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Efficacy of selected plant extracts against *Tribolium castaneum* Herbst in stored groundnut (*Arachis hypogaea* L.)

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The efficacy of powders of plant parts from *Azadirachta indica, Lawsonia inermis, Annona senegalensis* and *Hyptis suaveolens* at 10, 15 and 20 g/250 g seeds was tested using Complete Randomized Design (CRD) against the storage pest *Tribolium castaneum* (Herbst) in groundnut in the laboratory. At 28 days after application, mean number of seeds damaged was 0.33±0.33 for *A. indica* and 2.33±0.33 for *L. inermis* at 20 g concentration when compared to untreated seeds (10.00±1.15). Aluminium phosphide gave complete control (0.00±0.00). Twenty grammes (20 g) at 28 days of *A. indica* was efficacious as aluminium phosphide in protecting seeds against damage by *T. castaneum*. All powders provided some control of *T. castaneum*. The percentage mortality of adult pest in 20 g of *A. indica* (53.33%), *L. inermis* (33.33%) is high compared to *H. suaveolens* (16.66%) and *A. senegalensis* (20.00%) as compared to untreated (0% mortality). At the end of 6 weeks of storage, the weight loss from original weight of 250 g was 40.89 g (16.36%) for untreated seeds, 1.88 g (0.75%) for *A. indica* and 5.05 g (2.02%) for seed treated with *L. inermis* at 20 g concentration each. Aluminium phosphide-treated seeds suffered minimal weight loss (0.16 g, 0.06%) at 20 g concentration. *A. indica* and *L. inermis* are recommended for post-harvest control of *T. castaneum* in stored groundnut for planting.

Key words: Plant extracts, biocidal activity, *Tribolium castaneum,* groundnut.

INTRODUCTION

Groundnut is an important oil and protein source to a large portion of the population in Asia, Africa and the Americas. It is predominantly used for oil extraction in many Asian and African countries. In China, the average pod yields have hovered around 1.8 t/ha and total production has reached 7.0 mt annually (Ryan, 1992). However, potential yields reported are much higher between 7,500 kg and 11,000 kg pods/ha in experimental farms situated at Shandong province in China. In Southern Africa, the average groundnut yields are lower at 700 kg/ha, in comparism to potential yields of 4,000 kg pods/ha. Obviously, soil fertility, abiotic and biotic stress, factors limit groundnut crop

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growth and yield in many ways. However, in response to it a measurable progress in incorporating disease and pest resistance, and tolerance to abiotic stress factors have been achieved, during the previous two decades. Breeding options to enhance yield, its quality and/or to impart tolerance to biotic and abiotic stress factors have been carefully prioritized on a regional basis by the international and national groundnut agencies to suit consumer preferences (Ryan, 1992).

Groundnut, also known as peanuts, is considered a very healthy snack. Groundnut is the member of the legume family and is native to regions like South America, Mexico and Central America. However, it is successfully grown in other parts of the World as well. The name of the plant combines the morpheme ‘pea’ and ‘nut’. In the culinary sense, it is regarded as a nut, but in the botanical sense, the fruit of the plant is a woody legume. Since that is the case, the groundnut is actually a kind of pea. The groundnut is also known by different names like earthnuts, manila nuts and monkey nuts. Throughout the World, they are known for their nutrition and health benefits.

In storage, groundnut pods/seeds are attacked by several stored products pests including the groundnut borer *Caryedon serratus* (Oliver), the merchant grain beetle *Oryzaephilus mercator* (Fauvel), the khapra beetle *Trogoderma granarium,* the black fungus beetle *Alphitobius spp*., the flat grain beetle *Cryptolestes ferrugineus,* the tropical warehouse moth *Ephestia cautella* (Walker), the Indianmeal moth *Plodia interpunctella* (Hubner), the rice moth *Corcyra cephalonica* (Stainton). It is known that more than 100 species of insects are capable of infesting stored groundnuts (Redlinger and Davis, 1982; Ofuya and Lale, 2001). Of these, insect pests of groundnut, *T. castaneum* are the first to colonize a new stock. It consumes the endosperm and causes caking, musty smell and loss of grain weight (Davey et al., 1959). It is also known to cause up to an economic damage rate of 30 and 40%, respectively, of stored millet and wheat flour (Ajayi and Rahman, 2006).

