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Full Length Research Paper

Comparative efficacy of root, bark and leaf powders of *Dracaena arborea* for the control of two storage insect pests

I. O. Udo[1], T. T. Epidi[2]* and J. A. Osakwe[3]

[1]Department of Crop Science, University of Uyo, Akwa Ibom, Nigeria.
[2]Department of Crop Production Technology, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria.
[3]Department of Crop/Soil Science, Rivers State University of Science and Technology, Port Harcourt, Nigeria.

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Laboratory investigations were carried out to compare the efficacy of root, bark and leaf powders of *Dracaena arborea* for the control of *Sitophilus zeamais* and *Callosobruchus maculatus* on stored maize and cowpea grains, respectively. Two levels of concentration (1 and 5%) of the different powders were admixed with grains to determine the contact toxicity, damage assessment, progeny development and grain germination. The leaf powder at 5% concentration was more effective than the bark and root powders against the two insect species. The leaf powder at 5% concentration recorded a significant ($P < 0.05$) mortality of 26% against *S. zeamais* and 83% mortality against *C. maculatus* after 96 h of exposure. Mean damage in treated grains was as low as 1.09 to 3.23% compared with 4.64 to 16.16% in the control. Progeny production was significantly ($P < 0.05$) inhibited in treated grains while grain treatment did not affect germination.

Key words: *Dracaena arborea, Sitophilus zeamais*, *Callosobruchus maculatus,* mortality, toxicity.

INTRODUCTION

Grains constitute the most important staple foodstuff for the ever growing population in the tropics. Corn is utilized for example as flour, "pap", "ogi", "eko" while the "offals" are utilized in the production of animal feeds. Similarly, cowpea is processed into bean cakes called "akara" or used in making "moi-moi" and the "offals" also are utilized in animal feed production. Besides, grains are also stored as reserves for planting and for export trade thus generating foreign exchange (Denloye and Makanjuola, 2001).

In developing countries, food grain consumption often falls short of the demand as a result of heavy post-harvest losses due to physical, chemical and biological factors (Osuji, 1985; Obeng-Ofori et al., 1997; Udo, 2005) with the biological factors including fungi, mites, birds, rodents and insects. As in field crops, a wide range of insects attack grains in storage with the commonest being beetles and moths (Agrawal et al., 1988; Bekele et al., 1997). Insect pest damage to stored grains estimated at 20 to 30% in the tropics results in major economic losses to farmers (Dick, 1988; Niber, 1994; Udo, 2005). The extent of stored grain losses varies according to insect species and comes with serious economic consequences leading to food insecurity. For instance, *Callosobruchus maculatus* is known to cause up to 100% loss of stored cowpea and estimates have shown that over 30 million U.S. dollar is lost as a result of cowpea damage in Nigeria (Jackai and Daoust, 1986). In Ghana, 20% or more of about 300,000 t of maize stored is lost due to *Sitophilus zeamais* within a four month storage period (Tindall, 1983). In a survey conducted at Nyanza District of Kenya, it was found out that approximately 20% of maize cobs were already infested with weevils at the time of harvest (Nyambo, 1993).

As a measure to curtail the infestation of stored products by insect pests, farmers have largely depended on the use of synthetic insecticides. The attendant consequences of the use of synthetic insecticides include the development of resistant insect species, toxic residues on stored grains, health hazards to grain handlers, high

*Corresponding author. E-mail: tepidi@yahoo.com.

persistence and ecotoxicology (Zettler and Cuperus, 1990; White, 1995). Moreover, synthetic chemicals are expensive, erratic in supply due to foreign exchange constraints and therefore not accessible to rural poor farmers. These problems have stimulated interest in the re-evaluation of traditional botanical pest control agents. Plant materials with insecticidal properties provide small-scale farmers with locally available, biodegradable and inexpensive material for storage pest control.

Dracaena arborea (Willd.) Link (Dracaenaceae) is a woody stemmed tropical plant that grows up to 15 m high with a girth of 2.5 m and long broad leaves. It is locally available and is used for boundary demarcation. It is hardly attacked by insects, and is believed to have anti-parasitic and anti-fungal properties (Okunji et al., 1996). Recently, Epidi et al. (2008) reported on the efficacy of its leaf powder against *S. zeamais* and *C. maculatus.* This work therefore focuses on comparing the efficacy of root, bark and leaf powders of *D. arborea* for the control of *S. zeamais* and *C. maculatus*.

