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Efficacy of Candlewood *Zanthoxylum xanthoxyloides* (Lam.) for the Control of *Sitophilus zeamais* (Mots.) (Coleoptera: Curculionidae) and *Callosobruchus maculatus* F. (Coleoptera: Bruchidae).

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ABSTRACT

The bioactivity of dried leaves, bark and root of *Zanthoxylum xanthoxyloides* (Lam.) was assessed in the laboratory for their ability to protect stored grains from damage by *Sitophilus zeamais* and *Callosobruchus maculatus* on maize and cowpea, respectively. One hundred grams of sterilized grains were measured in glass jars and the ground plant materials added as direct admixtures to test for toxicity, progeny production and weight loss. The plant materials tested initially at a concentration of 5% (wt/wt) showed the root and bark inducing 100% mortality and causing significant ($P<0.001$) reduction in damage and progeny emergence. Further test with dried root and bark at various concentrations demonstrated that 0.5% (wt/wt) gave complete protection of grains against beetle infestation with no observable damage to grains. The potential practical use of *Z. xanthoxyloides* as grain protectant in farm-stored grains is discussed.

KEYWORDS: *Zanthoxylum*, Efficacy, *Sitophilus, Callosobruchus*, stored grains.

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INTRODUCTION

Grains constitute the most important staple foodstuff for the growing population in the tropics and are usually stored to provide a food reserve as well as seed for planting (Niber, 1994). However, grains in storage are subject to damage from attack by several species of insects leading to loss in weight and seed quality, especially germination ability.

Post harvest losses to storage insect pests have been recognized as a major constraint in Africa with reports of losses averaging 30% of grain dry weight in maize stored on farm due to *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae), *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) and *Sitotroga cerealella* (Olivier) (Coleoptera: Gelechiidae) (IITA, 1995). Loss in grain weight may be compounded because kernels damaged by insetcs may be contaminated with dangerous levels of aflatoxins (IITA, 1995). Furthermore, grains may be contaminated with dead beetles, pupae and larval cocoons, some of which contain highly dangerous carcinogenic substances (Zehrer, 1980).

Insect control in stored food products relies heavily upon the use of gaseous fumigants and residual chemical insecticides. The widespread use of synthetic chemicals has led to serious problems, including development of insect strains resistant to insecticides, toxic residues in stored grains, and health hazards to grain handlers and consumers (Shaaya *et al.*, 1991). The poor storage facilities of traditional farmers in developing countries are also unsuitable for effective conventional chemical control, as most storage types are open to re-infestation by insect pests. These problems call for new alternatives being sought and attention has been turned to developing new sources of insecticides from the vast store of chemical substances in plants, which often are safer and biodegradable (Olaifa *et al.*, 1987).

This study investigated the efficacy of candlewood, *Z. xanthoxyloides* for the control of *S. zeamais* and *C. maculatus* in stored grains.

MATERIALS AND METHOD

Insect species

S. zeamais and *C. maculatus* were collected from infested stock of grains at the

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Madina market, Accra and reared on whole maize and cowpea grains, respectively. Culture conditions were 28 ± 2 °C, 65% relative humidity and 12L: 12D photoregime (Weaver et al., 1994). Insects were transferred to a glass jar containing 500 g of grains, which were sterilized in an oven at 40 °C for six hours (Santhoy and Rejesus, 1975). After one week of oviposition, all insects were removed and discarded to enable the emergence of same age progeny that were used to establish the main culture.

Collection and preparation of Plant materials

Leaves, bark and roots of *Z. xanthoxyloides* were collected from the University Farm, Legon – Accra and brought into the Laboratory where they were air-dried at room conditions (32 - 37 °C, 75 – 80 % relative humidity) for five days. The dried materials were ground using a hand blender and sieved with a mesh size of 710 micron to obtain fine powder for the different tests.

Mortality on grains

Mortality of beetles was tested using 100 g of maize and cowpea grains in 200 ml plastic jars and mixed with powdered leaf, bark and root of *Z. xanthoxyloides* at a concentration of 5 % (wt/wt). 20 adults of *S. zeamais* of 7 – 14 days old and 3 – 7 days *C. maculatus* were introduced into treated and untreated grains. The jars were covered with white muslin cloth and held in place with rubber bands and placed in the controlled environment room maintained at 28 ± 2 °C, 65% relative humidity and 12L: 12D photoregime. The control had no admixture of plant material and the treatments were replicated five times. Mortality was recorded daily for one week. Insects were considered dead if they failed to respond to three probings with a blunt probe. At the end of the trial, ground root and bark were found to be biologically active against the beetles. Similar experiments using root and bark were carried out at concentrations of 0.1, 0.2, 0.3, 0.4 and 0.5 % against *S. zeamais* and *C. maculatus*.

