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Full Length Research Paper

Biocidal activity of selected plant powders against *Tribolium castaneum* Herbst in stored groundnut (*Arachis hypogaea* L.)

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The efficacy of powders of plant parts from *Telferia occidentalis* (fluted pumpkin), *Zingiber officinale* (ginger), *Vitex grandifolia* (Vitex) and *Dracaena arborea* (dragon tree) at 5g, 10g, and 15g/500g seeds was tested using Completely Randomized Design (CRD) against the storage pest *Tribolium castaneum* (Herbst) in groundnut in the laboratory. At 28 days after application, mean number of seeds damaged/85 cm^3 scoop at the concentration of 5g powder/500g seeds was 2.00 for *D. arborea* and 3.00 for *V. grandifolia* and were significantly lower ($p \leq 0.05$) than the control (6.67). Phostoxin gave complete control (0.00). Five grammes (5g)/500g of *D. arborea* and *V. grandifolia* were as efficacious as phostoxin in protecting groundnut seeds against damage by *T. castaneum*. No adults were recovered from seeds treated with 10g and 15g of *D. arborea* at 14 days after application of plant powders. Adult recovery (0.33) from seeds treated with *V. grandifolia* was equally poor and significantly lower ($p \leq 0.05$) than the control (16.33). Larval recovery from seeds treated with *V.* grandifolia (0.33) and *D.* arborea (0.67) were significantly lower ($p \leq 0.05$) than the control (10.00). At the end of three months of storage, mean weight loss from original weight of 500 g was 81.77g (16.35%) for untreated seeds, 28.58g (5.72%) for *V. grandifolia* and 28.56g (5.71%) for seeds treated with *D. arborea*. Phostoxin-treated seeds suffered minimal loss (0.76%). *D. arborea* and *V. grandifolia* at 5g/500g of seeds are recommended for post-harvest control of *T. castaneum* in stored groundnut for planting.

Keywords: Plant powders, biocidal activity, *Tribolium castaneum*, groundnut.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a legume grown primarily for its seeds which are eaten raw, salted and roasted, chopped into confectioneries or ground into peanut butter. In storage, groundnut pods/seeds are attacked by several stored products pests including the groundnut borer *Caryedon serratus* (Oliver), the merchant grain beetle *Oryzaephilus mercator* (Fauvel), the khapra beetle *Trogoderma granarium,* the black fungus beetle *Alphitobius spp*., the flat grain beetle *Cryptolestes ferrugineus*, the tropical warehouse moth *Ephestia cautella* (Walker), the Indian meal moth *Plodia interpunctella* (Hübner), the rice moth *Corcyra cephalonica* (Stainton), and the rust-red flour beetle substances some of which are not *Tribolium castaneum* Herbt . It is known that more than 100 species of insects are capable of infesting stored groundnuts (Redlinger and Davis, 1982, Ofuya and Lale, 2001). Of these insect pests of groundnut, *T castaneum* is the first to colonize a new stock. It consumes the endosperm and causes caking, musty smell and loss of grain weight (Davey et al., 1959). It is also known to cause up to an economic damage rate of 34 and 40% respectively of stored millet and wheat flour (Ajayi and Rahman, 2006). Over the years, synthetic chemical pesticides have provided an effective means for pest control. The shortcomings of the use of chemicals which include resistance by insects, adverse effect on non-target species, pollution of the environment including soil, water and air and hazard of residue necessitated the evolution of natural insecticides of plant origin (Deedat, 1994). Plants are composed of chemical directly beneficial for the growth

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and development of the plant. Rather, they are part of the plant's defense against plant-feeding insects and other herbivores (Rosenthal and Janzen, 1979). Plant materials that have been reported to be efficacious against insect pests include powders from the seed of neem (*Azadirachta indica* A. Juss) (Ivbijaro, 1983) and neem leaf extracts (Epidi *et al*. 2005), leaf powders of the Dragon tree (*Dracaena arborea*) and *Vitex grandifolia* (Epidi et al. 2008), and methanol leaf extracts of *Vitex negundo*, *V. trifolia, V. peduncularis and V. altissima* (Kannathasan et. al., 2007). Others are vegetable oils from groundnut, palm kernel, coconut (Hall and Harman, 1991; Lale, 1995), rhizomes of ginger (Vijayalakshmi et al., 1997), leaf extracts of *Teprosia vogelii* (Mallaya, 1985), oil from fresh garlic (Ho *et al*., 1997), leaves and seeds of *Ocimum basilium* (Grainge and Ahmed, 1988) and leaves of *Dracaena arborea* (Boeke *et al*., 2004).

