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Comparative Studies of Two Botanical Oils and a Synthetic Insecticide on Bamboo Powder Post Beetle *Dinoderus minutus* Fabricius (Coleoptera: Bostrichidae)

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Abstract
Dinoderus minutus is a serious storage pest of bamboo in the tropics. The toxicity of Jatropha oil, Neem oil and a mixture of Neem-Jatropha oil was evaluated in comparison to a standard synthetic insecticide, Cypermethrin against *D. minutus* on dried bamboo blocks in storage. The results showed significantly higher mortality of *D. minutus* on bamboo blocks treated with Neem seed oil (88.00±8.00), Jatropha oil (78.67±3.52) and the mixture of the two (76.00±4.00) compared to Cypermethrin (44.00±2.31) and control (1.33±1.33) at 24 hours post-exposure. The feeding holes of *D. minutus* on the bamboo blocks in the control treatment were significantly higher compared to what was obtained in the bamboo blocks treated with Jatropha oil, Neem oil, Neem-Jatropha oils mixture and cypermethrin. There was a significantly higher weight loss of bamboo blocks in the control treatment at 21 days after exposure compared to the oil and Cypermethrin-treated bamboo blocks. Furthermore, the fumigant toxicity showed time-dependent mortality as low mortality was recorded at 1-7 days post-exposure. All treatments with the exception of the control treatment showed a fumigant effect at 21 days of exposure time. Invariably, these botanical oils performed favourably well to the standard synthetic insecticide, and could therefore be considered as an alternative to Cypermethrin in the control of *D. minutus* on bamboo.

Keywords: Botanical oil, Synthetic insecticide, Bamboo, Dinoderus Minutus

Introduction

Dinoderus minutus is an important borer that attacks felled bamboo culms and finished bamboo products to utilise stored starch (Abood 2008). The bamboo borer or bamboo powder post beetle belongs to a small family of Bostrichidae. The adult beetles burrow into felled culms through wounds, cracks and cut ends, and make horizontal tunnels along the fibro-vascular tissues of the culms while the larvae make longitudinal tunnels. The damaged part of the culm becomes powdery, and the powder is coarser in nature than those of other powder-post beetles sift from the beetle hole (Norhisham *et al.*, 2015). Large populations of these borers leave numerous tunnels in the culm, causing loss of strength and consequently, making it useless as slight damage reduces the aesthetic and economic value of the bamboo culms. Bamboos are of great economic and cultural significance in most regions of the world. Bamboos are used in the construction industries and as scaffolding material. Bamboos are considered to have higher compressive strength than wood, concrete or bricks and great tensile strength as steel (Mary Roach, 1996: Evelin Rottke, 2002). Bamboo is an excellent raw material in paper and pulp industries and also used in the local communities for staking, medicine and food. The renewability and sustainability of bamboo have made it an indispensable resource as it has reduced the pressure and demand for wood thus, aiding forest conservation as a full grown wood takes many years to mature. Chemical treatment using various insecticides and preservatives has been the most widely used method in controlling post-harvest pests of bamboos, including *D. minutus*. Various preservatives such as 5% water solution of copper-chrome-arsenic composition (CCA), 5-6% water solution of copper-potassium dichromate-borax (CCB), 5-6% water solution of boric acid-borax-sodium pentachlorophenate in 0.8:1:1 or 1:1:5 ratios (BBP), 0.33% BHC in kerosene and the synthetic pyrethroid, deltamethrin have been used and found to be effective.

However, synthetic insecticides have been associated with mild or acute health hazards to humans and animals, and environmental pollution as they are often mishandled and not properly applied (Fening, 2013). In view of developing a safer and low-cost alternative to synthetic insecticides, efforts have been focused on plants-derived materials (Silva Diniz *et al.*, 2014;

Popoola *et al*., 2018) that possess bioactive chemicals and secondary metabolites against insects (Lopez *et al*., 2008; Qin *et al*., 2010). Botanical insecticides have been extracted from various plants (Iyang and Asemota, 2015) and their biological properties tested and found to include insecticidal, repellent, antifeedant, growth regulatory, oviposition inhibitory, and sterility-inducing effects against insect pests (War *et al*., 2014; George-Onaho *et al*., 2021). *Jatropha curcas* and *Azadirachta indica* (neem) are among the most studied botanicals worldwide because of their potent active ingredients. Data on the phytochemical composition of *J. curcas* shows that the main biocidal action has been ascribed to the phorbol ester (Jyothna *et al*., 2015). Six phorbol esters (Jatropha factors $C_1 – C_6$) have been characterized from *J. curcas* seed oil with the molecular formula $C_{44}H_{54}O_8Na$. Azadirachtin (Aza) has been reported to be the main biocidal constituent of Neem. The aim of this study was to investigate the insecticidal effect of Neem and Jatropha seed oil in comparison to cypermethrin on *D. minutus* using dried bamboo blocks in storage.

