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Full Length Research Paper

Toxicity of some plant powders to maize weevil, *Sitophilus zeamais* (motschulsky) [Coleoptera: Curculiondae] on stored wheat grains (*Triticum aestivum*)

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This research reported the effect of four plant powders including *Azadirachta india, Alstonia boonei, Garcina kola* and *Moringa oleifera* on the mortality adults and emergence of maize weevil (*Sitophilus zeamais*) on stored wheat grains. The powders were incorporated into 20 g of wheat grains at 0.0% (control) 2.5, 5.0, 12.5 and 25.5% (w/w). The ability of the plants powders to protect wheat grains were assessed in terms of mortality rates after 24 to 96 h of post treatment, percentage grain weight loss and damage after the first filial generation (F1). The results indicated that *A. indica* and *A. boonei* provide the highest protection of the treated grains. *G. kola* and *M. oleifera* were not good enough protectants at the concentrations tested. These plants powders did not adversely affect seed viability after three months of storage, suggesting that seeds treated with *A. indica, A. boonei, G. kola and M. oleifera* are suitable for consumption and planting stock. Seed powders of *A. boonei* can be used as a good alternative to pesticides against *S. zeamais* in addition with that of *A. indica* which effects are well established by many former works.

Key words: *Sitophilus zeamais, Azadirachta indica, Alstonia boonei, Garcina kola, Moringa oleifera,* wheat storage.

INTRODUCTION

The maize weevil, *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) is a major pest of stored maize grains in the tropics and temperate regions of the world (Adedire, 2001). Its infestation causes severe post harvest losses of staple food crops in Nigeria leading to major economic losses (Oni and Ileke, 2008). The pest also infests other stored cereal grains as alternative hosts. Notable among its secondary hosts is wheat that has becomes one of the staple foods in Africa for combating malnutrition and protein deficiency in young children. The destructive activities of insects and other storage pests have been adequately subdued by chemical control methods comprising fumigation of stored commodity with carbon disulphide, phosphine or dusting with malathion, carbaryl, pirimiphos methyl or permethrin. These chemicals have been reported to be effective against stored products pests (Ogunwolu and Idowu, 1994; Adedire et al., 2011). In the developed countries, conventional fumigation technology is currently being scrutinised for many reasons such as ozone depletion potential of methyl bromide and car cinogenic concerns with phosphine (Adedire, 2002; Adedire et al., 2011).

The problems of many synthetic insecticides which include high persistence, poor knowledge of application, increasing costs of application, pest resurgence, genetic resistance by the insect and lethal effects on non-target organisms in addition to direct toxicity to users (Berger, 1994; Okonkwo and Okoye, 1996; Akinkurolere et al., 2006; Oni and Ileke, 2008). Recently, there is a steady increase in the use of plant products as a cheaper and ecologically safer means of controlling insect pest infestations of stored cereal and grains especially in the

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Table 1. Plants powders evaluated for insecticidal activities against *Sitiphulus zeamais.*

Scientific name	Family	Plants used	Common name
Azadirachta indica	Meliaceae	Seed	Neem
Alstonia boonei	Apocynaceae	Stem bark	Cheesewood
Garcina kola	Guttiferae	Seed	Bitter kola
Moringa oleifera	Moringaceae	Seed	Drum stick tree

tropics (Lale, 1992; Adedire and Ajayi, 1996). Currently, attention is being given to the use of edible plant materials as grain protectants (Ivbijaro and Agbaje, 1986; Adedire and Lajide, 2003: Akinkurolere et al., 2006; 2009; Adedire et al., 2011) and the tropics is well endowed with these plant species some of which are also used for medicinal purposes.

The objectives of the present study were to increase the data bank of natural products used in control of stored insect pests and to test the toxicity of powders of Neem (*Azadirachta indica),* Cheesewood (*Alstonia boonei*)*,* Drumstick (*Moringa oleifera*) and Bitter kola (*Garcina kola*) against the maize weevil, *S. zeamais* on stored wheat. This investigation also assessed the effect of the plant powders on seed germination after three months of storage.

