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A Simple Laboratory Prescreen for Plants with Grain Protectant Effects Against the Maize Weevil; *Sitophilus zeamais* (Mots) (Coleoptera: Curculionidae)

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Abstract: A simple bioassay technique to assess pulverized indigenous plant materials for ability to protect maize grains from damage by weevils during storage, was employed. Of the 9 plants that were screened, *Zanthoxylum xanthoxyloides* (Lam.) Waterm. (Rutaceae), *Aristolochia ringens* Vahl. (Aristolochiaceae) and *Morinda lucida* Linn. (Rubiaceae) showed best protectant effects on adult toxicity, adult emergence and Weevil Perforation Index (WPI). The details of the bioassay procedure used and the results obtained are reported.

Key words: Pulverized plants, mortality, *Zanthoxylum xanthoxyloides*, *Aristolochia ringens*, *Sitophilus zeamais*, weevil perforation index

INTRODUCTION

Maize is one of the cheapest and staple food in a developing country like Nigeria. It is the main source of carbohydrate for human consumption and it is also, utilized in starch, oil food and feed industries and grown round the year. However, the most deleterious weevil that causes serious quantitative and qualitative losses of maize while in storage, is the maize weevil, *Sitophilus zeamais* (Mots).

The bulk of maize grain production comes from small scale farm holdings and traditional farmers. They use different kinds of plant products for pest control (Poswal and Akpa, 1991) either by mixing grains with protectants made up of plant materials or the use of their ashes so as to reduce grain damage by storage pests. This practice was discarded in preference for synthetic insecticide, which farmers and grain merchants found very effective in the control of pests (Fatope *et al.*, 1995).

The control of insect pests relies heavily on the use of synthetic insecticides but the increasing cost of application and the erratic supply in developing countries as a result of foreign exchange constraints have stimulated interest in the development of alternative control strategies and the re-evaluation of traditional botanical pest control agents (Deloble and Malonga, 1987; Makajuola, 1989). Such plant-derived botanicals are expected to be active as protectants against adults and larvae, they must be easy to use, cheap; accessible, biodegradable and with greater selectivity (Talukder and Howse, 1995).

This research work was therefore ,designed to screen 9 pulverized plant materials for their grain protectant ability on *Sitophilus zeamais*.

MATERIALS AND METHODS

Plant materials: *Colocasia esculenta* and *Euphorbia hirta* plants, were collected fresh from a farm within the University, while the other plant materials were purchased from Oja-Oba and Isinkan markets in Akure. They were all brought to the Laboratory, further air-dried and pulverized into fine powders with the aid of a ball-mill machine. The powders were sieved, transferred into air-tight containers and kept in the refrigerator till required (Table 1).

Insect cultures: Parent stock of *Sitophilus zeamais* was obtained from established laboratory culture reared on disinfested maize 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. Clean, undamaged and uninfested maize grains were purchased from Oja Oba and were disinfested in a deep-freezer for 96 h; after which they were air-dried in the laboratory to prevent mouldiness.

Sitophilus zeamais was then transferred onto the grains in 1 L Kilner jars and later brought into our laboratory from which an established culture was maintained as new generations emerged.

Insect bioassay with plant materials: The bioassay of the nine plant materials on adult *S. zeamais* was

Table 1: Effect of Plants percentage mortality of *Sitophilus zeamais* adults results