Over the years, synthetic chemical pesticides have provided an effective means for pest control. The short-comings of the use of chemicals which include; resistance by insects, adverse effect of non-target species, pollution of the environment including; soil, water, air and hazard of residue necessitated the evolution of natural insect-cides of plant origin (Deedat, 1994). Plants are composed of chemical directly beneficial for the growth and development of the plant. Rather they are part of the plant’s defense against plant feeding insects and other herbivores (Rosenthal and Janzen, 1979). Recently, a number of plant materials have been explored as sustainable alternatives for controlling short-lived insect pests during storage of grains and found to be quite effective. Some of these botanical pesticides that have been reported to be efficacious against pests wchich include powders from *Piper guineensis* (Ivbijaro and Agbaje, 1986), *Piper nigrum* (Rajapakse, 1990), *Zanthoxylum xanthoxyloides* (Ogunwolu and Odunlami,1996), root bark of *Annona senegalensis* (Aku et al.,1998), *Capsicum frutescens* (Echezona, 2006; Ofuya, 1986), plant mixtures (Arannilewa et al., 2006), essential oil derived from *Artemisia sieberi* (Negahban et al., 2007), powders from the seed of neem (*Azadirachta indica* A. Juss) (Ivbijaro, 1983) and neem leaf extracts (Epidi et al., 2005), leaf powders of the Dragon tree (*Dracaena arborea*) and *Vitex grandifolia* (Epidi et al., 2008) and methanol leaf extracts of *Vitex negundo, V. trifolia, V. peduncularis* and *V. altissima* (Kannathansan et al., 2007). Others are vegetable oils from groundnut, palm kernel, coconut (Hall and Herman, 1991; Lale, 1995), rhizomes of ginger (Vijayalakshmi et al., 1997), leaf extracts of *Teprosia vogeli* (Mallaya, 1985), oil from fresh garlic (Ho et al., 1997), leaves and seeds of *Ocimum basilium* (Grainge and Ahmed, 1988) and leaves of *Dracaena arborea* (Boeke et al., 2004). The Derived Savanna is known to have a wide array of plant species with great insecticidal potentials yet to be discovered. Furthermore, different insects react in varying ways to different plant products. In this study, powders from four plant species viz *Lawsonia inermis, Hyptis suaveolens, Annona senegalensis* and *Azadirachta indica* were evaluated for their efficacy against *T. castaneum.* In several studies *H. suaveolens* essential oil has shown useful insecticidal properties against many foodstuff pests (Peerzada, 1997; Othira et al., 2009). *H. suaveolens* essential oil shown a toxic activity against *Plutella xylostella* (L.) (Lepidoptera Plutellidae) larvae and Callosobruchus maculatus (F.) (Coleoptera Bruchidae) adults (Kéïta et al., 2006; Tripathi and Upadhyay, 2009). In recent studies, it was reported that *H. suaveolens* essential oil had a marked toxic and repellent activity against adults of both *S. granarius* and *S. zeamais* (Motschulsky) (Coleoptera Dryophthoridae) (Conti et al., 2010; 2011).

L. inermis (Lythraceae) commonly called henna produces a burgundy dye, lawsone. This molecule has an affinity for bonding with protein, and thus has been used to dye skin, hair, fingernails, leather, silk and wool. The dye molecule, lawsone is primarily concentrated in the leaves, and is in the highest levels in the petioles of the leaf. Women use Henna (*L. inermis*) to dye or decorate their feet, hand, and skin and are not easily affected by fungal infection and bacterial infection. Henna has been found to exhibit antibacterial, antifungal and dermatological properties (Wren, 1988). *A. senegalensis* (Annonaceae) generally known as ‘African custard-apple’ is a potent medicinal plant generally used traditionally in the treatment of many diseases. Larvicidal effect of plant extracts belonging to the family of Annonaceae including *Annona muricata*, *A. cherimolia*, *A. squamosa*, etc against Anopheles sp., *A. aegypti* and *Culex quinquefasciatus* was reported (Saxena et al., 1993, Isman, 2006; Bobadilla-Alvarez et al., 2002). *A. senegalensis* has shown his insecticidal effect on different development stages of *Caryedon serratus* (Coleoptera: Chrysomelidae) (Gueye et al., 2011). In northern part of Cameroon, both the leaves of *A. senegalensis* and *B. dalzielii* were used locally to protect maize, millet and sorghum against weevils' attacks (Ngamo et al., 2007). Neem tree (*A. indica*) is a tree in the mahogany family Meliaceae; is evergreen tree found in most tropical countries. Traditional and Ayurvedic uses of neem include the treatment of fever, leprosy, malaria and tuberculosis. Various folk remedies are used as an anthelmintic, antifeedant, antiseptic, diuretic, emmenagogue, contraceptive, febrifuge, parasiticide, pediculicide and insecticide (Makeri et al., 2007; Subramanian et al., 1996; NRC, 1992; Mukherjee et al., 1955; Ernst, 2007). In view of the importance of these plants for their insecticidal properties, the insecticidal efficacies are to be tested on *T. castaneum* (Herbst).

