Pak. j. sci. ind. res. Ser. B: biol. sci. 2011 **54** (3) 152-156

Laboratory Evaluation of Toxic and Repellent Properties of *Dracaena arborea* Against *Sitophilus zeamais* and *Callosobruchus maculatus*

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(received August 11, 2010; revised September 5, 2011; accepted September 17, 2011)

Abstract. Laboratory evaluation of ethanolic extract of *Dracaena arborea* leaves partitioned between equal volumes of chloroform, ethyl acetate, *n*-hexane and *n*-butanol to obtain various fractions was carried out to assess contact toxicity on filter paper and by topical application, toxicity of extracts applied on grains and repellent action against *Sitophilus zeamais* (Mots.) and *Callosobruchus maculatus* Fabricius on stored grains. Insects were exposed to both treated and untreated surfaces and mortality was scored at different times after treatment. Results obtained from the study showed the extract fractions causing significant mortality of both insects exposed to treatments. A contact toxicity of over 80% was recorded against *S. zeamais* from ethyl acetate fraction. Similarly, 100% mortality was recorded against *C. maculatus* from ethyl acetate fraction after 96 h of treatment. Results obtained from grain treatment produced a significant mortality of over 60% against *C. maculatus* from *n*-hexane fraction while the aqueous fraction significantly killed *S. zeamais* by over 15% compared with the control treatment. A strong repellent action was evoked against *S. zeamais* while moderate action was recorded against *C. maculatus.* An overall repellency of 40% and 24% was recorded from various extract fractions against *S. zeamais* and *C. maculatus*, respectively. The results obtained suggest a promising alternative to synthetic insecticides and the incorporation of *D. arborea* into storage pest management system is advised.

Keywords: toxicity, *Sitophilus zeamis, Dracaena arborea*, stored grains, extract fractions maculatus, *Callosobruchus*, repellency

Introduction

Grains in storage are subject to insect pest infestation if left without protectants and the consequence is serious threat to food security. There are records of enormous losses of up to 20 – 30% of stored products arising from insect pest attacks (Obeng-Ofori, 1995). Insect pests associated with stored products are beetles and moths with the common ones being *Sitophilus zeamais* and *Callosobruchus maculatus* attacking stored maize and cowpea, respectively. Over the years farmers relied upon the use of synthetic chemicals for the control of storage pests. The attendant consequences of the use of synthetic chemicals have been widely reported (Udo *et al.,* 2004; Obeng-Ofori, *et al.,* 1997; White, 1995; Shaaya *et al.,* 1991; Zettler and Cuperus, 1990). Alternative control measures are still being sougth out and one of them is the use of plant materials and plant products. Botanical treatments have been found to be safer to the environment, broad spectrum in action with little or no hazards to man and other animals. One such plant is *Dracaena arborea* which is a tropical plant growing up to 15 m high and 2.5 m girth with long, broad and blade-like leaves, and commonly utilized as boundary plants for demarcation of plots of land in the Southeastern parts of Nigeria. Okunji *et al.* (1996) has reported that anti-fungal and anti-parasitic compounds are present in *D. arborea.*

In this study, ethanolic extract fractions of *D. arborea* were screened for insecticidal activities against *S. zeamais* and *C. maculatus*. Extract fractions have the advantage of economic use of the plant material especially where the plant is not readily available and could also be used for such tests like repellency and tropical bioasssay.

Materials and Methods

Insects. *S. zeamais* and *C. maculatus* were collected from infested stock of grains at Etaha Itam market, Uyo, Nigeria and reared on sterilized maize and cowpea grains, respectively. After two weeks of oviposition, the parent adults were removed by sieving while emerging progeny were recultured and used for various bioassays.