The rainforest is known to have a wide array of plant species with great insecticidal potentials yet to be discovered. Furthermore, different insects react in varying ways to different plant products. In this study, powders from four plant species viz Ginger (*Zingiber officinale*), Dragon tree (*Dracaena arborea*), Pumpkin (*Telferia occi-denttalis*), and *Vitex grandifolia* were evaluated for their efficacy against *T. castaneum.* While *Z. officinale* and *Dracaena arborea* have been tested against some insects but *T. castaneum*, the other two plant species are being tested for the first time against an insect species. *T. occidentalis* was included in this work because some locals have reported that its roots are very toxic while *V. grandifolia* was chosen because the authors observed its leaves were hardly attacked by insects.

The objectives of this research were:

1. To find out the effect of different concentration(s) of powders of *Z. officinale*, *T. occidentalis*, *D. arborea* (dragon tree) and *V. grandifolia* on *T. castaneum*.
2. To evaluate the effects of these plants on the quality of groundnut seeds vis-a-viz weight and deterioration.

MATERIALS AND METHODS

This study was carried out in the Crop Science laboratory of the Rivers State University of Science and Technology, Nkpolu, Port Harcourt (latitude 4.5ºN and longitude 7.01ºE) Nigeria.

Source and preparation of plant materials

Rhizomes of *Z. officinale* were procured from the local markets. Roots of *T. occidentalis* were obtained from the University farm while leaves of *D. arborea* and *V. grandifolia* were procured from the rain forest of the Niger Delta of Nigeria. The leaves and roots were washed thoroughly in tap water, chopped and air-dried under room temperature for 7days. When fully dried, they were separately ground into fine powder. The powders were kept in air tight jars of 1 (one)liter capacity prior to use.

Culturing of insects

Initial stock was obtained from infested groundnut bought from the local market. The adult beetles were introduced into wheat flour to which 5% yeast (Park and Frank, 1984) had been added. They were removed 24hours after introduction. The emerging adults were transferred into another jar such that the F1 adults (which were used for the experiments) were of uniform size and age.

Other materials used for this research were phostoxin (Aluminium phosphide), weighing balance, Petri dishes, wheat flour, yeast, mosquito net and containers with lid.

Experiment 1: The effect of the plant powders on damage of groundnut seeds by *T. castaneum*

The four different powders were evaluated for their ability to protect seeds of groundnut against damage by *T. castaneum.* Three doses (5g, 10g and 15g) of each plant powder were thoroughly mixed with 500g of groundnut in separate 5 liter capacity jars. Fifteen pairs of the adult beetle (15♂, 15♀) were introduced into each of the jars. Phostoxin (2.5×10^{-5}g) was used as a standard and a control jar was included. The open end of each jar was covered with a lid lined with mosquito net to prevent escape of the insects. Since the incubation period of the eggs is 5-12 days (Howe, 1962), at weekly intervals starting from 14 days after introduction of the adults for three weeks, a sample of seeds using an 85cm^3 scoop was taken. Thereafter, the number of damaged seeds (seeds with holes) in each sample was determined. The experiment was a Completely Randomized Design (CRD) replicated thrice.

Experiment 2: Effect of the different plant powders on recovery of adults and larvae of *T. castaneum* 2wks after treatment of groundnut

In a similar but separate experiment, observations were taken on the number of surviving adults at two weeks after treatment. Adults were considered dead if they did not move when touched or tilted.
Experiment 3: Effect of the plant powders on weight of groundnut seeds at 12 weeks after introduction of plant powders

This experiment was also similar to experiment 1 except that the set–up was left for 12 weeks. At the end of 12 weeks, the content of each jar was poured into a 5 mm sieve and mechanically shaken to separate the groundnut seeds from both the insects and the plant powder. The seeds were thereafter weighed. The effect of the plant powders on the weight of groundnut was determined by subtracting the final weight from the original weight of 500 g.

Data analyses

The data obtained were subjected to analysis of variance (ANOVA) according to procedures of Statistical Analysis System (SAS, 1999). Means were separated by Duncan multiple-range test (DMRT).

RESULTS

The effect of the plant powders on damage of groundnut seeds by *T. castaneum*

At 14-21 days after the introduction of plant powders, untreated seeds had more holes than seeds treated with plant powders and phostoxin (Table 1). Mean number of seeds damaged per 85 cm^3 scoop was quite low (0.67-3.33) for *D. arborea* and 1.33 - 4.67 for *V. grandifolia*

Table 1. The effect of the plant powders on mean number of damaged groundnut seeds by *T. castaneum* at 14, 21 and28 days after introduction.

