Advancement in Medicinal Plant Research
Vol. 2(2), pp. 27-33, May 2014
ISSN: 2354-2152
Full Length Research Paper

Evaluation of some plant powders against Khapra beetle (*Trogoderma granarium* Everts) (Coleoptera: Dermestidae) on stored groundnut

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Accepted 19 May, 2014

ABSTRACT

Studies were conducted at the Agronomy laboratory of Michael Okpara University of Agriculture, Umudike, Nigeria in 2013. Plastic vials containing 1.5 g powder each of *Curcuma longa* L. (Turmeric) rhizomes, *Zingiber officinale* Rosc. (Ginger) rhizomes, *Allium sativum* L. (Garlic) bulb, *Ficus exasperata* P. Beauv (sand paper leaf) leaves, *Garcinia kola* Heckel (Bitter kola) seeds and 0.5 ml petroleum ether extract of *Z. officinale* were evaluated for their efficacy against *Trogoderma granarium* Everts (Khapra beetle) in stored groundnut. The experiment was laid in Completely Randomized Design (CRD) with four replicates. Adult mortality, progeny emergence, percentage grain damage, percentage weight loss and germination percentage were assessed. The results obtained from adult mortality counts revealed that all the botanicals exhibited significant ($P < 0.05$) protection of groundnut seeds from *T. granarium* infestation compared with the control, which recorded 10.6% mortality. *A. sativum* recorded the highest percentage of mortality of 96.2% at 49 days after treatment. Progeny emergence and weight loss was reduced in the treated seeds. Significantly ($P < 0.05$) higher germination percentage was recorded in the various botanicals when compared with the control, which recorded 10%. The botanicals which are readily available and cheap can be used as alternative to synthetic insecticides for the control of *T. granarium* in stored groundnut.

Keywords: Botanicals, efficacy, groundnut, *Trogoderma granarium.*

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INTRODUCTION

Groundnut, *Arachis hypogaea* L. is a legume crop belonging to the family Fabaceae, (Musa et al., 2009; Remison, 2005). Almost every part of groundnut is of commercial value. Groundnut seeds are nutritionally rich due to the presence of oil, protein, minerals, vitamins etc. Musa et al. (2010) reported that groundnut is a valuable source of vitamins B, E and K. It is the richest plant source of thiamin (vitamin B) and is also rich in Niacin which is low in cereals which resulted in being described as 'poor man's diet. There is versatility with respect to the groundnut seed consumption, since it is consumed in raw or roasted or salted or sweetened states. Groundnut improves soil nutrients, due to the presence of atmospheric nitrogen fixing bacteria in its root nodules while the seeds are extracted for vegetable oils. Groundnut cake is a good feed for animals and poultry due to its nutritive value and palatability (Musa et al., 2010). The residual oil cake contains 7 to 8% of Nitrogen, 1.5% of phosphorus and 1.2% of K_20 and is used as a fertilizer. Groundnut cake is an important protein supplement in cattle and poultry rations. It is also consumed as confectionary product. High quality oil from it is used in the pharmaceutical industry. However, the profitable production and preservation of this crop is greatly constrained by the Khapra beetle *Trogoderma granarium* (Musa, 2013).

In Nigeria, this insect pest seriously threatens the sustainable production of groundnut (Asawalam and

Igwe, 2011). In addition to direct losses caused by the insect, secondary feeding and infestation is often followed by colonization by secondary insect pest especially *Ephestia cautella* Walker, fungi (*Aspergillus flavus*) and consequently leading to deterioration in grain characteristics (EL-Nadi et al., 2001). Insect infestation causes dry mass loss and increases the level of free fatty acids in the kernels which results to a reduction in quality (Lale, 2002). The larva bore into the grain, where they feed, leaving the grains hollow. The insect also contaminate the produce with their moulds and frass. Oil extracted from infested groundnut is also contaminated.