Damage assessment

Damage assessment was done by using whole grains that were kept in the deep freezer for two weeks and equilibrated in the control environment room at the same conditions mentioned above. 5 % (wt/wt) of ground leaves, bark and root were added to 100 g of grains and 20 adults of *S. zeamais* of 7 – 14 days old and 3 – 7 days *C. maculatus* were introduced into treated and untreated grains. Each treatment was replicated five times and left to stand undisturbed for two weeks. Samples of 100 grains were taken from each cup and the number of damaged grains (grains with characteristic holes) and undamaged grains were counted and weighed. Percent weight loss was computed using the method of FAO (1985):

% Weight loss = [UaN – (U+D)] / UaN x 100

where U = weight of undamaged fraction in sample.

N = total number of grains in the sample

Ua = average weight of one undamaged grain.

D = weight of damaged fraction in the sample

Progeny production

Grains treated with dried plant materials were assessed for the emergence of the first filial generation. 100 g of grains were kept in the deep freezer for two weeks to control hidden infestation and equilibrated at the controlled environment room before being used for the test. Twenty adults *S. zeamais* of 7 14 days old and 3 - 7 days *C. maculatus* were introduced into the jars containing grains mixed with ground dried leaves, bark and root. The containers were covered with white muslin cloth held in place with rubber

Table 1 Toxicity of ground plant material to S. zeamais and C. maculatus

Treatment	Mean % mortality (± S.E.)	
	S. zeamais	*C. maculatus*
Dried leaf	45^{b} ± 0.73	64^{b} ± 0.37
Dried bark	100^{a} ± 0.00	100^{a} ± 0.00
Dried root	100^{a} ± 0.00	100^{a} ± 0.00
Control	0^{c} ± 0.00	0^{c} ± 0.00

Mean of five replicates of 20 insects each. Mean for each species in the same column followed by different letters are significantly different at ($P<0.001$), LSD test.

Table 2 Toxicity of dried root and bark against *S. zeamais* and *C. maculatus*

Dosage (%wt/wt)	Mean percent mortality, hours after treatment							
	Root				Bark			
	24	48	72	96	24	48	72	96
S. zeamais								
0	0^{d}	0^{d}	0^{d}	0^{c}	0^{d}	0^{d}	0^{d}	0^{d}
0.1	3^{c}	33^{c}	58^{c}	71^{b}	5^{c}	13^{c}	26^{c}	41^{c}
0.2	6^{bc}	35^{c}	69^{bc}	82^{ab}	15^{b}	35^{b}	65^{b}	75^{b}
0.3	13^{b}	59^{b}	79^{ab}	89^{ab}	18^{b}	46^{b}	86^{a}	96^{a}
0.4	19^{b}	73^{ab}	88^{ab}	96^{a}	15^{b}	45^{b}	93^{a}	100^{a}
0.5	31^{a}	81^{a}	96^{a}	100^{a}	30^{a}	85^{a}	95^{a}	100^{a}
C. maculatus								
0	0^{d}	0^{c}	0^{d}	0^{c}	0^{d}	0^{c}	0^{d}	0^{d}
0.1	35^{c}	60^{d}	66^{c}	79^{b}	15^{c}	21^{d}	31^{c}	41^{c}
0.2	56^{b}	86^{bc}	95^{b}	96^{a}	26^{bc}	49^{c}	72^{b}	80^{b}
0.3	56^{b}	82^{c}	91^{b}	95^{a}	30^{bc}	61^{bc}	80^{a}	81^{a}
0.4	78^{a}	98^{a}	100^{a}	100^{a}	40^{ab}	75^{ab}	94^{a}	97^{a}
0.5	61^{ab}	92^{ab}	100^{a}	100^{a}	58^{a}	86^{a}	97^{a}	100^{a}

Means in the same column followed by different letter(s) are significantly different ($P<0.001$), LSD test.

bands. The control grains were not mixed plant materials. Each treatment was replicated five times and left undisturbed for four weeks. The number of insects emerging was counted for one week.

