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Research Article

Effect of Plants Powdered Extracts against Lesser Grain Borer (*Rhyzopertha dominica*) Infestation of Stored Wheat

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Abstract

Background and Objective: Insect pests such as *Rhyzopertha dominica* have become a euphemism to wheat farmers and traders in Africa in general and Nigeria in particular due to the heavy loss they impart onto the stored wheat grains. This study was carried out to investigate the toxicity of powdered extracts obtained from three different species of plants: *Tephrosia vogelii*, *Hyptis suaveolens* and *Alstonia boonei* in protecting stored wheat grains from (*Rhyzopertha dominica*) infestation. **Materials and Methods:** Five different powdered doses were made from the leaves of the test plants with 0.0 g/20 g as the control (ethanol). The powdered doses were applied onto wheat grains and the test insect introduced. The experiment was laid in a Completely Randomized Design (CRD) with three replications. Data were collected from adult mortality, a number of eggs laid, larval development and grain damage. The data were subjected to analysis of variance at a 5% probability level with Duncan's Multiple Range Test (DMRT) used to separate the significant means. **Results:** Significant difference ($p \leq 0.05$) was found in the degree of toxicity imparted by various doses of the extracts on to the test insect. The high rate of mortality, reduced number of laid eggs and percentage of the emerged insects from the laid eggs were found among the treatments with respect to the control. The toxicity of the extracts increased with an increase in dose. **Conclusion:** It was concluded that 8.0/20 g of the powdered extracts were more toxic to the test insect. It was recommended that 8.0 g/20 g of *T. vogelii* be used in the control of *R. dominica*.

Key words: Dose, Duncan's multiple range test infestation, powdered extracts, *Rhyzopertha dominica*, wheat, mortality

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Wheat (*Triticum aestivum*) is a monocotyledonous plant of the family Poaceae¹. It is the world's most important staple food for humans in relation to production and consumption². Wheat is grown on more land area than any other commercial crop. World trade in wheat is higher than all other crops combined³. It is the most proteinous grain consumed in developing countries to combat malnutrition in young children, especially in Nigeria². However, despite its relative importance in curbing malnutrition and hunger in Nigeria and the world at large, it is attacked by various insect pests between harvest and storage. Stored product pests represent the most important group of pests⁴. The most economically important insect pest of stored wheat is the lesser grain borer *Rhizopertha dominica*^{2,5,6}. The *R. dominica* is a field-to-store pest and this may cause economic damage in the store⁵.

Rhizopertha dominica (Fabricius, 1792) (Coleoptera: Bostrichidae) is one of the most injurious pests of stored grains both in larval and adult stage^{7,8}. The adults are sturdy fliers, which fly from warehouse to warehouse, causing severe infestation and convert the stored grains to mere frass thereby imparting significant economic losses in terms of grain mass and nutrient depletion and pose a public health risk from contamination by allergens such as uric acid⁹⁻¹¹. The major strategy employed in its management and control in Nigeria is the application of synthetic chemicals that possessed several problems. These include conferring resistance to the insect pest, pest resurgence and lethal effects on non-target organisms in addition to direct toxicity to users and impart health hazards coupled with environmental contamination and expensive¹²⁻¹⁸. The use of botanical insecticides is seen as an alternative method for insect pests control and management¹⁹⁻²³. Unlike synthetic insecticides, which mostly kill insects, plant ingredients are known to suppress the feeding and breeding behavior of insects in many ways in addition to direct mortality²⁴. The use of plant parts with insecticidal properties has been reported from all over the world as they are convenient, less expensive, highly effective and safer for humans and environment²⁵⁻³¹. This study therefore aimed at investigating the toxicity of three plants leaves powdered extracts against *R. dominica* infestation of stored wheat grains.

MATERIALS AND METHODS

Study area: The research was conducted at the Entomology laboratory of Nigeria Stored Products Research Institute

(NSPRI) Lagos, Nigeria (Latitude 6°30'N, Longitude 3°23'E). The research was conducted for a period of 24 months.

