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SUSCEPTIBILITY OF *SITOPHILUS ZEAMAIS* MOTS. AND *CALLOSOBRUCHUS MACULATUS* F. TO PLANT PARTS OF *RICINODENDRON HEUDELOTII*

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Abstract: Studies were carried out in the laboratory to determine the efficacy of powders from plant parts of *Ricinodendron heudelotii* against the storage pests *Sitophilus zeamais* and *Callosobruchus maculatus* on stored maize and cowpea, respectively. Leaf, bark and root powders were added as admixtures to 100 g of grains to assess contact toxicity, damage assessment, progeny production and grain germination. Results indicated that the plant materials were toxic to the two insect species with over 30% and 75% mortality for *S. zeamais* and *C. maculatus,* respectively. Observable damage level was significantly ($p \le 0.05$) lower in treated grains while progeny production by both insect species was significantly ($p \le 0.05$) reduced. Grain germination of both crops was not affected by the powders. The potential use of *P. heudelotii* in storage pest management is discussed.

Key words: *Ricinodendron heudelotti*, *Sitophilus zeamais*, *Callosobruchus maculatus*, contact toxicity, damage

INTRODUCTION

Stored products are attacked by a wide range of insect pests, the commonest being beetles and moths, thus making insects the most important agents of destruction and deterioration of stored products (Agrawal *et al.* 1988). Insects therefore are responsible for irreparable damage to stored grains (Denloye and Makanjuola 2001) resulting in major economic losses to farmers throughout the world. In most tropical countries, postharvest losses in cereals and pulses were estimated as 20–30% while limited resource farmers in developing countries suffer proportionately higher losses (Cobbinah 1998).

The extent of stored grain losses vary according to insect species and it was observed that *Callosobruchus maculatus* can cause up to 100% loss of stored cowpea with an estimated value of over 30 million U.S. dollars in Nigeria (Jackai and Daoust 1986).

In Ghana, 20% or more of about 300 000 tonnes of maize stored is lost to *Sitophilus zeamais* and the loss of the stored crop to this insect is estimated to be 27% within a four month storage period (Tindall 1983).

As a measure of controlling the infestation of stored products by insect pests, farmers have largely depended on the use of synthetic insecticides. This has led to the development of insect strains resistant to insecticides, toxic residues on stored grains, health hazards to grain handlers, high persistence and ecotoxicology. Furthermore, synthetic chemicals are expensive, erratic in supply due to foreign exchange constraints and cost-benefit often not economic to use by resource poor farmers (Obeng Ofori *et al.* 1997; Asawalam and Adesiyan 2001). These problems have stimulated continued interest in the re-evaluation of traditional botanical pest control agents. Plant products therefore have played an important part in traditional methods of protection against crop pests and disease vectors in Africa (Poswal and Akpa 1991). Furthermore, the rain forest contains a wide array of species, many of which are yet to be identified.

This work therefore aims to evaluate the effectiveness of *Ricinodendron heudelotii* in controlling of the storage pests *S. zeamais* and *C. maculatus*. *R. heudelotii* is a tree belonging to the family Euphorbiaceae and is native of tropical Africa with leaves digitately alternate. The economic, industrial and medicinal uses of *R. heudelotii* have long been known (Etukudo 2003) but the insecticidal properties are yet to the exploited.

MATERIALS AND METHODS

Culturing of insects

S. zeamais and *C. maculatus* were collected 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% relative humidity and 12L:12D photoregime (Udo 2005).

Insects were treated for mites using the method of Udo (2005). Insects were placed in jars containing 500 g of sterilized grains to allow oviposition. After three weeks, par-

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ent adults were removed to enable the emergence of same age progeny that were used to establish the main culture with subsequent re-culturing after every two weeks.

Collection and preparation of plant materials

One kilogram each of leaves, bark and roots of *R. heudelotii* were collected from Uyo metropolis and air dried separately in the laboratory for one week to avoid possible volatilization of the active ingredients. On drying, leaves, bark and roots were ground into powder using an electric blender. They were separately packed into black polythene bags and labeled.

