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Research Article

Evaluation of Toxicity of Some Plant Materials Against the Bruchid (*Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) on Mung Bean (*Vigna radiata* (L.) Wilczek) Seeds in Storage

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Abstract

A laboratory study was conducted in the laboratory of the Department of Plant Health Management of Michael Okpara University of Agriculture Umudike, to determine the toxicity of powders of *Piper guineense* fruits, *Dennittia tripetala* fruits *Allium sativum* bulbs, *Zingiber officinale* rhizomes against the cowpea seed bruchid *Callosobruchus maculatus* (F.) (Coleoptera : Chrysomelidae) on stored mung bean (*Vigna radiata* (L.)Wilczek) seeds. The experimental design was a 4 x 5 factorial fitted into Completely Randomized Design (CRD) with three replications. The rates for the different powders were 0.0, 0.5,1.0,1.5, 2.0g admixed with 20 g of mung bean seeds placed in plastic containers. The effect of the treatments were assessed on insect mortality at 48 and 96 hours, oviposition 7 days post treatment, adult emergence on 28 days after infestation, and seed viability test at the expiration of the experiment (42 days post treatment). The results showed that plant powders were effective in controlling insect infestation by recording significantly higher mortality, reduction in the number of eggs laid, and suppression of the development and emergence of adult progenies from the treated mung bean seeds compared with the control. *Piper guineense* provided the best protection for stored mung bean at 2.0 g/20 g compared with the other treatments, followed by *Allium sativum. Dennittia tripetala* and *Zingiber officinale* were almost the same in their performance. Plant materials did not affect the viability of the seeds. The results obtained suggest that the plant materials possess insecticidal properties and can be utilized in protecting stored mung bean from *C. maculatus* infestation since they are environmental friendly, cheaper than synthetic insecticides and safer for humans.

Keywords: Mung Bean; *Callosobruchus maculatus*; Storage Insect Pests; Biopesticides; Toxicity

Introduction

Mung bean (*Vigna radiata* (L.) Wilczek) is one of the most important short season, summer growing legumes grown widely throughout the tropics and subtropics [1]. Mung bean cultivars [2] were a potential source of essential fatty acids, antioxidants, minerals and proteins. The seeds and sprouts are excellent examples of functional foods that lower the risk of various diseases [3]. The seeds and sprouts have health promoting effects in addition to their nutritive value [4]. Today there is an increasing interest in western countries in the sprouting of seeds as consumers demand minimally processed, additive-free, more natural, nutritional and healthy foods. The seeds may be milled or ground into flour for making noodles, breads and soups. In rural areas, the immature green pods are also used as vegetable. Mung bean stalks, leaves and husks constitute a significant proportion of livestock feed. After picking of the pods, the whole plant may be ploughed in the soil to improve fertility. Like other legumes, mung bean is attacked by field to stored insect pests. Insect pest can significantly reduce mung bean profitability, reducing both yield and seed quality.

In order to ensure food security for the citizenry, surplus grains are properly preserved in storage. Stored grains in addition to serving as a source of domestic food supply throughout the year, serve a as means to generate revenue for the farming families. Grains are however very susceptible to infestation by insect pests belonging to two main orders, Coleoptera (beetle) and Lepidoptera (moth), micro-organisms and to rodent pests in storage. Insects are the most important among storage pests because apart from their direct damage, they create conditions that allow secondary infection by rot organisms mainly fungi [5]. Once infection is established insect pests cause gradual and progressive damage leading to losses in weight, nutritional, organoleptic and aesthetic quality of stored grains. The most important insect pest of mung bean during storage is the cowpea bruchid (*Callosobruchus maculatus* (F.).

Most efforts directed at protecting grains during storage in time past were concentrated on the use of synthetic insecticides. However, apart from their prohibitively high costs and non availability to the peasant farmers, they have other limitations including their residual effects on the stored grains, persistence, pest resistance and deleterious effects on non-target organisms [6]. These limitations necessitate the continuous search for new insecticides with novel mechanisms of action. In this regard, many scientist are screening natural products, particularly of edible plant species as sources of degradable insecticides safer to man and the environment, and more easily and cheaply produced as crude or partially purified extracts [7].

