out in a Completely Randomized Design (CRD) on a laboratory table for three months.

Insect mortality count was taken at 24, 48, 72 and 96 h post treatment by sieving out the contents of each jar into a tray and carefully counting the number of dead insects. The powders, maize grains and surviving insects were returned to their original jars after each exercise. At 15 days post treatment (DPT), all insects (dead or alive) in each jar were sieved out in order to eliminate mixing with the emerging F1 progeny. F1 and F2 progenies were counted at 28 and 56 DPT, respectively after sieving. Grain damage was assessed after three months by counting the number of grains with adult emergent holes on a random sample of 100 seeds from each treatment jar using the formula below:

$$\%\text{Grain damage} = \frac{\text{Total number of grains sampled - Number of undamaged} \times 100}{\text{Total number of grains sampled}}$$

Data obtained were transformed using angular and arcsine transformation (for percentage data) before analysis of variance. Treatment means were separated with Students Newmann keuls ($p<0.05$) (SAS Institute, 1990).

Results

There was no significant difference in *S. zeamais* mortality at both 24 and 48 h within plant powder treatments and between the plant powders and the untreated check but significantly higher ($p<0.05$) weevil mortality was observed at 72 and 96 h (Table 1). The cumulative mortality values obtained at 72 and 96 h Post Treatment (PT) showed that the stem bark and leaf powders of *E. guineense* and leaf powder of *A. vera* were significantly superior ($p<0.05$) to *D. edulis* seed powder. Similarly, 20 and 10% rates of plant powders caused higher weevil mortality compared to the untreated check while the values in 20% dosage rate were higher ($p<0.05$) than in 10% treatment rate between 24 and 72 h period. Pirimiphos methyl (Actellic 2% dust) showed superiority ($p<0.05$) over plant powders in achieving higher insect mortality in 24 and 48 h post treatment (PT) but was equi-toxic with *E. guineense* bark and *A. vera* leaf powders in 72 and 96 h PT.

Pirimiphos methyl, *E. guineense* stem bark and leaf powders as well as *A. vera* leaf powder caused significant reduction ($p<0.05$) of F1 progeny at four weeks PT compared to *D. edulis* powder and the untreated check. At F2 stage none of the treatment powders caused significant suppression of *S. zeamais* among themselves. All treated grains had lower ($p<0.05$) number of F1 progeny than the

Table 1: Effect of plant powders and pirimiphos methyl dust on adult *Sitophilus zeamais* mortality at 24,48, 72 and 96 h post treatment

	Cumulative mean (%) mortality of *S. zeamais* (h)			
Treatments	24	48	72	96
Untreated control	4.8b	6.2b	12.1c	13.7c
Dacryodes edulis (seed)	6.6b	6.6b	13.9c	17.6b
Erythrophleum guineense (leaf)	6.0b	8.2b	17.2b	20.0a
Erythrophleum guineense (bark)	6.4b	8.5b	20.0a	20.0a
Aloe vera (leaf)	6.3b	8.6b	20.0a	20.0a
Pirimiphos methyl (2% dust)	12.3a	12.3a	20.0a	20.0a
SE±	1.5	1.2	3.0	3.0
Concentration (%) w/w				
0	4.8c	6.2c	12.1c	13.7b
10	6.7b	7.8b	17.2b	20.0a
20	7.5a	9.0a	19.6a	20.0a
SE±	0.2	0.3	0.6	0.1

Means followed by the same lettert(s) in a column are not significantly different by Student Newmann Keuls test ($p<0.05$)

Table 2: Effect of plant powders and pirimiphos methyl dust on progeny emergence of *Sitophilus zeamais* at 28 and 56 days post treatment

	*Mean progeny emergence of *S. zeamais*	
Treatments	28 days (F1)	56 days (F2)
Untreated control	8.3a	6.1a
Dacryodes edulis (seed)	8.0a	4.8b
Erythrophleum guineense (leaf)	5.3b	4.8b
Erythrophleum guineense (bark)	4.8b	4.8b
Aloe vera (leaf)	5.3b	4.8b
Pirimiphos methyl (2% dust)	4.8b	4.8b
SE±	0.9	0.3
Concentration (%) w/w		
0	8.3b	6.1b
10	6.5a	5.1a
20	5.7a	5.0a
SE±	0.2	0.1

Means followed by the same lettert(s) in a column are not significantly different by Student Newmann Keuls test (p<0.05).
*Transformed Data

Table 3: Effect of plant powders and pirimiphos methyl dust on percentage maize grain damage at three months post treatment