MATERIALS AND METHODS

Culturing of insects

S. zeamais and *C. maculatus* were obtained from infested stock of grains at the Uyo main market, Nigeria and reared on whole grains in the Crop Protection Laboratory, University of Uyo, Nigeria. Culture conditions were 28±2°C, 65 to 70% relative humidity and 12L:12D photoregime (Udo, 2005). Insects were treated for mites by exposing them to sunlight in a plastic bowl with the mouth covered with muslin cloth for 3 h. Insects with heavy mite burden died while the surviving insects were washed in 1 % sodium hypochlorite solution and dried on filter paper before being transferred into sterilized grains using the method of Udo (2005). After being treated for mites, insects were introduced into 500 g of sterilized maize and cowpea grains, respectively in glass jars having the mouth covered with white muslin cloth and held in place with rubber bands.

Both cultures were left to stand undisturbed in the laboratory for 21 days to allow for oviposition. After this period, the parent adults were sieved out using a 2 mm impact test sieve. The progenies emerging thereafter were used to establish cultures and sub-cultures for the various bioassay. Insects used for the experiments were sexed under a stereomicroscope after chilling for 3 min in a deep freezer to reduce their mobility and caution was taken to keep the males in a separate jar from the females.

Collection and preparation of plant materials

One kilogram each of leaves, bark and root of *D. arborea* were collected from Uyo metropolis and air dried separately in the laboratory for one week. Upon drying, the materials were ground into powder using hand blender. The powdered materials were bagged in black polythene bags, labeled and utilized within 2 to 5 days.

Toxicity of powdered plant materials against *S. zeamais* and *C. maculates*

One hundred grams each of pre-equilibrated maize and cowpea grains were measured into 200 ml plastic cups and 1 and 5% of powdered leaf, bark and root of *D. arborea* were added. The control treatment was set up without the plant powders. Ten pairs of sexed adults (that is, 20 insects) of each species of between 3 to 7 days old were introduced into the treated and untreated grains. The plastic cups were covered with white muslin cloth held in place with rubber bands. The experiment was laid out using completely randomized design with four replicates. Mortality was recorded after 24 h and up to 96 h with insects assumed dead on failure to respond to three probings using a blunt dissecting probe (Obeng-Ofori et al., 1998).

Damage assessment

One hundred grams of maize and cowpea grains each were measured into 200 ml plastic cups and powdered leaf, bark and root materials of *D. arborea* were added at both 1 and 5% levels. Ten pairs, each of *S. zeamais and C. maculatus* were introduced into the cups and covered with white muslin cloth held in place with rubber bands. Each treatment was replicated four times and left to stand undisturbed for four weeks. Control treatment had no plant powders. Samples of 100 grains each of maize and cowpea were taken from each cup (Obeng-Ofori et al., 1997; Udo, 2005) and the number of damaged grains (grains with characteristic holes) and undamaged grains were counted and weighed. Percent weight loss was computed using FAO (1985) method as follows:

$$\%\text{ weight loss} = \frac{[UaN - (U+D)] \times 100}{UaN}$$

where U is the weight of undamaged fraction in the sample; N is the total number of grains in the sample; Ua is the average weight of one undamaged grain, and D is the weight of damaged fraction in the sample

Determination of progeny production

One hundred grams of maize and cowpea grains, respectively were measured into 200 ml plastic cups and powdered leaf, bark and root of *D. arborea* were added at l and 5%. Ten pairs of sexed adult *S. zeamais* and *C. maculatus* were introduced into the cups and covered with white muslin cloth held in place with rubber bands. The control treatment had no plant powder. Each treatment was replicated four times and allowed to stand undisturbed for five weeks (Udo, 2005). The number of insects emerging was counted after 24 h and up to 96 h.

Determination of grain sprouting

Twenty five grams of grains each of maize and cowpea, respectively were treated with powdered leaf, bark and root of *D. arborea* and allowed to stand for four weeks. Thereafter, 10 healthy grains were visually selected and soaked in one litre (1 L) of distilled water for 6 h. The grains were later removed and placed on moist cotton wool in a Petri dish in the laboratory.

Sprouting was observed from the first day up to the tenth day and each treatment was replicated four times.

Data analyses

The data obtained were subjected to analysis of variance (ANOVA) according to procedures of Statistical Analysis System (SAS, 1999).

Table 1. Toxicity of leaf, bark and root powders of *D. arborea* tested at 1% against S. *zeamais* and C. *maculatus.*

Insect pest	Plant part	Mean percent mortality, hours after treatment			
		24	48	72	96
S. *zeamais*	Leaf powder	1 ± 0.50	3 ± 0.58	3 ± 01.00	4 ± 0.50
	Bark powder	0 ± 0.00	3 ± 1.00	3 ± 1.00	3 ± 1.00
	Root powder	1 ± 0.50	3 ± 1.00	3 ± 1.00	5 ± 1.41
	Control	0 ± 0.00	0 ± 0.00	0 ± 0.00	0 ± 0.00
	LSD	NS	NS	NS	NS
C. *maculatus*	Leaf powder	4 ± 0.50	9 ± 0.96	24 ± 2.50	31 ± 3.69
	Bark powder	8 ± 0.58	28 ± 2.65	41 ± 2.06	48 ± 2.52
	Root powder	8 ± 1.29	24 ± 0.96	36 ± 2.08	49 ± 1.71
	Control	0 ± 0.00	0 ± 0.00	0 ± 0.00	0 ± 0.00
	LSD	5.83	11.54	15.89	18.60

