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Full Length Research Paper

Laboratory evaluation of four medicinal plants as protectants against the maize weevil, *Sitophilus zeamais* (Mots)

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The petroleum ether extract of four medicinal plants; *Aristolochia ringens* (Vahl), *Allium sativum* (L), *Ficus exasperata* (L) and *Garcinia kola* (H), were evaluated as grain protectant against the maize weevil, *Sitophilus zeamais* (Mots) in the laboratory at 0.5, 1.0 and 1.5% (w/v) concentrations. Parameters assessed were adult mortality, rate of adult emergence, grain damage effect and weevil peforation index (WPI). There was increase in adult mortality with days of exposure in all concentrations. *Ar. ringens* followed by *Al. sativum* were most potent both in adult mortality and adult emergence. This study reveals *Ar. ringens* to be a potent bioinsecticide for protecting maize grains from *S. zeamais* infestation and damage. The details of the bioassay procedure used and the results obtained are reported.

Key words: Medicinal plants, bioinsecticide, *Aristolochia ringens*, *Sitophilus zeamais*, weevil perforation index.

INTRODUCTION

The economic situation in a developing country, like Nigeria, has been adversely affected mostly by the post-harvest losses of commodities which are usually encountered, especially during storage (Arannilewa et al., 2002). The losses of grain in storage either directly, through consumption of the grain, or indirectly by producing "hot-spots" (thereby causing migration of moisture and as a result making the grains more suitable for other pests) are some of the inevitable losses encountered (Longstaff, 1986).

There is therefore an increasing need to search for edible, cheap and safe plant materials that will not contaminate food products in acting as grain protectants in small-scale storage systems. Other problems associated with the continuous use of synthetic insecticides, such as resistance and residue, will stimulate the use of any effective, easy to use, inexpensive, biodegradable and safe alternatives which are already a part of our diet (Okonkwo and Okoye, 1996).

There have been lots of search for locally available plant materials that may be of grain protectant ability (Odeyemi, 1993; Ivbijaro, 1983; Ofuya, 1986; Lale, 1992, 1995; Ivbijaro and Agbaje, 1986; Arannilewa et al., 2002; Arannilewa, 2002; Adedire and Lajide, 1999; Ajayi and Adedire, 2003; Adedire and Akinneye, 2003; Akinkurolere et al., 2006). There have also been some degrees of success and achievements in the use of such botanicals. It is hoped that these concerted efforts shall eventually bring forth botanicals that can be used as alternate bioinsecticides. This study reports on the evaluation four medicinal plant extracts in the control of *Sitophilus zeamais* in stored maize.

MATERIALS AND METHODS

Insect cultures

Parent stock of *Sitophilus zeamais* (Mots) was obtained from established laboratory culture reared on disinfested maize grains at ambient temperatures of 28±2°C and relative humidity of 75±5% respectively in a grain storage research laboratory, Federal University of Technology, Akure, Nigeria. The food medium (maize) used for bioassay was disinfested in a deep freezer for 96 h and later air-dried in the laboratory to prevent mouldiness (Adedire and

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Table 1. Plants evaluated for insecticidal activities against *Sitophilus zeamais*.

Scientific name	Family	Parts used	Common name
Aristolochia rigens	Aristolochiaceae	Root bark	Gaping Dutchman's pipe
Allium sativum	Liliaceae	Bulbs	Garlic
Ficus exasperata	Moraceae	Leaves	Sandpaper leaf
Garcinia kola	Guttiferae	Seeds	Bitter kola

Lajide, 1999). *S. zeamais* was then transferred onto the grains in 1 litre kilner jars and from this an established culture for the experiment was maintained as new generations emerged.

Plant materials

The selected plants and parts used for this experiment (Table 1) were collected, air-dried, pulverized and kept in separate plastic containers inside a refrigerator till the time for Soxhlet extraction. The exercise was carried out for 4 – 5 h. Thereafter, the thimble was removed from the units and the petroleum ether was recovered by re-distilling the content of the Soxhlet extractor at 40 - 60°C. The resulting extract was air-dried in order to remove traces of solvent. All the plants are medicinal (Arannilewa, 1992).

