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Control of *Sitophilus zeamais* (Motsch) [Coleoptera: Curculionidae] on Sorghum Using Some Plant Powders

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Abstract Plant powders prepared from five plant species were tested under constant conditions at 30 ± 2℃ and 60 - 65% r. h. for their ability to protect sorghum grains against *Sitophilus zeamais* in storage. Doses at 0.5, 1.0 and 2.0g and 0.12g of the check (permethrin (0.6%) were applied for assessments of adult mortality, emergence and damage. Leaf powders of *E. balsamifera, J. curcas and L. inermis* gave the highest adult mortality (60.0 - 100%), while peel powder of *C. sinensis* and leaf powder of *L. hastata* recorded 47.50 - 82.50% adult mortality. Least adult emergence (0.00%) was observed when 2.0g of *J. curcas* was applied, while the highest (57.82%) was obtained from 0.5g *L. hastata.* All the plant powders showed significant ($p < 0.05$) adult mortality against *S. zeamais* with weevil perforation index (WPI) of < 50.00. This study was designed to observe the possibility of using plants parts to reduce grain damage caused by insect pests during storage.

Keywords Guinea Corn, Plant Powders, Protectants, *Sitophilus zeamais*

1. Introduction

Guinea corn (*Sorghum bicolor* (L.) Moench) is one of the major cereal crops widely grown in Nigeria, and a very important staple food for the populace particularly in the northern part of the country (Tashikalma *et al.,* 2010). The Nigerian sorghum production was 11.5 tons in 2010 and forecast was 11.7 tons in 2011 (USDA, 2010). The crop yield has increased because of the acceptance by farmers of improved varieties developed by local research institutes. There are various traditional food preparations of guinea corn. Boiled guinea corn is one of the simplest uses and small, corneous grains are normally desired for this type of food product. The whole grain may be ground into flour or decorticated before grinding to produce either a fine particle product or flour, which is then used in various traditional foods (Leder, 2004). It is also a very valuable industrial crop for non-alcoholic drink as well as confectionery industry in Nigeria (Baiyengunhi and Fraser, 2009).

S. zeamais feeds on cereals and starch grains including guinea corn, *Sorghum bicolor* (L) (Effraim, 1996; PaDIL, 2009). The economic importance and wide distribution of *Sitophilus* species have prompted many researchers to go into studies on various aspects of the weevils, especially *S. zeamais* (Udo, 2005; Asawalam and Emosairue, 2006; Abulude *et al*., 2007; Asawalam *et al*., 2007, 2008; Ngamo *et al*., 2007; Ousman, *et al*., 2007; Parugrug and Roxas, 2008; Efidi *et al*., 2009; Danjumma *et al*., 2009; Owolabi *et al*., 2009; Makate, 2010).

The use of botanical pesticides to protect plants from pests is very promising because of several distinct advantages (Parugrug and Roxas, 2008). Many plant powders have been found to be very effective in the control of *S. zeamais* attacking maize grains in the storage (Adedire and Ajayi, 1996; Asawalam and Emosairue, 2006; Asawalam *et al*., 2007; Kabeh and Jalingo, 2007; Mulungu *et al.,* 2007; Parugrug and Roxas, 2008; Ukeh *et al.,* 2008; Danjumma *et al.,* 2009). However, studies on the effects of these powders on the insect pest attacking guinea corn grains have not been given much attention. Plant powders are cheap, easily biodegradable and readily available and will not contaminate food products in acting as protectants in small-scale storage systems (Ukeh *et al.,* 2008). This study is aimed at using plant parts to reduce grain damage caused by insect pests, particularly *Sitophilus spp.*

2. Materials and Methods

2.1. Rearing of the Insect

Adults of *S. zeamais* were obtained from naturally infested sorghum grains. Adults *S. zeamais* were cultured in incubator, at 30±2℃, 65±5%. Whole grains of local variety called "Kaura" bought from local farmers were disinfested in an oven at 60℃ for 1 hour (Asmanizar *et al.,* 2008) before using them as a substrate for insect rearing. Fifty pairs of *S. zeamais* were introduced into the rearing bottles containing

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250g sorghum. The bottles were covered with muslin cloth and secured with rubber bands. The parent weevils were sieved out after oviposition. Later the seeds were kept in the incubator for adult emergence. The F1 generation was used for the experiment.