MATERIALS AND METHODS

Insect culture

Adult *S. zeamais* used for this study were obtained from already existing culture in the Research Laboratory of the Department of Environmental Biology and Fisheries, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria. Sixty pairs of *S. zeamais,* sexed following the reports of Odeyemi and Daramola (2000) and Adedire (2001) were introduced into 1 L plane glass kilner jar containing 400 g of weevil – susceptible maize grains and covered with muslin cloth. The jar was placed in an insect rearing cage at ambient temperature of 30±3°C and 70±5% relative humidity.

Plant materials

The plant materials used in this study were *A. indica*, *M. oleifera*, *A. boonei* and *G. kola*. These materials were sourced fresh from a farm at Igbara-odo Ekiti, Ekiti State, Nigeria. These plant materials were dried in an open laboratory and ground into very fine powder using an electric blender (supermaster ®, Model SMB 2977, Japan). The powders were further sieved to pass through 1 mm^2 perforations. The powders were packed in plastic containers with tight lids and stored in a refrigerator at 4°C prior to use. The characteristics of the plant used are shown in Table 1.

Sampling of wheat grains

Wheat, *Triticum aestivum* hard red winter varieties were obtained from a newly stock grains free of insecticides in a warehouse in Akure, Ondo State, Nigeria. Firstly, the grains were cleaned and disinfested by keeping at -5°C for 7 days to kill all hidden infestations. This is because all the life stages, particularly the eggs are very sensitive to cold (Koehler, 2003). The disinfested wheat grains were then placed inside a Gallenkamp oven (Model 250) at 40°C for 4 h (Jambere et al., 1995) before they were stored in plastic containers with tight lids disinfested by swabbing with 90% alcohol.

Insect bioassay

Portions of 0.5, 1.0, 2.5 and 5.0 g of each plant powders corresponding to 2.5, 5.0, 12.5 and 25.0% w/w concentration were weighed and each added to a 20 g of clean undamaged and uninfected wheat grains in 250 ml plastic containers. The seeds in the controls contained no plant powders. The containers with their contents were gently shaken to ensure thorough admixture of the wheat seeds and treatment powders. Ten pairs of a day old adults *S. zeamais* were introduced to each of the containers and covered. Three replicates of the treatments and untreated controls were laid out in Complete Randomized Design. The adult mortality was assessed after every 24 h for 4 days. Adults were considered dead when probed with sharp objects and there were no responses. On day 5, all insects, both dead and alive were removed from each container and the seeds returned to their respective containers. Progeny emergence (F1) was then recorded at 6 weeks (42 days). The containers were sieved out and newly emerged adult weevils were counted with an aspirator. At week 6, the grains were re-weighed by using Metler weighing balance and the percentage loss in weight was determined as follow:

$$\%\ \text{weight loss} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times \frac{100}{1}$$

After re-weighing, the numbers of damaged grains were evaluated by counting wholesome and bored or seed with weevil emergent holes. Percentage seed damaged was also calculated as follows:

$$\%\ \text{seed damage} = \frac{\text{Number of perforated grains}}{\text{Total number of grains counted}} \times \frac{100}{1}$$

Viability bioassay

Seed viability test was conducted on batches of 20 g of wheat grains each treated with 2.50, 5.0, 12.5 and 25% w/w concentration of the plant powders and kept at ambient condition for 3 months in order to assess the effect of the plant product on the wheat grains. Thirty seed were randomly picked from each stored wheat grain batch and placed on moist whatman filter paper No. 1 inside disposable Petri dishes at the rate of 10 seeds per plate kept in a

Table 2. Effect of four plant powders on mortality of adult *Sitophilus zeamais.*