Effect of plant extracts on weevil mortality

The toxic effect of plants on adult *S. zeamais* was accomplished in Petri-dishes (9 cm diameter) containing 25 g of maize grains with concentrations of 0.5, 1.0 and 1.5% (w/v) plant extracts in petroleum ether. The extracts were thoroughly mixed with the aid of a glass rod and agitated for 5 – 10 min to ensure uniform coating. The dishes were left open for approximately 30 min so as to allow traces of petroleum ether to dry off; after which 20 newly emerged adult *S. zeamias* were introduced into the dishes and mortality was observed daily for 4 days. Grains that were solvent treated served as the control experiment. Adults were considered dead where no response was observed after probing them with forceps.

Effect of extracts on adult emergence and grain damage

Another experiment was performed with the infested and treated grains left for 49 days (i.e 7 weeks). At the end of the 49-day observation period, the extent of weevil damage was assessed using the exit-hole counted as a measure of damage to the grains. Grains that were riddle with exit-holes were counted; the percentage damage (PD) and weevil perforation index (WPI) of the weevils to the grains were calculated using the methods in Adedire and Ajayi (1996) and Fatope et al. (1995), respectively.

$$PD = \frac{\text{Total number of treated grains perforated}}{\text{Total number of grains}} \times 100$$

$$WPI = \frac{\text{\% of treated grains perforated}}{\text{\% of control grains perforated + \% of treated grains perforated}} \times 100$$

Data 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 AND DISCUSSION

The use of plant extracts in the control of stored products insects is an ancient practise (Qi and Burkholder, 1981). Oils are commonly used in insect control because the oils are relatively efficacious against virtually all life stages of insects (Nezan, 1983; Adedire, 2002; Don-Pedro, 1989, 1990).

The toxicity bioassay of the plant extracts on adult *S. zeamais* is presented in Table 2. Adult mortality significantly increased with increase in concentration and days of exposure. The highest value of 100% mortality was observed in the treatment with *Aristolochia ringens* by the 3rd day. This was followed by *Allium sativum* (85.0%), *Garcinia kola* (50.0%) and then *Ficus exasperata* (20.0%) (all at 1.50% (w/v) concentration). There was no mortality with the control.

Ar. ringens and *Al. sativum* may have been very potent because of the strong choky odours they produce; and which may have exerted a toxic effect by disrupting normal respiratory activity of the weevils, thereby resulting in asphyxiation and subsequent death (Adedire and Ajayi, 1996). Richards (1978) reported that essential oils of plant origin are highly lipophilic; and therefore have the ability to penetrate the cuticle of insects. This may be another reason for the potency of the extracts. By this method the plant material apart from its odour, may have also acted as a contact poison. Lajide et al. (1993) reported that another species *Aristolochia albida* was discovered to have acidic metabolites like aristolic acid, aristolochic acid, aristoloctam and aristolone. These metabolites may be present in *A. ringens*, and may have been responsible for its high potency against the adult weevil.

The number of adults that emerged after 7 weeks of storage is presented in Table 3. The number of emerged adults decreased with increase in concentration of extract. *Ar. ringens* had the least number of emerged adult (1.00) at 1.50% (w/v) concentration. *Al. sativum* (9.67) was next to *A. ringens,* followed by *G. kola* (10.33) and *F. exasperata* (50.00). The oil extract on application, covered the outer layer (testa) of the grains (thereby serving as food poison to the adults insects); while some of them penetrated into the endosperm and germ layers (thereby suppressing oviposition and larval development). *G. kola* (seeds) are known to contain flavonoids, apigenin and fisetin, bi-flavonoids and ametoflavone (Iwu and Igboko, 1982). *Al. sativum* has been discovered to be active as a repellent, antifeedant, bactericide, fungicide

Table 2. Effect of plant extracts on adult weevils of *Sitophilus zeamais*.