Table 2. Toxicity of leaf, bark and root powders of D. *arborea* tested at 5% against S. *zeamais* and C. *maculatus.*

Insects pest	Plant part	Mean percent mortality, hours after treatment			
		24	48	72	96
S. *zeamais*	Leaf powder	11 ± 1.50	21 ± 1.26	21 ± 3.0	26 ± 2.63
	Bark powder	5 ± 0.82	8 ± 1.73	8 ± 1.91	9 ± 2.06
	Root powder	4 ± 0.96	4 ± 1.50	8 ± 1.29	9 ± 2.22
	Control	0 ± 0.00	0 ± 0.00	0 ± 0.00	0 ± 0.00
	LSD	7.27	10.15	12.2	15.58
C. *maculatus*	Leaf powder	30 ± 1.41	54 ± 1.71	69 ± 0.96	83 ± 0.58
	Bark powder	14 ± 2.06	19 ± 1.26	34 ± 1.29	41 ± 0.96
	Root powder	19 ± 3.09	44 ± 1.70	46 ± 1.70	59 ± 3.20
	Control	0 ± 0.00	0 ± 0.00	0 ± 0.00	0 ± 0.00
	LSD	15.45	10.58	10.15	13.17

RESULTS AND DISCUSSION

Toxicity of powdered materials

Leaf, bark and root powders of *D. arborea* tested at 1% against *S. zeamais* and *C. maculatus* showed some level of bioactivity (Table 1) only against *C. maculatus* with bark and root powders inducing over 45% mortality after 96 h of treatment. However, toxic effect was observed for both insect species when the concentration was raised to 5% (Table 2). Leaf powder affected about 26% of *S. zeamais* and 83% of *C. maculatus* after 96 h of treatment. On the other hand, root powder resulted in over 59% mortality in *C. maculatus* after 96 h of exposure. Except at 5% concentration, leaf powder was not more efficacious than bark and root powders against the two insect species. Epidi et al. (2008) reported the efficacy of leaf powder of *D. arborea* incorporated into cowpea and maize flour against *C. maculatus* and *S. zeamais,* respectively.

The reduced effectiveness of powdered materials of *D. arborea* tested at 1% against *S. zeamais* is probably due to the possession of strong elytra that covers the entire abdomen of the insect thereby restricting toxicant absorption (Obeng-Ofori et al., 1998). Again, the body size of *S. zeamais* might enhance its efficiency in detoxifying any toxicant in the plant powders applied. The significant mortality recorded against *C. maculatus* is noteworthy as *D. arborea* could be incorporated into traditional pest control systems. Adult *Callosobruchus* being soft bodied and lacking ability to burrow into grains like their *Sitophilus* counterpart brought them always in contact with the powdered materials of *D. arborea*. As observed, increased dosage rate from 1 to 5% significantly increased mortality in the two insect species compared with the untreated control, thus providing a promising remedy to tackling stored grains insect pest problem. The presence of secondary metabolites in *D.*

Table 3. Effect of root, bark and leaf powders of *D. arborea* on damage (%) caused by *S. zeamais* and *C. maculatus* to stored grains after 4 weeks of exposure

Treatment	**Mean percent damage**	
1%wt/wt	***S. zeamais***	***C. maculatus***
Leaf powder	1.39 ± 0.93	1.47 ± 0.73
Bark powder	2.37 ± 2.03	1.71 ± 0.60
Root powder	3.23 ± 2.06	1.45 ± 0.92
Control	4.79 ± 1.38	4.64 ± 2.07
LSD	NS	1.97
5%wt/wt		
Leaf powder	1.19 ± 0.46	2.55 ± 1.25
Bark powder	1.58 ± 1.22	1.92 ± 1.99
Root powder	1.09 ± 1.44	1.83 ± 1.12
Control	16.16 ± 5.49	6.23 ± 2.03
LSD	4.25	2.56

arborea identified as mannispirostan A, and Spiroconazole A (Okunji et al., 1996) which is pennogennin triglycoside may be responsible for the activity against the two storage insect pest. Since *D. arborea* is available locally, and in the tropics, it could be utilized effectively in protecting stored grains in the tropics (Niber, 1994; Udo, 2005).