Test plants: Fresh leaves of *Hyptis suaveolens* (Lamiaceae), *Alstonia boonei* (Apocynaceae) and *Tephrosia vogelii* (Fabaceae) were procured from vendors at Oyingbo market in Lagos and identified in the Herbarium of the Department of Botany, University of Lagos, Nigeria.

Source of insects: The larvae and adults of *R. dominica* were derived from a laboratory mass-rearing facility. Insects were supplied with fresh wheat grains and were reared in wood cages according to the technique described by Dabire *et al.*³². Toxicity tests were carried out on 1st, 3rd and 5th instars larvae and adults of *R. dominica*.

$$\text{Toxicity Factor (TF)} = \frac{48 \text{ hrs LC}_{50} \text{ value of the least toxic compound}}{48 \text{ hrs LC}_{50} \text{ value of the more toxic compound}}$$

Preparation of plants powdered extracts: The fresh leaves of the three test plants: *Hyptis suaveolens*, *Alstonia boonei* and *Tephrosia vogelii* were air-dried at room temperature, pounded to a fine powder by pestle and mortar according to the protocols described by Dabire *et al.*³³. The powders were further sieved to pass through 1 mm² meshes as described by lleke and Bulus¹⁶. The powders were packed in plastic containers with tight lids and kept in the dark according to the method described by Udo¹⁴.

Disinfestation of test wheat grains: Wheat grains were obtained from the Bariga market, Lagos. They were identified at the International Institute of Tropical Agriculture (IITA), Ibadan. All damaged seeds and debris were sorted out from the grains after which disinfestations were carried out in an oven at 50°C for six hours to kill all life stages of insects within the grains. The grains were then left respectively for 24 hrs to stabilize at ambient conditions.

Culture of test insects: *R. dominica* (Fab.) were maintained on disinfested wheat grains. Fifty unsexed 7-14 day old adults of *R. dominica* were introduced into 500 g of disinfested wheat grains in 1 L Kilner jars respectively in three replicates in the laboratory. All adult insects were left for seven days to allow for oviposition, after which they were removed. They were then left undisturbed until adults were observed to emerge. At each peak of emergence, the adults were removed and used to set up new cultures. Series of fresh cultures were made from these to ensure regular supply of adult insects of known ages for use in subsequent experiments.

Experimental design: Fifty grams of disinfested wheat grains were measured into each of the six plastic containers. 0.5, 1.0, 2.0, 4.0 and 8.0 g/20 g of *Hyptis suaveolens*, *Alstonia boonei* and *Tephrosia vogelii* were applied on the grains and manually agitated. The controls were treated with ethanol. Thirty unsexed insects were released into each plastic container as well as that of the control. The experiment is arranged in a Completely Randomized Design with three replications. The containers were kept in the laboratory. Monthly readings were taken for six months in which 20g of the treated and untreated wheat were taken from each container and assessed for insect damage according to Odeyemi and Ashamo³⁴.

Insect damage in grains: Monthly insect damage in each treatment and control was determined from 100 g batches of grains in each jute bag as described by another study³⁴:

$$\text{Percentage weight loss} = \frac{(W_u \times N_d) - (W_d \times N_u)}{W_u (N_d + N_u)} \times 100$$

Where:

W_u : Weight of undamaged grains

N_u : Number of undamaged grains

W_d : Weight of damaged grains

N_d : Number of damaged grains

Data analysis: The data obtained were analyzed using Analysis of Variance (ANOVA) using SPSS (11.0 versions) with Duncan's Multiple Range Test used to compare the significant means.

RESULTS

The result obtained for the toxicity of the powdered extracts on *R. dominica* is presented in Table 1. The result showed that powdered extracts from *Tephrosia vogelii* are

the most toxic to *R. dominica* with LC₅₀ value of 9.58 at 48 hrs of exposure. While *Alstonia boonei* powdered extracts are the least toxic with LC₅₀ of 23.47 at 48 hrs of exposure.