Plant powder	Family	Part	Concentration % (wt/wt)	% Mortality (±S.E)/ days post-treatment 1	2	3	4
Zanthoxylum xanthoxyloides	Rutaceae	Root bark	5.0	38.40 ± 6.00^{c}	95.00 ± 2.89^{f}	100.00 ± 0.00^{h}	100.00 ± 0.00^{k}
			10.0	70.00 ± 5.00^{d}	100.00 ± 0.00^{g}	100.00 ± 0.00^{h}	100.00 ± 0.00^{k}
			20.0	8170 ± 4.41^{e}	100.00 ± 0.00^{g}	100.00 ± 0.00^{h}	100.00 ± 0.00^{k}
Aristolochia ringens	Aristolochiaceae	Root bark	5.0	3.40 ± 1.67^{ab}	13.40 ± 3.33^{c}	33.40 ± 4.41^{e}	46.70 ± 3.33^{h}
			10.0	3.40 ± 1.67^{ab}	20.00 ± 2.89^{d}	43.40 ± 3.33^{f}	56.70 ± 4.41^{i}
			20.0	6.70 ± 1.67^{b}	48.40 ± 4.41^{e}	73.40 ± 4.41^{g}	81.70 ± 1.67^{j}
Garcinia kola	Clusiaceae	Seeds	5.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	1.70 ± 1.67^{ab}	3.40 ± 1.67^{abc}
			10.0	1.70 ± 1.67^{ab}	5.00 ± 0.00^{ab}	6.70 ± 1.67^{bcd}	11.70 ± 1.67^{defg}
			20.0	5.00 ± 0.00^{ab}	6.70 ± 1.67^{b}	10.00 ± 0.00^{d}	16.70 ± 4.41^{g}
Morinda lucida	Rubiaceae	Stem bark	5.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	1.70 ± 1.67^{ab}
			10.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	3.40 ± 1.67^{abc}	6.70 ± 1.67^{abcde}
			20.0	1.70 ± 1.67^{ab}	3.40 ± 1.67^{ab}	6.70 ± 1.67^{bcd}	11.70 ± 1.67^{defg}
Euphorbia hirta	Euphorbiaceae	Leaves and stem(shoot)	5.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	1.70 ± 1.67^{ab}	5.00 ± 0.00^{abcd}
			10.0	0.00 ± 0.00^{a}	1.70 ± 1.67^{ab}	5.00 ± 0.00^{abcd}	6.70 ± 1.67^{abcde}
			20.0	0.00 ± 0.00^{a}	3.40 ± 1.67^{ab}	5.00 ± 0.00^{abcd}	15.00 ± 2.89^{fg}
Croton zambesicus	Euphorbiaceae	Leaves	5.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	1.70 ± 1.67^{ab}	3.40 ± 1.67^{abc}
			10.0	0.00 ± 0.00^{a}	1.70 ± 1.67^{ab}	3.40 ± 1.67^{abc}	8.40 ± 1.67^{bcdef}
			20.0	0.00 ± 0.00^{a}	5.00 ± 0.00^{ab}	6.70 ± 1.67^{bcd}	13.40 ± 1.67^{efg}
Colocasia esculenta	Araceae	Leaves	5.0	0.00 ± 0.00^{a}	1.70 ± 1.67^{ab}	1.70 ± 1.67^{ab}	5.00 ± 5.00^{abcd}
			10.0	0.00 ± 0.00^{a}	3.40 ± 1.67^{ab}	5.00 ± 0.00^{abcd}	10.00 ± 2.89^{cdefg}
			20.0	0.00 ± 0.00^{a}	5.00 ± 0.00^{ab}	8.40 ± 1.67^{cd}	15.00 ± 0.00^{fg}
Ficus exasperata	Moraceae	Leaves	5.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
			10.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.0 ± 0.00^{a}
			20.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	1.70 ± 1.67^{ab}	6.70 ± 1.67^{abcde}
Tetrapleura tetraptera	Mimosaceae	Fruits	5.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
			10.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	1.74 ± 1.67^{ab}
			20.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	3.40 ± 1.67^{abc}
(control)			0.0	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 (NDMRT)

accomplished in petridishes (9 cm diameter) containing 25 g of maize grains. Portions (1.25, 2.50 and 5.00 g) of dry, pulverized plant materials corresponding to 5, 10 and 20% (wt/wt) were separately added to the grains inside the petridishes. Untreated grains served as control. The powders and grains were then mixed up with the aid of a glass rod and 20 newly emerged adults (0-48 h) were introduced into the dishes. Adult mortality was recorded on the 4th day; after which all dead and live weevils were removed and the dishes were covered and kept till new adults emerged (i.e., 7 weeks). All experiment were carried out in 3 replicates.