The male Khapra beetle is distinguished by the elongate apical segment of the clubbate antennae (Musa, 2013). The antennal club is wider in width and shorter in females than in males (Ofuya and Lale, 2001). The development of *T. granarium* from egg to adult emergence takes 4 to 6 weeks (Musa, 2013).

Several methods of insect pest control have been employed against this hazardous insect pest of stored oil seeds and processed cereal products in Nigeria. According to Redlinger et al. (1988) and Menn (1983), the effective control of storage insects like *T*. *granarium* has centered mainly on the use of synthetic insecticides. Despite the effectiveness, many problems are associated with these chemicals such as the development of insect resistance, toxic residues in food, workers' safety and high cost of procurement. These problems have necessitated research on the use of alternative eco-friendly insect pest control strategies like the use of botanical insecticides. These plant materials include; Ginger *(Zingiber officinale),* Garlic *(Allium sativum),* Bitter kola *(Garcinia kola),* sandpaper *(Ficus exasperata),* and Turmeric *(Curcuma longa)*.

The use of botanical pesticides to protect plants from pest is very promising (Ivbijaro, 2012) because of several distinct advantages. Bell et al. (1990) reported that botanical pesticides are generally much safer than conventionally used synthetic pesticides. They usually do not pose any adverse effect on the ecosystem. Furthermore, plant-derived insecticides are cheaper. Some plants have more than one chemical as an active principle responsible for their biological properties. According to Maina and Lale (2004), aqueous extracts of neem oil, neem kernel powder and neem press cake proved effective against the Khapra beetle.

The work of Nadra (2007) showed that *Capsicum frutescens* caused significant mortality (85%) to *T. granarium* at concentrations of 1, 2, 4 and 6% within 7 days. Dwivedi and Bajaj (2000) assessed leaf extracts for its repellent activities against Khapra beetle.

Musa (2013) recorded 100% mortality at 6% w/w in groundnut seeds treated with *A. sativum* clove powder against Khapra beetle (*T*. *granarium*). Fruit and leaf essential oils of *Schinus molle* showed insect repellent and insecticidal activity against *T. granarium and Tribolium castaneum.*

Ashfaq et al. (2012) reported that *Moringa oleifera* leaf powder was effective on both the larvae and adults of *T*. *granarium* and showed repellent properties. Al–Moajel (2004) showed insecticidal activity in *A. cepa* L. against *T. granarium* in wheat. Asawalam and Igwe (2011) reported that extracts of turmeric and lemon grass proved effective in increasing adult mortality of *T*. *granarium* in stored groundnut.

According to Makanjuola (1989) and Maina and Lale (2004), aqueous extracts of neem oil, neem kernel powder and neem press cake are effective against the Khapra beetle.

Gemechu et al. (2013) reported an increase in adult mortality, reduction in F_1 progeny emergence and grain damage as a result of botanical powders and cooking oils application against *sitotroga cereallela* in stored maize.

The objective of this study was to evaluate the efficacy of *Zingiber officinale*, *Allium sativum*, *Garcinia kola*, *Ficus exasperata* and *Curcuma longa* powder against *T. granarium* in stored groundnut.

MATERIALS AND METHODS

Study area

The experiment was conducted in Agronomy Laboratory of Michael Okpara University of Agriculture, Umudike, Abia State , Nigeria. Umudike is located on latitude 5°22′ North and longitude 7°33′E and an altitude of 122 m above sea level (NRCRI, 2010).

Insect culture

T. granarium was collected from Umuahia main market, Abia State Nigeria. They were cultured in a 5 L plastic container covered with a muslin cloth and held by the side with an expansible rubber band to allow for aeration and avoid suffocation of the insects and equally prevent escape of the insects. The experiment was carried out under ambient environmental conditions. The culture of *T. granarium* was established on a susceptible groundnut variety (RRB). The plant parts to be evaluated for insecticidal properties (Table 1) were air-dried and blended with Thomas milling machine. The powders were kept separately in vials and stored at room temperature until needed. The amounts of powder mixed with groundnut seed were calculated by weight basis of powder / grain weight (w/w) that is 1.5 g plant materials for 50 g of groundnut seeds and 0.5 ml of the petrol ether extract of *Z. officinale* and freshly emerged adults of about two weeks old were used for the experiment.