The result for the percentage mortality of *R. dominica* due to exposure to different powdered extracts from the three test plants is shown in Table 2. The result indicated that, 8.0 g/20 g of the powdered extracts obtained from *T. vogelii*, *H. suaveolens* and *A. boonei* induced highest percentage mortality of 77.3, 64.7 and 58.15%, respectively. The percentage of mortality increases with an increase in concentration.

The result for the percentage inhibition of oviposition and progenies development induced by various concentrations of the test plants is presented in Table 3. The result showed that 18 eggs were laid under 8.0 mg L⁻¹ of *Tephrosia vogelii* powdered extracts out of which only 28.55% emerged as adults. Similarly, the least number of eggs laid and the percentage adult emergence were found under 8.0 g/20 g of the remaining test plant extracts. The number of eggs laid and the percentage of adult emergence decrease with an increase in concentrations.

However, the result for the average mean percentage of damage induced by *R. dominica* on the treated wheat grains is shown in Table 4. The result revealed that the mean percentage damage of the test insect on wheat grains treated with various doses of *T. vogelii* extracts for a period of six months reduced from 4.17% to as low as 0.35% with an increase in dose. These values are significantly lower than that of the control (9.12%). More so, the grains treated with *H. suaveolens* extracts reduced the infestation rate from 5.06% to as low as 1.02% with an increase in dose. A similar result was found in terms of the grains treated with *A. boonei* extracts (the infestation rate reduced from 5.49 to 1.29%) with an increase in dose. Complete protection of the grains for three months was found in 8.0 g/20 g dose obtained from *T. vogelii* while the remaining extracts give full protection for two months.

Table 1: Relative toxicity of various test plant Powdered extracts on *R. dominica*

Ethanolic extracts	24 hrs LC ₅₀ (g/20 g)	95% CL	TF	48 hrs LC ₅₀	95% CL	TF
<i>Tephrosia vogelii</i>	12.74	-	1.03	9.58	-	1.05
<i>Hyptis suaveolens</i>	16.56	-	1.34	19.48	-	2.14
<i>Alstonia boonei</i>	19.77	13.76-45.51	1.63	23.47	-	2.58

CL: Confidence limit, LC₅₀: Lethal concentration, TF: Toxicity factor, Test of significance: LC₅₀ values with no overlap in 95% confidence limits are significantly different

Table 2: Mortality of *R. dominica* adults due to exposure treated grains with Powdered extracts of test plants

Ethanolic extract	0.0 g/20 g	0.5 g/20 g	1.0 g/20 g	2.0 g/20 g	4.0 g/20 g	8.0 g/20 g
<i>Tephrosia vogelii</i>	0.00 ^{a1}	38.0 ^a	51.5 ^a	62.3 ^a	68.9 ^a	77.3 ^a
<i>Hyptis suaveolens</i>	0.00 ^a	26.5 ^b	37.0 ^b	50.2 ^b	57.7 ^b	64.7 ^b
<i>Alstonia boonei</i>	0.00 ^a	25.0 ^b	31.5 ^c	46.9 ^c	51.2 ^c	58.1 ^c

N.B: ^{a1}Mean values bearing the same superscript(s) down a column are not significantly different (p = 0.05)

