

Original Research Article

The Effectiveness of *Dennettia tripetalla* (G. Backer), *Xylopi aethiopica* (A. Rich) and *Aframomum melegueta* (K. Schum) Extracts for the Control of *Cylas puncticollis* (Boheman) infesting sweetpotato in Calabar, Nigeria

ABSTRACT

Laboratory investigations were performed to ascertain the efficacies of *Dennettia tripetalla* (G. Backer), *Xylopi aethiopica* (A. Rich) and *Aframomum melegueta* (K. Schum) for the control of *Cylas puncticollis* (Boheman), an African sweet potato weevil. Extracts of the leaves and fruits of the test plants were separately applied at concentration of 1, 3 and 5 % (w/v) for investigation. The biological assays were conducted for six months under plethoric ambient temperature, relative humidity (28±3°C, 65±5% RH) and 12Hr light/dark photoperiods; laid out in a completely randomized design with each treatment replicated four times. Results disclosed that 3 and 5 % extracts of the three test plants led to significantly (P<0.05) higher mortality of *C. puncticollis* as when compared to 1% and control (3.75 extract of the tubers). n-hexane extracts of all the test plant products significantly (P <0.05) repelled more than 60% of *C. puncticollis* within one-hour of exposure. —Extracts of *A. melegueta* fruit (at 3 and 5%) and *X. aethiopica* fruit (at 5%) had the most significant (P<0.05) insecticidal activity, followed by extract of *D. tripetalla* (at 5%). Adult emergence was also significantly higher in control than treated tubers with *A. melegueta* products giving the lowest significant number of emerged adults. Quantitative analysis of the plant products revealed the presence of active phytochemicals, such as alkaloids flavonoids, tannins, saponins, steroids, carotenoids and phenols in various proportions. The results of this research demonstrate the efficacies of the test plants extract products for the control of *C. puncticollis* infesting sweet potato roots during post-harvest storage at the small scale farming level in Calabar, Nigeria.

Keywords: Extracts, *Cylas puncticollis*, plethoric temperature, mortality and insecticidal activity

1. INTRODUCTION

1.1 Background

Sweet potato (*Ipomoea batatas* [L.] Lam.) is a dicotyledonous plant and a member of the family convolvulaceae. It originated from Central America [1] and is now widely grown —in many parts of the tropics, subtropics and temperate regions of the world [2]. A small herbaceous, annual or perennial, trailing root crop, it is believed to have evolved from the non-tuberous wild

Comment [C.N1]: It has been accept internationally that sweetpotato can be written as one word.

Comment [C.N2]: Location where this work was done.

Formatted: Font: Italic

Comment [C.N3]: What kind of extract, i.e. aqueous, powder etc.?

Comment [C.N4]: Not clear?

Comment [C.N5]: Quantitative analysis was not carried out in this work, therefore it should be deleted.

relative, *Ipomoea trifrida* which has the same chromosome number $2n = 90$ with *Ipomoea batatas*[3]. The crop has many cultivars differentiated on the basis of the texture and color of the tuber, leaf shape and structure, root depth in the soil and maturation time. It is propagated vegetatively and has a growth period that varies between four to six months depending on the variety and place of cultivation (Ref.?). It can be grown on relatively infertile ground with little input and can withstand irregular periods of drought and rainfall [4].

Globally, Sweet potato is the seventh most important crop among all known edible crops (Ref.?). About ninety-two percent of the sweet potato produced universally is ~~from~~ done in Asia and Pacific Islands, and 89% of this is cultivated in China. The United States produces 1million metric ton (MT) valued at \$200million annually (Ref?), however, about two thirds of the world production is utilized in one country, China [5]. In Africa, Nigeria ranks first with sweet potato production level of 3.49 million metric tons, but this is about 0.2% of the world's sweet potato [6] Sweet potato is exploited as a basic ingredient of diet, vegetable (the succulent roots, leaf stalks and tender leaves), snack, feed for animals, starch is obtained from it industrially, amongst others [7].

Sweet potato, unlike other tubers (yam and cassava) is grown in smaller volumes in Africa. In Nigeria for example, root crop survey by National Root Crops Research Institute, Umudike, Abia State in 2000 and 2005, showed that the crop was grown mainly in the North and Middle Belts regions of the country. It has however been introduced to the South and is becoming a very popular staple food among the low income earners [1]. Though, still considered a minor crop in Cross River State, its cultivation and use is gaining grounds and the crop will undoubtedly become increasingly popular in the years to come, as increasing population generally necessitates an expansion of food supply options in any community, and especially as there has been some increase in market prices of cassava, cocoyam, and yam, in Calabar, and

Comment [C.N6]: Check current stat.

other urban areas in the State, in recent times. Due to the aforementioned situation, and in addition to increasing agricultural awareness, there is a diversification of emphasis from cultivation of yam, cocoyam and cassava, to the production of sweet potato, which until recently had been grown by crude methods on circumscribed areas of Northern Nigeria [8].