Data analysis

Analysis of variance using Genstat 5 Release 3.2 was performed on data generated. Data involving counts were transformed using square root transformation while those involving percentages were transformed using arcsine transformation. Correction for natural mortality in control treatment was done using Abbott's (1925) formula.

RESULTS

All dried and ground materials tested showed various levels of mortality over the control (Table 1). There was a significant difference ($P<0.001$) in mortality of *S. zeamais* and *C. maculatus* in grains mixed with root and bark which caused 100% mortality of both species while the leaves recorded the least toxicity. Toxicity of dried root and bark tested further at concentrations of 0.1, 0.2, 0.3, 0.4 and 0.5% (wt/wt) showed that 0.5% dose was the most potent, inducing 100% mortality within 96 hours (Table 2). However, in most cases, the 0.5% (wt/wt) was not significantly ($P<0.001$) different from the 0.3% (wt/wt) and this is noteworthy because sufficient control could be achieved with the 0.3% dosage, thus reducing the amount of material needed for protecting stored grains. There was a significant ($P<0.001$) reduction in damage caused by *S. zeamais* and *C. maculatus* to grains mixed with root and bark powder which provided 100% protection to the grains (Table 3). The dry leaves and control treatment were however not significantly different ($P<0.001$) in protecting grains. The root and bark completely inhibited progeny emergence of *S. zeamais* and *C. maculatus* (Table 4) while the dry leaves and control treatment were not significantly ($P<0.001$) different.

DISCUSSION

The significant mortality in *S. zeamais* and

Table 3 Effect of *Z. xanthoxyloides* on damage caused by *S. zeamais* and *C. maculatus* to stored grains.

	Mean % weight loss	
5% wt/wt of dried material	*S. zeamais*	*C. maculatus*
Leaf	$10^a \pm 1.68$	$11^a \pm 1.98$
Bark	$0^b \pm 0.00$	$0^b \pm 0.00$
Root	$0^b \pm 0.00$	$0^b \pm 0.00$
Control	$13^a \pm 2.41$	$12^a \pm 1.13$

Mean of five replicates of 20 insects each. Means for each species and in each column followed by different letter(s), are significantly different at (P<0.001), LSD test.

Table 4 Effect of dry ground material on the number of F1 progeny produced by *S. zeamais* and *C. maculatus*

	Mean number of F1 Progeny	
Dried ground material	*S. zeamais*	*C. maculatus*
Leaf	$135^a \pm 20.33$	$62^b \pm 10.64$
Bark	$0^b \pm 0.00$	$0^c \pm 0.00$
Root	$0^b \pm 0.00$	$0^c \pm 0.00$
Control	$154^a \pm 20.20$	125a ± 6.40

Mean of five replicates of 20 insects each. Means for each species and in each column followed by different letter(s), are significantly different at (P<0.001), LSD test.

C. maculatus could be attributed to the presence of highly pungent (Adesina, 1986) constituent secondary metabolite, with phenolic properties (Elujoba and Nagels, 1985) reputed for insecticidal activity (Obeng-Ofori *et al.*, 1997). The significant reduction in weight loss caused by *S. zeamais* and *C. maculatus* especially with grains treated with root and bark indicates the presence of antifeedant properties *Z. xanthoxyloides* (Niber, 1994). This offers good protectant potentials as these parts of the plant could be prepared and used to prevent damage of stored produce by these insect pests. The complete suppression of progeny production by *S. zeamais* and *C. maculatus* suggests the high presence of ovicidal and repellent properties in these parts of the plant (Ogunwolu and Idowu, 1994). This confirms the findings of Ogunwolu and Odunlami (1996) who reported the reproduction suppression properties of root bark powder of *Z. xanthoxyloides* against the bruchid *C. maculatus* due to high contact toxicity at concentrations of 0.125 – 3 g per 20 g of cowpea seed. The results obtained suggest that *Z. xanthoxyloides* could be a safe and promising source of naturally occurring insecticide in storage pest management systems. In traditional post-harvest system in Africa, resource-poor farmers could prepare the roots and bark of *Z. xanthoxyloides* into powder locally and use them to protect stored grains. The use of plant materials in pest control could become an important supplement to synthetic pesticides because they are broad spectrum in action and are based on local materials that are potentially less expensive. Many are also safe to the environment and harmless to man and other mammals (Obeng-Ofori *et al.*, 1997)

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