Damage assessment

Grains treated with leaf, bark and root powders of *D. arborea* at 1% significantly (P < 0.01) reduced the damage caused by *C. maculatus* but did not affect *S. zeamais*. Also, no differences were observed between root, bark and leaf powders (Table 3). However, when the dosage was increased from I to 5%, leaf, bark and root powders of *D. arborea* gave significant (p < 0.001) protection of the grains against damage by both *S. zeamais* and *C. maculatus* compared to the control. Again, no differences were observed between the powders.

At 1% treatment level, it could probably be argued that the toxic factor in the plant materials was not sufficiently adequate to affect *S. zeamais* but when the concentration was raised to 5%, the insects were affected and damage was reduced. The reduced damage caused by both *S. zeamais* and *C. maculatus* could also be attributed to the odour of fatty acids such as lipids associated with the plant (Okunji et al., 1996). Harborne (1982) has linked the presence of esters in plants with antifeedant activities of insects while Schmutterer (1995) also reported that esters were essential for the antifeedant activity of Azadirachtin in the neem tree. The result obtained suggests good potential for the use of *D. arborea* in the management of stored product pests, thus becoming an important complement or alternative to synthetic insecticides.

Reproduction inhibition

Leaf, bark and root powders of *D. arborea* significantly (P < O.O1) reduced the F_1 generation of *S. zeamais* and *C. maculatus* (Table 4) when applied at 1 and 5%. The reduction in the number of *C. maculatus* produced could probably be accounted for by the fact that eggs of *C. maculatus* are laid on the seed coat thus having easier contact with the powders while eggs of *S. zeamais* are laid within chambers in the grains. The bioactivity of the plant against progeny development suggests the possible presence of ovicidal and larvicidal constituents in *D. arborea* (Elujoba and Nagels, 1985). The result agrees with the findings of Ogunwolu and Odunlami (1996), who reported the reproduction suppression properties of root bark powder of *Zanthoxylum zanthoxyloides* against *C. maculatus* due to high contact toxicity. No differences were observed between the various plant powders, an indication that active principle responsible for toxicity is probably present in equal amount in the bark, root and leaves.

Grain sprouting

Maize and cowpea grains treated with 1 and 5% leaf, bark and root powders of *D. arborea* did not differ from the control in percent sprouting (Table 5). The result obtained shows that the plant powders did not differ from themselves and from the control, and that the plant powders did not affect seed sprouting. Therefore, with over 80% sprouting recorded for maize and cowpea, the fear that has been expressed by many farmers has been put to rest (Cobbinah, 1998).

Table 4. Mean number of adult insects produced in grains treated with 1 and 5% leaf, bark and root powders of *D. arborea* at different days after oviposition period.

Insect pest	Concentration (%)	Plant part	Days after oviposition period		
			1	7	14
S. *zeamais*	1	Leaf powder	30.00	21.25	21.50
		Bark powder	17.00	25.00	19.50
		Root powder	20.00	23.50	28.00
		Control	52.00	62.50	46.00
		LSD	11.21	17.43	12.71
C. *maculatus*	1	Leaf powder	25.47	26.80	72.50
		Bark powder	32.50	28.56	58.75
		Root powder	28.71	33.80	76.80
		Control	74.20	92.50	104.85
		LSD	15.85	21.80	18.03
S. zeamais	5	Leaf powder	19.30	22.49	21.30
		Bark powder	13.58	26.84	32.59
		Root powder	15.75	19.35	27.98
		Control	38.08	53.46	75.93
		LSD	17.05	13.49	10.42
C. *maculatus*	5	Leaf powder	37.84	29.52	41.56
		Bark powder	31.08	31.84	39.44
		Root powder	29.87	23.48	23.66
		Control	53.49	72.76	78.43
		LSD	14.27	11.89	17.43

Means of four replicates, LSD test (P < 0.01).

Table 5. Sprouting (%) of grains treated with leaf, bark and root powders of *D. arborea.*

Treatment level (%)	Plant part	Percent sprouting	
		Maize	Cowpea
1	Leaf powder	67.50	62.50
	Bark powder	70.00	67.50
	Root powder	72.50	67.50
	Control	72.50	70.00
	LSD	NS	NS
5	Leaf powder	70.00	76.32
	Bark powder	68.75	72.50
	Root powder	72.51	73.65
	Control	70.62	71.82
	LSD	NS	NS

NS = Not significant

Conclusion

The results obtained from the study show that *D. arborea,* in the form of root, bark and leaf powders could be incorporated into our pest management systems for the control of *C. maculatus* and *S. zeamais*. The botanical is widely distributed and abound round the year; therefore, availability would not pose a problem in the case of repeated usage by resource poor farmers. Also, as already indicated, it is safe to the environment, man and other mammals. The use of *D. arborea* therefore could be an important supplement to synthetic pesticides.

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