1.2 Problem statement/justification of study

The cultivation and storage of sweet potato ~~tubers~~ are bordered by certain determinants, such as climatic conditions, soil fertility, pathogenic nematodes and insect pests, cause both qualitative and quantitative losses. Insect pests are major cause of damage to the tuber during these processes, resulting in enormous losses. Sweet potato weevils of the genus *Cylas* is predominant insect pest, limiting cultivation and storage of sweet potato tubers worldwide [9].

Comment [C.N7]: Please sweetpotato is a root and not a tuber crop?

Although chemical pesticides are known to have effective and rapid reduction of pests on crops, but because of their toxic effects on the environment and non- target organisms [10], there is currently a preference for “integrated pest management”, a decline in absolute dependence on chemical pesticides. One approach being explored vigorously is the utilization of available plant materials as bio-pesticides, for local pest control especially in poor communities [11]. In Cross River State, the impact of *C. puncticollis* on sweet potato has been reported by Nta and Oku, [12] but there is no documentation of any substantial effective post-harvest control measure against this insect, especially with regards to bio-pesticides.

Cross River State has favourable ~~conditions~~~~indices~~ for the cultivation of ~~three sets of~~ sweet potato thrice in a year. The increase cultivation implies an impending increase in population density of *Cyclas* sp., hence the necessity for locally suited, cheap and eco-friendly control strategies involving the use of available plant materials for this important pest in small-scale cultivation and storage systems.

Many spices and other plant substances in form of extracts, powders and pellets could be channeled as possible 'entomotoxicants', deterrents, anti-feedant and anti-reproductive agents for the riddance of pests in stored tubers.

Dennettia tripetalla (G. Baker) (Annonaceae) commonly known as pepper fruit because of the strong pepperish and pungent taste of the leaves, bark and root is commonly found in the tropical rainforest of southern Nigeria. *D. tripetalla* have been reported to have analgesic and anti-inflammatory effects on mice and rats [13], antifungal effects [14] and insecticidal activities against *Sitophilus oryzae* [15].

Xylopia aethiopica (Dunal) (Annonaceae); the African spice plant, is an evergreen plant distributed in West Africa. It is reported to have medicinal value against skin infection, candidiasis, stomach ache, antibacterial, antifungal action [16] and insecticidal effects against mosquitoes and termites [17].

Aframomum melegueta (K. Schum) is a perennial and herbaceous, aromatic plant in the family Zingiberaceae, cultivated for its spicy, fleshy, pungent and aromatic fruits/seeds. Commonly called grains of paradise, it is widely distributed along the coast of West Africa. *A. melegueta* is used to control post-partum bleeding, helminthic infestation, congestion, heartburn and inflammatory conditions in humans. Oparaekpe *et al.*, [18] reported that the fruit has insecticidal action against post-flowering insect pests of cowpea and storage insect pests [19].

This research is undertaken to assess the insecticidal effects of *A. melegueta*, *X. aethiopica* and

D. tripetalla leaves and fruits extracts against *C. puncticollis*, a sweet potato tuber weevil.

Infesting stored sweetpotato roots.

Comment [C.N8]: It attacks all the plant parts

2. MATERIALS AND METHODS

The experiments were done at the Department of Zoology and Environmental Biology, University of Calabar, in Calabar Municipality of Cross River State (5° 45' N, and 8° 30' E), Nigeria, between September, 2012 and March, 2013. The climateic condition in Cross River State is characterized by a ~~pattern of alternating~~ wet (April to September) and dry (October to March) seasons with mean annual precipitation of 260.0mm in 2012 and 220.6mm in 2013, atmospheric temperature range 34.3°C to 22.3°C and an average relative humidity in the range of 68-92% percent.

Comment [C.N9]: Is this in mm or cm. check again.

2.1 Collection of test plant materials

The leaves and fruits of *D. tripetalla*, *X. aethopica* and *A. melegueta* were used. The leaves were collected from Germplasm of Department of Genetics and Biotechnology, University of Calabar, Nigeria, while the dry fruits were bought from a local market in Calabar. The plant parts were carried in aseptic polythene packs to the Herbarium unit in Botany Department of University of Calabar, and the plant identities confirmed.

2.2 Preparation of extract of test plant substances

The extraction of essential oil from each plant substance was done using n-hexane as solvent. Two hundred grams (200g) of individual ground sample was liquesce in 500cm³ of n-hexane in an absracting thimble and put in a soxhlet apparatus for abstraction. The condenser of the apparatus was connected to water supply. Temperature of the heating mantle was maintained at 60 – 65°C. The extraction process was carried out for 5–6 hours for each sample. The filtrate was evaporated in a rotary evaporator under reduced pressure at 40°C. The resultant essential oil from each plant was sealed in a labeled reagent bottle and stored in refrigerator for further biological assay.