Treatment (g)		14 Days	21 Days	28 Days
		mean ± SEM	mean ± SEM	mean ± SEM
Z. officinale	5	8.33 ± 0.88^{b}	4.00 ± 1.15^{abc}	3.67 ± 0.67^{abc}
	10	8.00 ± 1.15^{b}	4.00 ± 2.31^{abc}	4.33 ± 0.33^{abc}
	15	7.67 ± 0.67^{b}	6.00 ± 1.15^{ab}	4.67 ± 2.03^{abc}
D. arborea	5	3.00 ± 0.58^{de}	1.67 ± 0.67^{c}	2.00 ± 0.00^{cd}
	10	2.33 ±0.33^{def}	1.33 ± 0.33^{c}	3.33 ± 0.33^{bc}
	15	0.67 ± 0.33^{e}	2.67 ± 1.76^{bc}	3.00 ± 0.00^{cd}
V. grandifolia	5	3.33 ± 0.67^{de}	1.67 ± 0.67^{c}	3.00 ± 0.58^{cd}
	10	3.67 ± 0.33^{d}	1.33 ± 1.33^{c}	2.00 ± 1.16^{cd}
	15	4.67 ± 1.67^{cd}	1.00 ± 0.58^{c}	3.00 ± 0.00^{cd}
T. occidentalis	5	7.00 ± 1.00^{bc}	2.00 ± 0.58^{bc}	6.33 ± 1.20^{ab}
	10	7.67 ± 1.45^{b}	1.33 ± 0.33^{c}	3.67 ± 1.86^{abc}
	15	7.00 ± 0.58^{bc}	1.67 ± 0.88^{c}	4.67 ± 0.33^{abc}
Control		11.67 ± 1.45^{a}	7.67 ± 2.60^{a}	6.67 ± 0.88^{a}
Phostoxin (2.5×10^{-5} g)		0.00 ± 0.00^{f}	0.00 ± 0.00^{c}	0.00 ± 0.00^{d}

Means ± SEM with similar super scripts within a column are not significantly different ($p \leq 0.05$).

are in contrast with the control (6.67 - 11.67). Furthermore, *D. arborea* and *V. grandifolia* powders were more efficacious in protecting groundnut seeds against damage than powders of *Z. officinale* and *T. occidentalis*.

Seed damage assessment at 21 days post introduction showed that phostoxin-treated seeds were not damaged. On the other hand, seeds treated with all three doses (5g, 10g and 15g) of *D. arborea* and all doses of *V. grandifolia* were less damaged than those treated with *Z. officinale*.

At 28 days after the introduction of plant powders, untreated seeds did not differ in damage from seeds treated with *Z. officinale* and *T. occidentalis*. *V. grandifolia,* 10g and 15 g of *D. arborea* were as efficacious as phostoxin in protecting the seeds against damage by *T. castaneum* (Table 1).

Effect of the different plant powders on the recovery of adults and larvae of T.castaneum 14 days after treatment of groudnut

At 14 days after the introduction of plant powders, no live adults were recovered from phostoxin-treated seeds. However, more adults were recovered from untreated seeds (16.33) than those that were treated with plant powders (Table 2). Fewer adults were recovered from seeds treated with *D. arborea* and *V. grandifolia* compared to *Z. officinale* and *T. occidentalis.*

With respect to the number of live larvae recovered, no significant differences were found among powders of *D. arborea, V. grandifolia* and phostoxin-treated seeds. Furthermore, results from powders of *Z. officinale, T. occidentalis* and the control did not differ. However, the number of larvae recovered from them was significantly more than the number recovered from *D. arborea*, *V. grandifolia* and phostoxin.

Effect of the plant powders on weight of groundnut seeds at 12weeks after introduction of plant powders

At 12 weeks after introduction of plant powders, there was a significant drop ($p \leq 0.05$) of 81.77g (16.35%) in the weight of untreated seeds from the original weight of 500 g compared to seeds treated with *D. arborea* and *V. grandifolia* whose weight loss was 28.56g (5.71%) and 28.58 g (5.72%) respectively. *Z. officinale* and T. *occidentalis* powders did not differ from the control (Table 3). Phostoxin-treated seeds suffered minimal weight loss of 3.81 g (0.76%).