At the end of the 7 week (i.e., 49 days) observation period, the number of adults that emerged was recorded for each treatment and the number of grains perforated in treated and control were counted for determination of Percentage Damage PD (Adedire and Ajayi, 1996) and Weevil Perforation Index (Fatope *et al.*, 1995).

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

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

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 (NDMRT) (Zar, 1984).

RESULTS AND DISCUSSION

Many procedures have been employed by various investigators to screen plant materials for grain protectant effects. Okonkwo and Okoye (1996), Ogunwolu and Idowu (1994) adopted procedures which monitor the ability of test materials to kill adult weevils while, Ogunwolu and Odunlami (1996) and Onu and Aliyu (1995) also recorded ability of test materials to reduce oviposition, development and adult emergence in some other weevils.

In all tests however, a grain protectant is expected to control storage pests by suppressing oviposition or exterminating eggs, larvae, pupae or adult stages of pests, through antifeedance, repellence, contact or systemic poisoning. Of the 9 plants that were screened, only *Zanthoxylum xanthoxyloides* caused 100% adult mortality from the 2nd day, zero adult emergence and 0.00 Weevil Perforation Index (WPI) value after 49 days (i.e., 7 weeks) of storage, in all the concentration (Table 2).

Table 2: Effect of plant powders on adult emergence and damage caused on grains (after 7 weeks of Storage)

Plant powder	Concentration % (wt/wt)	+Mean no of adults counted (±S.E)	*Total no of grains counted	No of grains damaged	No of grains undamaged	Percentage damage	$WPI
Zanthoxylum xanthoxyloides	5.0	0.00 ± 0.00^{a}	150.0	0.00	150.0	0.0	0.00
	10.0	0.00 ± 0.00^{a}	153.0	0.00	153.0	0.0	0.00
	20.0	0.00 ± 0.00^{a}	140.0	0.00	140.0	0.0	0.00
Aristolochia ringens	5.0	1.00 ± 0.88^{a}	157.0	3.00	154.0	1.9	3.53
	10.0	0.30 ± 0.00^{a}	145.0	1.00	144.0	0.7	1.33
	20.0	0.00 ± 0.00^{a}	151.0	0.00	151.0	0.0	0.00
Garcinia kola	5.0	27.00 ± 0.88^{jk}	235.0	83.00	152.0	35.3	40.44
	10.0	24.00 ± 1.00^{hi}	209.0	69.00	140.0	33.0	38.82
	20.0	14.00 ± 0.88^{ef}	195.0	47.00	148.0	24.1	31.67
Morinda lucida	5.0	7.30 ± 0.67^{b}	178.0	18.00	160.0	10.1	16.26
	10.0	2.70 ± 1.76^{a}	163.0	8.00	155.0	4.9	8.61
	20.0	0.70 ± 0.67^{a}	166.0	2.00	164.0	1.2	2.26
Euphorbia hirta	5.0	17.70 ± 1.45^{g}	195.0	50.00	145.0	25.6	33.00
	10.0	15.70 ± 0.33^{fg}	249.0	49.00	200.0	19.6	27.40
	20.0	12.70 ± 1.45^{def}	221.0	37.00	184.0	16.7	24.31
Croton zambesicus	5.0	30.00 ± 1.15^{k}	263.0	88.0	175.0	33.5	39.18
	10.0	27.30 ± 0.88^{jk}	271.0	81.00	190.0	29.9	36.51
	20.0	23.70 ± 0.88^{hi}	243.0	71.00	172.0	29.2	36.00
Colocasia esculenta	5.0	$14.00\pm0,58^{ef}$	216.0	45.00	171.0	20.8	28.60
	10.0	10.30 ± 0.66^{bcd}	210.0	30.00	180.0	14.3	21.57
	20.0	9.00 ± 1.00^{bc}	195.0	27.00	168.0	13.8	21.00
Ficus exasperata	5.0	25.00 ± 1.15^{ij}	249.0	72.00	177.0	28.9	35.72
	10.0	22.70 ± 0.88^{hi}	250.0	70.00	180.0	28.0	35.00
	20.0	21.30 ± 0.88^{h}	243.0	65.00	178.0	26.7	34.00
Tetrapleura tetraptera	5.0	26.00 ± 1.15^{ij}	277.0	77.00	200.0	27.8	34.84
	10.0	23.00 ± 1.15^{hi}	263.0	66.00	197.0	25.1	32.56
	20.0	21.30 ± 0.88^{h}	244.0	66.00	184.0	24.6	32.11
(control)	0.00	38.30 ± 0.88^{L}	275.0	143.00	132.0	52.0	50