Comment [C.N10]: Did you mean extracting?

Comment [C.N11]: Ditto

2.3 Rearing and maintenance of *Cylas puncticollis* population.

Cylas puncticollis infested ~~rootstubers~~ harvested from an abandoned Sweet potato farm in University of Calabar were used to establish the stock. These insects were reared and maintained on sweet potato tubers under ~~environmental~~ ambient temperature of $28 \pm 2^{\circ}\text{C}$ and relative humidity of $70 \pm 5\%$, 12 hour dark/light photoperiods. Rearing was done in wooden-netted cages of dimension $(20 \times 20 \times 20) \text{ cm}^3$ each and mesh size 0.25mm. 150g of sterile sweet potato ~~tubers~~ roots were weighed using Mettler Toledo-technology digital weighing balance) and placed in each cage. Thirty pairs (15 males and 15 females) of adult *C. puncticollis* were later introduced into each cage and the door shut.

Adult insects in each rearing cage ~~were as kept~~ held for 14 days to mate and oviposit ~~succeeding which they were taken out and thrown out and were discarded afterwards.~~ Insects for the experiments were taken from this stock.

2.4 Experimental designs

Laboratory assays were conducted in a completely randomized design,– using fruits and leaves extracts of *A. melegueta*, *X. aethiopica* and *D. tripetalla*; applied at three treatment doses (1 percent, 3 percent and 5 percent) for each plant and a control; giving a total of nineteen treatment groups. Each treatment was replicated four times giving a total of seventy six experimental units.

2.5 Application of treatments and collection of data

2.5.1 Weevil mortality test

To assess the contact effects of n-hexane extract of test plant parts on mortality of *Cylas puncticollis* (adults), 100g of disinfected sweet potato tubers –were weighed into a transparent plastic container $[(12 \times 12 \times 6.0) \text{ cm}^3]$ for each replicate. Each treatment was administered by direct admixture to the tubers at different rates (1 percent, 3 percent and 5

percent), calculated on the basis of weight of test plant extract to weight of sweet potato tuber (w/w) while the control received no treatment. Ten pairs of one-day old *Cylas puncticollis* full grown insects were imported into exclusive test containers to mate and oviposit for 5 days. Test containers had their covers bored through and covered by nylon mesh (size = 0.25mm) to facilitate confinement of weevils and aeration. The layout was done on the laboratory bench in a completely randomized design (CRD) with each treatment replicated four times.

Adult mortality count was done at 24, 48, 72 and 96 hour post-treatment. At each count the numbers of dead weevils were noted, the dead weevils removed and thrown out while the ones alive were left to continue the experiment. Insect was considered dead, when no movement was exhibited by it when pricked with an entomological needle. After one week the weevils were thrown out, and the tubers kept aside for F₁ progeny emergence. From these data, percentage weevil mortality at 24, 48, 72 and 96 hours succeeding treatment were calculated as;

$$\frac{\text{Number of dead weevil/treatment}}{\text{Total number of weevils}} \times 100$$

2.5.2 Adult *C. puncticollis* emergence and reproductive potential inhibition test (RPI)

The emergence and percentage reproductive potential inhibition test of adult *C. puncticollis* were determined based on the emergence of first filial generation (F₁) progeny. Five weeks following the removal of the weevils from the weevil mortality bioassay, the full grown weevils coming out from each treatment were numbered and noted. These count data gave a measure of the effect of the extract on weevils' reproduction (reproductive capacity inhibition test). Emerged weevils were sieved out daily to prevent mating and subsequent oviposition by

F₁ progeny (Stathers *et al.*, 2005). The bioassay was concluded after seven weeks when there were no more emergence of adults. All data obtained for RPI test were determined from adult emergence using the formulae;

Comment [C.N12]: Not listed at reference section. Use appropriate style for this journal.

Reproductive Potential Inhibition (RPI) =

$$\frac{\text{No. of adult emerging in Control} - \text{Adults emerging in treatment}}{\text{Number of Adults Emerging in Control}} \times 100$$

2.5.3 Weevil damage test

Effects of test plant extract on degree of weevil damage of tubers were assessed based on number of tubers perforated with more than five exit – holes at ten weeks post treatment. Count data were taken on number of tubers perforated.

All biological assays were repeated five times and data obtained were pulled and subjected to analysis. The percentage of damage caused by the *C. puncticollis* to the tubers was computed following the method of Adedire and Ajayi (1996)

Comment [C.N13]: Not listed at reference section. Use appropriate style for this journal.