The objective of this work was to evaluate the effectiveness of powders of plant materials (*Piper guineense* fruits, *Dennittia tripetala* fruits, *Allium sativum* bulbs, *Zingiber officinale* rhizomes) in reducing the number of eggs and decreasing the development and emergence of adult progenies of bruchid beetle *C. maculatus* from the treated mung bean seeds.

Materials and Methods

Insect culture

The insects used to establish a laboratory colony of C.maculatus came from a batch of infested cowpea purchased at Umuahia main market, Abia State. Beetles were reared subsequently with fresh uninfested mung bean seeds in plastic containers covered with muslin cloth to allow air circulation and held tightly with rubber band. Insect rearing and the experiment were carried out at an ambient temperature of 28 ± 2^{0}C and relative humidity of 75 ± 5%. One – two (1-2) day old adult bruchids were obtained by sifting the stock culture a day before the experiment.

Collection of uninfested mung bean grains and plant materials

Clean mung bean seeds were obtained from College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike, Abia State. The fruits, bulbs, and rhizomes of the plant materials were sourced from the Umuahia main market. These plant materials were evaluated for insecticidal activity against Callosobruchus maculatus.

The list of Plant materials used are given in Table 1.

Scientific name	Common name	Family	Part used
Piper guineense	Guinea pepper	Piperaceae	Fruits
Dennettia tripetala	Pepper fruit	Annonaceae	Fruits
Allium sativum	Garlic	Liliaceae	Bulbs
Zingiber officinale	Ginger	Zingiberaceae	Rhizomes

Table 1: List of plant materials used for the study.

Preparation and application of plant materials

The dried plant materials were seperately pulverized using a HP kitchen hammer mill (model KOAHLBACH). The powders were sieved particle size of 300 μm with a British laboratory test standard sieve (serial number 133032) and kept in air tight plastic containers prior to use [8]. Each of the powders were weighed 0.5,1.0, 1.5 and 2.0 g into plastic containers contianing 20 g of uninfected mung bean seeds and thoroughly mixed by manual agitation. A control experiment containing no plant power was also set up. Each treatment was replicated three times in a Completely Randomized Design (CRD).

Four freshly emerged adults of (1-2 day old) were introduced into the plastic containers and covered with muslin cloth held tightly by the perforated cover and rubber bands. Mortality counts of the bruchids were carried out at 48, and 96 hours by sieving out and counting all dead beetles in each container. Oviposition counts were done after 7 days by pouring out seeds in each container and counting the number of eggs laid. Adult emergence was recorded till 14 days after the first emergence. For viability test, 10 seeds were randomly selected from each container, moistened and put in petri dishes lined with filter paper and left for 7 days.

Statistical analysis

Data obtained were subjected to analysis of variance procedure and significant means were separated using Fishers' Protected Least Significant Difference at 5% level of probability.

Results

The mean percentage mortality of *C.maculatus* treated with powders of *P.guineense* fruits, *D.tripetala* fruits, *A.sativum* bulbs and *Z.officinale* rhizomes on stored mung bean seeds are shown on (Table 2) 48 hours after infestation. All the plant powders exhibited varying degrees of insecticidal activiteis killing *C. maculatus* more than the control (P<0.05). *P. guineense* caused the highest mortality of 20.0% followed by *A. sativum* with 15.0%. The least mean percentage mortality was recorded by *D. tripetala* and *Z. officinale* with 13.30% respectively.

Percentage mortality of adult *C. maculatus* exposed to plant powder 96 hours after infestation is shown in (Table 3). *P. guineense* caused the highest mortality 56.70% followed by *A. sativum* 50.00%, *D. tripetala* 45.00% and *Z. officinale* 43.30%. The mortality effect of *P. guineense* was significantly (P<0.05) higher than *D. tripetala* and *Z. officinale* but significantly the same with *A. sativum.* The mean dosage effect on mortality of *C. maculatus* adults 96 hours after infestation shows that 2 g/20 g mung bean seeds treatment had the highest mortality effect of 66.70%.