Toxicity of ground plant materials to *S. zeamais* and *C. maculatus*

One hundred grams of each cowpea and maize grains were measured into 200 ml plastic cups and leaf, bark and root powders of *R. heudelotii* were mixed with the grains in proportion of both 1% and 5%. The control treatment had no plant powders added. One hour after the addition of plant powders, 10 pairs of adult insects of each species between 3–7 days old were introduced into treated and untreated grains (Udo 2000). The plastic cups were covered with white muslin cloth held in place with rubber bands. The experiment was replicated four times and mortality was recorded after 24 h and up to 96 h after treatment. Insects were considered dead on failure to respond to three probings using a blunt dissecting probe (Obeng-Ofori *et al*. 1997).

Damage assessment

The grains used for this study were kept in the deep freezer for two weeks to avoid hidden infestation. One hundred grams of grains each of cowpea and maize, respectively, were measured into 200 ml plastic cups and leaf, bark and root powders of *R. heudelotii* added at 1% and 5%. Ten pairs each of *S. zeamais* and *C. maculatus* were introduced into treated and control grains and the cups were covered with white muslin cloth. Each treatment was replicated four times and left to stand undisturbed for four weeks. Afterwards samples of 100 grains were taken from each cup (Udo 2005) and the number of damaged grains and undamaged grains were counted and weighed. Per cent weight loss was computed according to the method of FAO (1985) as follows:

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

where:
U = weight of undamaged fraction in the sample
N = total number of grains in the sample
Ua = average weight of one undamaged grains
D = 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 leaf, bark and root powders of *P. heude!otii* added at the rate 1% and 5%.

Ten pairs of adults *S. zeamais* and *C. maculatus* of different sex were introduced into treated and control cups covered with white muslin cloth and held in place with rubber bands. Each treatment was replicated four times and the experiment left to stand undisturbed for five weeks (Udo 2005). The number of insects emerging was counted after 24 h and up to 96 h of the sixth week.

Grain germination

Twenty five grams of grains of each cowpea and maize, respectively, were treated with leaf, bark and root powders of *R. heudelotii* and allowed to stand for four weeks. Thereafter, 10 grains were selected and soaked in one litre of distilled water for six hours. Then the grains were removed and placed on moist cotton wool in a Petri dish in the laboratory. Germination was observed from the first day up to the tenth day. Each treatment was replicated four times while the control treatment had no plant powders added.

RESULTS

Effectiveness of powdered plant materials

Various levels of bioactivity of plant parts against *S. zeamais* and *C. maculatus* were observed when leaf, bark and root powders of *P. heudelotii* were applied at 1% (Table 1).

About 10% mortality was recorded from bark powder after treatment against *S. zeamais* while mortality of over 80% was recorded from root powder against *C. macu-*

Table 1. Toxicity of leaf, bark and root powders of *R. heudelotii* against *S. zeamais* and *C. maculatus* added at 1% wt/wt

Insect pest	Plant parts	Days after oviposition period			
		24	48	72	96
S. zeamais	leaf powder	4±0.50	9±0.96	9±0.96	13±0.56
	bark powder	6±0.96	13±1.29	16±1.26	18±1.29
	root powder	3±1.00	9±0.96	9±0.96	15±0.82
	control	0±0.000	0±0.000	0±0.000	0±0.000
	LSD	ns	ns	6.54	6.34
C. maculatus	leaf powder	29±1.90	45±1.83	54±2.06	60±2.16
	bark powder	30±2.16	54±2.50	66±2.75	70±2.94
	root powder	28±2.08	48±3.69	73±3.10	83±1.91
	control	0±0.000	0±0.000	0±0.000	0±0.000
	LSD	12.23	18.73	18.01	16.01

Means of four replicates of 20 insects each, LSD test ($p < 0.05$)
ns – not significant difference

Table 2. Toxicity of leaf, bark and root powders of *R. heudelotii* against *S. zeamais* and *C. maculatus* at 5% wt/wt

Insect pest	Plant parts	Days after oviposition period			
		24	48	72	96
S. zeamais	leaf powder	8±12.9	8±1.29	13±3.69	23±3.77
	bark powder	9±2.22	18±2.08	25±1.41	31±1.26
	root powder	3±0.58	3±0.58	14±1.50	20±1.15
	control	0±0.000	0±0.000	0±0.000	0±0.000
	LSD	ns	12.48	16.44	16.09
C. maculatus	leaf powder	54±1.26	59±4.99	74±3.40	78±3.11
	bark powder	49±1.716	56±3.86	74±2.22	79±2.99
	root powder	40±1.83	63±3.87	70±3.56	70±2.16
	control	0±0.000	0±0.000	0±0.000	0±0.000
	LSD	10.87	28.75	20.75	18.73