1. Percentage Damage (PD) = $\frac{\text{No. of treated tubers perforated}}{\text{Total number of tubers}} \times 100$

2. Weevil perforation index (WPI) was also calculated from the obtained data by Fatopeet *al.*, (1995) method.

Weevil perforation index (WPI) =

$$\frac{\% \text{ of perforated tubers in treatment}}{(\% \text{ of perforated tubers in control}) + (\% \text{ of perforated tubers in treatment})} \times 100$$

2.6 Statistical analysis

Data obtained ~~were subjected to for respective study parameters were evaluated~~ employing one-way analysis of variance (ANOVA) ~~and to check for~~ significant differences between the various treatments determined using Waller-Duncan Post hoc. test. All data analyses were undertaken using SPSS version 17.0 software for windows, and conclusions drawn at 95% probability level.

3. RESULTS

3.1 Toxicity Biological Assays

3.1.1 Weevil mortality

At 96 hours post treatment, significant differences ($P < 0.05$) were observed among the plant products extracts of *Xylopia_aethiopica*, *Dennettia_tripetalla*, *Aframomum_melegueta* and control on cumulative mean mortality (%) of adult *Cylas_puncticollis*.

n-hexane extract of the three test plants significantly ($P < 0.05$) increased cumulative mean mortality of adult *C. puncticollis* than their control. Fruit extracts of *A. melegueta* was the most potent giving the highest mortality of 100 percent at 3 percent and 5 percent concentrations. This was followed by fruits extract of *A. melegueta* at 1 percent, *X. aethiopica* at 1 percent and *D. tripetalla* at 1 percent and 3 percent which gave 80.0 percent, 77.50 percent, 73.75 percent, and 81.25 percent mortality of insects respectively. There were also variations on the effects of the leaves extract on mortality. *A. melegueta* leaves extracts at 3 percent and 5 percent were significantly ($P < 0.05$) more lethal to *C. puncticollis* than other leaves extracts and control. 1 percent *A. melegueta* leaves extract however similar effect with 5 percent *X. aethiopica* had and 5 percent *D. tripetalla* leaves extracts.

3.1.2 Effects of n-hexane extracts of test plant on repellent of adult *C. puncticollis*

The repellent bioassay showed that extracts of *A. melegueta* had the greatest repellent effect on *C.puncticollis*, followed by *X. aethiopica* and then *D. tripetalla*. With respect to plant parts, fruits extract of *A. melegueta* was the most potent while fruit extract of *D. tripetalla* had the least repellent effect on adult *C.puncticollis*. A similar trend was observed on the repellent potency of the leaves extracts with *A. melegueta* repelling 72.08%, followed by *X. aethiopica* which repelled (70.41%) and the least being *D. tripetalla* which repelled 60.41% of the insects.

At 3 and 5%, *A. melegueta* fruits and leaves extracts, *X. aethiopica* fruits and leaves extracts, as well as 5% *D. tripetalla* leaves and fruits extracts, *C. puncticollis* adults were repelled significantly ($P < 0.05$) more than at all other concentrations.

1% *A. melegueta* and 3% *D. tripetalla* fruits extract repelled a similar percentage of *C. puncticollis* while 3% *D. tripetalla* leaves extract and 1% *X. aethiopica* fruit extract had comparable effects. The concentrations that were least repellent were; 1% leaves extract of *X. aethiopica*, *D. tripetalla* and *A. melegueta*, as well as 1% fruit extract of *D. tripetalla*.

3.2 Weevil damage/weevil perforation index (WPI)

When compared with controls where plant materials were not applied, all test plants extracts gave significantly lower ($P < 0.05$) percentage tuber damage. Extracts of the three test plants also followed a similar trend with the control having the highest and significantly different ($P < 0.05$) weevil damage on sweet potato tubers (38.29 percent). *A. melegueta* fruit extracts at 3 percent (7.57 percent) and 5 percent (5.47 percent); *X. aethiopica* fruits extract at 1 percent (10.62 percent), 3 percent (8.52 percent) and 5 percent (8.57 percent) and *X. aethiopica* leaves at 5 percent (8.48 percent) all had comparable effects and lowest percentage weevil damage on the tubers.

3.3 Cumulative progeny emergence and weevil reproductive potential inhibition (RPI)

All the test plants extracts individually showed a significant effect ($P < 0.05$) on progeny emergence when compared with the control. The control gave the highest cumulative mean progeny emergence of *C. puncticollis* (160.00) which was statistically significant ($P < 0.05$) from progeny emergence in all other treatments.

The extract of the respective plant part was potent in inhibiting reproduction and reducing adult emergence. The lowest number of progeny emerged was in 5% *A. melegueta* fruit extract (13.75, RPI – 97.40%). At 5%, *X. aethiopica* fruit (28.00, RPI – 82.50%), *D. tripetalla* fruits (29.50, RPI – 81.56%) and *A. melegueta* leaves extracts had similar effect (26.75, RPI = 85.28%) on cumulative progeny emergence and reproductive potential inhibition (RPI).