Plants	Conc. (%, v/w)	Mean mortality (±S.D) (%) at 1 - 4 days post treatment			
		1	2	3	4
Ar. ringens	0.50	13.33±0.54^{a}	38.33±0.00^{bc}	55.33±0.00^{c}	79.33±0.27^{d}
	1.00	45.00±0.47^{bc}	72.67±0.94^{d}	85.00±0.72^{d}	94.33±0.47^{e}
	1.50	60.33±0.27^{c}	98.00±0.94^{e}	100.00±0.00^{e}	100.00±0.00^{e}
Al. sativum	0.50	0.00±0.00^{a}	2.67±0.27^{a}	12.00±0.00^{a}	33.33±0.54^{b}
	1.00	1.67±0.27^{a}	18.33±0.27^{b}	30.33±0.00^{b}	45.00±0.27^{bc}
	1.50	8.33±0.54^{a}	39.33±0.82^{bc}	65.00±0.27^{d}	85.00±0.00^{d}
G. kola	0.50	0.00±0.00^{a}	1.67±0.27^{a}	3.33±0.00^{a}	6.67±0.54^{a}
	1.00	0.00±0.00^{a}	3.33±0.27^{a}	5.33±0.27^{a}	10.00±0.00^{a}
	1.50	0.00±0.00^{a}	10.00±1.25^{a}	31.67±0.94^{bc}	50.00±0.27^{c}
F. exasperata	0.50	0.00±0.00^{a}	0.00±0.00^{a}	1.67±0.27^{a}	4.33±0.54^{a}
	1.00	1.67±0.00^{a}	3.33±0.27^{a}	5.00±0.27^{a}	12.67±0.27^{a}
	1.50	1.67±0.27^{a}	8.33±0.27^{a}	13.33±0.00^{a}	20.00±0.27^{b}
Control (solvent-treated)	0.00	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}

Each value is the mean of three replicates. Means followed by the same letter are not significantly different (P > 0.05) from each other, using New Duncan's Multiple Range Test.

Table 3. Effect of plant extracts on *Sitophilus zeamais* adult emergence (7 weeks post-treatment).

Plants	Conc (%, v/w)	Mean number of emerged adults (±S.D)
Ar. ringens	0.50	10.33 ± 1.28^{b}
	1.00	7.00 ± 1.19^{a}
	1.50	1.00 ± 0.00^{a}
Al. sativum	0.50	18.00 ± 2.76^{b}
	1.00	12.33 ± 1.19^{b}
	1.50	9.67 ± 1.19^{b}
G. kola	0.50	27.67±1.28^{c}
	1.00	11.00±1.19^{b}
	1.50	10.33±0.00^{b}
F. exasperata	0.50	56.33±3.33^{d}
	1.00	52.67±1.19^{d}
	1.50	50.00±1.28^{d}
Control (Solvent-treated)	0.00	82.67±1.28^{e}

Means followed by the same letter are not significantly different (P > 0.05) from each other using New Duncan's Multiple Range Test.

and nematicide (Graigne et al., 1985; Mason and Linz, 1997). These compounds may be responsible for their potency.

Table 4 presents the effects of plant extracts on grain damage. A similar trend of plant activities was observed among the plants used. *Ar. ringens* gave the lowest value of 0.42% grain damaged, followed by *Al. sativum* (2.81%) and *G. kola* (4.22%), while *F. exasperata* gave 21.83% grain damage. Another observation from this research is that plant materials that acted as stomach and contact poisons were found to be active in suppressing growth or development of insects. This is what may be responsible for the result obtained in Table 4. The percent damage values show the activities of one plant material at different concentrations while the weevil perforation index (WPI) compares the activities of different species of plant extracts used.

From this study, it is becoming evident that *Ar. ringens* and *Al. sativum* displayed some potential as antifeedants, food poisons, contact poisons and repellents. The results therefore strongly suggest the possibility of using the extracts of these plants as toxicants, repellents and food poisoning agents against *S. zeamais.* Since there is very little information on the activities, and active metabolites

Table 4. Effect of extracts on grain damage.

Plants	Conc. %, v/w)	Total No. of grains	No of perforated grains	Unperforated grains	% grain damage	*WPI
A. ringens	0.50	244	11	233	4.51	10.65
	1.00	236	9	227	3.81	9.15
	1.50	238	1	237	0.42	1.10
A. sativum	0.50	249	20	229	8.03	17.51
	1.00	238	10	228	4.20	10.00
	1.50	249	7	242	2.81	6.91
G. kola	0.50	242	27	215	11.16	22.78
	1.00	234	10	224	4.27	10.14
	1.50	237	10	227	4.22	10.04
F. exasperata	0.50	224	58	166	25.89	40.64
	1.00	134	50	84	37.31	50.00
	1.50	229	50	141	21.83	36.60
Control (solvent- reated)	0.00	238	90	148	37.81	50

*Weevil Perforation Index (WPI). A value above 50 is an indication of negative protectant ability.

of *Ar. ringens,* an investigation is presently going on, to identify its metabolites and also to understand the metabolite(s) responsible for its high potency in insect control. The mode of action of the metabolites will also be studied.

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