Tropical and Subtropical Agroecosystems

LABORATORY ASSESSMENT OF THE REPELLENT AND ANTI-FEEDANT PROPERTIES OF AQUEOUS EXTRACTS OF 13 PLANTS AGAINST THE BANANA WEEVIL *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae)

[EVALUACIÓN DE LA CAPACIDAD REPELENTE DE EXTRACTOS ACUOSOS DE 13 PLANTAS PARA EL CONTROL DE *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae)]

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SUMMARY

Aqueous extracts of 13 plants were assessed in a laboratory with ambient temperature of 28 $\pm$ 2 ^{0}C and relative humility of 80 $\pm$ 2% for repellent and anti-feedant properties against the banana weevil. The aim is to further explore the use of natural pesticides in management programmes against the banana weevil, the most damaging insect pest of bananas. Reared weevils were exposed to 5% and 10% concentrations of the extracts of (a) *Allium cepa* L. (b) *A. sativum* L. (c) *Azadirachta indica* A. Juss (d) *Cymbopogon citratus* D. C. Stapf (e) *Dennetia tripetala* (G. Baker) (f) *Garcinia* kola Henkel (g) *Monodora myristica* (Gaerth) Dunal (h) *Nicotiana tabacum* L. (i) Ocimum *gratissimum* L. (j) *Piper guineense* Schum and Thonn (k) *Tetrapleura tetraptera* Schum and Thonn (l) *Syzygium aromaticum* (L) Merr and Perry and (m) *Zingiber officinale* Rosc respectively in laboratory bioassays. Repellency assays were conducted using the area preference method on filter papers. Anti-feedant properties were determined using percentage repellency of the insects from treated feeding materials and number of holes bored on treated filter papers. Results showed that plants (j) and (l) elicited repellency of class IV (60.1 - 80%); plants (a), (b), (c), (d) and (e) elicited repellency of class III (40.1 - 60%); plants (f), (g), (i), (k) and (m) elicited repellency of class II (20.1 - 40%) and plant (h) elicited repellency of class I (0.1 - 20%). Antifeedant properties appeared to follow a similar trend and both effects appeared to be dosage dependent. The various constituents and/or action of the respective plant materials which might produce the insecticidal properties are discussed. Results indicated attractive potentials for field trials.

Key words: Banana weevil, aqueous extracts, repellency, antifeedant properties.

RESUMEN

Las propiedades repelentes contra el escarabajo del plátano de extractos acuosos de 13 plantas fueron evaluados en laboratorio, con el objetivo de explorar el uso de pesticidas naturales en programas de control del escarabajo del plátano. Los escarabajos fueron expuesto a extractos (en concentraciones de 5 y 10%) de (a) *Allium cepa* L. (b) *A. sativum* L. (c) *Azadirachta indica* A. Juss (d) *Cymbopogon citratus* D. C. Stapf (e) *Dennetia tripetala* (G. Baker) (f) *Garcinia kola* Henkel (g) *Monodora myristica* (Gaerth) Dunal (h) *Nicotiana tabacum* L. (i) *Ocimum gratissimum* L. (j) *Piper guineense* Schum and Thonn (k) *Tetrapleura tetraptera* Schum y Thonn (l) *Syzygium aromaticum* (L.) Merr y Perry y (m) *Zingiber officinale* Rosc respectivamente. Los ensayos de capacidad repelente fueron realizados mediante el método de área preferida usando papel filtro. Las propiedades para evitar el consumo se estimo a partir de la capacidad repelente de materiales tratados y el número de agujeros horadados en el papel filtro. Los resultados mostraron que (j) y (l) tienen una capacidad repelente tipo IV (60.1-80%); las plantas (a), (b), (c), (d) y (e) tuvieron capacidad repelente tipo III (40.1-60%); plantas (f), (g), (i), (k) y (m) tuvieron repelencia tipo II (20.1-40%) y planta (h) tuvo una repelencia tipo I (0.1-20%). La reducción consumo siguió un patrón similar y ambos efectos parecen ser dosis dependiente. Los compuestos y/o modos de acción de los materiales evaluados que parecer poseer propiedades insecticidad son discutidos. Los resultados indican potencial para llevar a cabo estudios de campo.

Palabras clave: Extractos acuosos, repelentes, escarabajos, plátano.