Table1

Effect of extracts of *A. melegueta*, *D. tripetalla* and *X. aethiopica* on *C. puncticollis* damage (%) and weevil perforation index (WPI) of sweet potato tubers

	Plant parts	Conc. %w/w	Weevil damage (%)	WPI (extracts)
<i>A. melegueta</i>	Fruits	1	11.52 ^b ± 2.53	22.54 ^b ± 3.87
		3	7.51 ^a ± 0.88	16.30 ^a ± 1.58
		5	5.47 ^a ± 0.86	12.39 ^a ± 1.72
	Leaves	1	14.95 ^c ± 1.06	27.99 ^f ± 1.44
		3	12.47 ^b ± 1.78	22.80 ^b ± 2.52
		5	18.57 ^a ± 1.76	14.93 ^a ± 2.56
<i>D. tripetalla</i>	Fruits	1	15.09 ^c ± 2.33	27.86 ^f ± 3.68
		3	13.60 ^c ± 2.20	25.79 ^e ± 3.27
		5	12.03 ^b ± 1.76	23.89 ^c ± 2.41
	Leaves	1	15.16 ¹⁰ ± 1.34	28.23 ^f ± 1.81
		3	14.25 ^d ± 1.51	26.93 ^f ± 2.22
		5	12.45 ^d ± 1.86	24.23 ^d ± 2.81

<i>X.aethiopica</i>	Fruits	1	10.62 ^a ± 1.28	21.54 ^b ±2.08
		3	8.52 ^a ± 1.01	18.08 ^a ±1.80
		5	7.02 ^a ± 1.21	15.31 ^a ±2.28
	Leaves	1	13.55 ^c ± 1.60	25.92 ^c ±2.32
		3	11.60 ^b ± 1.47	23.04 ^b ±2.29
		5	8.48 ^a ± 0.91	18.03 ^a ±1.60
Control	0	0	38.29 ^f ± 4.29	49.53 ^g ±2.75

Values are presented as Mean ± SEM. Values in each column having similar superscript are not significantly different based on Waller-Duncan Post hoc. test

Table2

Effect of n-hexane extracts of *D. tripetalla*, *A. melegueta* and *X. aethiopica* on cumulative progeny emergence and reproduce potential inhibition (RPI) of *C. puncticollis*

Plants	Plant parts	Conc. %w/w	Cumulative progeny emergence (extract)	Reproductive Potential Inhibition (RPI) extract
<i>A. melegueta</i>	Fruits	1	38.75 ^c ± 1.10	75.78 ^c ±0.69
		3	32.00 ^c ± 0.91	79.99 ^{gh} ±0.5
		5	13.75 ^a ± 0.85	91.40 ^k ± 0.53
	Leaves	1	58.00 ⁱ ± 1.08	63.74 ^c ± 0.67
		3	33.75 ^d ± 0.94	78.90 ^g ± 0.59
		5	26.75 ^b ± 1.17	83.28 ^j ±0.69
<i>D. tripetalla</i>	Fruits	1	80.00 ^k ± 0.81	50.00 ^a ±0.51
		3	57.00 ⁱ ± 0.81	64.37 ^c ±0.51
		5	29.50 ^b ± 2.39	81.56 ^{hi} ±1.49
	Leaves	1	84.00 ^L ± 1.82	47.50 ^a ±1.14

		3	80.00 ^k ± 1.08	49.99 ^a ±0.67
		5	71.75 ^j ± 1.10	55.15 ^b ±0.69
<i>X. aethiopica</i>	Fruits	1	51.00 ^b ± 1.29	68.12 ^d ±0.80
		3	42.25 ^a ± 1.10	73.59 ^c ±0.69
		5	28.00 ^b ± 1.82	82.50 ⁱ ±1.14
	Leaves	1	68.50 ^j ± 1.55	56.71 ^d ±0.69
		3	49.50 ^h ± 1.70	69.06 ^d ±1.06
		5	36.00 ^e ± 0.91	77.49 ^f ±0.57
Control	0	0	160.00 ^m ±1.08	

Values are presented as Mean ± SEM. Values in each column having similar superscript are not significantly different based on Waller-Duncan test

4. DISCUSSION

The results obtained from this research showed that the leaves and fruits of *Aframomum melegueta*, *Dennettia_tripetalla* and *Xylopia_aethiopica* had varying levels of insecticidal activities. When compared to the control, all the plant materials were effective in reducing insect population under laboratory conditions; however their effectiveness increased with increase in concentration.

Plants have been reported to have phytochemicals which act as chemical defenses against herbivores and other organisms in the environment [20]. It is therefore possible that the strong pungent odour produced by these plants prevented the weevil from normal feeding which resulted in starvation and their subsequent death [21] [22].

