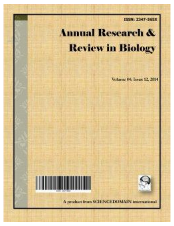

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Managing *Acanthoscelides obtectus* Say on Stored *Phaseolus lunatus* L. with Six Indigenous Botanical Powders

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Authors' contributions

This work was carried out in collaboration between both authors. Author AAJM designed the study, handled the data collection and performed the statistical analysis. Author AIN managed the literature searches and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Telfairia occidentalis, Piper guineensis, *Gmelina arborea*, *Bryophyllum pinnate*, *Amaranthus viridis*, and *Musanga ceropolides* were separately assessed for insecticidal effects on *Acanthoscelides obtectus* Say, a pest of stored *Phaseolus lunatus* L. The plants were assessed in a completely randomized design for aduticidal and reproductive inhibition potential as well as effect on seed weight at three treatment doses (2%, 4%, 6% and 0 as the control). Results showed that at 144 hours post-treatment, *P. guineensis* at 6% dose had the highest significant (P=0.05) mortality (59.5%) of *A. obtectus*. This was followed by *P. guineensis* which had comparable effect 2% (50.9%) and 45 (54.9%). The least significant mortality was observed in control. At 4% and 6% *A. viridis* had similar mortality effect on *A. obtectus* as 6% *G. arborea*, while 2% *A. viridis*, 6% *B. pinnate*, 2% and 4% *G. arborea* had similar effect. The highest number of progeny emerged after

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49 days were observed in control (345.33±8.84) while *P. guineensis* significantly (P=0.05) inhibited progeny followed by 6% *G. arborea* and 6% *M. ceropolides*. *Phaseolus lunatus* seeds treated with 6% *P. guineensis* also had the least significant weight loss while the control had the greatest weight loss of 32.56 g. Though all these test plants significantly (P=0.05) increased adult mortality, reduced progeny emergence and weight loss in seeds than the control. *Piper guineensis* however, exhibited the best insecticidal property. *Piper guineensis* and *G. arborea* were significantly more active in inhibiting *A. obtectus* reproduction and progeny emergence, but increased adult mortality leading to reduction in weight loss.

Keywords: Acanthoscelides obtectus; botanical powders; stored Phaseolus lunatus; mortality.

1. INTRODUCTION

Plants are excellent sources of bioactive chemicals and can act as alternative agents of insect control [1]. Phytochemicals may act as growth regulators larvicides, feeding and oviposition deterrence, repellants or attractants of insects [2].

Farmers in Nigeria often protect their produce from damages caused by insect during storage by applying synthetic insecticides. These chemicals though effective and quick in action providing immediate control measures are expensive and leave long-lasting residues on the produces, non target organisms and the environment (soil and water). These often led to undesirable side effects such as health problems, development of pest resistance and resurgence [3]. There is therefore a renew interest in the application of readily available, cheap and safe plant-based insecticide for crop protection [4,5,6].

Numerous plant-products have been successfully used for insect pest control [7]. Botanical products of *Telfairia occidentalis*, *Gmelia arborea, Piper guineensis*, *Amaranthus viridis*, *Bryophyllum pinnatum* and *Musanga cecropolides* which have been reported to have medicinal and pesticidal properties are readily available and accessible in rural communities of peasant farmers in Nigeria and therefore can be used as crop protectants. In this research, the powders of the aforementioned botanicals were assessed individually for insecticidal activities against *Acanthoscelides obtectus*, a pest of stored *Phaseolus vulgaris*.

Telfairia occidentalis Hook F. belongs to the vegetable family of Cucurbitaceae. The leaves and edible shoots of this plant have been reported to prevent haemolytic anaemia in rats [8], while the aqueous extracts have been reported to have antidiabetes properties [9], and purgative effect on gastrointestinal tract [10]. The aqueous extract has also been reported as a save antidote for cyanide poisoning [11].

Gmelina arborea Roxb (Verbenaceae), a tropical evergreen tree, widely plant in Asia, tropical Africa and America is a plantation and small scale timber crop [12,13]. The timber of *G. arborea* is rarely attacked by wood borers [13]. Aqueous extracts from leaves, fruits and bark of this plant are insecticidal to legume pot-borer and pot-sucking bug [14] and fungi [15].