+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 (NDMRT), *Each value is the total number of grains of three replicates per concentration. $ Weevil Perforation Index. A value above 50 is an index of negative protectant ability or enhancement of infestation by weevils

Following *Z. xanthoxyloides* was *A. ringens* which induced 81.70% adult mortality within 4 days of application at 20% concentration. 1.00, 0.30 and 0.00 adult emergence values were recorded at 5, 10 and 20% concentrations, respectively. 0.00% damage and 0.00WPI were also recorded for the plant at 20% concentration. These values have therefore, suggested *A. ringens* to be effective based on the qualifications outlined above for any plant material that may display some grain protectant ability. *Morinda lucida* which evoked low mortality values on the adults, was however, observed to suppress larval growth and development into adults. This was as a result of the number of emerged adults that were counted (7.30; 2.70 and 0.70 at 5, 10 and 20% concentrations, respectively). An inference to note from these plant treatments is that some plants that may have strong activity on adults may be less active on larval growth and development; while some that may be weak in controlling the adults may be strong in suppressing larval growth, development and adult emergence. *Morinda lucida* can be suspected to fall into this category.

However, in all the plant materials that were tested, *Zanthoxylum xanthoxyloides* was found to be most active in killing the adults, in preventing adult emergence and protecting grains from being damaged.

Marr and Tang (1992) have attributed the insecticidal activities of Hawaiian *Zanthoxylum* plants to ccompounds such as isobutylamides, mono and sesquiterpenes and aliphatic ketones. Sofowora (1982) also discovered berberine, Chelerythrine, Canthin-6-one, p-hydroxy-benzoic acid, anillic acid and other phenolic acid derivatives to be present in the plant. All these may have been responsible for the high insecticidal activities of *Zanthoxylum xanthoxyloides.*

Aristolochia ringens possesses a strong choky odour and this may have exerted a toxic effect on the weevils by disrupting their normal respiratory activities, thereby resulting in asphyxiation and subsequent death. It is therefore, possible that *A. ringens* displayed some fumigant activity on the weevils. Lajide *et al.* (1993) reported that another species, *Aristolochia albida*, contains some acidic metabolites like *Aristolic acid*, *Aristolochic acid*, *Aristoloctam* and *Aristolone.* These metabolites may also be present in *A. ringens* and therefore be responsible for its high potency against weevils.

Apart from *Z. xanthoxyloides* and *A. ringens* which have been suspected to be potent, it is possible that other plant materials evaluated, like *M. lucida,* may be potent if an insect assay is carried out on their extracts. Extracts of *Z. xanthoxyloides* and *A. ringens* are expected to be very potent, while the extracts of the less potent powders may also be potent when applied.

All the plant materials, except *C. esculenta* have been found out to be medicinal (Arannilewa, 1992). It is therefore, believed that their medicinal values will make them fit, if they are successfully discovered to be insecticidal as extracts.

CONCLUSION

Conclusively, the prescreen research work on 9 plant materials has unveiled the potency of two plant materials, *Zanthoxylum xanthoxyloides* and *Aristolochia ringens*, to be active as grain protectants on the maize weevil; *Sitophilus zeamais*.

Further investigations on the potency of the two plant materials on storage pests and determination of the active ingredients in them shall all be carried out.

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