INTRODUCTION

The banana weevil *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae) is a major constraint in the production of plantains and bananas (IITA, 1992). It is known to interfere with root initiation, kill existing roots, limit nutrient uptake, reduce plant vigour, delay flowering and increase susceptibility to other pests and diseases (Gold and Messiaen, 2000). Losses of more than 40% of the plant crop and 52% of the third ratoon crop have been reported (Gold and Messiaen, 2000; Rukazambuga, 1996).

About 90% of the cropping systems of plantain and banana is on small subsistence farms in backyard gardens (INIBAP, 1988). Therefore the crop husbandry technologies, particularly pest control, should be of low cost, easy to adopt, safe for the homestead of the growers and readily available. Caution against synthetic pesticides is now of a global consciousness. Apart from being expensive and toxic to handlers and the environment, the banana weevil now shows resistance to most classes of chemicals and perhaps, botanical compounds may serve as substitutes (Gold and Messiaen, 2000).

Gold *et al* (1998), after x-raying possible control methods for the banana weevil, concluded that a broad integrated pest management (IPM) approach might provide the best method to fully control this insect pest. One of the physiological responses by insects to unfavourable environment caused by the presence of repellent materials is the dispersal or withdrawal from such environment. Thus, one method of manipulating the environment is through application of materials, which can repel the insects and/or inhibit their feeding. Walangululu et al. (1993) reported that powdered leaves of *Tephrosia* species had a repellent effect on adult banana weevils and so could be exploited to prevent oviposition at the base of the host plant. Even though further screening of this plant by IITA (1999) found it ineffective, more studies are necessary in this direction. Farmers in the Philippines, Ecuador and Southern Chile, for example use plant parts either placed in the field or applied as herbal concoctions for soil pest inhibition (Altieri, 1993).

In this study, aqueous extracts of thirteen plants were screened in the laboratory as a preliminary stage in determining organic source of repellents and antifeedants against adult banana weevil. These plants have variously been reported as possessing insecticidal properties against wide range of insects. However, reports of their effects on field insects, particularly soil borne insects are sparse. The goal of the study was to further assess the feasibility of inclusion of plant extracts in pest management programmes against the banana weevil. Aqueous extracts require simple techniques to prepare and apply. The plant materials are of low cost and abundantly available in the study area, the humid rainforest zone of southeastern Nigeria.

MATERIALS AND METHODS

Rearing of banana weevils

The banana weevils were reared as reported by Uzakah (1995) with modifications. Concrete pots measuring 70cm x 70cm x 60cm were constructed into which maiden suckers cut at 20cm above the collar were planted, nine in each pot. The pots were filled to a third of its volume with sterilised topsoil before the suckers were planted. Weevils were trapped from farmers' plots using the split pseudostem technique as reported by Swennen (1990). Two hundred field collected male and female weevils of the same size were put in each pot and the open end of the pot covered with fine cotton mesh, to allow for aeration, light and watering. The mesh was kept in place by pressing with pieces of concrete blocks. Male weevils were distinguished from the females by the angle of inclination of their last abdominal segment and the punctuations on their rostrum. The curvature and punctuations are greater in the males (Uzakah, 1995).

After seven weeks of rearing, the suckers were uprooted and eggs, larvae and pupae extracted. Different stages extracted were fed separately in big plastic buckets in the laboratory with fresh pieces of corm and pseudostem in order to have insect forms of approximate ages. The open end of the plastic containers were covered with fine cotton mesh and held firmly with rubber bands. Feeding materials were changed every three days. Adult weevils used for laboratory bioassays were fed in the laboratory for a period not less than six months. This was to ensure that the insects were well adjusted to the laboratory condition before application of treatments.

Selection of plant species and preparation of aqueous extracts:

The thirteen plant species used in this study and the parts from which extracts were obtained were selected because they have already been reported to elicit insecticidal properties against other insect species. The selected plants and parts used were: *A. cepa* (leaves); *A. sativum* (leaves), *A. indica* (seeds); *D. tripetala* (seed); *G. kola* (seeds); *M. myristica* (seeds); *N. tabacum* (leaves); *O. gratissimum* (leaves); *P. guineense* (seeds); *T. tetraptera* (fruit); *S. aromaticum* (fruit) and *Z. officinale* (stem). These parts were sun-dried and ground to fine powder using hand grinder. The extracts were prepared using methods of Rezaul Karim *et al.* (1992). Five and ten percent extracts were prepared by soaking 50g and 100g respectively of the powdered plant parts in one litre of distilled water for 12 hours and then filtering with muslin cloth. Additional water was added to make up one litre of filtrate.