The objectives of the study included to find the effect of different concentration(s) of powders of *L. inermis, H. suaveolens, A. senegalensis, A. indica* on *T. castaneum* and to evaluate the effects of these plants on the quality of groundnut seeds vis-a-viz weight and deterioration.

MATERIALS AND METHODS

Study area

This study was carried out in the Biological Science Laboratory of Kogi State University, Anyigba, Kogi State, Nigeria.

Sources and preparation of plant extracts

Fresh leaves of Neem (*A. indica*), Horehound (*H. suaveolens* L.), Wild custard apple (*A. senegalensis* Pers.) and Henna (*L. inermis* L.) were collected from Kogi State University environs. The plants were authenticated at the department of Botany, Kogi State University. The leaves were air dried for 2 weeks. When fully dried they were separately ground into fine powder. The powders were kept in air tight jars prior to use.

Preparation of groundnuts

Groundnut kernel (*A. hypogaea* L.) was purchased from Anyigba main market, Kogi State. Healthy groundnut seeds were carefully selected into a container and were preserved.

Source of pest (*Tribolium castaneum* Herbst)

The red flour beetle (*Tribolium castaneum* Herbst) were naturally obtained from infested stored groundnuts in Anyigba main market and kept in a jar containing groundnut to feed on. The adult beetles of uniform size were used for the experiments.

Experiment 1: The effects of the plant powders on damage of groundnut seeds by *Tribolium castaneum*

The four different powders were evaluated for their ability to protect seeds of groundnut against damage by *T. castaneum.* Three doses (10, 15 and 2g) of each plant powders were thoroughly mixed with250 g of groundnut in separate 2 L capacity jars. Thirty adult beetles were introduced into each of the jars. Aluminium phosphide (10, 15 and 20 g) was used as a standard and a control jar was included. The open end of each jar was covered with a lid lined with mosquito net to prevent escape of the insects. For 14, 21 and 28 days after introduction of the adult, the number of damaged seeds (seeds with holes) in each sample were determined by counting. The experiment was a completely randomized design (CRD) replicated thrice.

Experiment 2: Effect of the different plant powders on recovery of adult beetle of *T. castaneum* two weeks after treatment of groundnut

In a similar but separate experiment observations were taken on the number of surviving adults two weeks after treatment. Adults were considered dead if they did not move when touched or tilted.

Experiment 3: Effect of the plant powders on weight of groundnut seeds 6 weeks after introduction of plant powders

This experiment was also similar to experiment 1 except that the set up was left for 6 weeks. At the end of 6 weeks, the content of each jar was poured into a 5 mm sieve and mechanically shaken to separate the groundnut seeds from both the insects and the plant powder. The seeds were thereafter weighed. The effect of the plant powders on the weight of groundnut was determined by subtracting the final weight from the original weight of 250 g:

$$W_0 = W_1 - W_2$$

Where W_0= weight difference; W_1 = original weight (before infestation); W_2 = final weight (after infestation).

Data analysis

The data obtained is represented as Mean±SEM and were presented in Tables 1 to 3.