Plant powders	Conc. w/w	Mean % mortality ± S.E at 24 to 96 h post treatment			
		24 h	48 h	72 h	96 h
Azadirachta indica	2.5	33.7± 0.3[a]	68.5 ± 0.3[a]	96.7 ± 0.3[a]	100.0±0.0[a]
	5.0	60.3±0.6[b]	87.7±0.3[b]	I00.0±0.3[a]	100.0±0.0[a]
	12.5	70.3± 0.2[c]	100.0 ±0.0[c]	100.0 ±0.0[a]	100.0±0.0[a]
	25.0	76.7 ±0.3[c]	100.0 ±0.0[c]	100.0 ±0.0[a]	100.0±0.0[a]
Alstonia boonei	2.5	28.7± 0.3[a]	60.7± 0.3[a]	82.1 ±0.1[a]	98.0 ±0.5[a]
	5.0	37.3 ± 0.6[b]	82.3± 0.2[b]	100.0 ±0.0[b]	100.0±0.0[a]
	12.5	49.2 ± 0.2[c]	86.3 ± 0.2[b]	100.0 ±0.0[b]	100.0±0.0[a]
	25.0	62.4 ±0.2[d]	100.0 ±0.0[c]	100.0 ±0.0[b]	100.0±0.0[a]
Garcina kola	2.5	10.0 ± 0.2[a]	38.1± 0.2[a]	57.8±0.4[a]	77.7±0.3a
	5.0	17.1± 0.1[a]	43.3± 1.2[a]	69.9± 0.4[b]	81.4± 0.2[ab]
	12.5	29.9± 0.4[b]	59.9± 0.4[b]	76.1± 0.1[b]	89.5±0.3[b]
	25.0	43.0± 0.5[c]	67.3± 0.6[b]	89.7 ±0.3[c]	100.0+0.0[c]
Moringa oleifera	2.5	0.0 ± 0.0[a]	0.0 ± 0.0[a]	10.0 ± 0.0[a]	10.0 ±0.0[a]
	5.0	0.0 ± 0.0[a]	10.0 ±0.0[b]	20.0 ± 0.0[b]	30.0 ±0.0[b]
	12.5	10.0± 0.3[b]	33.3 ±1.2[c]	47.7± 0.3[c]	50.3± 1.2[c]
	25.0	24.7± 0.3[c]	43.7 ±0.3[d]	51.6 ±0.7[c]	59.4 ±0.2[c]
Control (untreated)	0.0	0.0± 0.0[a]	0.0± 0.0[a]	0.0± 0.0[a]	0.0± 0.0[a]

Each value is a mean of ± standard error of three replicates. Mean followed by the same letter in a column are not significantly different (P<0.05) from each other using new Duncan multiple range test.

Gallenkamp incubator. Emerged seedlings were counted at the end of 7 days after planting and % viability was calculated as follow:

$$\% \text{ viability} = \frac{\text{Number of germinated seed}}{\text{Total number of seeds planted}} \times \frac{100}{1}$$

Statistical analysis

Data were subjected to analysis of variance and where significant differences existed, treatment means were compared at 0.05 significant level using the New Duncan's Multiple Range Test (Zar, 1984).

RESULTS

Toxicity of plants powders

The toxic effects of the four plant powders to *S. zeamais* on wheat grains are presented in Table 2. The plant powders tested at 5% level showed the various bioactivity against *Sitophilus zeamais.* All the tested powders significantly (P<0.05) reduce the longevity of adults on treated wheat grains. All the plant powders showed weevil mortality ranging from 59.4 to 100.0%. Adult mortality increased with length of exposure. There was significant difference (P<0.05) in mortality of insect amongst the treatments. *A. indica* and *A. boonei* powders were most effectives against *S. zeamais* evoking 100% mortality, after 72 h of exposure. This followed by *G. kola* that recorded 89.7% weevil mortality after 72 h of exposure. *M. oleifera* powder was least toxic causing 59.4% weevil mortality after 96 h of exposure.

Progeny production

The different plants powders significantly (P<0.05) reduced the progeny of *S. zeamais* (Table 3). *A. indica* and *A. boonei* powders prevented F1 emergence of *S. zeamais* population compared to other treatment and control. The percentage adult emergence in the untreated wheat seeds was significantly different (P<0.05) from emergence in the treated seeds. *A. indica* and *A. boonei* powders completely inhibited the development of *S. zeamais*. From control (untreated), the number of emerged adult insects was about 64. Emergence from seeds treated with *A. indica* and *A. boonei* powders are the least with zero (0) adult insect. From seeds treated with *G. kola* powder at 2.5, 5.0, 12.5 and 25.0% w/w concentration, only an average of 3, 2, 1 and 0 (zero) adult insect(s) emerged respectively while *M. oleifera* powder had an average of 36, 31, 27 and16 adult insects respectively.