Repellency bioassays

Bioassays were conducted under ambient laboratory temperature of 28 ± 2°C and relative humidity of 80 ± 2%. The repellent action of the extracts against the weevil was evaluated by two methods.

(i) Area preference method as reported by Obeng-ofiori et al. (1998). In this study, test areas consisted of 22cm Whatman No. 1 filter papers cut in half. Different test extracts and concentrations were applied to a half filter paper disc as uniformly as possible with pipette. The other filter paper halves were treated with water alone. The treated and control half discs were air-dried and full discs remade by attaching treated and untreated halves with sellotape. Each filter paper was placed in a petridish and six weevils placed at the centre of the paper and covered with perforated lids lined with 2mm wire mesh, and banded with rubber bands. Each treatment was replicated three times and laid out in a completely randomised design (CRD). The number of weevils present on the control (water treated) and the treated (NT) (extract treated) strips were recorded after 30 minutes, I hour, 2 hours, 3 hours, 24 hours and 48 hours. The experiments were set up at about 6.00 p.m. Nigerian time. Exposure time was extended to 24 hours (overnight) because the weevil is nocturnal in habit (Uzakah, 1995). Percent repellency (PR) values were computed using the formula:

$$PR = \left(\frac{NC - NT}{NC + NT} \right) \times 100$$

Where:
PR = percent repellency
NC = weevil number present on control strip
NT =weevil number present on strip treated with extract

PR Data were analysed using Analysis of Variance after arcsine transforming them. Negative PR values were treated as zero.

Repellency from feeding materials.

This test served to determine repellency effect as well as antifeedant effect. When organisms are repelled from feeding materials, they are less likely to feed on them. Tests were conducted in a choice arena of large basin of 60cm diameter where treated and untreated feeding materials were provided for selection by the weevils. Treated materials were 6cm x 5cm pseudostem pieces dipped for about ten seconds in the respective extracts and concentrations. The pseudostem pieces were collapsed by applying pressure on them with the fingers to enable them draw and retain the extracts before exposure to the weevils. The materials were placed at the sides of the bottom of the basin, equidistant from one another. Fifty-six weevils, starved for 48 hours were released at the centre of the basin. The experiment was also replicated 3 times. The number of weevils found on the treated and untreated pseudostem pieces were recorded and PR computed as in the filter paper bioassay.

Anti feedant test.

This was done as reported by Dales (1996). The various plant extracts at the 10% concentration only were applied to filter papers of equal size using pipette, and placed in petridishes. One adult weevil starved for 48 hours, was placed in each dish and holes produced by the insect on the paper after 24 hours of exposure were recorded. The filter papers were renewed daily for a period of five days. Each of the experiment was replicated three times. Percentage deterrency was computed as follows:

$$\frac{\text{No. holes control} - \text{No. holes treated}}{\text{Total No. holes control and treated}} \times 100$$

A negative PR value was also treated as zero and the data analysed using ANOVA procedure after transforming them into arcsine values.

Determination of repellency classes.

Repellency values obtained during the study on filter paper bioassay was classified as reported by Dales (1996). Studies on the circadian rhythm of the banana weevil by Uzakah (1995) showed that the insect is nocturnal and most active during scotophase (6pm – dawn). Repellency values obtained at dawn (after 24 hours exposure) following activity of the night was regarded as more reliable values. However, final classification took into consideration values obtained from the two concentrations of the extracts from the filter paper and feeding material bioassays. The mean values were weighted to obtain the classes.

RESULTS

Repellency on filter papers

Results are shown on tables 1 and 2 for repellencies at 5% and 10% concentrations respectively for the thirteen plant extracts. All the plants showed repellent effects which were dosage dependent. Repellency values generally altered from one exposure time to the other and appeared to stabilise with longer exposure time. The range of percentage repellency values on filter paper is shown on Figure 1.

Repellency on feeding materials:

Results are shown on tables 3 and 4. All thirteen plants showed repellent effects against the weevil. Percentage repellency values generally appeared to be proportional to the concentration of the extract. Such trend however, had exceptions. Percentage repellency values were higher on feeding materials than on filter papers. When the weevils were put in the test arena, they wagged their antennae indiscriminately and made orientations of the klinotaxis type. They gradually approached the materials by the sides of the basin and moved from one to the other until they settled down, sometimes very briefly, at other times for longer periods on those of their choice. Percentage repellency values therefore changed from one exposure time to the other but stabilised gradually thereafter. This condition was more pronounced on feeding materials than on filter papers. The range of Percentage repellency values on feeding materials are shown on Figure 2.