Materials and Methods

Insect stock culture

Adults of *D. minutus* were obtained from the Advanced Entomology Laboratory, Department of Zoology, University of Ibadan (7.44°N, 3.90°E), Nigeria. Cassava chips and bamboo culms were used as culture media and heat-sterilized in an oven (Memmert type UL 40) at 60°C for 90 minutes (Atijegbe *et al*., 2014). The adult *D. minutus* collected were cultured and maintained on the culture media in 1L Kilner jars in the laboratory under temperature and relative humidity of 27°C±3°C and 78±10% using the digital thermometer and whirling psychrometer (740), respectively. Frass generated due to boring and feeding activities of the insects were sieved out weekly using a sieve of mesh size 0.25 mm to rejuvenate the culture stock and prevent excessive moisture and growth of mould. Subsequently, insects were collected from the stocked culture for further experiments.

Bamboo substrate preparation

Matured bamboo (*Bambusa vulgaris*) stands were harvested from the Forestry Research Institute of Nigeria, Ibadan, Nigeria (FRIN) arboretum. Bamboo culms were cut and split into blocks of 4.0 cm x 3.0cm x 1.0 cm in size (Norhisham *et al*., 2013). The bamboo blocks were air-dried for 4 weeks and the moisture content was determined using the oven drying method as described by (Stumpf, 1998). The dried bamboo was further sterilised in a hot air oven at 60°C for 1 hour (Asmanizar *et al*., 2008) to kill any insect that might have infested it from the field and during the drying process.

Sources and preparation of neem oil, jatropha oil and cypermethrin

Jatropha curcas seed oil and neem seed oil were purchased from the National Research Institute for Chemical Technology (NARICT), Zaria, Kaduna State. Cypermethrin, a synthetic insecticide of the class pyrethroid was purchased from a commercial agro-chemical shop in Ibadan. The oil treatments used in the experiment consisted concentration of *J. curcas* (Jyothna *et al*., 2015) and Neem seed oil and a 50:50 ratio of Neem-Jatropha mixture while 0.6% cypermethrin (manufacturer's recommendation) served as the positive control.

Boring and feeding deterrence bioassay

Each experimental setup consists of five bamboo blocks in 320 cm^3 plastic jars. The bamboo blocks were dipped in Jatropha oil, Neem seed oil and 50:50 mixtures of both seed oils. The positive control was dipped in cypermethrin while the negative control was left untreated. The treated bamboo blocks were air dried to dry completely at room temperature in the Entomology Laboratory of the Department of Forest Conservation and Protection, Forestry Research Institute of Nigeria (FRIN) (7.394°N, 3.871°E), Jericho Hills, Ibadan, Nigeria. The initial weights of the bamboo blocks were measured using a digital weighing balance [Model: Pioneer PA413 (max 410g x 0.001g)] and 25 unsexed adults *D. minutus* were introduced into each jar. All treatments were maintained in three replicates and arranged in a completely randomized design (CRD) on the laboratory bench for 60 days. Data on mortality, number of holes bored, and final weight of bamboo blocks were taken. The percentage mortality was calculated using:

Mortality % = Number of dead insects/Number of insects introduced x 100

Fumigant bioassay

The fumigant toxicity of Jatropha and Neem seed oil in a 250 cm^3 glass jars with healthy non-infested bamboo blocks prepared for insect feed. A 1.0ml of the different oil treatments were spread on the filter paper (Whatman No.1) cut to the glass cap diameter and allowed to air dry at room temperature and attached to the screw caps while the control filter paper was untreated. Ten adult insects were introduced and three replicates were maintained for each treatment in a Completely Randomized Design (CRD). Mortality count was taken after 24 hours through twenty one day period of exposure.

Statistical analysis

Data obtained will be subjected to Analysis of Variance (ANOVA) using SAS statistical software and means separated using Fisher's least significant difference (LSD) at $p \leq 0.05$.

Results and Discussion

Results

Mortality of D. minutus on treated bamboo blocks

The result of the insecticidal effects of Jatropha and Neem seed oil mixture on the mortality of *D. minutus* is shown in Table 1. There was significantly higher mortality of *D. minutus* on bamboo blocks treated with Neem seed oil, Jatropha oil and the mixture of the two oils at 1, 7 and 21 days post-exposure compared to the Cypermethrin and the control treatments (Table 1).