Piper guineensis Schum. & Thonn (Piperaceae), commonly called guinea pepper or black pepper is a non-timber forest product used traditionally as spice and medicine [16], and exhibits insecticidal properties. Extracts from the root and stem of *P. guineensis* cause reduction in oviposition but increase mortality in many insects [17].

Amaranthus viridis Linn. (Amaranthaceae) commonly known as Queen amaranth or Efo is a member of the family Amaranthaceae. It is eaten as a vegetable in Nigeria and form part of the Ayurvedic medicine in India [18]. The senescent leaves of *A. viridis* have been reported to have insecticidal activities against *Spodoptera exiqua* [19].

Bryophyllum pinnatum Lam (Grassulaceae) is a perennial herb having succulent leaves. The plant is useful in traditional medicine for the management of various ailments especially abscesses and skin diseases. The plant has antifungal, anti-inflammatory, antibacterial and insecticidal properties [20,21].

Phaseolus lunatus Linn. (Fabiaceae - Papilionoideae) is an important legume cultivated for subsistence and commercial purposes in the tropics and subtropical areas of the world [22]. It is highly nutritious, relatively low cost protein food used in the management of diabetics, rheumatism and diarrhea. It is reputed to improve kidney functions as well as have diuretic, depuratic and emollient properties [23]. Many seed beetles infest this important legume during storage hence, decreasing its values [24].

2. MATERIALS AND METHODS

2.1 Location/Site of Experiment

The experiment was conducted at the Department of Plant and Ecological Studies, University of Calabar, Cross River, Nigeria between the year 2015 and 2016. Cross River State is located at 5°45[1]N and 8°30[1] and has an area of 2.156 km^2.

2.2 Collection of Test Plant Materials (Leaves)

M*usanga cecropoides, Telfairia occidentalis, Amaranthus viridis* and *Piper guineensis* were obtained from the local market in Calabar while *Gmelina arborea* was obtained from a plantation in Akamkpa, Cross River State, Nigeria and *Bryophylum pinnatum* from Botanical Garden, University of Calabar, Calabar. The leaves of these plants were put in a sterile perforated bag and taken to the herbarium unit in Department of Plant and Ecological Studies, University of Calabar for authentication.

2.3 Preparation of Plant Powders and *Phaseolus lunatus*

The plant leaves were shade-dried for one-week (7 days). Thereafter separately pulverized with an electric milling machine (Super Master, Model SMB2977, Japan) and sieved through 0.25 mm mesh-clothe to obtain fine homogeneous powders which were stored in separate air-tight containers and used for assessment within two days.

Phaseolus lunatus was purchased from the Watt Market in Calabar Cross River State, Nigeria. Damaged seeds were sorted by hand-picking leaving only healthy seeds (unbroken seeds with no feeding holes). The healthy seeds were kept in deep-freezer at -18°C for 24 hrs to sterilize them. These undamaged-sterile seeds were used for assessment.

2.4 Application of Treatment

The powder of each test plant leaf was assessed at different concentrations of 2%, 4% and 6% with 0% w/w as the control admixed separately with 100 g of *P. lunatus* disinfected seeds in 125 ml plastic containers. Twenty (one-day-old) unsexed, *A. obtectus* adults were introduced into each container and covered with perforated lid to enhance aeration and prevent insects escape. Each treatment had three replicates laid out in a completely randomized design. Adult mortality was assessed at 24, 48, 72, 96, 120 and 144 hours after treatment. Insects were pronounced dead when they did not respond when gently touched with entomological pin.

To assess the first filial generation deterrent efficacy of the plant powders, after mortality test assessment for six days, all insects (dead and alive) were carefully removed and the experimental set-up was kept undisturbed for seven weeks. The number of adult progeny emerging were counted at the fifth, sixth and seventh week. These count data gave the cumulative progeny emergence at the 7^{th} week and the reproduction inhibition potentials of the six botanicals.

At the end of seven weeks, all insects and the frass were removed and the *P. lunatus* was re-weighed.

2.5 Analysis of Data

Data obtained for respective parameters were subjected to one way analysis of variance (ANOVA) to check for significant differences among the various treatments using SPSS version 17.0 software for probability level.

