Management of the yam moth, *Dasyses rugosella* Stainton, a pest of stored yam tubers (*Dioscorea* spp.) using plant products

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Abstract

Yams are members of the genus *Dioscorea*, which produce bulbils, tubers or rhizomes that are of economic importance. West Africa accounts for 90-95% of world production, Nigeria being the major producer. In 2004, the total world production of yam was about 47 million metric tonnes (MT), with 96% of this coming from Africa. Nigeria accounts for about 70% of world production. In spite of the great economic importance of this food item, 20-30% (about 9.4-14.1 million tonnes) is lost during storage. Storage losses of the order of 10-15% after the first three months and approaching 50% after six months have been observed. Yam tubers in storage are attacked by several moth and beetle pests. The moth pests include *Dasyses rugosella* Stainton, *Euzopherodes vapidella* Mann and *Decadarchis minuscula* Walsingham. *Dioscorea alata* L (water yam) was found to be the most susceptible species of yam to infestation by these moths. The plant powders tested for their efficacy against *D. rugosella* included *Capsicum frutescens* L. (fruit), *C. annum* Miller (fruit), *Piper guineense* Schum and Thonn (seed), *Aframomum melegueta* Schum (seed), *Allium cepa* L. (scale), *A. sativum* L. (scale), *Citrus sinensis* Osbeck (peel) and *Azadirachta indica* A. Juss (leaf). In another experiment, the oil extracts of the following plants were tested against *D. rugosella*, *Jatropha gossypifolia* L. (fruits), *Arachis hypogaea* L. (seeds), *Citrus sinensis* Osbeck (seeds), *Elaeis guineensis* Jacq (kernel), *Piper guineense* Schum and Thonn (seeds), *Aframomum melegueta* Schum (seeds) and *Adansonia digitata* L. (fruits). Results showed that powders of *C. annum* and *C. frutescens* were effective against the adult moth producing 100% mortality within 24hrs of application of powder. In addition, *P. guineense*, *A. cepa* and *A. sativum* were effective against *D. rugosella* within 3 days of application of plant powder. However, *C. annum* and *C. frutescens* were able to effectively persist for 14days after application of plant powders. There was no fecundity of the moth in sample treated with *C. annum* and *C. frutescens* while fecundity was reduced in others. The survival of the moth from eggs to adults when treated with the plant powders showed that there was significantly ($P<0.05$) more adult emergence in the control (73.3%) compared to others. Oil extracts of *Arachis hypogaea* and *E. guineensis* were effective in preventing adult emergence. This study showed that some plant products (powders of *C. annum* and *C. frutescens* and oils of *A. hypogaea, P. guineense* and *E. guineensis*) were toxic or very effective against the yam moth, *D. rugosella* and the powders can be applied on cut or damaged surfaces of yam tubers to prevent hatching of the eggs of the moth thereby helping in their management and also minimize rotting.

Keywords: Toxicity, *Dasyses rugosella*, Management, Mortality, Powder extract

1. Introduction

Yams are members of the genus *Dioscorea*, which produce bulbils, tubers or rhizomes that are of economic importance. Yams are staple food for millions of people in the tropical regions of the world, as it is the second most important tropical root crop in West Africa after cassava. West Africa accounts for 90-95% of world production, Nigeria being the major producer (Osunde, 2008). In 2004, the total world production of yam was about 47 million metric tonnes (MT), with 96% of this coming from Africa. Nigeria accounts for about 70% of world production. In spite of the great economic importance of this food item, 20-30% (about 9.4-14.1 million tonnes) is lost during storage. Storage losses reach 10-15% after the first three months and approach 50% after six months (Osunde, 2008). The heavy post harvest losses and quality deterioration caused by storage pests are major problems of agriculture in developing countries, such as Nigeria. Several viruses, bacteria, nematodes, mammals and insects frequently attack the stored yam tubers. The most important insects that attack stored yam tubers are the beetles and

moths. The moths include *Dasyses rugosella* Stainton, *Euzopherodes vapidella* Mann and *Decadarchis minuscula* Walsingham.