Results from the biological assays indicated that all plants extracts had significantly higher insect mortality than the control. The highest mortality observed in *A. melegueta* fruit extract at 3% and 5% and *X. aethiopica* fruit extract at 5% treatment doses, within 24 hour exposure time,

confirmed the report by Kouninkiet *al.*, [23] that essential oils from whole fruits or leaves of aromatic plants exhibited acute toxicity on coleopteran storage pests such as *C. puncticolis* and *S. zeamais*.

The Phytochemical screening of *X. aethiopica* showed the presence of α -pinene, β -pinene, 3-carene and terpinene-4-ol, that of *D. tripetalla* revealed the presence of β -phenylnitroethane, alkaloids, dennettine, three phenanthrine alkaloids, spotted as ovariopsine, stephenanthrine and argentinine and a simple phenolic compound vanillin [24], while that of *A. melegueta* contained five mono-terpenoids; α -Linalools, 1,8-cineols, (S)-2 heptylacetate, (S)-2-heptanol and citrate. The presence of these anti-oxidant and semio-chemical in the test plants must have been responsible for the toxicity of the oil extracts.

Biological assay on adult repellent indicated that the leaves and fruits of the three test plants at 3 and 5% application doses repelled *C. puncticolis* in a similar way within 60 minute of exposure. The observed increase in repellence effect with increasing concentration at limited time of exposure was due to the presence of semio-chemicals in the test plants that may have probably changed the behavior of the insects through the chemoreceptors present in the antennae. These semio-chemicals probably provided a vapour barrier preventing *C. puncticolis* from touching tubers surfaces [25]. These observations also correspond with the reports of Tapondjouet *al.*, [26], Ukehet *al.*, [27], Talukdar and Howse [28], Javid and Poswal [29] and Egwunyengaet *al.*, [30] who separately reported that n-hexane or ethanolic extract of *D. tripetalla*, *A. melegueta* and *X. aethiopica* could individually cause 40.1% to 100% repellence when used to protect grains or dry fish from storage coleopterans (beetles).

From these investigations, *A. melegueta* had 100% repellence effect on *C. puncticolis* at 5% treatment dose. Ukeh&Umoetok [31] reported that α -linalool is the major component in

essential oils of *A. melegueta* conferring repellent activity against *Tribolium castaneum* and *Rhyzopertha dominica*. Linalool, Citral and Cineole are familiar reversible competitive inhibitors of acetylcholinesterase[32], the principal enzyme that ends nerve impulses through speed up of the hydrolysis of the neurotransmitter acetylcholine (ACH) to cholin and acetate in the nervous system of insects [33]. Therefore the action of monoterpenoids (C-® Linalool, citral and cineole) on insects is thought to include: repellent, neurotoxicity, paralysis and death. It is not surprising therefore, that these plants extracts especially at 3 and 5% exhibited significant inhibition of reproductive potential, as well as reduced F₁ cumulative progeny emergence, in *C. puncticollis*.

This study also revealed that all treatments with n-hexane extract from all test plants parts and at all concentrations resulted in more weevil death and reproductive potential inhibition than the control. The reason for this could be that extract action are often target specific and have unique modes of action [34] [35]. More so, organic solvents such as n-hexane have been reported as being very effective in extracting active ingredients from plant parts[36]. Arannilewaet *al.*, [37] also reported that extracts are potent against all insects and their developmental stages and have been reported to have higher capacity to penetrate into the vascular bundles of tubers thus suppressing oviposition and any larval development and so resulting in complete failure of embryonic development.

The efficacy of these test plants extracts in the laboratory was dependent on dosage, with higher doses providing better protection with significantly fewer adults emerging and attacking sweet potato.

5. CONCLUSION

Results obtained from this research revealed that though *A. melegueta*, *X. aethiopica* and *D. tripetalla* fruits and leaves extracts were effective in controlling sweet potato weevil, *C. puncticollis*; the most effective was *A. melegueta* fruit extract. These plants could be incorporated in integrated pest management practices by local farmers. The plant extracts exerted considerable repellent, anti-reproductive and anti-feedant effects which ultimately led to significant reduction in tuber damage. To the resource-poor farmers in Nigeria, this research forms the basis for the use of these plant products in crop protection so as to reduce the application of synthetic insecticides.