3. RESULTS

At 144 hours after treatment, significant differences (P=0.05) were observed among the plants powders of *M. cecropoides, T. occidentalis, P. guineensis, G. arborea, B. pinnatum, A. viridis* and control on mean mortality of adult *A. obtectus* of stored *P. lunatus*. *P. guineensis* powder at 2, 4 and 6% concentration had the highest significant mortality followed by *A. viridis* and 6% *G. arborea* had comparable effects on mortality. 6% *B. pinnatum*, 2% *A. viridis* and 4% *G. arborea* also had similarly mortality effect. The least significant mortality was however observed in control (Fig. 1a and 1b).

3.1 Progeny Emergence

At seven (7) weeks post-treatment, all the test plants extracts individually showed significant effect on progeny emergence relative to control. The control gave the highest cumulative mean emergence of *A. obtectus* (345.33) which was significantly different (P=0.05) from the progeny emergence in all other treatments. 6% *P. guineensis* had the lowest significant number of progeny emerged, followed by 4% and 2% concentrations. 6% *T. occidentalis* and 6% *M. cecropoides* had comparable effects at 2, 4 and 6% of *B. pinnatum* respectively (Fig. 2).

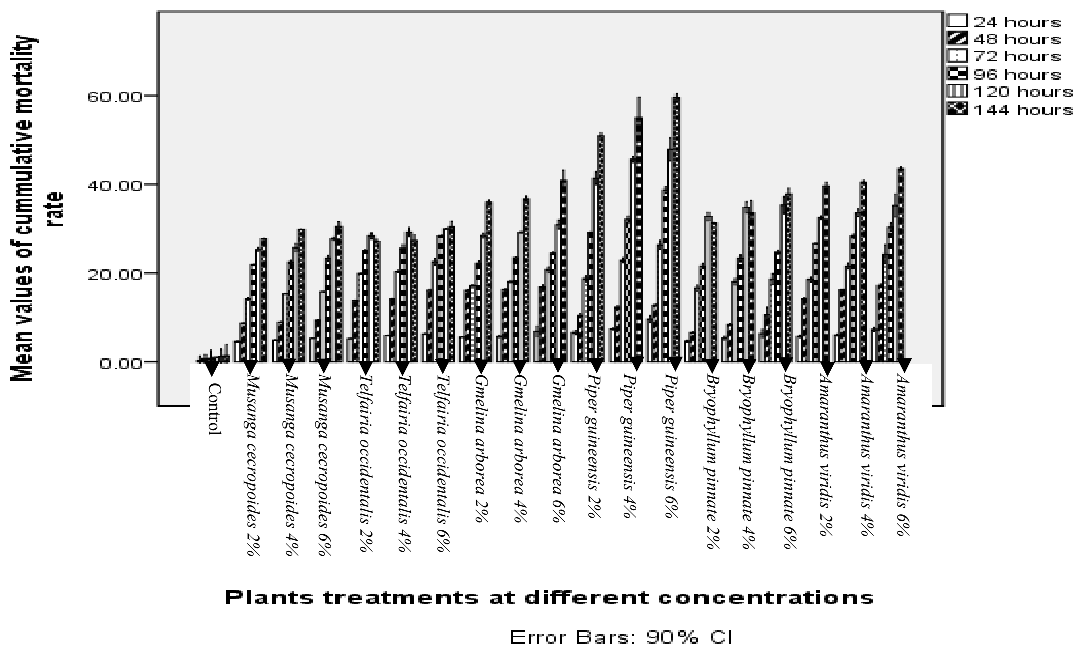

Fig. 1a. Mean mortality rate of *Acanthoscelides obtectus* in different concentrations of the test plant powder