Table 3: Oviposition and progeny development of *R. dominica* on wheat grains

Plant extract	Concentration (g /20 g)	Mean number of eggs laid	Mean adult emergence	Mean percent adult emergence (%)
<i>Tephrosia vogelii</i>	0.00	89.73 ^a	83.79 ^a	93.38
	1.0	52.45 ^b	26.08 ^b	49.72
	2.0	40.32 ^c	18.90 ^c	46.88
	4.0	35.11 ^d	13.05 ^d	37.17
	8.0	18.25 ^e	5.210 ^e	28.55
<i>Hyptis suaveolens</i>	0.00	87.98 ^a	82.25 ^a	93.49
	1.0	59.02 ^b	35.20 ^b	59.64
	2.0	48.97 ^c	28.30 ^c	57.79
	4.0	40.37 ^d	21.20 ^d	52.51
	8.0	25.13 ^e	10.70 ^e	42.58
<i>Alstonia boonei</i>	0.00	87.25 ^a	81.06 ^a	92.91
	1.0	60.28 ^b	43.12 ^b	71.53
	2.0	55.14 ^c	35.20 ^c	63.84
	4.0	46.00 ^d	24.10 ^d	52.39
	8.0	32.15 ^e	14.80 ^e	46.03

*1Means bearing the same superscripts down a column are not significantly different (p = 0.05)

Table 4: Percentage mean damage by *R. dominica* on treated wheat grains

Extract	0.0 g/20 g	0.5 g/20 g	1.0 g/20 g	2.0 g/20 g	4.0 g/20 g	8.0 g/20 g
<i>T. vogelii</i>						
1st Month	1.69	0.00	0.00	0.00	0.00	0.00
2nd Month	4.54	0.00	0.00	0.00	0.00	0.00
3rd Month	6.23	2.15	0.76	0.27	0.04	0.00
4th Month	10.16	3.68	1.44	0.98	0.26	0.08
5th Month	13.25	6.92	3.91	2.83	1.89	0.95
6th Month	18.84	12.27	9.85	5.94	3.64	1.04
Mean	9.12	4.17	2.66	1.67	0.97	0.35
<i>H. suaveolens</i>						
1st Month	1.71	0.00	0.00	0.00	0.00	0.00
2nd Month	4.21	0.00	0.00	0.00	0.00	0.00
3rd Month	6.40	2.79	1.24	1.10	0.94	0.56
4th Month	9.98	5.28	3.56	1.78	1.05	0.82
5th Month	13.82	8.04	6.93	3.51	2.52	1.96
6th Month	19.65	14.26	11.07	7.95	5.33	2.79
Mean	9.29	5.06	3.80	2.39	1.64	1.02
<i>A. boonei</i>						
1st Month	1.68	0.00	0.00	0.00	0.00	0.00
2nd Month	4.61	0.00	0.00	0.00	0.00	0.00
3rd Month	6.29	2.68	2.38	1.37	1.13	0.87
4th Month	10.20	6.03	5.01	2.86	2.41	1.03
5th Month	12.99	8.59	6.96	4.92	3.11	2.69
6th Month	18.74	15.68	13.31	9.05	7.89	3.14
Mean	9.09	5.49	4.61	3.03	2.42	1.29

DISCUSSION

In view of the excellent possibilities to use plant extracts against *R. dominica* infestation of stored wheat grains, the three plant powdered extracts were found to be essential as they conferred certain degrees of toxicity to the test insect. *T. vogelii* extracts prevent more than 50% of the eggs laid to emerge. This finding is in agreement with that of Ogendo *et al.*³⁵ who reported toxicity of *Tephrosia vogelii* on *S. oryzae* inducing more than 50% insect mortality. More so, Babarinde *et al.*³⁶ and Odewole³⁷ individually reported that extracts of *T. vogelii* exhibited strong insecticidal activity

against several insect pests of crops. Similarly, Koon and Dorn³⁸ reported powdered hexane extracts of dried leaves of *T. vogelii* effective protectants of stored legume seeds against bruchids infestation and reduced the damage caused by *Callosobruchus maculatus*, *C. chinensis* and *Acanthoscelides obtectus* on the treated seeds by 7.1% compared with 99.8% recorded on grains in the control experiment. These findings, therefore, proved the assertion made by Belmain *et al.*³⁹ that, plant extracts have potentials against insect pests infestation of stored products. Similarly, Ileke and Bulus¹⁶ reported toxicity of powders and extracts of *Azadirachta indica* and *Piper guineense* seeds to *R. dominica*. Thus, botanicals extracts

have been reported by Amuji *et al.*⁴⁰ to exhibit an appreciable magnitude of toxicity to insects inducing mortality.