RESULTS

At 14-21 days after introduction of plant powders, untreated seeds had more holes than seeds treated with plant powders and aluminium phosphide (Table 1). Mean number of seeds damaged was quite low at 21 and 28 days for *A. indica* (0.66±0.33 and 0.33±0.33) and *L. inermis* (4.00±0.57 and 2.33±0.33) at 20 g concentration as compared with the control. Furthermore, *A. indica* and *L. inermis* powders were more efficacious in protecting groundnut seeds against damage than powders of *A. senegalensis* and *H. suaveolens.* Seed damaged assessment at 28 days post introduction showed that aluminium phosphide-treated seeds were not damaged.

At 14 days after introduction of plant powders, no live adults were recovered from aluminium phosphide-treated seeds (100% mortality). However, more adults were recovered from untreated seeds (0% mortality) than those treated with plant powders (Table 2). Fewer adults were recovered from seeds treated with *A*. *indica* (53.3% mortality) and *L. inermis* (33.33% mortality) at 20 g

Table 1. The effect of the plant powders on number of damaged groundnut seeds by *Tribolium castaneum* at 14, 21 and 28 days after introduction.

Treatment (g)	14 days	21 days	28 days
A. indica			
10	8.33±0.33	3.00±0.57	2.33±0.33
15	5.00±0.57	1.33±0.33	0.66±0.33
20	3.33±0.33	0.66±0.33	0.33±0.33
L. inermis			
10	7.00±0.57	4.66±0.33	3.66±0.33
15	5.33±0.33	4.66±0.88	2.33±0.66
20	4.33±0.33	4.00±0.57	2.33±0.33
H. suaveolens			
10	16.33±0.33	9.66±0.33	8.33±0.88
15	13.00±1.15	8.66±0.66	7.33±0.88
20	11.33±0.88	6.00±0.57	4.33±0.33
A. senegalensis			
10	16.00±0.57	8.33±0.33	4.66±0.33
15	9.66±0.88	5.66±0.88	3.66±0.66
20	8.66±0.33	4.00±0.57	3.33±0.33
Phostoxin (ALP)			
10	0.00±0.00	0.00±0.00	0.00±0.00
15	0.00±0.00	0.00±0.00	0.00±0.00
20	0.00±0.00	0.00±0.00	0.00±0.00
Control	18.66±0.88	14.66±1.45	10.00±1.15

Values are Mean±SEM

concentration which showed the highest % mortality of *T. castaneum* as compared to *H. suaveolens* (16.66% mortality) and *A. senegalensis* (20.0% mortality) at 20 g concentration.

At 6 weeks after introduction of plant powders, there was a drop of 40.89 g (16.36%) in the weight of untreated seeds from the original weight of 250 g compared to seeds treated with *A. indica* and *L. inermis* whose weight loss was 1.88 g (0.75%) at 20 g concentration and 5.05 g (2.02%) at 20 g concentration, respectively. *H. suaveolens* weight loss was 8.75 g (3.75%) at 20 g concentration and *A. senegalensis* powders weight loss was 7.72 g (3.08%) at 20 g concentration (Table 3). Aluminium phosphide-treated seeds suffered minimal weight loss of 0.16 g (0.06%) at 20 g concentration.

DISCUSSION

Recently, post-harvest loss of grain due to insect pests has become a major concern all over the world such that demand for good quality products, which are free from chemical residues, is high and increasing rapidly (Kashi,1981). The significantly fewer number of holes found on groundnut seeds treated with ground leaves of *A. indica* and *L. inermis* compared to untreated groundnut is an indication that these two plants can serve as protectants against *T. castaneum*. It is possible that the plants factors conferring protection on the seeds against *T. castaneum* may have repellent and antifeedant and toxic properties. If repellent and antifeedant, the adult pest would not be inclined to bore into the seeds to feed. If toxic, the adult pest may not do more than scarify the seeds before dying. If death does not occur immediately, the factor(s) may have a debilitating effect on the adult pest, and their life cycle may be unusually prolonged. Whatever is the case, the resultant effect is fewer number of holes and/ or scarifications on the seeds. Epidi et al. (2005) reported that neem leaf extract was efficacious against insect pest. Ivbijaro (1983) report shows the toxicity of neem seed (*Azadirachta indica* A. Juss).

The number of live adults recovered would further demonstrate the efficacy of the different plant powders. Fewer adults of *T. castaneum* were recovered from *A. indica* and *L. inermis* treated lots compared to other plant powders. Further, the number of adults recovered from the control was much higher than that from the ground leaf powder indicating that the materials did not support normal growth and development and caused mortality of *T. castaneum.*

These further show that these plants have great potential in protecting stored grains against *T. castaneum*.