Treatments and experimental design

The treatments were arranged in Completely Randomized Design (CRD) and replicated four times. Each treatment was introduced into 50 g of groundnut grains in each plastic vial. Twenty freshly emerged adults were collected from the culture and introduced to each vial at the same time to maintain uniformity in age as described by Parugrug and Roxas (2008). The vials were arranged 5 to 10 cm apart on a flat table and left undisturbed in the laboratory after shaking gently for two minutes to ensure uniform distribution of the botanical powders and extract.

Table 1. Plants to be evaluated for insecticidal properties.

Scientific name	Local name	Common name	Family	Parts used
Allium sativum	*Ayo*	Garlic	Alliaceae	Bulb
Zingiber officinale	*Jinja*	Ginger	Zingiberaceae	Rhizome
Garcinia kola	*Agbaillu*	Bitter Kola	Guttiferaceae	Seed
Curcuma longa	*Ehiri*	Turmeric	Zingiberaceae	Rhizome
Ficus exasperata	*Akwukwonea*	Sand paper	Moraceae	Leaves

Adult mortality

Adult mortality was assessed on 7, 14, 21, 28, 35, 42 and 49 days after exposure of the insects to the treatments. Adult were considered dead when gently probed with sharp objects and there were no responses. Percent adult mortality was determined by the method of Parugrug and Roxas (2008) using the following formula:

$$(\%)\ \text{Mortality} = \frac{\text{No of dead insects}}{\text{Total no of insects}} \times 100$$

Percentage weight loss

The grain percentage weight loss was calculated thus:

$$(\%)\ \text{Weight loss} = \frac{\text{Initial weights} - \text{final weight}}{\text{Initial weight}} \times 100$$

F1 progeny emergence test

After 20 days of introduction of adult insects into the experimental vials, all insects both dead and alive were removed from each experimental vial. After, the seeds were returned to their respective jars. Thereafter, the newly emerged adult insects (F1 progeny) were recorded at 21, 28, 35 and 42 days post treatment.

Percentage grain damage

Percentage grain damage was calculated on 49th days after treatment (DAT). Numbers of perforated holes were recorded and the following general formula was used to determine the percentage of grain damage:

$$(\%)\ \text{Grain damage} = \frac{\text{No of perforated grains}}{\text{Total no of grains counted}} \times 100$$

Germination percentage

Germination test was carried out to ascertain the effect of these treatments on the germination ability of the groundnut seeds after treatment. Five seeds from each treatment were placed in a petri–dish containing moistened filler paper. After 10 days germination percentage was calculated using the formula:

$$\text{Germination percentage} = \frac{\text{No of germinated seeds}}{\text{Total no of seeds in the petri-dish}} \times 100$$

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) Procedure and significant different means were separated using Least Significant Difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