2.2. Collection and Preparation of Plant Materials

Leaves of *Jatropha curcas* L., *Euphorbia balsamifera* L., *Lawsonia inermis* L. and *Leptadenia hastata* L. were collected from the bushes around and identified at the Department of Biology, Umaru Musa Yar'adua University, Katsina. The *Citrus sinensis* L. peels were obtained from Bindawa market. All the plant materials were dried under shade, in a well-ventilated area in the Biology Laboratory 1 of the Department of Biology, Umaru Musa Yar'adua University, Katsina, before grinding into fine powders using Laboratory blender (Model 8010ES) and sieved using 80µm Laboratory sieve. The powders were labelled and kept separately in glass containers and stored at room temperature prior to use. The conventional insecticide (Permethrin 0.6%) was purchased from the same market. The powders were tested individually for their potential in protecting sorghum grains during storage. Below is the list of test powders used:

Scientific Name	Common Name	Family	Part used
Citrus sinensis L.	Orange	Rutaceae	Peels
Euphorbia balsamifera L.	Balsam spurge	Euphorbiaceae	Leaves
Jatropha curcas L.	Physic nut	Euphorbiaceae	Leaves
Leptadenia hastata L.	Decne	Asclepiadaceae	Leaves
Lawsonia inermis L.	Henna	Lythraceae	Leaves

2.3. Adult Mortality Test

Twenty grams of clean, disinfested sorghum was weighed into each of the sterilized Petri dishes and the treatments 0.5, 1.0 and 2.0g (2.5, 5.0 and 10.0% w/w respectively) of the test materials were applied accordingly, while that of permethrin (0.6%) was 0.12g/ 20g of sorghum grains (0.6% w/ w) as check, and the control; where neither of the materials was added was also replicated as in the treatments. The powders were thoroughly mixed with the sorghum grains with the aid of a glass rod to ensure thorough admixture. Five pairs of newly emerged adult weevils were introduced into the treated and untreated sorghum in the Petri dishes. They were covered with muslin cloth and held in place with rubber bands. Each treatment was replicated four times. The experiment was arranged in a Completely Randomized Design on a Laboratory bench. The number dead adults was taken daily for 28 days.

2.4. Adult Emergence

To calculate the adult emergence, direct examination of the grains was done with the aid of a dissecting microscope (Parugrug and Roxas, 2008) after all adults must have died, after which observation was made on the number of unhatched eggs. The new individuals that emerged were also counted. Percentage mean adult emergence was then calculated.

2.4. Assessment of Perforated Grains

Damage to the sorghum grains was assessed in each trial after all adults have died. Samples of 50 grains were randomly taken from treated and untreated grains and the number of insect-damaged grains was counted. Weevil Perforation Index (WPI) was calculated using the formula below as given by Fatope *et al.* (1995) quoted by Arannilewa *et al.* (2006).

$$WPI = \frac{\%\ \text{Treated grains perforated}}{\%\ \text{Control grains perforated} + \%\ \text{Treated grains perforated}} \times 100$$

The data were subjected to two-way Analysis of variance (ANOVA) using Statistical Analysis System (SAS) 1999 version at 5% ($p<0.05$) level of significance and significant differences between treatments was separated using LSD.

3. Results

Table 1 shows that *J. curcas, L. inermis* and Permethrin recorded 100.00% adult mortality at all doses, while *E. balsamifera* resulted in 100.00% adult mortality only with 2.0g concentration. A part form the control which gave 15.00% mean mortality, only *C. sinensis* and *L. hastata* at 0.5g were observed to give less than 50.00% adult mortality. The effect of the test powders on adult mortality was significantly ($p<0.05$) different among the treatments and between them and the control.

All the test powders were observed to have potentials of reducing adult emergence (Table 2). Least adult emergence (0.00%) was observed when the sorghum grains were treated with *J. curcas* at 2.0g dose, while *L. hastata* gave the highest emergence (57.82%) at 0.5g dose. The effect of these plant powders on adult emergence of *S. zeamais* grown on *sorghum* grains was significantly ($p<0.05$) different among the treatments and the control. Adult emergence decreased with increase in the amount of the test powders used, except in the case of *L. inermis* where it increased with the increase in the doses applied.

Weevil Perforation Index (WPI) indicated that the plant powders used have significant effects as grain protectants as the amount of grain damage was reduced after the application of the powder (Table 3). Moreover, the efficacy was observed to be directly proportional to the amount of powder applied. *J. curcas* applied at 0.5/20g recorded the least (7.69) WPI, while *L. hastata* had the highest (38.24) WPI. The plant powders used showed significant ($p<0.05$) grain protection ability when applied at 0.5g/20g of grains. The Table also reveals that as the amount of the plant powders was increased to 1.0g/ 20g grains, the protectant ability increased, with *J. curcas* having the least (1.45) WPI value, while *L. hastata* powder showed highest (31.00) WPI value. Significant ($p<0.05$) differences was observed between the treatments. Similarly when the amount of the plant powders used was increased to 2.0g it resulted in 0.00 WPI on *J. curcas* treated seeds which was similar to the conventional insecticide (0.60% Permethrin) used at the rate of 0.12g/20g of grains.