Treatment (plant extracts)	Dosages	g/20g mung bean seeds				
	0.0	0.5	1.0	1.5	2.0	Mean
Piper guineense	0.00	25.00	25.00	25.00	25.00	20.00
Dennettia tripetala	0.00	8.30	16.70	16.70	25.00	13.30
Zingiber pjacinale	0.00	8.30	16.70	16.70	25.00	13.30
Allium sativum	0.00	16.70	16.70	16.70	25.00	15.00
Mean	0.00	14.60	18.80	18.80	25.00	

LSD (0.05) Plant powders = 7.32 (P = 0.225) ns

LSD (0.05) Dosages (Concentrations) = 8.19 (<0.001) **

LSD (0.05) Plant powders x Dosages = 16.37 (P = 0.966) ns

Table 2: Mean percentage mortality of adult C. *maculatus* exposed to selected plant powder 48 hours post treatment

Treatment (plant extracts)	Dosages	g/20 g mung bean seeds				
	0.0	0.5	1.0	1.5	2.0	Mean
Piper guineense	0.00	58.30	66.70	75.00	83.30	56.70
Dennettia tripetala	0.00	50.00	58.30	58.30	58.30	45.00
Zingiber officinale	0.00	41.70	58.30	58.30	58.30	43.30
Allium sativum	0.00	50.00	66.70	66.70	66.70	50.00
Mean	0.00	50.00	62.59	64.60	66.70	

LSD (0.05) Plant powders = 6.68.32 (P = 0.001)**

LSD (0.05) Dosages (Concentrations) = 7.47 (<0.001) **

LSD (0.05) Plant powders x Dosages = 14.94 (P = 0.601) ns

Table 3: Mean percentage mortality of adult C. *maculatus* exposed to selected plant powder 96 hours post treatment.

The effect of treating mung bean seeds with plant powders on oviposition by *C. maculatus* is shown in (Table 4). There was reduction in oviposition in all the treated samples compared with the control. *P. guineense* had the best protectant action among the plant powders with mean oviposition count of 58.33%, which was significantly different from other powders. *Z. officinale* had the least protectant action with the highest mean oviposition count of 66.80%.

Adult emergence count of *C. maculatus* from mung bean seeds treated with plant powders is shown in (Table 5). Adult bruchid emergence was significantly suppressed by all the plant powders (P<0.05) when compared with the control. *Piper guineense* had the highest suppression effect, with mean count of 36.00 which was statistically different from other plant powders.

Treatment (plant extracts)	Dosages	g/20 g mung bean seeds				
	0.0	0.5	1.0	1.5	2.0	Mean
Piper guineense	88.33	64.00	57.67	47.00	41.67	58.33
Dennettia tripetala	87.67	67.00	64.00	56.33	43.00	63.60
Zingiber officinale	87.67	71.67	63.00	59.67	52.00	66.80
Allium sativum	88.33	68.67	61.00	52.67	45.00	63.13
Mean	88.00	67.83	59.92	53.92	45.42	

LSD (0.05) Plant powders = 3.82 (P = 0.001) **

LSD (0.05) Dosages (Concentrations) = 4.21 (<0.001) **

LSD (0.05) Plant powders x Dosages = 8.54 (P = 0.485) ns

Table 4: The effect of treating mung bean seeds with selected plant powders on oviposition by *C. maculatus.*

Treatment (plant extracts)	Dosages	g/20 g mung bean seeds				
	0.0	0.5	1.0	1.5	2.0	Mean
Piper guineense	73.33	43.33	30.67	20.00	12.67	36.00
Dennettia tripetala	73.33	51.33	41.00	30.00	20.00	43.13
Zingiber officinale	71.33	50.67	41.00	33.67	26.33	44.60
Allium sativum	76.00	49.00	39.00	29.33	21.00	42.87
Mean	73.50	48.58	37.92	28.25	20.00	

LSD (0.05) Plant powders = 3.32 (P = 0.001) **

LSD (0.05) Dosages (Concentrations) = 3.71 (P<0.001) **

LSD (0.05) Plant powders x Dosages = 7.43 (P = 0.307) ns

Table 5: Adult Emergence count of *C. maculatus* from mung bean seeds treated with selected plant powders.