6. REFERENCES

1. Bashaasha B, Mwanga ROM, Ocitti P, Obwoya C, Ewell PT. Sweet Potato in the Farming and Food System of Uganda: *A Farm Survey Report*. CIP, Lima, Peru, 63pp, 1995
2. Islam S, Yoshimoto M, Yahara S, Okuno S, Ishiguro K, Yamakawa O. Identification and characterization of foliar polyphenolic composition in sweet potato (*Ipomoea batatas* L.) genotypes. *Journal of Agriculture and Food Chemistry*, 2002; 50: 3718-3722
3. Srisuwan S, Sihachakr D, Siljak-Yakovlev S. (2006). The origin and evolution of sweet potato (*Ipomoea batatas* Lam.) and its wild relatives through the cytogenetic approaches. *Journal of Plant Science*, 2006; 171: 424-433.
4. Ethisianya CN, Lale NES, Umeozor OC, Amadi CO, Zakka U. Evaluation of Effectiveness of variety, tillage methods and time of harvest on sweet potato yield and the population of sweet potato weevil, *Cylas puncticollis* (Boheman) (Coleoptera: Brentidae), *International Journal of Advanced Scientific and Technical Research*, 2011; 2(2): 165-183.
5. Meadows BC. North Carolina agricultural statistics. Report No. 187, Raleigh, North Carolina, 1997.
6. Food and Agricultural Organization of the United Nations (FAO). Food and agricultural organization of the United Nation statistics division online at (downloaded from www.fao.org on 5 February, 2008).

Formatted: Font: Not Italic

7. Loebenstein G. Origin, distribution and economic importance of sweet potato. In: Loebenstein, G. & Thottappily (eds.) *The Sweet potato*, Springer science and business media, (pp. 9-12), 2009.
8. Yayock JY, Lombin G, Owonubi JJ. *Crop science and production in warm climates*. Macmillan Publishers, London, 1988.
9. Chalfant RB, Jansson RK, Seal DR, Schalk JM. Ecology and management of Sweet potato insects. *Ann. Rev. Entomology*, 1996: 35: 157-180.
10. Ekaluo UB, Ibiang YB, Ikpeme EV, Ekanem BE, Erem FA. (2013). Effect of Deltamethrin and Ridomil on sperm parameters and reproductive hormones of male albino rats. *Journal of Toxicology and Environmental Health Science*, 2013: 5(1): 9-14
11. Nta AI, Ibiang YB, Uyoh EA, Edu NE, Ekanem BE, John QE. (2013). Insect pest damage to leaves of cowpea (*Vigna unguiculata* L. Walp): Comparative effects of aqueous extracts of *Piper guineensis*, *Allium sativum* and *Myristica fragrans*. *Journal of Environmental Science, Toxicology and Food Technology*, 2013: 3(2): 17-20.
12. Nta AI, Oku EE. (2010). Effect of delayed harvest on the infestation of sweet potato (*Ipomoea batatas*) varieties by *Cylas puncticollis*. *International Journal of Zoology*, 2010: 2(1): 7-9.
13. Oyemitan IA, Iwalewa EO, Akanmu MA, Olugebade TA. Antinociceptive and anti-inflammatory effects of essential oil of *Dennettia tripetala* G. Baker (Annonaceae) in rodents. *African Journal of Traditional Complementary and Alternative Medicine*, 2008: 5(4): 355-362.
14. Nwachukwu EO, Osuji JO. Evaluation of plant extracts for antifungal activity against *Sclerotium rolfsii* causing cocoyam corm rot in storage. *Research Journal of Agriculture and Biotechnology Sciences*, 2008: 4(6): 784-787.
15. Ukeh DA, Oku EE, Idorenyin AU, Nta, AI, Ukeh JA. Insecticidal effect of fruit extracts from *Xylopi aethiopica* and *Dennettia tripetala* (Annonaceae) against *Sitophilus oryzae* (Coleoptera: Curculionidae). *Chilean Journal of Agricultural Research*, 2012: 72(2): 195-200.
16. Okigbo RN, Mbajuka CS, Njoku CO. Antimicrobial potentials of *Xylopi aethiopica* and *Ocimum gratissimum* L. on sore pathogen of man. *International Journal of Molecular Medicine and Advance Sciences*, 2005: 1: 392-397.