Several attempts have been made to resolve the problem of food production confronting the tropical countries by placing emphasis on increasing production of grain crops with lesser attention given to tubers such as yams (Osagie, 1992). Chemical method still remains the most effective means of controlling both field and storage pests. Despite the success in the control of insect pests using synthetic insecticides, there are several drawbacks such as high mammalian toxicity, high level of persistence in the environment, health hazards, toxic residues on food, adverse effects on non-target organisms and pest resistance (Sighamony et al., 1986). These parameters have necessitated the use of other control measures which have little or no negative impact on the environment and are not toxic to mammals. One solution to these problems would be to replace synthetic chemicals with compounds, which occur naturally in plants (Olaifa et al., 1987). Vegetable oils, plant powders and extracts have been used to reduce post harvest losses of cereals and grain legumes (Lale, 1992; Odeyemi, 1998; Adedire and Lajide, 1999; Ofuya et al., 2007; Nwaubani and Fasoranti, 2008). So far, many reports on deterrent activity of plant products on stored product insects have been focused on beetle pests (Lale, 1992) and very few reports exist on the efficacy against moth pests. This work investigated the control of *D. rugosella* using plant products at 28±3°C and 75±5% r.h.

2. Materials and methods

2.1. Rearing of Dasyses rugosella

The infested water yam tubers, *Dioscorea alata* that formed the initial source of culture were collected from farms and market stores around Akure, Nigeria, and were brought to the laboratory. The infested tubers were kept in 2-lt jars. Signs of moth infestation of tubers included presence of black granules of larval faecal matter held together by silken threads and the presence of empty pupal cases on the surface of the tubers. The openings of the jars were covered with muslin cloth placed with rubber bands to prevent the escape of emerged adult moths. The jars were in turn kept inside insect breeding wire mesh cages (75x60x50cm^3). The four stands of the cages were placed in Petri dishes filled with water to which a few drops of kerosene were added to prevent access of predatory ants to the cultures. The Petri dishes were refilled with water whenever they were likely to dry up. A culture of *D. rugosella* was set up and maintained with healthy and fresh tubers as old infested tubers deteriorated. The culture and experiment were maintained at 28 ± 2°C and 75 ± 5% r.h.

2.2. Preparation of plant powders and extracts

Some of the plant parts used was purchased from the local markets in Akure and some were obtained from farms located within the Federal University of Technology, Akure, Nigeria. The main criterion for selecting the plants was that they are edible and form an important part of the diet of Nigerians. The plants included *Allium cepa* L., *A. sativum* L., *Citrus sinensis* Osbeck, *Capsicum annum* Miller, *C. frutescens* L., *Azadirachta indica* A. Juss, *Piper guineense* Schum and Thonn and *Aframomum melegueta* Schum. The characteristics of the plants evaluated are shown in Table 1. The plant parts were rinsed in clear water to remove sand and other impurities, cut into smaller pieces; sun dried and pulverized using an electric blender, then sieved to pass through 1mm mesh size and kept in specimen bottles until needed.

Table 1 Plants evaluated for their insecticidal activity.

Name of Plant	Common name	Family	Parts used
Citrus sinensis Osbeck	Sweet orange	Rutaceae	Seed/peel
Allium cepa L.	Onion	Liliaceae	Bulb
Allium sativum L.	Garlic	Liliaceae	Bulb
Capsicum annum Miller	Pepper	Solanaceae	Fruit
Capsicum frutescens L.	Chilly pepper	Solanaceae	Fruit
Piper guineense Schum & Thonn	Black pepper	Piperaceae	Seed
Aframomum melegueta Schum	Alligator pepper	Zingiberaceae	Seed
Arachis hypogaea L.	Ground nut	Papilionaceae	Seed
Jatropha gossypiofoila L.	Wild cassada	Euphobiaceae	Seed
Elaeis guineensis Jacq	Oil palm kernel	Palmae	Seed
Adansonia digitata L.	Baobab tree	Bombacaceae	Seed
Azadirachta indica A. Juss	Neem	Meliaceae	Leaf

Oil was extracted from the seeds of *Adansonia digitata* L., *Arachis hypogaea* L., *Aframomum melegueta* Schum, *Citrus sinensis* Osbeck, *Elaeis guineensis* Jacq, *Jatropha gossypifolia* L. and *Piper guineense* Schum & Thonn, using soxhlet extractor; these oils were tested as insecticides against the eggs of the yam moth. The different seeds were cleaned, sun dried and pulverized into fine powder using electric blender. One hundred grams of each powdered materials was weighed into a thimble and extracted with petroleum ether in a soxhlet extractor. The extraction was carried out for about four hours. Thereafter, the thimble was removed from the units and the petroleum ether was recovered by re-distilling the content of the soxhlet extractor at 40-60^{o}C. The resulting extract was air dried in order to remove traces of the solvent.