Treatment effect on mortality

The cumulative mortality of *T. granarium* from 1st to 7th weeks after application of the botanicals and oil was significantly different ($P < 0.05$) (Figure 1). All the botanicals used (*A. sativum*, *Z. officinal*e, *Z officinale* oil, *G. kola*, *C. longa* and *F. exasperata* powder) recorded significantly high adult mortality (80 to 98%) when compared with the control. Also, higher adult weevil mortality due to the application of the botanicals were observed as the exposure time of the insect to the treatment increased. At 2 weeks, the mortality was not high but as exposure time increased, there was a progressive increase in the toxicity of the botanicals to the test insect showing appreciable mortality of *T. granarium*. The efficacy of the treatments is in the order *A. sativum* > *Z. officinale* oil > *C. longa* > *F. exasperata* > *G. Kola* > *Z. officinal*e powder. The treatments were found significant ($P < 0.05$) with respect to the cumulative percentage adult mortality (Figure 1) which is in line with the work of Musa (2013) who recorded 100% mortality at 6% w/w in groundnut seeds treated with *A. sativum* clove powder against Khapra beetle (*T. granarium*). Fruit and leaf essential oils of *Schinus molle* showed insect repellent and insecticidal activity against *T. granarium and T. castaneum.* The work of Nadra (2007) showed that *Capsicum frutescens* caused significant mortality (85%) to *T. granarium* at concentrations of 1, 2, 4 and 6% concentrations within 7 days. Previous studies by Al-Moajel (2004) have shown insecticidal activities in *A. ascalonicum* L. and *A. cepa* L. a close relative of *A.*

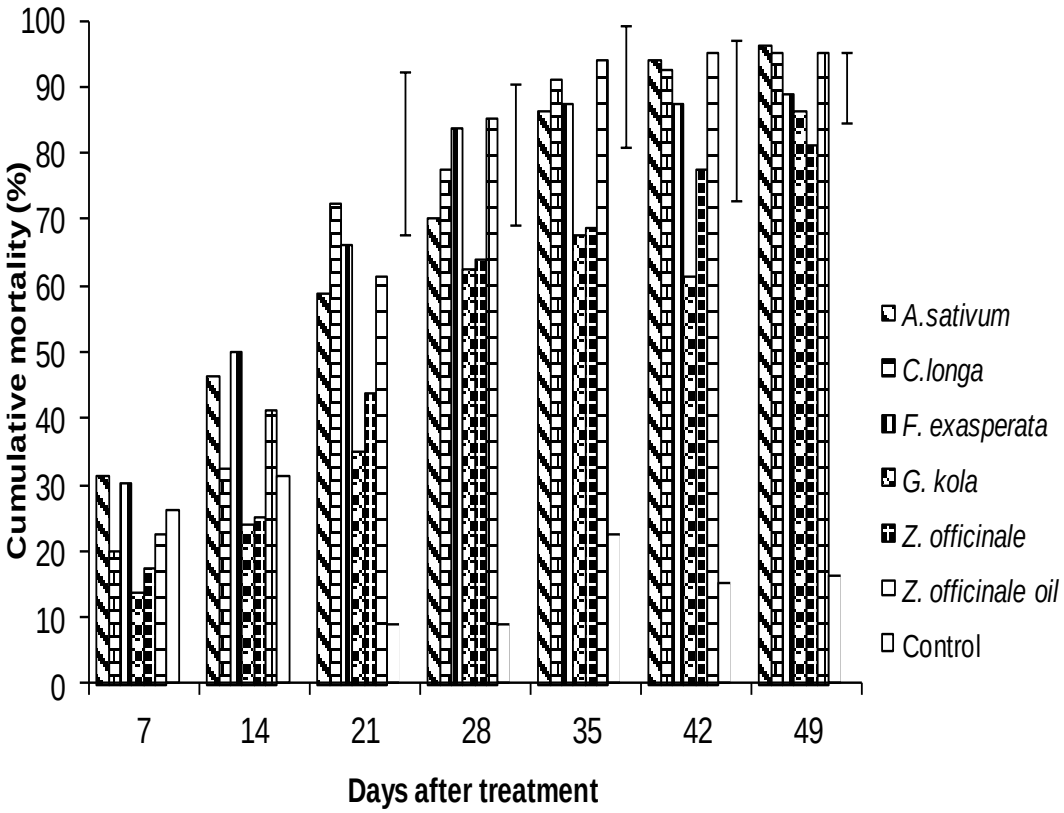

Figure 1. Cumulative percentage adult mortality of *Trogoderma granarium* treated with botanical powders (Vertical bars represent LSD0.05).