Comment [C.N14]: Spell out

Formatted: Font: Italic

17. Adewoyin FB, Odaibo AB, Adewuinmi CO. (2006). Mosquito repellent activity of *Piper guineense* and *Xylopiaaethiopica* fruits on *Aedesaegypti*. *Africa Journal of Traditional Complementary and Alternative Medicines*, 2006: 3(2): 179-183.
18. Oparaeke AM, Dike MC, Amatoobi CI. (2005). Field evaluation of extract of five Nigerian spices for control of reflowering insect pest of cowpea, *Vigna_unguiculata* (L.) ~~W~~alp. *Journal of Plant Protection Science*, 2005: 41(1): 14-20.
19. Ekeh FN, Onah IE, Atama CI, Ivoke N, Eyo JE. Effectiveness of botanical powders against *Callosobruchus_maculatus* (Coleoptera: Bruchidae) in some stored leguminous grains under laboratory conditions. *African Journal of Biotechnology*, 2013: 12(2): 1384-1391.
20. Ogunwenmo KO, Idowu OA, Innocent C, Esan EB, Oyelana OA. Cultivation of *codiaeum*(L) (Euphorbiaceae) slow variability in phytochemical and cytological characteristics. *African Journal of Biotechnology*, 2007: 6(2): 2400-2405.
21. Lee SE, Lee BH, Choi WS, Park BS, Kim JG, Campbell BC. Fumigant toxicity of volatile natural products from Korean spices and medicinal plants towards the rice weevil *Sitophilus_oryzae* (L). *Journal of Pest Management Science*, 2001: 57: 548-553.
22. Kouninki H, Haubruge E, Noudjou FC, Lognnay G, Malaisse F, Ngassoum MB, Goudoum A, Mapongmetsem PM, Ngamo LS, Hance T. Toxicity of some terpenoids of essential oils of *Xylopia_aethiopica* from Cameroon against *Sitoplihus_zeamais*-Motschulsky. *Journal of Applied Entomology*, 2007: 13(4): 269-274.
23. Kouninki H, Haubrugs E, Noudjou FE, Lognay G, Malaisse F, Ngassoium MB, Goudoum A, Mapongmetsem PM, Mgamo LS, Hance T. Potential use of essential oils from Cameroun applied as fumigant or contact insecticides against *Sitophilus_zeamais* (~~M~~Motsch). *Communications in Agricultural and Applied Biological Sciences*, 2007: 70: 798-992.
24. Lopez-Martin J, Anam EM, Boira H, Sanz MJ, Blazquaz MA. (2002). Chromone and Phenanthrene alkaloids from *Denetiatripetalla*. *Chemicals Pharmaceutical Bulletin*, 2002: 50(12): 1613-1615.
25. Nerio LS, Olivero V, Stashenko E. (2010). Repellent activity of essential oils: A review. *Journal of Biotechnology*, 2010: 101: 372-378.
26. Tapondjou LA, Adler C, Bouda H, Fontem DW. Efficiency of powder and essential oil from *Chenopoliumamvrosiodes* leaves as post-harvest grain protectant against one-stored product. *Journal of Stored Product Research*, 2002: 8: 95-105.

27. Ukeh DA, Birkett MA, Pickett JA, Bowman AS, Lunz AJ. Repellent activity of Alligator pepper, *Aframomum melegueta* and Ginger, *Zingiber officinale* against the maize weevil *Sitophilus zeamais*. *Journal of Phytochemistry*, 2009: 70: 751-758.
28. Talukder FA, Howse PE. Evaluation of *Aphanamispolystachya* as a source of repellents anti-feedants, toxicants and protectant in storage against *Tribolium castaneum* (Herbst), *Journal of Stored Product Research*, 1995: 31: 55-61.
29. Javid I, Poswal M. Evaluation of certain spices for the control of *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae) in cowpea seeds. *Journal of African Entomology*, 1995: 3: 87-89.
30. Egwunyenga OA, Alo EB, Nmorsi, P. G. (1997). Laboratory evaluation of the repellency of *Danettia tripetalla* Backer (Annonaceae) to *Demestes maculatus* F. (Coleoptera: Deimestidae). *Journal of Stored Product Research*, 1997: 34(3): 195-199
31. Ukeh DA, Umoetok SB. Repellent effect of three monoterpenoid odours against *Tribolium castaneum*, (Herb) and *Rhyzopertha dominica* (F) in Calabar, Nigeria. *Journal of Crop Protection*, 2011: 30: 1551-1555.
32. Rajasekhara RK, Naskar SK, Prasad AR, Prasuna AL, Jyothi KN. (2010). Differential volatile emission from sweet potato plant: mechanism of resistance in sweet potato for weevil *Cyrtolus formicarius* (Fab): *Journal of Current Science*, 2010: 99(11): 1597-1601.
33. Lopez MD, Pascual-Villalobos, Mode of inhibition of acetylcholinesterase by monoterpenoids and implications for pest control. *Journal of Industrial Crops and Products*, 2010: 31: 284-288.
34. Liu ZH, Mishra AK, Tan RY. Repellent, insecticidal and phytotoxic activities of isoalantolactane from *Inularia racemosa*. *Journal of Crop protection*, 2006: 25: 508-511.
35. RattamRS. (2010). Mechanism of action of insecticidal secondary metabolites of plant origin. *Journal of Crop Production*, 2010: 29: 913-920
36. Ajaiyeoba EO, Ekundayo O. Essential Oil constituents of *Aframomum melegueta* (Roscoe) K. Schum seeds (alligator pepper) from Nigeria. *Flavour Fragrance Journal*, 1999: 14: 109-111.
37. Arannilewa ST, Odeyemi OO, Adedire CO. Effects of medicinal plant extract and powder on the maize weevil- *Sitophilus zeamais* Motsch (Coleoptera; Curculionidae). *Annals of Agricultural Science*, 2002: 3: 1-10.

Formatted: Font: (Default) Times New Roman, 12 pt, Italic

Formatted: Font: (Default) Times New Roman, 12 pt, Italic

Formatted: Font: Italic