Table 1. Mortality of *S. zeamais* adults reared on sorghum grains 28 days after treatment

Test powder	Adult mortality (%) ± S. E.		
	Amount of test powders used (g/20g)		
	0.5	1.0	2.0
C. sinensis	47.50 ± 1.25^{c}	65.00 ± 0.5^{b}	82.50 ± 0.75^{b}
E. balsamifera	60.00 ± 1.00^{b}	70.00 ± 0.5^{b}	100.00 ± 0.00^{a}
J. curcas	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}
L. hastata	47.50 ± 0.75^{c}	62.50 ± 0.5^{b}	50.00 ± 1.00^{c}
L. inermis	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}
Permethrin (0.12g)	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}
Control	15.00 ± 0.50^{d}	15.00 ± 0.50^{c}	15.00 ± 0.50^{d}

Means followed by the different letters in a column are significantly different ($p<0.05$).

Table 2. Emergence of *S. zeamais* adults reared on sorghum

Test powder	Adult emergence (%) ± S. E.		
	Amount of test powders used (g/20g)		
	0.5	1.0	2.0
C. sinensis	52.32 ± 2.90^{d}	39.34 ± 1.88^{c}	25.72 ± 2.10^{c}
E. balsamifera	28.84 ± 1.59^{c}	21.05 ± 0.80^{b}	15.15 ± 1.41^{b}
J. curcas	4.55 ± 0.90^{a}	1.25 ± 1.25^{a}	0.00 ± 0.00^{a}
L. hastata	57.82 ± 1.70^{e}	45.34 ± 3.00^{d}	53.27 ± 3.18^{d}
L. inermis	9.90 ± 2.49^{b}	18.60 ± 2.75^{b}	29.65 ± 1.89^{c}
Permethrin (0.12g)	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
Control	90.58 ± 2.27^{f}	90.58 ± 2.27^{e}	90.58 ± 2.27^{e}

Means followed by the different letters in a column are significantly different ($p<0.05$).

Table 3. Weevil perforation index obtained from sorghum grains

Test powder	Weevil Perforation Index (WPI) ± S. E.		
	Amount of test powders used (g/20g)		
	0.5	1.0	2.0
C. sinensis	37.62 ± 0.85^{d}	29.55 ± 0.48^{e}	25.18 ± 1.48^{c}
E. balsamifera	26.03 ± 2.13^{c}	14.92 ± 1.51^{c}	8.37 ± 1.41^{b}
J. curcas	7.69 ± 1.86^{b}	1.45 ± 1.45^{b}	0.00 ± 0.00^{a}
L. hastata	38.24 ± 0.97^{e}	31.00 ± 1.17^{f}	36.13 ± 1.78^{e}
L. inermis	8.22 ± 2.32^{b}	15.92 ± 1.34^{d}	26.35 ± 1.81^{d}
Permethrin (0.12g)	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
Control	50.00 ± 0.00^{f}	50.00 ± 0.00^{g}	50.00 ± 0.00^{f}

Means followed by the different letters in a column are significantly different ($p<0.05$).