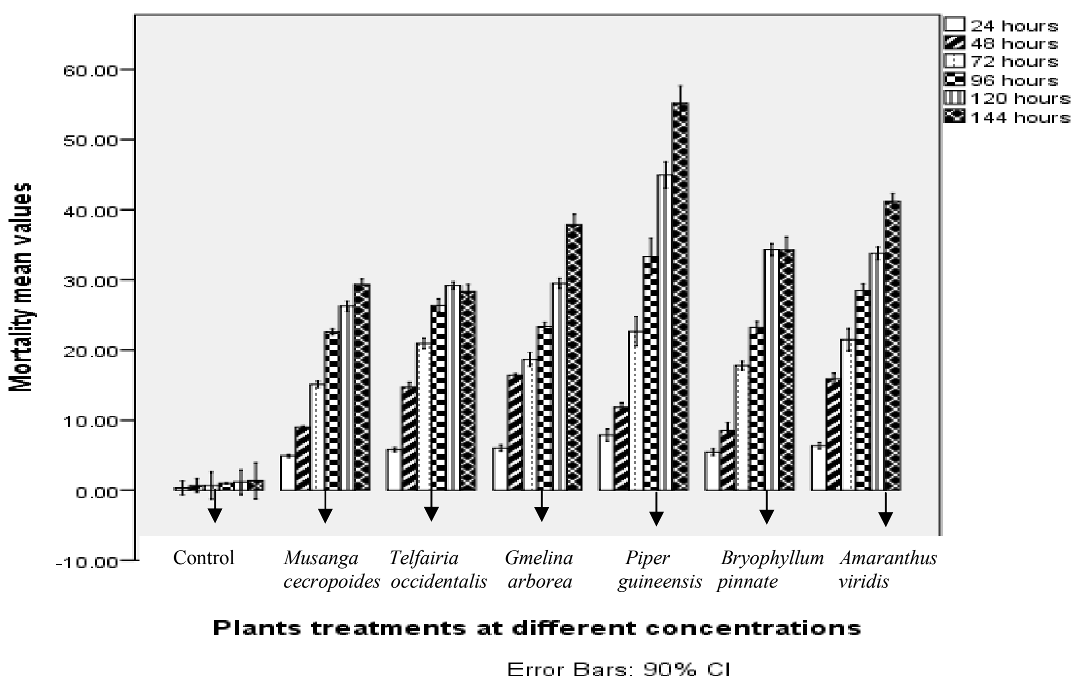

Fig. 1b. Mean mortality rate of *Acanthoscelides obtectus* in different test plant powder

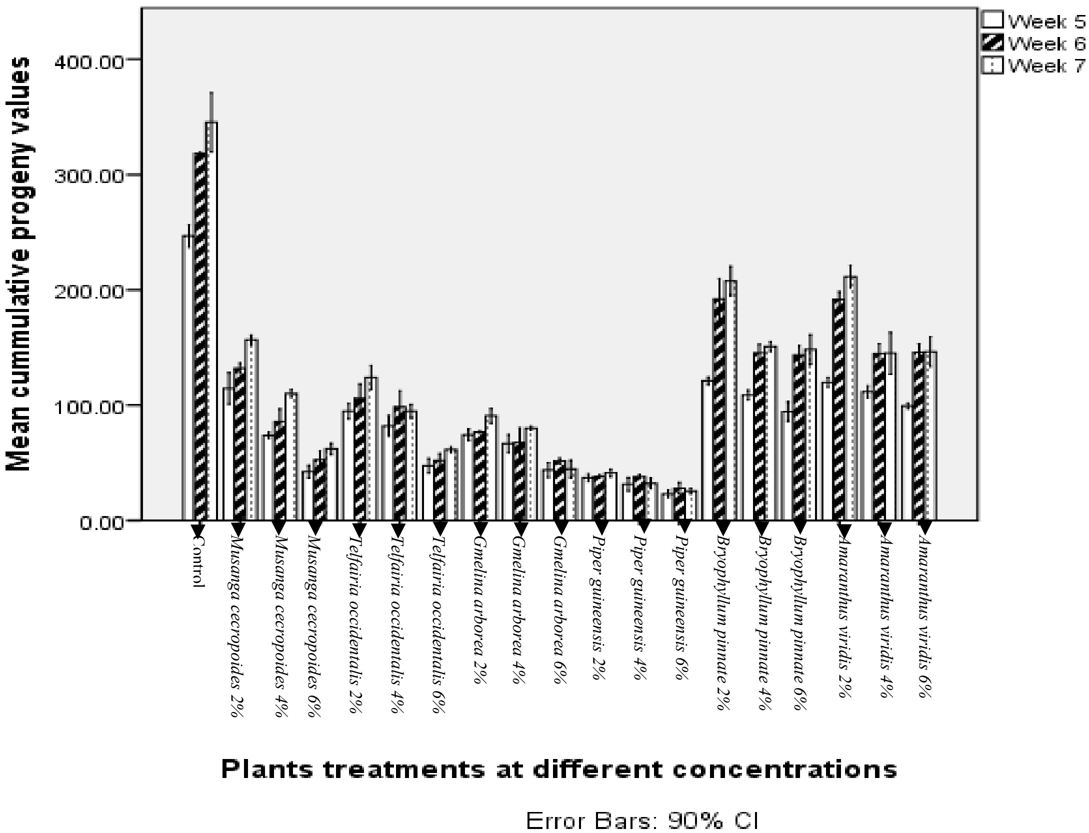

Fig. 2. Progeny emergence of *Acanthoscelides obtectus* in different concentrations of the test plant powder