Table 1. Mean percentage repellency values for 5% concentration of aqueous extracts of 13 plants obtained on different exposure time in a filter paper bioassay on adult banana weevil.

Plants Extracted	Mean percentage* repellency values after					
	30 mins.	1 hour	2 hours	3 hours	24 hours	48 hours
A. cepa	33 ± 0.33^{f}	38 ± 1.59^{d}	49±2.31^{e}	21±2.31^{e}	38±1.59^{d}	50±0.00^{e}
A. sativum	60 ± 1.98^{c}	49 ± 2.31^{c}	55±2.79^{c}	21±2.31^{e}	55±2.97^{b}	60±1.98^{c}
A. indica	55 ± 2.97^{d}	38 ± 1.59^{d}	38±1.59^{f}	33±0.33^{d}	55±2.97^{b}	49±2.31^{e}
C. citratus	60 ± 1.98^{c}	49 ± 2.31^{c}	49±2.31^{e}	38±1.59^{c}	49±2.31^{c}	55±2.97^{d}
D. tripetala	55 ± 2.97^{d}	38 ± 1.59^{d}	38±1.59^{f}	38±1.59^{c}	33±0.33^{e}	50±0.00^{e}
G. kola	49 ± 2.31^{e}	38±1.59^{d}	21±2.31^{h}	33±0.33^{d}	38±1.59^{d}	21±2.31^{g}
M. fragrans	55 ± 2.97^{d}	38±1.59^{d}	50±0.00^{d}	38±1.59^{c}	55±2.97^{b}	49±2.31^{f}
N. tabacum	16 ± 1.32^{g}	21±2.31^{e}	16±1.32^{i}	16±1.32^{f}	16±0.66^{f}	21±2.31^{g}
O. gratissimum	38 ± 1.59^{c}	38±1.59^{d}	33±0.33^{g}	21±2.31^{e}	38±1.59^{d}	38±1.59^{f}
P. guineense	72 ± 0.25^{b}	66±0.66^{b}	77±0.80^{a}	83±0.33^{a}	77±0.80^{a}	66±0.66^{b}
T. tetraptera	55 ± 2.97^{d}	49±2.31^{c}	38±1.59^{f}	21±2.31^{e}	38±1.59^{d}	21±2.39^{g}
S. aromaticum	83 ± 0.33^{a}	77±1.65^{a}	72±0.25^{b}	60±1.98^{b}	77±0.80^{a}	72±0.25^{a}
Z. officinale	49 ± 2.31^{d}	38±1.59^{d}	33±0.33^{g}	38±1.59^{c}	49±2.31^{c}	38±1.59^{f}

* Values are means of 3 replicates ±SE.
Column means followed by different letters are significantly different at 0.05% level of Duncan's Multiple Range Test.

Table 2. Mean percentage repellency values for 10% concentration of aqueous extracts of 13 plants obtained on different exposure time in a filter paper bioassay on adult banana weevil.

Plants extracted	Mean percentage* repellency values after					
	30 mins.	1 hour	2 hours	3 hours	24 hours	48 hours
A. cepa	55 ± 2.97^{d}	55 ± 0.79^{d}	60±1.98^{c}	49±2.31^{c}	55±2.97^{d}	38±1.59^{d}
A. sativum	60 ± 1.98^{c}	55 ± 0.79^{d}	60±1.98^{c}	66±0.75^{a}	66±0.75^{c}	55±2.97^{c}
A. indica	55 ± 2.97^{d}	55 ± 2.97^{d}	49±2.31^{e}	60±1.98^{b}	55±2.97^{d}	60±1.98^{b}
C. citratus	55 ± 2.97^{d}	55 ± 2.97^{d}	55±2.97^{b}	60±1.98^{b}	55±2.97^{d}	60±1.98^{b}
D. tripetala	60 ± 1.98^{c}	60±1.98^{c}	55±2.97^{b}	38±1.59^{d}	55±2.97^{d}	55±2.97^{c}
G. kola	38 ± 1.59^{f}	38±1.59^{e}	16±0.66^{h}	38±1.59^{d}	49±2.31^{f}	38±1.59^{d}
M. fragrans	49 ± 2.31^{e}	38±1.59^{e}	38±1.59^{f}	38±1.59^{d}	60±1.98^{e}	21±2.31^{e}
N. tabacum	21 ± 2.31^{g}	16±1.32^{f}	16±1.32^{h}	16±1.32^{f}	21±2.31^{f}	16±1.32^{f}
O. gratissimum	38±1.59^{f}	39±1.59^{e}	21±2.39^{g}	38±1.59^{d}	49±2.37^{e}	21±2.31^{e}
P. guineense	83 ± 0.33^{a}	77±0.80^{b}	66±0.66^{b}	66±0.66^{a}	72±0.25^{b}	77±1.65^{a}
T. tetraptera	49 ± 2.31^{e}	38±1.59^{e}	21±2.31^{g}	21±2.31^{e}	55±2.97^{e}	38±1.59^{d}
S. aromaticum	77 ± 1.65^{b}	83±0.33^{a}	72±0.25^{a}	66±0.66^{a}	77±1.66^{a}	77±1.65^{a}
Z. officinale	49 ± 2.31^{e}	38±1.59^{e}	38±1.59^{f}	21±2.39^{e}	55±2.97^{e}	21±2.39^{e}