DISCUSSION

The significantly fewer number of holes found on groundnut seeds treated with ground leaves of *D. arborea* and *V. grandifolia* compared to untreated groundnut is an indication that these two plants can serve as a protectants against *T. castaneum*. It is possible that the plant factors conferring protection on the seeds against *T. castaneum* may have repellent, antifeedant and toxic properties. If repellent and antifeedant, the larvae would not be inclined to bore into the seeds to feed. If toxic, the larvae may not do more than scarify the seeds before dying. If death does not occur immediately, the factor(s) may have a debilitating effect on the larvae, and their lifecycle may be unusually prolonged. Whatever is the case, the resul-

Table 2. Effect of different plant powders on number of adults and larvae of *T. castaneum* at 14 days after treatment of groundnut.

Treatment (g)		Mean no. of adults / scoop	Mean no. of larvae/ scoop
Z. officinale	5	3.00 ± 0.58^{d}	5.00 ± 0.58^{cd}
	10	2.00 ± 0.00^{def}	4.00 ± 0.58^{d}
	15	2.67 ± 0.67^{de}	4.33 ± 0.33^{cd}
D. arborea	5	1.33 ± 0.33^{efg}	0.67 ± 0.33^{e}
	10	0.00 ± 0.00^{g}	0.00 ± 0.00^{e}
	15	0.00 ± 0.00^{g}	0.00 ± 0.00^{e}
V. grandifolia	5	0.33 ± 0.33^{fg}	0.33 ± 0.33^{e}
	10	0.66 ± 0.66^{fg}	0.00 ± 0.00^{e}
	15	0.33 ± 0.33^{fg}	0.00 ± 0.00^{e}
T. occidentalis	5	8.00 ± 0.58^{c}	8.67 ± 0.33^{a}
	10	11.33 ± 1.20^{b}	7.00 ± 1.15^{b}
	15	8.33 ± 0.33^{c}	5.67 ± 0.66^{ab}
Control Phostoxin		16.33 ± 0.67^{a}	10.00 ± 1.00^{a}
(2.5×10^{-5} g)		0.00 ± 0.00^{g}	0.00 ± 0.000^{e}

Means ± SEM with similar super scripts within a column are not significantly different ($p \leq 0.05$).

Table 3. Effect of the plant powders on weight of groundnut seeds at 12weeks after introduction of plant powders.

Treatments (g)		Weight Groundnut (g)
		Mean ± SEM
Z. officinale	5	413.71 ± 19.02^{def}
	10	429.56 ± 7.08^{def}
	15	398.52 ± 17.80^{f}
D. arborea	5	471.44 ± 7.48^{abc}
	10	472.68 ± 2.41^{abc}
	15	473.78 ± 6.86^{abc}
V. grandifolia	5	471.42 ± 7.48^{abc}
	10	476.44 ± 6.02^{ab}
	15	480.49 ±6.02^{a}
T. occidentalis	5	404.55 ± 19.89^{ef}
	10	439.04 ± 11.20^{cde}
	15	442.74 ± 8.62^{bcd}
Control Phostoxin		418.33 ± 8.06^{def}
(2.5×10^{-5} g)		496.19 ± 2.02^{a}

Means ± SEM with similar super scripts within a column are not significantly different ($p \leq 0.05$).

tant effect is fewer number of holes and/or scarifications on the seeds. Boeke *et al.*(2004) reported that *D. arborea* was repellent to *Callosobruchus maculatus* while Epidi et al. (2008) noted that it was toxic to both *C. maculatus* and *Sitophillus zeamais* . Methanol extracts of related species of *V. grandifolia* viz *V.* negundo, *V. trifolia*, *V. peduncularis* and *V. altissima* have been shown to possess varying levels of toxicity against the larvae of a mosquito, *Culex quinquefasciatus* (Kannathasan et al., 2007).

The number of live adults and larvae recovered would further demonstrate the efficacy of the different plant powders. Fewer adults and larvae of *T. castaneum* were recovered from *D. arborea* and *V. grandifolia* treated lots compared to other plant powders. Further, the num-ber of adults and larvae recovered from the control was much higher than that from the ground leaf powders indicating that the plant materials did not support normal growth and development, and caused mortality of *T. castaneum*. These further show that these plants have great potential in protecting stored grains against *T. castaneum*.

T. castaneum inflicts serious damage on groundnut kernels, feeding on the embryo and endosperm (Davey et al., 1959). The efficacy of the plant powders as grain protectants against *T. castaneum* was clearly demonstrated by the significant reduction in weight of the untreated groundnut seeds compared with the treated ones. *D. arborea* and *V. grandifolia* possibly through a combination of repellency, feeding deterrence and toxicity limited feeding by *T. castaneum* hence recording the least weight loss.

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