4. Discussion

All the tested powders were found to be effective in killing the adult weevils. *J. curcas* and *L. inermis* gave 100.00% mortality in all the doses used (0.5, 1.0 and 2.0g/20g grains). This agrees with the findings of Boateng and Kusi (2008) which recorded 100.00% adult mortality of *Dinarmus basalis* grown on cowpea grains when treated with oil extract of *J. curcas* at the rate of 0.5, 1.0, 1.5 and 2.0ml/150g grains. Asmanizar *et al.* (2008) also reported 100.00% adult mortality of *S. zeamais* when treated with seed crude extract of *J. curcas.* Similarly, Suleiman *et al.* (2011) reported 100% adult mortality of *S. zeamais* when 0.5–2.0g of *J. curcas* was applied to 20g of sorghum grains. This effect could be due to the presence of curcin which is toxic to animals' body as suggested by Duke (1985). The 100.00% adult mortality effect of *L. inermis* obtained in this study agrees with the findings of Al-Moajel (2004) who tested some various botanical powders for protecting wheat grains against *T. granarium*. The increase in mortality in *C. sinensis* treatment indicates that the effect is directly proportional to the amount used. The results have revealed that peel powder of *C. sinensis* is effective in killing adults *S. zeamais* growing in sorghum grains. This agrees with the findings of Adedire and Ajayi (1996) and Dawit and Bekelle (2010) which reported that the plant powder was very promising. The effectiveness of *C. sinensis* peel powder is probably due to silica or silica like component, which are adhesive and the ability of the particles to adhere to the grain which was also suggested by Dawit and Bekelle (2010). Leaf powder of *E. balsamifera* was also found to very promising and increased adult mortality as the concentration was raised. There is no enough literature on the use of *E. balsamifera* in the protection of stored products against insect pests; however, Zorloni (2007) reported the effectiveness of *E. balsamifera* in the control of animal ectoparasites. Being one of the members of the family Euphorbiaceae, its killing effect may be due to the presence of hydrogen cyanide in the plants body which is toxic to animals. Leaf powder of *L. hastata* showed a killing effect on the weevils, although it gave low mortality, only higher than the control. The mortality effect of this plant powder increased from when the dose was increased from 0.5 to 1.0g, but decreased when the application was further increased to 2.0g. Aliero and Wara (2009) reported results that have provided a scientific support for the ethnomedical uses of aqueous extracts of *L. hastata* in the treatment of bacterial diseases and suggested its potential as antifungal agent. Permethrin affected the survival of the adult weevils with 100.00% mortality during the study period, agreeing with the findings of Danjumma *et al.* (2009).

The results showed that the different powders used, negatively affected the emergence of adults. It was observed that there were significant effects on the emergence of adults reared on the treated and untreated sorghum grains. *J. curcas* powder was found to be most effective in affecting the emergence of adults than any other powder, while *L. hastata* was found to be the least effective. There was adult emergence from sorghum grains treated with 0.5g of *J. curcas* powder. Hence, *J. curcas* is the most effective in affecting the emergence, while *L. hastata* had least effect. The effect on adult emergency was significantly different among all the plant powders tested and between the plant powders and permethrin, as well as the control. Sorghum grains treated with 2.0g of different plant powders reveals significant decrease in the adult emergence except in *L. inermis* where the emergence increased. This plant showed exceptional property where the lower concentration was observed to be more effective than the higher doses.

Powders of *C. sinensis* and *E. balsamifera* applied were found effective in protecting the sorghum grains from damage caused by *S. zeamais.* The powder of *C. sinensis* also showed WPI of less than 50 in all the three different doses applied which means it has positive protectant ability. This might be attributed to the repellent and toxicity effects of the plant powder as observed in the previous bioassays. Similar observations were also made by Adedire and Ajayi (1996) which reported 65.24% damage of maize grains caused by *S. zeamais* treated with 1.0ml/10g acetone extract of *C. sinensis,* and WPI value was recorded to be 42.77 after 95 days of post treatment. Powder of *J. curcas* was observed to be the most promising and effective as protectant of sorghum grains against *S. zeamais.* It did not cause any grain damage at higher amount used and had similar effects to that of the conventional insecticide. It was observed to be more effective than all the other plant powders used even when applied at lowest amount. This agrees with the findings of G/Selase and Getu (2009) which reported significant reduction in cowpea grain weight loss by *J. curcas* and some other plants when applied against *Z. subfasciatus.* This action might be as a result of its effectiveness in killing all the adult weevils introduced within a short period of time, and its larvicidal effects. *L. hastata* was found to be less effective in reducing grain damage and weight loss compared to the other test powders, even though it had the potential of killing all the adult weevils which might be because of their long stay before they all died, which gave them a chance to actively feed on the grains, leading to the damage, though the WPI value shows its positive protectant ability. Leaf powder of *L. inermis* was also promising in reducing grain damage and weight loss, but unlike other powders, its effects had been inversely proportional to the amount used which is not in agreement wih the findings of Al-Moajel (2004) which reported an increase in effectiveness of leaves powder of *L. inermis* with increase in concentration. The WPI was also less than 50 at all the varying doses used showing its positive protectant ability of grains against *S. zeamais.*

5. Conclusions

The results obtained from this study have revealed the plant powders had significant effects on mortality and adult emergence of *S. zeamais* reared on sorghum grains. The observed differences on mortality and emergence of this pest on treated and untreated sorghum grains indicated that the test powders had effects on the developmental stages. The plant powders also showed positive protectant ability against *S. zeamais* attacking sorghum grains in the store.

Further research work is required to study the active ingredients of these plant powders, preparation of their formulations, mode of application and action, effects on target and non-target organisms, etc.

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