2.3. Experimental set up

Cut tubers of yam (*D. alata*) were kept in plastic jars after drying. Plant powders weighing 0.15 and 0.25g per species were measured using a sensitive weighing balance (Mettler E200). The different plant powders were applied evenly to the cut surfaces of the tubers measuring 7cm diameter and about 10cm long. The top of the jars was covered with muslin cloth. The bottoms of the plastic jars were lined with filter papers. Ten (0-24hr old) adult *D. rugosella* (4 males, 6 females) were placed in the jars containing treated tubers of yam. This was done for all the plant materials and the treatment replicated six times. The jars were arranged in a completely randomized manner in insect breeding cages. The mortality of the adults was recorded at 1, 2 and 3 d after the application of the powder. Mortality was also recorded after reintroduction of adults at 7, 14 and 21d after the application of the powder. At the end of three days, the adults, dead or alive were removed from the jars and the fecundity of adults in treated samples and the control were determined. Similarly, twenty (0-24 h old) eggs of *D. rugosella* were introduced on top of treated tubers using the above concentrations. The jars were observed daily and the number of adults emerging from each treatment was recorded.

In another experiment, 1 mL of each oil extract was spread on 9 cm diameter filter paper inside Petri dish and allowed to stay for a few minutes. Twenty (0-24 h old) eggs of *D. rugosella* were introduced on top of the filter papers and replicated three times. Percentage hatchability was recorded. The hatched eggs were then introduced on incisions made on small yam tubers and the number of adults emerging was recorded. All data obtained were subjected to analysis of variance and where significant differences existed, treatment means were separated using the Tukey's test.

3. Results

The effect of the various plant powders on mortality of *D. rugosella* at different periods after treatment is presented in Tables 2 and 3. In each treatment, the mortality of *D. rugosella* increased gradually with time of exposure. At both treatment levels, 100% mortality was obtained in those tubers treated with *Capsicum annum* and *C. frutescens* at 1 d after application. However after 3 d of application of powders, 100% mortality was produced in those tubers treated with *C. annum*, *C. frutscens*, *A. cepa*, *A. sativum* and *P. guineense*. There was no significant difference (P>0.05) in the mortality produced by *C. sinensis*, *A. indica* and *A. melegueta*. *C. annum* and *C. frutescens* powders were still effective after 14 days of application of powders.

Table 2 Mean percentage mortality of *Dasyses rugosella* adult treated with various powders (0.15g/16g of yam).

	Post treatment period (d), mean ± SE					
Powder	**1**	**2**	**3**	**7**	**14**	**21**
Allium cepa	66.7±3.8c	100.0±0.0d	100.0±0.0c	40.0±6.7b	20.0±8.2a	13.3±6.7ab
Allium sativum	40.0±7.8c	86.7±6.7c	100.0±00c	13.3±6.7a	13.3±6.7a	13.3±6.7ab
Citrus sinensis	0.0±0.0a	26.7±6.7a	60.0±6.7b	13.3±6.7a	13.3±6.7a	13.3±6.7ab
Capsicum frutescens	100.0±0.0d	100.0±00d	100.0±0.0c	100.0±0.0d	53.3±6.7b	26.7±6.7b
Capsicum annum	100.0±0.0d	100.0±00d	100.0±0.0c	86.7±6.7c	40.0±3.8b	20.0±6.7b
Azadirachta indica	0.0±0.0a	40.0±11.5b	73.3±11.5b	13.3±6.7a	13.3±6.7a	0.0±0.0a
Piper guineense	40.0±6.7c	80.0±6.7c	100.0±0.0c	33.3±6.7b	33.3±6.7ab	13.3±6.7ab
Aframomum melegueta	13.3±1.8b	20.0±6.5a	66.7±6.7b	33.3±6.7b	13.3±6.7a	0.0±0.0a
Control	0.0±0.0a	10.0±0.0a	10.0±0.0a	10.0±0.0a	10.0±6.7a	10.0±0.0a

* Means followed by the same letter in the same column are not significantly different at 5% significance limit using Tukey's test.