Table 2. Effect of the different plant powders on the recovery of adults of *T. castaneum* at 14 days after treatment of groundnut.

Treatment (g)	Percentage mortality (%)
A. indica	
10	33.33
15	40.00
20	53.3
L. inermis	
10	26.66
15	33.33
20	33.33
H. suaveolens	
10	10.00
15	13.33
20	16.66
A. senegalensis	
10	16.66
15	16.66
20	20.00
Phostoxin (ALP)	
10	100
15	100
20	100
Control	0

Table 3. Effects of the plant powders on weight of groundnut seeds at 6 weeks after introduction of plant powders.

Treatment (g)	Difference in weight of groundnut $W_0=W_1-W_2$	$W_0/250 \times 100$ (%)
A. indica		
10	4.85	1.94
15	3.27	1.31
20	1.88	0.75
L. inermis		
10	7.38	2.95
15	6.11	2.44
20	5.05	2.02
H. suaveolens		
10	15.53	6.21
15	11.18	4.47
20	8.75	3.75
H. senegalensis		
10	12.48	4.99
15	9.53	3.81
20	7.72	3.08
Phostoxin (ALP)		
10	0.44	0.18
15	0.28	0.11
20	0.16	0.06
Control	40.89	16.36

T. castaneum inflicts serious damage on groundnut kernels, feeding on the embryo and endosperm (Davey et al., 1959). The efficacy of the plants powder as grain protectants against *T. castaneum* was clearly demonstrated by the reduction in weight of the untreated groundnut seeds compared with the treated ones. *A. indica* and *L.*

inermis possibly through a combination of repellency, feeding deterrence and toxicity limited feeding by *T. castaneum* hence recording the least weight loss.

The use of essential oils derived from plant materials in the control of weevil pests of stored products is legendary and it is a practice quite as old as civilization itself. Essential oils are commonly used because they are quite efficacious against all life stages of insects. Moreover, it has been widely reported that terpenes from a variety of essential oils derived from vegetative sources have potent insect pest control properties, which affect the biology of target insects in different ways by acting either as ovicides, repellants, antifeedants, fumigants, contact toxicants or insecticides (Hough-Goldstein, 1990; Watanabe et al., 1993; Rice and Coats, 1994; Tsao et al., 1995). It is therefore, possible that the efficacy seen with the dried leaves of the four botanicals against the pests (*T. castaneum*) could be attributed to these and other constituents.

Aluminium phosphide (ALP) is used as a rodenticide, insecticide and fumigant for stored cereal grains. It is used to kill small verminous mammals such as moles, rabbits, and rodents. The pellets typically also contain other chemicals which evolve ammonia which help to reduce the potential for spontaneous ignition or explosion of the phosphine gas. Pure phosphine is odorless, but technical grade phosphine has a highly unpleasant odor like garlic or rotten fish, due to the presence of substituted phosphine and diphosphine (P_2H_4). As rodenticide, aluminium phosphide pellets are provided as a mixture of food for the consumption by the rodents. The acid in the digestive system of the rodent reacts with the phosphide to generate the toxic phosphine gas. Phosphine is routinely used to kill insects found in stored products.

Conclusion and Recommendations

Botanical control is said to be the best pest control of stored grain pest because it is biodegradable, environmental friendly and does not leave toxic residue. Therefore, plant extracts can be another source of insecticides/pesticides against stored grain pest. The shortcomings of the use of synthetic chemicals which includes resistance by insects, adverse effect on non-target species, pollution of the environment including soil, water and air and hazard of residue necessitated the evolution of natural insecticides of plant origin (Deedat, 1994). It is recommended that the active molecule in *A. indica* and *L. inermis* responsible for its activities be isolated for the development of biopesticides to protect our grains in storage. For more effectiveness of plant extracts, a large amount proportional to the quantity of grains is required for post-harvest control of *T. castaneum* in stored groundnut for planting.

In conclusion, plant extracts have a good potential in serving as alternatives to synthetic pesticides because of their high efficiency and environmental friendliness.

Conflict of interest

The author did not declare any conflict of interest.

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