* Values are means of 3 replicates ±SE.
Column means followed by different letters are significantly different at 0.05% level of Duncan's Multiple Range Test.

Table 3. Mean percentage repellency values for 5% concentration of aqueous extracts of 13 plants obtained on different exposure time in a feeding material bioassay on adult banana weevil.

Plants extracted	Mean percentage* repellency values after					
	30 mins.	1 hour	2 hours	3 hours	24 hours	48 hours
A. cepa	55±0.79[b]	55±0.79[c]	49±2.31[b]	38±1.59[d]	38±1.59[cd]	49±2.31[b]
A. sativum	66±0.75[b]	66±0.75[b]	66±0.66[a]	72±0.25[ab]	77±0.80[a]	66±0.66[a]
A. indica	60±1.98[b]	55±1.65[c]	66±0.66[a]	77±0.80[a]	77±0.99[a]	66±1.49[a]
C. citratus	66±0.75[b]	66±0.75[b]	66±0.75[a]	77±0.80[a]	77±0.80[a]	60±1.98[a]
D. tripetala	72±0.25[a]	66±0.75[b]	55±2.97[b]	60±1.98[b]	60±1.98[a]	60±1.98[a]
G. kola	38±1.59[c]	55±1.65[v]	60±1.98[a]	55±2.97[c]	38±1.59[bc]	49±2.31[b]
M. fragrans	60±1.98[b]	55±1.65[v]	49±2.31[b]	55±2.97[c]	49±2.31[bc]	55±2.97[a]
N. tabacum	21±2.31[d]	66±0.75[b]	38±1.59[c]	16±0.66[e]	16±1.32[d]	0.00[d]
O. gratissimum	38±1.59[c]	38±1.59[d]	21±2.31[d]	49±2.31[cd]	55±2.97[b]	49±2.31[b]
P. guineense	60±1.98[b]	72±0.25[a]	72±0.25[a]	60±1.98[b]	72±0.25[a]	60±1.98[a]
T. tetraptera	55±2.97[b]	55±2.79[c]	38±1.59[c]	38±1.59[d]	55±2.97[b]	49±2.31[b]
S. aromaticum	83±0.33[a]	77±1.65[a]	60±1.98[a]	60±1.98[b]	77±1.65[a]	72±0.25[a]
Z. officinale	60±1.98[b]	60±1.98[b]	55±1.32[b]	49±2.31[cd]	60±1.98[a]	21±2.31[c]

* Values are means of 3 replicates ±SE.
Column means followed by different letters are significantly different at 0.05% level of Duncan's Multiple Range Test.

Table 4. Mean percentage repellency values for 10% concentration of aqueous extracts of 13 plants obtained on different exposure time in a feeding material bioassay on adult banana weevil.