Table 3 Mean percentage mortality of *Dasyses rugosella* adult treated with various plant powders (0.25g/16g of yam).

	Post treatment period (days) mean ± SE					
Powder	**1**	**2**	**3**	**7**	**14**	**21**
Allium cepa	80.0 ± 11.5c	100.0±0.0d	100.0±0.0c	66.7±11.5c	20.0±6.7b	20.0±11.5b
Allium sativum	40.0 ± 11.5b	100.0±0.0d	100.0±0.0c	33.3±6.7b	13.3±6.7a	13.3±6.8ab
Citrus sinensis	26.7 ± 6.7b	66.7±6.7c	80.0±0.0b	33.3±6.7b	13.3±6.7a	0.0±0.0a
Capsicum frutescens	100.0 ± 0.0d	100.0±0.0d	100.0±0.0c	100.0±0.0d	73.3±6.7c	26.7±6.7b
Capsicum annum	100.0 ± 0.0d	100.0±0.0d	100.0±0.0c	100.0±0.0d	53.3±6.7bc	13.3±6.7b
Azadirachta indica	0.0 ± 0.0a	60.0±0.0c	80.0±0.0b	33.3±6.7b	13.3±6.1a	10.0±0.0a
Piper guineense	66.7 ± 6.7c	100.0±0.0d	100.0±0.0c	46.7±6.7b	40.0±11.0b	13.3±6.7ab
Aframomum melegueta	20.0±11.5ab	33.3±6.7b	86.7±6.7b	40.0±0.0b	13.3±6.7a	13.3±6.7ab
Control	0.0±0.0a	10.0±0.0a	10.0±0.0a	10.0±0.0a	10.0±6.7a	10.0±0.0a

*Means followed by the same letter in the same column are not significantly different at 5% significance limit using Tukey's test.

The fecundity of *D. rugosella* showed that no eggs were laid on samples treated with *C. annum* and *C. frutescens* at both treatment levels (Table 4). When eggs were introduced on treated tubers of yam, significantly ($P<0.05$) more adult emergence was recorded in the control than treated samples (Table 5), although the value was lowest in samples treated with *C. frutescens*.

Table 4 Fecundity of *Dasyses rugosella* treated with various plant powders.

	0.15g/16g of yam		**0.25g/16g of yam**	
Plant	**Mean total no of eggs laid ± SE**	**No of eggs per individual**	**Mean total no of eggs laid ± SE**	**No of eggs per individual**
Allium cepa	40.0 ± 1.8b	6.7	0.0 ± 0.0a	0.0
Allium sativum	60.0 ± 3.2b	10.0	23.4 ± 1.7b	3.8
Citrus sinensis	160.2 ± 5.1c	26.7	62.6 ± 4.7c	10.4
Capsicum frutescens	0.0 ± 0.0a	0.0	0.0 ± 0.0a	0.0
Capsicum annum	0.0 ± 0.0a	0.0	0.0 ± 0.0a	0.0
Azadirachta indica	200.0 ± 11.1c	33.3	119.4 ± 5.2d	19.9
Piper guineense	60.0 ± 5.0b	10.0	55.4 ± 4.3c	9.2
Aframomum melegueta	170.0 ± 7.2c	28.3	72.0 ± 3.5c	12.0
Control	437.4±46.5d	72.9	437.4 ± 46.5e	72.9

*Means followed by the same letter in the same column are not significantly different at 5% significance level using Tukey's test.

Table 5 Survival of *Dasyses rugosella* eggs treated with various powders.