The mean percentage germination of mung bean seeds treated with plant powders is shown in (Table 6). There was no significant difference among the plant powders on percentage germination of mung bean seeds treated. The dosage 0.5 g/20 g mung bean seeds had the least percentage germination with 30.00% which differed from others.

Discussion

The study shows that the powder extracts had insecticidal activity against *C. maculatus* and can be used for the control of the bruchid on mungbean storage. They conformed with the properties required for controlling insects feeding on internal plant parts

Treatment (plant extracts)	Dosages	g/20 g mung bean seeds				
	0.0	0.5	1.0	1.5	2.0	Mean
Piper guineense	23.33	26.67	36.67	50.00	63.33	40.00
Dennettia tripetala	23.33	30.00	46.67	46.67	56.67	40.67
Zingiber officinale	20.00	33.33	46.67	46.67	53.33	40.67
Allium sativum	23.33	30.00	40.00	50.00	60.00	40.67
Mean		22.50	30.00	42.50	48.33	58.33

LSD (0.05) Plant powders = 3.40 (P = 0.957) ns

LSD (0.05) Dosages (Concentrations) = 3.80 (<0.001) **

LSD (0.05) Plant powders x Dosages = 7.60 (P = 0.051)*

Table 6: Percentage Germination of mung bean seeds treated with selected plant powders.

which include; toxicity to adults, reduction of oviposition, toxicity to immature stages prior to or immediately following penetration of plant tissues [9]. Toxicity on mortality started manifesting 48 hours and progressed to 96 hours after infestation. At 96 hours, mortality progressively expressed above 70%. *P. quineense* significantly differ from other powder extracts.The results showed that the plant powders were effective in reducing insect infestation by recording significantly higher mortality when compared with the control. *P. guineense* fruit provided the best protection for stored mung bean by exhibiting an increased mortality 56.70% compared with the other treatments at 96 hours after infestation. *A.sativum* bulb powder ranked second with 50.00% mortality. The result obtained revealed that there was no significant difference in the percentage mortality of *D.tripetala* fruits and *Z.officinale* rhizomes powder. Similarly the results agree with the report of [10] on the toxicity of various plant materials on *C.maculatus*. The powder extracts deterred oviposition to *C. maculatus* which may have been as a result of the active ingredient in the plant materials. The result was in line with Emeasor., *et al*. [11].

According to researchers, ovipositional preference has been attributed to seed coat morphology and seed size [12]. Evidently, more eggs were laid on seeds that are large, whole, smooth and pristine. There was a significant reduction as dosage increases. The result was in line with [13]. The powder extracts suppressed the adult emergence of the bruchids. It has also been suggested that powder extracts could cause the death of insect pest by the particles blocking the spiracles of the bruchids thereby impairing respiration and causing asphyxiation and death. The suppression of the beetles were dosage dependent. Higher dosages suppressed adult emergence more. The viability of the mung bean seeds were not affected by the plant material powders. There were no significant difference among the plant powders. Seeds not attacked by the beetle germinated normally.

Conclusion

The results showed the insecticidal potentials of the plant materials in protecting stored mung bean seeds from damage by *C. maculatus* without any deleterious effects on viability of seeds. All the plant materials showed varing degrees of insecticidal abilities although *Piper guineense* performed best among the plant materials used. We therefore recommend the use of these plant materials especially *P. guineense* in the control of *Callosobruchus maculatus* in storage as against synthetic insecticides, since it is cheaper, safe, easy to apply, and ecologically friendly.

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