Table 2. Effect of botanical powders on progeny emergence of *T. granarium* on groundnut seed after 42 days post treatment.

Treatments	Time interval after exposure (days)			
	21	28	35	42
A. sativum	0.75	1.25	1.75	3.25
Z. officinale	0.50	1.25	2.25	3.50
Z. officinale (oil)	0.25	0.75	2.25	4.00
G. kola	1.50	3.25	4.25	4.75
C. longa	1.00	1.50	1.75	3.50
F. exasperata	1.50	2.00	3.00	4.75
Control	5.50	10.50	16.50	20.00
LSD (0.05)	1.526	2.042	2.447	2.998

sativum against *T. granarium* in wheat. Musa (2013) observed 100% adult mortality of *T. granarium* in groundnut seeds treated with *Moringa oleifera* leaves and *A. sativum* cloves.

Effect of botanical powders on progeny emergence of *T. granarium*

The effect of botanicals on progeny emergence of *T. granarium* is presented in Table 2. The number of emerged *T. granarium* decreased with an increase in the number of days after treatment. The number of emerged progeny in the control (20.0%) was significantly higher ($P < 0.05$) than other powders at 5% probability level indicating that the powders were very effective at reducing progeny emergence. At the 35th day after infestation, progeny emergence increased while the highest percentage adult emergence was obtained from the control compared to the treatments.

Table 3. Percentage damage of groundnut seeds by *T. granarium* after 49 days post treatment with botanicals.

Treatments	Damage %
A. sativum	2.39 (8.73)
Z. officinale	2.52 (9.03)
Z. officinale (oil)	2.33 (8.77)
G. kola	3.58 (10.60)
C. longa	3.03 (9.81)
F. exasperata	4.68 (12.31)
Control	18.02 (24.91)
LSD (0.05)	3.961 .86)

Values in parenthesis are transformed values.