Preparation of extract fractions. Leaves of *D. arborea* with voucher number UUH (84a), Faculty of Pharmacy, University of Uyo, were collected from the wild in Uyo,

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Nigeria and air dried in the laboratory for five days. Dried leaves were ground and 1 kg soaked in 90% ethanol in glass jars and left to stand in the dark for 72 h to prevent possible volatilization of active principles. Filtration was carried out and ethanol was evaporated using rotary evaporator. The residue obtained was dissolved in 60 mL of distilled water and subjected to partitioning using equal volumes of *n*-hexane, chloroform, ethyl acetate and *n*-butanol to obtain different extract fractions used for the various bioassays.

Contact toxicity on filter paper. Whatman No. 1 filter paper (10.9 cm diameter) placed in glass petri dishes was impregnated with 200 µL/mL of each extract fraction and 10 adults each of *S. zeamais* and *C. maculatus* were introduced into each dish, respectively. Control treatments had the filter paper impregnated with distilled water and mortality was recorded after 24 h and up to 96 h. Insects were assumed dead on failure to respond to three probes with a blunt dissecting probe after a 5-min recovery time.

Contact toxicity by topical application. Forty adult insects, each of *S. zeamais* and *C. maculatus* were chilled in the deep freezer for three minutes to reduce their activity (mobility) and transferred into petri dishes. One micro litre of each extract fraction was applied using a micro pipette to the dorsal surface of the thorax of each insect taken individually. Distilled water was applied to control insects and each treatment was replicated four times. Mortality was recorded after one hour for 48 h.

Toxicity of extracts applied on grains. Toxicity of the extract fractions applied on maize and cowpea grains, respectively, against *S. zeamais* and *C. maculatus* was tested by applying 200 mg/kg to 50 g of grains in a 200 mL plastic cup. Ten pairs of each insect species were introduced into treated and control grains. Mortality was recorded after 24 h and up to 96 h after treatment with insects presumed dead on failure to respond to three probes with a blunt dissecting probe.

Repellency test. Repellent effect of the extract fractions was tested using the method described by Obeng-Ofori *et al.* (1997). Whatman No.1 filter paper were cut into halves with one half being treated with the extract fractions while the other half was treated with distilled water to serve as the control. After being air dried for one hour, the full discs were re-made by attaching treated and control halves with paper tapes. Each filter paper was placed in a petri dish and ten weevils introduced into the center of the paper. Number of weevils present on control (Nc) and treated (Nt) strips were recorded after 30 min and up to 48 h. Percent, repellency was computed as:

$$PR = \frac{Nc - Nt}{Nc + Nt} \times 100\%$$

Where:

PR = percent repellency
Nc = number of insects present on control strip
Nt = number of insects present on treated strip.

Table 1. Contact toxicity of extract fractions of *D. arborea* applied on filter paper against *S. zeamais* and *C. maculatus*

Extract fractions (200 µL/mL)	Percent mortality after treatment 24 h	48 h	72 h	96 h	Control	LSD
S. zeamais						
Ethyl acetate	7 ± 0.50	17 ± 0.95	28 ± 1.25	82 ± 2.44	0 ± 0.00	10.40
Chloroform	0 ± 0.00	17 ± 0.95	33 ± 1.73	47 ± 1.25	0 ± 0.00	31.60
n-hexane	0 ± 0.00	0 ± 0.00	8 ± 0.50	17 ± 0.50	0 ± 0.00	9.60
n-butanol	0 ± 0.00	7 ± 0.50	8 ± 0.50	12 ± 0.81	0 ± 0.00	NS
Aqueous	7 ± 0.50	7 ± 0.50	23 ± 0.81	62 ± 0.81	0 ± 0.00	18.00
C. maculatus						
Ethyl acetate	0 ± 0.00	0 ± 0.00	13 ± 0.81	13 ± 0.81	0 ± 0.00	NS
Chloroform	0 ± 0.00	0 ± 0.00	0 ± 0.00	0 ± 0.00	0 ± 0.00	NS
n-hexane	7 ± 0.50	7 ± 0.50	23 ± 0.81	23 ± 0.81	0 ± 0.00	NS
n-butanol	0 ± 0.00	7 ± 0.50	18 ± 0.95	18 ± 0.95	0 ± 0.00	NS
Aqueous	7 ± 0.50	7 ± 0.50	13 ± 0.81	13 ± 0.81	0 ± 0.00	NS

Means = (SEM) of four replicates of 20 insects each; LSD test = ($P < 0.05$); NS = Non significant.