Treatments	Mean grain damage (%)
Untreated control	76.7a
Dacryodes edulis (seed)	66.7b
Erythrophleum guineense (leaf)	22.8
Erythrophleum guineense (bark)	14.8d
Aloe vera (leaf)	23.0c
Pirimiphos methyl (2% dust)	12.0d
SE±	1.2
Concentration (%) w/w	
0	72.5a
10	25.0b
20	15.0c
SE±	1.3

Means followed by the same letter(s) in a column are not significantly different by Student Newmann Keuls test (p<0.05)

untreated check (Table 2). Higher reduction of progenies were also observed at 4 and 8 weeks PT at 20 and 10% powder rates of treatment compared to the untreated check but the values between 20 and 10% rates were not statistically significant. Pirimiphos methyl and *E. guineense* stem bark offered the best protection (p<0.05) to maize grains against the weevils as both treatments recorded significantly lower grain damage compared to *E. guineense* and *A. vera* leaf powders whose values were in turn superior to *D. edulis* powder and the untreated check. Grain damage values between *E. guineense* and *A. vera* leaf powders were not significant. Twenty percent rate of plant powders achieved significant reduction of grain damage caused by the weevils compared to 10% rate while the latter had values significantly lower (p<0.05) than in the untreated check (Table 3).

Discussion

The results in the present study have shown that the powders of *E. guineense* (stem bark/leaf) and *A. vera* leaf are toxic to *S. zeamais* and can suppress progeny development of the weevils resulting in better protection of maize grains from pest damage. Although, *E. guineense* stem bark powder and pirimiphos methyl dust achieved significant protection of maize grains, their values were not statistically significant in the reduction of progeny development compared to leaf powders of *E. guineense* and *A. vera*. These observations are similar to those reported by Ivbijaro and Agbaje (1986), Ogunwolu and Idowu (1994), Ogunwolu and Odunlami (1996), Onu and Sulyman (1997).

E. guineense (stem bark/leaf) and *A. vera* (leaf) were more persistent at 72 and 96 h PT and thus achieved higher mortality of *S. zeamais* than *D. edulis* seed powder. The results however, indicate that plant powders are slow mortality agents as their values at 24 and 48 h PT were inferior ($p<0.05$) to that in pirimiphos methyl treated grains. The lower number of F2 progeny recorded compared to F1 indicates that repeated treatment common to many plant powders used in storage protection may not be necessary for longer grain storage. The protection offered by *E. guineense* and *A. vera* products to maize grains against *S. zeamais* infestation could be traced to a combination of factors such as higher adult insect mortality and lower progeny development.

The exact mechanism of activity of these plant products against the weevils is not very clear but physical abrasion of the insect cuticle with consequent loss of body fluid or blockade of the spiracle (Ogunwolu *et al*., 1998) might be implicated. This was evident when the adult weevils were introduced to the treatment jars and they were forced to migrate to the walls of the jars in a bid to avoid contact with the lethal powders of *E. guineense*, *A. vera* and pirimiphos methyl dust. In this study, the stem bark of *E. guineense* was more potent than the leaf, thus confirming the work of Lale (2002), which reported the efficacy of stem bark powder of neem over the leaf powder.

Although, pirimiphos methyl dust achieved higher mortality of adult *S. zeamais* between 24 and 72 h PT and protected maize grains better than some plant powders, the product is not readily available in the local markets. Where available, this product is expensive, may be adulterated and ineffective. The indiscriminate use of synthetic insecticides for storage protection may leave toxic residues in food and result to health risk to consumers of the treated products. The search for natural products, which have pesticidal properties, has intensified worldwide and some successes have been achieved. The result shown in the present study would add to the database of plant products available for use as biopesticides.

E. guineense is a tropical plant growing up to 5 m high. In Nigeria, the plant grows in the wild in the Guinea savanna and is used as fish poison as well as to kill or repel pests from cultivated farms (Adeoye and Oyedepo, 2004). On the other hand *D. edulis* is found in the forest belt and the fruit is used as a local butter for eating roasted or cooked maize in the southern part of the country. *A. vera* is grown in pots around the homes and it is used as anti-inflammatory therapy by trado-medical practitioners in Nigeria. It is known to possess a wide range of anti-microbial activity and used as cure for cancer, burns and ulcer (Anonymous, 2005). There is need to evaluate these plant products on-farm to access their suitability for rural storage protection. The active principles in *E. guineense* and *A. vera* need to be isolated, identified, characterized and synthesized for further tests as such compounds may be more potent in their pure form than is the case with the crude form.

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