Means of four replicates of 20 insects each, LSD test ($p < 0.05$)
ns – not significant difference

Table 3. Effect of leaf, bark and root powders of *R. heudelotii* on damage caused by *S. zeamais* and *C. maculatus* to stored grains

Treatment level	Plant parts	Percent germination	
		maize	cowpea
1%	leaf powder	1.86±1.16	0.62±0.33
	bark powder	1.59±0.98	0.70±0.54
	root powder	0.01±0.41	1.70±1.23
	control	3.93±1.04	2.70±1.88
	LSD	1.47	ns
5%	leaf powder	0.88±0.65	1.40±0.94
	bark powder	0.97±0.51	1.22±1.13
	root powder	1.19±0.48	0.77±0.28
	control	2.39±1.04	9.46±4.07
	LSD	1.09	3.37

LSD test ($p < 0.01$)
ns – not significant difference

Table 4. Mean number of adult insects produced in grains treated with leaf, bark and root powders of *R. heudelotii* at 5% after different periods of oviposition

Plant parts	Per cent germination		
	1	7	14
S. zeamais			
Leaf powder	18.49	40.17	35.87
Bark powder	29.43	38.20	29.43
Root powder	31.28	36.43	32.64
Control	53.64	62.37	59.28
LSD	12.42	22.51	17.25
C. maculatus			
Leaf powder	22.50	18.75	27.09
Bark powder	18.95	25.62	32.58
Root powder	27.23	19.58	28.15
Control	48.19	53.69	62.73
LSD	18.45	15.04	21.24

Table 5. Germination of grains treated with leaf, bark and root powders of *D. arborea*

Treatment level	Plant parts	Percent germination	
		Maize	Cowpea
1%	leaf powder	70.00	87.00
	bark powder	70.00	82.00
	root powder	70.00	91.00
	control	69.00	90.00
	LSD	ns	ns
5%	leaf powder	70.00	82.00
	bark powder	80.00	87.00
	root powder	81.00	85.00
	control	80.00	83.00
	LSD	ns	ns

ns – not significant difference

latus 96 h after treatment. Similarly, increasing the concentration from 1 to 5% significantly ($p \leq 0.05$) affected both insect species over the control. All the powders were observed to cause over 70% mortality in *C. maculatus* after 96 h of exposure, while bark powder produced over 30% mortality in *S. zeamais* after 96 h of treatment. Leaf and root powders recorded mortality of over 20% against *S. zeamais* (Table 2).

Damage assessment

Grains treated with leaf, bark and root powders of *R. heudelotii* at 1% significantly ($p \leq 0.01$) reduced damage caused by *S. zeamais* to stored maize. Root powder gave the highest protection by recording a mean percent weight loss of 0.01% (Table 3).

However, at 5%, leaf powder gave the highest significant ($p \leq 0.01$) reduction in damage caused by *S. zeamais* with a mean percent weight loss of 0.88%. Root powder was more effective in reducing damage caused by *C. maculatus* to stored cowpea at 5% treatment level compared with the 1% treatment level where no significance was recorded even though leaf powder gave a protection 40.62%.

Progeny production

Leaf, bark and root powders of *R. heudelotii* applied at 1% significantly ($p \leq 0.05$) reduced the progeny production of *C. maculatus* while progeny of *S. zeamais* was not significantly affected at the same treatment level (Table 4).

However, when the treatment level was raised to 5%, progeny production in both insect species was significantly ($p \leq 0.05$) brought down. Leaf powder applied at 5% gave a mean progeny development of about 3 insects in *C. maculatus*. At both 1 and 5% treatment levels, the progeny production in *C. maculatus* was considerably reduced compared with the control.