Table 2. Toxicity of extract fractions of *D. arborea* applied topically against *S. zeamais* and *C. maculatus*

Extract fractions 20 µg/mL	Percent mortality after treatment 24 h	48 h	72 h	96 h	Control	LSD
S. zeamais						
n-hexane	0 ± 0.00	0 ± 0.00	5 ± 0.50	10 ± 0.57	0 ± 0.00	NS
n-butanol	70 ± 1.73	75 ± 1.89	75 ± 1.89	85 ± 1.50	0 ± 0.00	47.40
Chloroform	0 ± 0.00	0 ± 0.00	10 ± 0.57	15 ± 0.50	0 ± 0.00	10.40
Ethyl acetate	15 ± 0.95	35 ± 0.95	40 ± 0.82	65 ± 0.95	0 ± 0.00	24.80
Aqueous	95 ± 0.50	100 ± 0.00	100 ± 0.00	100 ± 0.00	0 ± 0.00	7.40
C. maculatus						
n-hexane	0 ± 0.00	10 ± 1.00	15 ± 1.38	25 ± 1.89	0 ± 0.00	NS
n-butanol	95 ± 0.50	95 ± 0.50	95 ± 0.50	95 ± 0.50	0 ± 0.00	13.40
Chloroform	0 ± 0.00	0 ± 0.00	0 ± 0.00	10 ± 0.57	0 ± 0.00	NS
Ethyl acetate	95 ± 0.50	100 ± 0.00	100 ± 0.00	100 ± 0.00	0 ± 0.00	6.80
Aqueous	95 ± 0.50	100 ± 0.00	100 ± 0.00	100 ± 0.00	0 ± 0.00	7.40

Means = (SEM) of four replicates of 10 insects each; LSD test = (P < 0.05); NS = Non significant.

Table 3. Percent mortality of *S. zeamais* and *C. maculatus* exposed to grains treated with extract fractions of *D. arborea*

Extract fractions (200 mg/kg)	Percent mortality after treatment 24 h	48 h	72 h	96 h	Control	LSD
S. zeamais						
n-hexane	0 ± 0.00	5 ± 0.81	5 ± 0.50	5 ± 0.50	0 ± 0.00	3.60
Chloroform	0 ± 0.00	5 ± 0.57	5 ± 0.50	5 ± 0.50	0 ± 0.00	3.00
Ethyl acetate	0 ± 0.00	5 ± 0.57	5 ± 0.81	10 ± 1.00	0 ± 0.00	4.75
n-butanol	0 ± 0.00	5 ± 1.00	5 ± 1.00	5 ± 1.00	0 ± 0.00	NS
Aqueous	5 ± 1.15	5 ± 1.15	15 ± 1.29	15 ± 1.47	0 ± 0.00	8.45
C. maculatus						
n-hexane	10 ± 2.16	35 ± 2.71	40 ± 2.60	60 ± 2.98	0 ± 0.00	12.20
Chloroform	10 ± 2.87	30 ± 3.77	35 ± 4.69	45 ± 5.83	0 ± 0.00	29.85
Ethyl acetate	5 ± 1.41	25 ± 2.44	30 ± 2.98	40 ± 3.68	0 ± 0.00	18.60
n-butanol	10 ± 2.06	30 ± 1.25	35 ± 1.82	50 ± 1.71	0 ± 0.00	11.70
Aqueous	15 ± 1.91	20 ± 2.50	20 ± 2.50	25 ± 2.06	0 ± 0.00	15.20

Means = (SEM) of four replicates of 20 insects each; LSD test = (P < 0.05); NS = Non significant.