However, mortalities of *D. minutus* recorded in the three botanical oil treatments, were not significantly different from one another.

Boring and feeding deterrence of D. minutus on treated bamboo

The feeding behaviour of *D. minutus* tested on treated bamboo showed significantly higher boring activities by the number of insect holes present in the control treatment compared to what was obtained in the bamboo treated with *Jatropha* oil, Neem oil, a mixture of the two oil and cypermethrin throughout the period of exposure (Table 2). The weight loss in the bamboo blocks after twenty-one days of exposure to *D. minutus* was significantly higher in the control compared to the treated bamboo blocks (Figure 1). Furthermore, the lowest weight loss value was obtained from the Neem-Jatropha mixture and it is significantly lower than weight loss in the cypermethrin-treated bamboo blocks.

Fumigant toxicity of Jatropha oil, Neem oil and cypermethrin on D. minutus

The fumigant result showed time-dependent mortality as no mortality was recorded for Jatropha oil and Neem seed oil at 1 and 7 days post-exposure (Figure 2). However, at 21 days post-exposure, the percentage of mortalities of *D. minutus* was significantly higher in all treatments with the exception of the control treatment. The Neem-Jatropha mixture and cypermethrin-treated bamboo blocks caused significantly higher mortalities at 21 days after exposure to fumigant action.

Discussion

The present study evaluated the insecticidal effects of Neem seed oil, Jatropha seed oil, and a mixture of Neem-Jatropha in comparison to a standard synthetic insecticide Cypermethrin for the treatment of bamboo against *D. minutus*. This is geared towards incorporating these botanicals in Integrated Pest Management (IPM) as an alternative to synthetic insecticides for a safer environment. The result showed that these seed oil treatments caused a substantial degree of mortality and offered great protection to the bamboo blocks when compared to the cypermethrin. This is consistent with the studies of Mbaidiro and Onzo (2022) on the effectiveness of Neem and Jatropha oil against *Spodoptera frugiperda* and found these plant oils to be as effective as the standard synthetic insecticide. Holtz *et al*., (2021) also studied the effectiveness of Neem and Jatropha oil combinations in the control of pink hibiscus mealybug and found the combinations effective. The efficacy of Neem oil as a bio-insecticide has been studied and reported over the years by many scholars in the management of many fields and stored product pests. Remadevi *et al*., (2012) studied the efficacy of Neem oil, and camphor oil among other oils in the control of bamboo borer *D. minutus;* the authors reported that all the oils tested were useful in controlling the formation of powder in the bamboos for up to one year. Toffa *et al*., (2021) also reported the effectiveness of Neem oil in the management of *D. porcellus* and Erakhrumen (2012), in his investigation, reported that Neem seed oil possesse anti-microbial properties and can be used as a preservative for bamboo culms against fungal infestation and deterioration. The efficacy of Neem oil has been attributed to its biochemical constituent (Insanu *et al*., 2013; Dono *et al*., 2020) which poses deterrent and antifeedant properties on insect pests.

Many studies have shown the insecticidal and deterrent attribute of Jatropha oil on insect pests of fields and stored grains (Silva *et al*., 2012; Diabate *et al*., 2014; Ukpai *et al*., 2017). Jythona *et al*. (2015) reported the insecticidal action of a higher concentration of Jatropha oil on *D. minutus* which was attributed to the presence of phorbol esters and considered it a worthy alternative to synthetic insecticide or as a complimentary measure to other prophylactic measures in the management of bamboo borer, *D. minutus*

The result of this study showed statistically similar effectiveness of Jatropha and Neem oil and their mixtures to the synthetic Cypermethrin in inducing mortality in *D. minutus* and conferring protection to bamboo and its products in storage. The challenge of bamboo deterioration and loss in storage if adequately tackled can help reduce the burden placed on forest woods and invariably, address the impact of deforestation in the environment. Furthermore, to reduce the negative impacts of synthetic insecticides to human health and the environment, the use of botanical insecticides which are cheaper and safer should be encouraged. Thus, from this study, it can be concluded that Jatropha oil, Neem oil and their mixture can be considered an alternative to Cypermethrin.