The toxicity of the three plant extracts revealed by this study has therefore confirmed the previous findings of Oumarou *et al.*⁴¹ who reported the bioefficacy of *Hyptis suaveolens* extracts on *Anopheles gambiae*, Ileke and Emmanuel⁴² reported high bioefficacy of *Alstonia boonei* leaf extract against cowpea beetle (*Callosobrochus maculatus*) infestation of stored cowpea seeds. Similarly, Emeasor and Ndumele⁴³ reported the insecticidal potency of aqueous extract of *Tephrosia vogelii* in the control of insect pests of cucumber (*Cucumis sativus* L.). The toxicity of these plants powdered extracts can probably be attributed to the various chemical constituents present in the extracts as stressed by Mbailao *et al.*⁴⁴ and Ileke and Oni¹³.

The effect of the three test plants extracts in suppressing progeny development and oviposition of *R. dominica* can be attributed to the toxicity and lethality conferred by the extracts on the oviposition thereby interfering with the physiological process of developing eggs. This finding conforms with that of Osawe *et al.*⁴⁵ who reported extracts of *A. boonei* leaves adversely affected the survival and growth of *Sesamia calamistis*. Similarly, Meena *et al.*⁴⁶ reported suppression of progeny development of rice moth (*Corcyra cephalonica*) by plant extracts. The growth inhibition may result from toxicity or feeding deterrent properties of the plant as reported by several authors such as Akhtar and Isman⁴⁷, Hikal *et al.*⁴⁸ and Suleiman *et al.*⁴⁹ who individually reported insecticidal efficacy of some plant extracts in suppressing progeny development of stored insect pests.

The protection capacity of the three plants powdered extracts is in agreement with the work of Abdullahi *et al.*⁵⁰ who reported the protection ability of lime in reducing the grain damage caused by storage pests. Negbenebor and Nura⁵¹ reported that ethanolic extracts obtained from the leaves of *Hyptis suaveolens*, *Alstonia boonei* and *Tephrosia vogelii* protected stored cowpea seed from damage by cowpea weevil when stored in airtight plastic containers without affecting the seed viability. A similar finding is reported by Ilyasu and Gabriella⁵². The toxicity of the three plant extracts on the test organism is an indication of the relative importance of the powdered extracts in preventing the wheat grains from damage by *R. dominica* infestation. This may increase the longevity of the seeds and their market qualities without disrupting the nutritional qualities. This finding, therefore, adds to the existing data on the efficacy of plant extracts as biopesticides of stored food. Thus, the findings from this study implied that powdered extracts obtained from leaves of *H. suaveolens*, *A. boonei* and *T. vogelii* possessed

potential insecticidal properties against lesser grain borer and as such control the insect's infestation of stored wheat. However, higher doses of the powdered extracts were recommended for use against lesser grain borer.

CONCLUSION

It was concluded that powdered extracts from the leaves of *H. suaveolens*, *A. boonei* and *T. vogelii* have high toxicity to *R. dominica* thereby protecting wheat grains from its infestation to as long as three to six months. The effect of the extracts is dose-dependent, increases with an increase in dose. Thus, 8.0/20 g of the powdered extracts of *T. vogelii* is highly recommended for biological control of *R. dominica* in stored wheat grains.

SIGNIFICANCE STATEMENT

This study discovered that powdered extracts obtained from the three test plants are effective in protecting wheat grains from *Rhizopertha dominica* infestation. As such, the extracts can be beneficial in the biological control of the pest using natural insecticides. It adds to the existing list of plants with insecticidal potency. This study will also help the researchers to uncover the critical areas of using bio-pesticides that many researchers were not able to explore. Thus a new theory on the effects of natural botanical pesticides in the biological control of insect pests of stored products may be arrived at.

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