Weight loss and damage assessment

Wheat seeds treated with plants powders showed significant different (P<0.05) in the reduction of weight

Table 3. Effect of plants powders on number of *Sitophilus zeamais* adult emergence, percentage wheat grain weight loss, damaged and seed viability after three months of storage.

Plant powders	Conc. w/w	Adult emergence after 42 days	% Weight loss	% Grain damaged	% Seed viability
Azadirachta indica	2.5	0.0 ± 0.0[a]	0.0 ± 0.0[a]	0.0 ± 0.0[a]	89.3 ± 0.6[a]
	5.0	0.0 ± 0.0[a]	0.0 ± 0.0[a]	0.0 ± 0.0[a]	92.7 ± 0.7[a]
	12.5	0.0 ± 0.0[a]	0.0 ± 0.0[a]	0.0 ± 0.0[a]	92.7 ± 0.7[a]
	25.0	0.0 ± 0.0[a]	0.0 ± 0.0[a]	0.0 ± 0.0[a]	93.3 ± 0.6[a]
Alstonia boonei	2.5	0.0 ± 0.0[a]	0.8 ± 0.1[a]	0.0 ± 0.0[a]	90.0± 0.0[a]
	5.0	0.0 ± 0.0[a]	0.1 ± 0.0[a]	0.0 ± 0.0[a]	90.0± 0.0[a]
	12.5	0.0 ± 0.0[a]	0.0 ± 0.0[a]	0.0 ± 0.0[a]	90.0± 0.0[a]
	25.0	0.0 ± 0.0[a]	0.0 ± 0.0[a]	0.0 ± 0.0[a]	90.0± 0.0[a]
Garcina kola	2.5	3.3 ± 0.6[a]	10.4 ± 0.2[b]	0.9 ± 0.3[a]	90.0 ± 0.0[a]
	5.0	2.0 ± 0.0[a]	6.3 ±0.2[ab]	0.5± 0.5[a]	100.0 ± 0.0[a]
	12.5	1.4 ± 0.2[a]	3.9 ± 0.4[a]	0.4 ± 0.1[a]	93.3 ± 0.6[a]
	25.0	0.0 ± 0.0[a]	0.3 ± 0.6[a]	0.0 ± 0.0[a]	I00.0 ± 0.0[a]
Moringa oleifera	2.5	35.7 ± 0.5[c]	22.9 ± 0.4[c]	5.3 ± 0.8[b]	89.3 ± 0.6[a]
	5.0	31.3 ± 0.8b[c]	17.7 ±0.3[bc]	3.0 ± 0.1[ab]	90.0± 0.00[a]
	12.5	27.0 ± 0.7[b]	14.2 ± 0.4[ab]	1.7± 0.3[a]	93.3 ± 0.6[a]
	25.0	15.7 ± 0.2[a]	9.3 ± 1.2[a]	0.0± 0.0[a]	93.3± 0.6[a]
Control (untreated)	0.0	64.1± 0.8[d]	39.3± 0.2[d]	22.7 ± 0.3[d]	100.0±0.0[a]

Each value is a mean of ± standard error of three replicates. Mean followed by the same letter in a column are not significantly different ($P<0.05$) from each other using new Duncan multiple range test.

and damaged caused by *S. zeamais* (Table 3). The highest weight loss of 22.9% was recorded from wheat grains treated with 2.5% of *M. oleifera* followed by 2.5% *G. kola* powder with 10.4% loss (Table 3). There was neither seed damage nor weight loss recorded in the treated wheat seeds with *A. indica* and *A. boonei* powders. The powders of *A.* indica and *A. boonei* had 0% loss each. However, wheat seeds treated with 12.5 and 25.0% of *Garaina kola* powder had 0.4 and 0.0% seed damage respectively while grains treated with 12.5 and 25.0% of *M. oleifera* had 3.0 and 1.7% seed damage respectively. In the untreated wheat seeds, 22.7% damage occurred as revealed by emergent holes of the weevils. As a result of feeding activity of *S. zeamais* adults and larvae on wheat seeds, the weight of the untreated wheat seeds were significantly reduce by 39.3% compared with the treated seeds.