Results and Discussion

Contact toxicity on filter paper. Results of the toxic effect of extract fractions of *D. arborea* applied on filter paper against *S. zeamais* and *C. maculatus* is shown in Table 1. There was a contact mortality of 80% from the ethyl acetate fraction while *n*-hexane and chloroform fractions recorded a mortality of 45% and 15%, respectively after 96 h of treatment against *S. zeamais*. The aqueous fraction also significantly induced a mortality of 60% in *S. zeamais* after 96 h of insect exposure to treated filter papers.

Contact toxicity by topical application. Significant insect mortality was recorded from topical application of the different extract fractions against the two insect species (Table 2). Ethyl acetate and the aqueous fractions were observed to induce 100% mortality of the insects after 96 h treatment.

Toxicity of the extract fractions applied on grains. Different levels of toxicity of the extract fractions were observed against *S. zeamais* and *C. maculatus* after 96 h of exposure to treated grains (Table 3). The *n*-hexane fraction recorded a mortality of 60% against *C. maculatus* while the aqueous fraction produced 15% mortality in *S. zeamais*.

Table 4. Percent repellency (PR) values for extract fractions of *D. arborea* tested against *S. zeamais* and *C. maculatus*

Extract fraction	Mean percent repellency	
	S. zeamais	*C. maculatus*
n-hexane	38	42
Chloroform	44	6
Ethyl acetate	44	25
n-butanol	25	13
Aqueous	50	33
Overall PR	40	24
LSD	11.04	17.46

Mean = (SEM) of four replicates of 10 insects each; LSD test = (P <0.01).

Repellency test. Table 4 shows the repellent effect of the various extract fractions against the two insect species with *S. zeamais* being significantly repelled by about 40% while *C. maculatus* had an overall repellency of 24%. The individual extract fractions showed the aqueous fraction repelling *S. zeamais* and *C. maculatus* by 50% and 33%, respectively. Ethyl acetate fraction also repelled *S. zeamais* and *C. maculatus* by about 44% and 25%, respectively.

The significant mortality of *S. zeamais* in filter paper impregnated with the extract fractions indicated the presence of residual toxic principle in *D. arborea*. Some secondary metabolites identified as mannispirostan A and spiroconazole A have been identified in *D. arborea* (Okunji *et al.,* 1996). *S. zeamais* was more susceptible to filter paper treatment of the extract fractions probably because of their close contact with treated surfaces, compared to *C. maculatus* which were observed to be very mobile and hanging on the underside of perforated petri dish covers. This observation has also been reported against these insect pests when tested against methanol extract of *Zanthoxylum xanthoxyloides* Lam. (Udo *et al.,* 2004, Ofuya and Okuku, 1994).

The extract fractions applied topically against *S. zeamais* and *C. maculatus* induced significant insect mortality of the two insect species and dead beetles were found having their metathoracic wings stretched outside the elytra thus suggesting contact toxicity and not due to ingestion of treated grains (Obeng-Ofori *et al.,* 1997). Topical application therefore, facilitated the direct contact of toxicants or active ingredients in *D. arborea* with insects' bodies (Adedire and Ajayi, 1996). Udo and Epidi (2009) reported similar results on the efficacy of ethanolic extract fractions of *Ricinodendron heudelotii* (Baill) Pierre ex Pax against the two insect pests.

C. maculatus was more susceptible to contact action of the extract fractions applied on grains than *S. zeamais* probably because of the absence of hard and highly sclerotized thoracic cuticle as in their *Sitophilus* counterpart. Similar results were obtained by other researchers (Epidi *et al.,* 2008; Owusu *et al.,* 2007), who reported on the efficacy of the leaf powder of *D. arborea* against the two insect species.

The significant repellent action observed against *S. zeamais* and *C. maculatus* is noteworthy as this could prevent the insects from settling, feeding and laying eggs into grains protected with extracts of *D. arborea*. The result obtained from this study recommends the incorporation of *D. arborea* in storage pest management systems particularly in Africa. It could become an important supplement or alternative to synthetic insecticides.

Acknowledgement

The author is grateful to Dr. (Mrs.) Uduak Essiett, a Botanist in the University of Uyo for identifying the plant specimen.

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