Powder	**No of eggs incubated**	**0.15g/16g of yam % adult emergence**	**0.25g/16g of yam % adult emergence**
Allium cepa	20	26.7 ± 1.6c	25.0 ± 2.5c
Allium sativum	20	30.0 ± 2.1b	30.0 ± 1.9b
Citrus sinensis	20	43.3 ± 1.9b	41.7 ± 2.6b
Capsicum frutescens	20	13.3 ± 2.0d	10.0 ± 1.9d
Capsicum annum	20	15.0 ± 2.0d	15.0 ± 1.9d
Azadirachta indica	20	36.7 ± 3.5b	35.0 ± 3.5b
Piper guineense	20	25.0 ± 1.9c	21.7 ± 2.3c
Aframomum melegueta	20	33.0 ± 2.1b	35.0 ± 3.8b
Control	20	73.3 ± 1.6a	73.3 ± 1.6a

*Means followed by the same letter in the same column are not significantly different at 5% significance level using Tukey's test.

The bioassays also showed that some plant powders were effective in controlling *D. rugosella*. Also oils from seeds of *Arachis hypogaea*, *Elaeis guineensis, P. guineense* and *Jatropha gossypifolia* were effective in controlling the eggs of *D. rugosella* (Table 6).

Table 6 Effect of oil extract on egg of *Dasyses rugosella.*

Name of extract	% Hatchability	% Adult emergence
Jatropha gossypiofolia	50.0 ± 8.7d	46.7 ± 3.6d
Arachis hypogaea	3.3 ± 0.7a	0.0 ± 0.0a
Citrus sinensis	53.3 ± 1.7d	48.7 ± 6.7d
Elaeis guineensis	16.7 ± 6.7b	10.0 ± 2.3b
Piper guineense	16.7 ± 4.7b	6.7 ± 1.3b
Aframomum melegueta	40.0 ± 3.6c	33.3 ± 6.7c
Adansonia digitata	53.3 ± 2.5d	46.7 ± 2.7d
Control	73.0 ± 7.2e	53.3 ± 3.3e

*Means followed by the same letter in the same column are not significantly different at 5% significance level using Tukey's test.

4. Discussion

The two *Capsicum* species, *C. annum* and *C. frutescens* powders were very effective against *D. rugosella* causing 100% mortality of adults within 1 d of application. They also reduced oviposition and suppressed adult emergence showing that they probably have oviposition-deterrent and ovicidal properties. The observed activity may be due to the "pepperish" nature and pungency of the *Capsicum* species. The pungency of *Capsicum* species was attributed to capsacin (Miyakado et al., 1979). The powders of *A. cepa*, *A. sativum* and *P. guineense* were also slightly effective against the moths from this study producing 100% mortality of adults at 3 d after application. These powders probably acted through contact and fumigant mode of action. The biological activity of *P. guineense* was ascribed to the presence of chavicin and piperine, an unsaturated amide (Lale, 1992).

Plant products have been extensively used against Coleopteran pests such as *Callosobruchus maculatus* (F.) and *Sitophilus zeamais* Motschulsky (Ashamo and Odeyemi, 2001; Maina and Lale, 2005; Oparaeke and Dike, 2005; Kachhwaha et al., 2006; Ofuya et al., 2007). However there is paucity of information on the control of moth pests of yam tubers using plant products. Ofuya et al. (2007) observed that powders from dry flower buds of *Eugenia aromatica* Baill. and dry fruits of *P. guineense* were effective against *C. maculatus*.

The oil of *A. hypogaea* was very effective in suppressing adult emergence in *D. rugosella* with no adult emergence while the oil from *P. guineense* and *E. guineensis* were also effective against the eggs since adult emergence was significantly lower than that in the control. Many vegetable oils have been screened for use in preventing post-harvest losses due to insects (Golob and Webly, 1980; Don Pedro, 1989). For example, Don Pedro (1989) showed that some vegetable oils (ground nut, traditional coconut, industrial coconut, palm, and shark silver oil) were able to kill eggs of *Dermestes maculatus* Degeer on dried fish. The oil probably blocked the minute perforations on the surface of the eggs causing suffocation due to lack of oxygen.

Since adult moth do not feed on food commodities but only visit to deposit their eggs the use of oviposition inhibitors would be advantageous for the management of lepidopteran pests. The powders of these plants could be applied to cuts or bruises on the surface of yam tubers before storage. Local farmers have been known to apply neem powder to cuts on yam tubers. All the plants whose powders were used are edible and many are spices and form an important component in the diet of tropical people and are therefore likely to be safe for human consumption at least at the rates applied in this study. Further research is being carried out on the *Capsicum* species to determine their bioactive compounds.

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