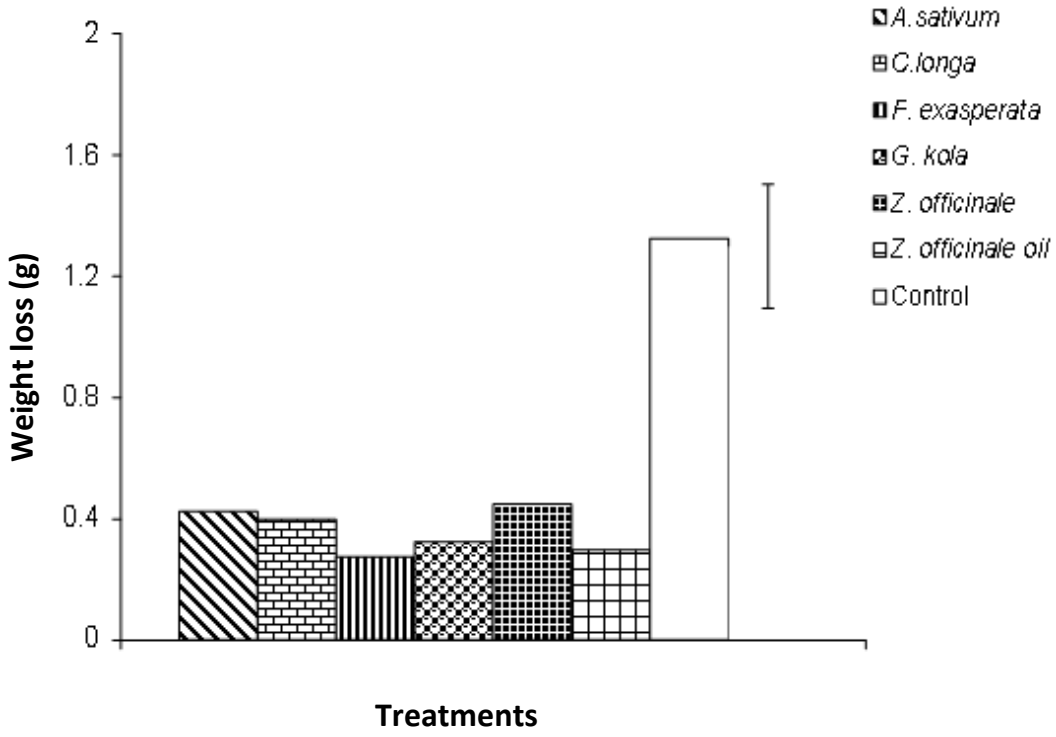

Figure 2. Effect of botanical powders on cumulative weight loss (g) of groundnut seeds infested by *T. granarium.*

Percentage damage of groundnut seeds by *T. granarium*

Table 3 shows mean percentage damage of groundnut seeds caused by *T. granarium*. The table revealed that the powders were very effective at controlling damage. Mean numbers of perforated seeds in the various treatments was significantly different from the untreated seeds which recorded 18.02% damage. This is similar to the work of Asawalam and Igwe (2011). The efficacy of these powders may be attributed to their active components responsible for their insecticidal properties.

Effect of botanical powders on cumulative weight loss of groundnut seeds

Cumulative weight loss of groundnut seeds is presented in Figure 2. The control recorded a significantly higher percentage weight loss when compared to the treated

Table 4. Effect of botanical powders on groundnut seeds viability after 49 days of post treatment.

Treatments	Germination (%)
A. sativum	70.0 (57.1)
Z. officinale	95.0 (83.4)
Z. officinale (oil)	100.0 (90.0)
G. kola	85.0 (73.6)
C. longa	90.0 (76.7)
F. exasperata	100.0 (90.0)
Control	40.0 (38.9)
LSD (0.05)	17.58 (8.24)

Values in parenthesis are transformed values.

seeds. Minimal weight loss was observed in the treatment with *F. exasperata* and *Z. officinale* oil. The effectiveness of *Z. officinale* oil and *Z. officinale* powder and *A. sativum* is in consonance with the work of Gemechu et al. (2013).

Effect of various powders on germination of groundnut seeds

Table 4 shows the percentage germination of the treated groundnut seeds compared with the untreated. The table revealed that germination in the control was significantly different from various treatments ($P < 0.05$). *Z. officinale* powder recorded highest germination percentage. The least germination was obtained on control 40 (39%). This finding is similar to the result of Asawalam and Igwe (2011) who reported that essential oil of turmeric positively affected seed germination of groundnut. Musa (2013) reported that *A. sativum* and *M. olifera* powder has a high potential of preserving groundnut seed on storage without having a negative effect on germination.

CONCLUSION AND RECOMMENDATION

In this work, the respective plant powders and oil proved to be effective in reducing adult mortality of *T. granarium*. However, *Z. officinale* oil, *A. sativum* and *C. longa* recorded the highest adult mortality of 96%, 95% respectively while *Z. officinal*e powder, *G. kola* and *F. exasperata* resulted to 81, 85 and 86% adult mortality respectively. This result revealed that the botanicals were effective in reducing mortality. The result also showed that all the botanicals were effective in reducing weight loss and grain damage when compared with the untreated control. However, *Z. officinal*e oil, *Z. officinal*e powder and *A. sativum* were highly effective compared with the control. The botanicals significantly reduced damage caused on groundnut by the Khapra beetle and is therefore recommended for farmers. These botanical powders are readily available locally and environmentally friendly with low cost. Hence, there is need for farmers to adopt the use of these botanicals rather than high cost synthetic pesticides that are harmful to humans and our environment.

Further studies should be done with the botanical powders and oil at varying concentrations to determine the appropriate dosage that will be most effective against the Khapra beetle. Also possible commercial formulation for resource poor farmers is encouraged, by isolating the active constituents that are responsible for the toxicological effects of these botanical powders and oils.

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