Grain germination

Maize and cowpea grains treated with leaf, bark and root powders of *P. heudelotii* did not differ in their germinating capacity compared with the untreated control. At both 1% and 5% treatment level, over 70% germination was achieved for both maize and cowpea grains (Table 5)

DISCUSSION

The significant mortality of both *S. zeamais* and *C. maculatus* when leaf, bark, and root powders of *R. heudelotii* were applied at 1 and 5% indicates the presence of insecticidal properties in this plant. This agrees with the result obtained by earlier research workers (Niber 1994; Boeke *et al*. 2004; Udo 2005). Further, secondary metabolites identified as aleuritolic acid, a lipid with short-chained fatty acids have been associated with this plant (Momeni *et al.* 2005) and may play a role with respect to its potency against insects. Thus, if well utilized, *R. heudelotii* would minimize the use of hazardous chemicals in stored product pest control. Also, since *P. heudelotii is locally abundant*, the leaves could be collected and admixed with grains by small scale farmers in traditional pest control systems.

The reduction in damage caused to stored maize and cowpea, respectively by *S. zeamais* and *C. maculatus* is noteworthy and may indicate the presence of antifeedant properties in *R. heudelotii*. Again since lipids have been found present in *R. heudelotii*, it is possible that a reduced damage caused by *S. zeamais* and *C. maculatus* was due to the influence of fatty acids. Harborne (1982) linked the presence of esters in plants with antifeedant activities of insects while Schumutterer (1995) reported that esters were essential for the antifeedant activity of azadirachtin in neem tree.

The reduction in the number of F_1 progeny produced by both *S. zeamais* and *C. maculatus* when leaf, bark and root powders of *R. heudelotii* were applied to stored maize and cowpea, respectively, suggests the presence of ovicidal properties in the plant. A reduced number of *C. maculatus* produced when compared to *S. zeamais* might have arisen from the fact that eggs of *C. maculatus* are laid on the seed coat while eggs of *S. zeamais* are laid within grain chambers. Thus, it is possible that the eggs of *C. maculatus* were brought in closer contact with toxic secondary metabolites in *R. heudelotii* thus causing higher egg mortality. In a similar work, Ogunwolu and Odunlami (1996) reported the reproduction suppression properties of root bark powder of *Z. xanthoxyloides* against *C. maculatus* due to high contact toxicity at concentrations of 0.125–3 g per 20 g of stored cowpea.

There was no significant difference in germination of maize and cowpea grains treated with leaf, bark and root powders of *R. heudelotii*. This demonstrated that the powder materials did not impair seed or grain germination. With over 80% germination recorded for both maize and cowpea, *R. heudelotii* does not have adverse effect on seed germination.

CONCLUSION

This study clearly demonstrated that leaf, bark and root powders of *R. heudelotii* possess insecticidal properties against *C. maculatus* and *S. zeamais*. Thus, it has great potential as a grain protectant against infestation and damage by *C. maculatus* and *S. zeamais*. Therefore, for stored products pest management, *R. heudelotti* could serve as an important supplement or alternative to synthetic insecticides.

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POLISH SUMMARY

WRAŻLIWOŚĆ *SITOPHILUS ZEAMAIS* MOTS. I *CALLOSOBRUCHUS MACULATUS* F. NA CZĘŚCI ROŚLIN *RICINODENDRON HEUDELOTII*

Badania wykonano w laboratorium, celem określenia skuteczności proszku z części roślin *Ricinodendron heudelotii,* przeciwko szkodnikom przechowalnianym *Sitophilus zeamais* i *Callosobruchus maculatus,* odpowiednio na przechowywanym ziarnie kukurydzy i wspięgi pospolitej. Proszki z liści, kory pierwotnej i korzeni dodawano do 100 g ziarna w celu określenia toksyczności kontaktowej, uszkodzeń, wytwarzania potomstwa oraz kiełkowania ziarna. Uzyskane wyniki wskazywały na toksyczność materiałów roślinnych dla dwóch gatunków owadów i wywoływały śmiertelność *S. zeamais* i *C. maculatus,* wynoszącą odpowiednio 30 i 75%. Dający się zaobserwować poziom wywołanych szkód był istotnie ($p \leq 0,05$) niższy w traktowanym ziarnie, natomiast wytwarzanie potomstwa przez obydwa gatunki owadów było istotnie ($p \leq 0,05$) zredukowane. Kiełkowanie ziarna obydwu gatunków roślin nie zostało istotnie zmienione przez badane proszki. Przedyskutowano potencjalne wykorzystanie *R. heudelotii* w zwalczaniu szkodników przechowalnianych.