Viability assessment

The effect of plant powders on the viability of treated grains showed that none of the plant powders adversely affected the viability of the wheat grains when compared with the untreated control after 3 months of storage (Table 3). Almost all the treated seeds germinated. There was no significantly different t ($P>0.05$) in the mean percentage viability of control (untreated) and seed treated with four different plant powders. The untreated wheat seeds had the highest germination of 100% and that of *A.* indica, *A. boonei*, *G. kola* and *M. oleifera* at different concentration ranges between 89.3 to 93.3%, 90.0 to 92.7%, 90.0 to 100.0%, and 89.3 to 93.3% respectively.

DISCUSSION

The resultant high mortalities of adults *S. zeamais* observed on wheat grains treated with *A. indica* powders could be due to high toxic effect of the product on adult *S. zeamais*. This toxicity has been attributed by various authors to the presence of many chemical ingredients such as triterpenoids, which includes azadirachitin, salanin, meliantriol (Butterwoth and Morgan, 1968). The present observation thus corroborate those made by Kilonzo (1991), Jackai and Oyediran (1991), and Gerard and Ruf (1995) who found neem kernel powder to have a high toxic effect on feeding and survival of different pest species including fleas, *Maruca* vitrate and Keratinophagus insects under Laboratory condition. Mbailao et al. (2006) made similar report on *Callosobruchus maculatus.* Similar results were also reported by Ofuya (1992), Onu and Baba (2003), Mania and Lale (2004), Kabeh and Lale (2004), all on *C. maculatus.* These authors demonstrated that neem contains azadiratins, which is toxic to stored product insects.

A. boonei powder also prevented the emergence of *S. zeamais* adults, an effect that is in agreement with the observation of Osawe et al. (2007) who report that the aqueous extracts of the stem bark and leaves of this plant adversely affected survival and growth of *Sesamia calamists.* Growth inhibition may result from toxicity or feeding deterrent properties of the plant (Akhtar and Isman, 2004; Erturk, 2006). Some chemical compounds of the indole alkaloid group (alstonine, porphine and astonimide) and triterpenoids have been identified from the bark of *A. boonei* (Phillipson et al., 1987; Anonymous, 1992, 2001).

The percentage mortality and low adult emergence at high concentration caused by the powder of *G. kola* can be attributed to the bitter compound in the seed (Trease and Evans, 1989; Arannilewa et al., 2006). The powder on application covered the testa of the grains, serving as food poison to the adults insects; while some of them penetrated into the endosperm and germ layer thereby suppressing oviposition and larval development. Iwu and Igboko (1982) established the chemical constituent of *G. kola* seed as bi-flavonoids xanthone and benzophenones. *M. oleifera* at high concentration also reduced adult emergence of *S. zeamais*. Mbailo et al. (2006) reported the effect of *M. oleifera* oil on longevity of *Callosobruchus maculatus* adults on cowpea seeds.

The trial has shown that treating wheat seed with *A. indica, A. boonei* and *G. kola* powders at most of the tested concentration, prevent adult weevils emergence, reduction in weight loss and seed damage by *S. zeamais.* The observed non emergence of F1 generation of *S. zeamais* on wheat from *A. indica* and *A. boonei* powders could be as a result of high mortality of adult insects, thus disrupting mating and sexual communication as well as deterring females from laying eggs (NRC, 1992) and complete suppression of the developmental stages of insects. The fact that the powders did not affect the viability of treated seeds is of great importance to the users who may wish to adopt this technology for the preservation of wheat grains. Wheat is now being cultivated in some Northern State in Nigeria. Further studies are needed to determine the efficacy of these medicinal plants oils, which will reduce the bulkiness of the powders when used for storage control of crop pest in bags or in storage bins.

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