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Table 1: Mean percentage mortality ([redacted]S.E) of *Dinoderus minutus* on treated bamboo blocks at different exposure periods

Treatments	Period of exposure (days)		
	1	**7**	**21**
Jatropha oil	78.67±3.52a	88.00±6.11a	100.00±0.00a
Neem oil	88.00±8.00a	94.67±1.33a	100.00±0.00a
Neem + Jatropha	76.00±4.00a	89.33±7.06a	100.00±0.00a
Cypermethrin	44.00±2.31b	54.67±10.91b	98.67±1.33a
Control	1.33±1.33c	21.33±3.53c	25.33±3.53b

Numbers followed with the same letters in the column are not significantly different from one another (p<0.05)

Table 2: Mean ([redacted]S.E) no of holes bored by *Dinoderus minutus* on treated bamboo blocks at different exposure periods

Treatments	Period of exposure (days)		
	1	**7**	**21**
Jatropha oil	1.00±0.00b	1.23±0.14b	1.38±0.21b
Neem oil	1.00±0.00b	1.00±0.00b	1.00±0.00b
Neem + Jatropha	1.00±0.00b	1.14±0.14b	1.14±0.14b
Cypermethrin	1.00±0.00b	1.00±0.00b	1.00±0.00b
Control	1.52±0.11a	2.58±0.13a	2.63±0.18b

Numbers followed with the same letters in the column are not significantly different from one another (p<0.05)

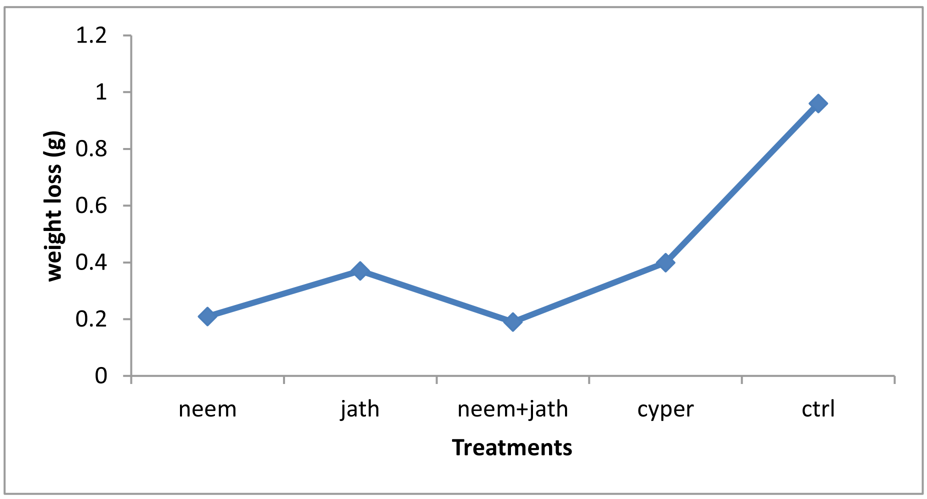

Figure 1: Damage caused by D. minutus on treated bamboo blocks

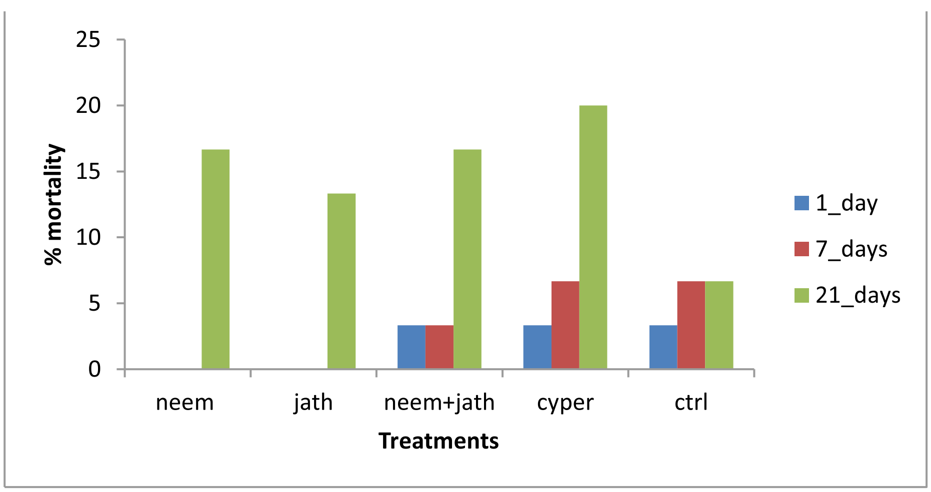

Figure 2: Fumigant toxicity effect of jathropha, neem oil and cypermethrin on D. minutus at different periods of exposure