Table 1. Effect of six plants leaves powder on *Phaseolus lunatus* L. *weight loss*

%	M*usanga ceropolides*	*Telfairia occidentalis*	*Gmelina arborea*	*Piper guineensis*	*Bryophylum pinnatum*	*Amaranthus viridis*	Control
2%	11.62±0.45^{cd}	22.17±0.01^{f}	18.72±2.82^{e}	3.89±0.05^{b}	22.77±0.29^{f}	26.78±0.08^{g}	32.56±0.38^{h}
4%	12.94±0.53^{d}	12.33±0.23^{de}	10.26±0.24^{cd}	3.66±0.02^{ab}	12.49±0.29^{cd}	13.28±0.09^{d}	
6%	1.88±0.04^{ab}	11.50±0.15^{cd}	9.71±0.03^{c}	0.91±0.05^{ab}	11.54±0.22^{cd}	12.47±0.29^{cd}	

- *Means with different superscript within the column are significantly different at 5% probability level, while means followed by the same superscript letters in each column are not significantly different by Duncan Multiple Range Test*

3.2 Effect of Test Plants on Weight Loss and Seed Damage

The least significant (P=0.05) weigh reduction in *P. lunatus* was observed with *P. guineensis* treatment (2% = 3.89, 4% = 3.66 and 6% = 0.91) while the control had the highest weight loss (32.56±0.38). 6% *M. cecropoides* and 4% *P. guineensis* had comparable effects, 2% *M. cecropoides*, 6% *T. occidentalis*, 4% *G. arborea*, 4% and 6% *B. pinnatum* and 6% *A. viridis. T. occidentalis, A. viridis*, *G. arborea, B. pinnatum, M. cecropoides and P. guineensis* all had similar effect in weight loss of seed.

4. DISCUSSION

The results obtained from this research indicated that the leaves of the six test plants; *M. cecropoides, P. guineensis, B. pinnatum, A. viridis, G. arborea* and *T. occidentalis* had different levels of insecticidal activities. Though all the treatments levels of the different plants were effective in decreasing *A. obtectus* population under laboratory conditions, their efficacies were directly proportional to concentration and period of exposure as seen with highest mortality recorded at highest concentration of 6% and at 144 Hrs. after treatment. This confirms the report by [25] that plants have phytochemicals which act as defenses against herbivores. The pungent smell produced by these plants must have repelled the weevils and prevented them from normal feeding resulting in starvation and subsequent death [26].

Plants exhibit many characters that give resistance to majority of herbivores and pathogens. Many characters operate directly against these enemies through their toxic, repellent and antimicrobial effects or function as mechanical barriers, but other resistance strategies work indirectly [1].

Results obtained from this research indicate that the mortality of adult *A. obtectus* was highest in *P. lunatus* treated with the six botanicals compared to the control. [27] reported that powder of insecticidal plant parts reduces insect movement and cause death through desiccation of insects or occlusion of their spiracles, thus preventing respiration and resulting in suffocation and death.

There was also a reduction in number of progeny emerged from all treated seeds relative to the control. A similar trend has been reported by [28,29]. The reduced adult emergence could be due to the elimination or death of immature stages as a result of the various treatments.

The highest mortality of adults and lowest progeny emergence observed in *P. guineensis* treatments may be linked to the presence of amides piperine and chavicine (Sylvatine and ß-dihydropiperine and 6 trichostachine) which have contact toxicity and fumigant activities on insect [30,31]. The similar effects observed on mortality of weevils treated with *G. arborea* and *A. viridis* could be due to Isoquercitinrutin and hydroxycinnamate.

5. CONCLUSION

Results of this study have showed that botanical powders of our indigenous plants especially *P. guineensis*, *A. viridis and G. arborea* produced significant inhibiting effect on *A. obtectus* reproduction and progeny emergence, but increased adult mortality leading to reduction in weight loss, suggesting their use in the management of *A. obtectus* infestation of stored *P. lunatus*.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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