Plants extracted	Mean percentage* repellency values after					
	30 mins.	1 hour	2 hours	3 hours	24 hours	48 hours
A. cepa	38±1.59[d]	72±0.25[b]	55±2.98[cd]	55±0.79[bc]	72±0.25[ab]	55±0.79[bc]
A. sativum	77±0.80[b]	83±0.33[a]	66±0.75[bc]	77±0.80[a]	77±0.80[a]	77±0.80[a]
A. indica	66±1.49[b]	83±0.35[a]	72±0.25[bc]	88±0.89[a]	77±0.80[a]	66±0.66[b]
C. citratus	66±0.75[b]	77±1.65[ab]	72±0.25[bc]	77±0.80[a]	77±1.65[a]	66±0.75[b]
D. tripetala	66±0.75[b]	55±1.65[c]	77±0.99[b]	66±0.75[ab]	77±1.65[a]	72±0.66[b]
G. kola	60±1.98[bc]	55±1.65[c]	49±2.31[d]	55±2.97[bc]	72±0.25[ab]	60±1.98[b]
M. fragrans	66±0.66[b]	66±0.66[bc]	60±1.98[c]	55±2.97[bc]	60±1.98[ab]	72±0.25[b]
N. tabacum	38±1.59[d]	16±0.66[d]	21±2.31[e]	16±1.32[d]	16±1.32[d]	16±1.32[d]
O. gratissimum	72±0.25b	55±2.97c	60±1.98c	72±0.25[a]	49±2.31[bc]	72±0.25[b]
P. guineense	88±0.89[a]	94±0.66[a]	94±0.66[a]	77±0.80[a]	88±0.89[a]	94±0.66[a]
T. tetraptera	60±1.98[bc]	66±0.66[bc]	72±0.25[bc]	55±2.97[bc]	72±0.25[ab]	55±2.97[bc]
S. aromaticum	94±0.66[a]	88±0.89[a]	83±0.33[a]	88±1.32[a]	94±0.66[a]	88±1.32[a]
Z. officinale	60±1.98[bc]	72±0.25[b]	60±1.98[c]	60±1.98[ab]	72±0.25[ab]	55±2.97[bc]

* Values are means of 3 replicates ±SE.
Column means followed by different letters are significantly different at 0.05% level of Duncan's Multiple Range Test.

Anti feedant properties:

Results are shown on table 5. All the plant extracts exhibited feeding deterrency effects. The deterrency values were low for all the materials. The insects used in the study died between the fifth and seventh day of exposure.

Repellency classes of the extracts:

The repellency classes are as shown on table 6. *P. guineense* and *S. aromaticum* elicited the highest repellencies while *N. tabacum* elicited the lowest

Table 5. Percentage feeding deterrency values from adult banana weevils exposed to 10% concentration of the aqueous extracts of 13 plants for five days following starvation for 48 hours.

Plants extracted	% feeding deterrency values *					
	Day 1	Day 2	Day 3	Day 4	Day 5	Mean
A. cepa	21.2^{b}	0.0^{c}	0.0^{a}	23.1^{c}	0.0^{a}	8.9^{c}
A. sativum	14.3^{b}	22.2^{b}	0.0^{a}	68.4^{a}	0.0^{a}	21.0^{b}
A. indica	21.2^{b}	33.3^{b}	0.0^{a}	6.6^{c}	0.0^{a}	12.2^{b}
C. citratus	33.3^{a}	4.8^{c}	0.0^{a}	3.2^{c}	0.0^{a}	8.3^{c}
D. tripetala	33.3^{a}	10.0^{b}	0.0^{a}	6.6^{c}	0.0^{a}	10.0^{c}
G. kola	33.3^{a}	10.0^{b}	0.0^{a}	33.3^{bc}	0.0^{a}	15.3^{bc}
M. fragrans	29.0^{a}	0.0^{c}	0.0^{a}	3.2^{c}	0.0^{a}	6.4^{c}
N. tabacum	2.6^{c}	0.0^{c}	0.0^{a}	0.0^{cd}	0.0^{a}	0.5^{cd}
O. gratissimum	2.6^{c}	0.0^{c}	0.0^{a}	0.0^{cd}	0.0^{a}	0.5^{cd}
P. guineense	5.3^{c}	0.0^{c}	0.0^{a}	6.6^{c}	0.0^{a}	2.4^{cd}
T. tetraptera	29.0^{a}	83.3^{a}	0.0^{a}	45.5^{b}	0.0^{a}	31.6^{a}
S. aromaticum	2.6^{c}	0.0^{c}	0.0^{a}	6.6^{c}	0.0^{a}	1.8^{cd}
Z. officinale	5.3^{c}	0.0^{c}	0.0^{a}	0.0^{cd}	0.0^{a}	1.1^{cd}

* Values are means of 3 replicates.
Column means followed by different letters are significantly different at the 0.05% level Duncan's Multiple Range Test.

Table 6: Repellency classes of aqueous extracts of 13 plants determined through laboratory bioassay on the banana weevil.

Plants extracted	Mean PR on filter paper*	Repellency class**
A. cepa	45	III
A. sativum	55	III
A. indica	50	III
C. citratus	53	III
D. tripetala	48	III
G. kola	35	II
M. fragrans	44	III
N. tabacum	18	I
O. gratissimum	34	II
P. guineense	74	IV
T. tetraptera	37	II
S. aromaticum	74	IV
Z. officinale	39	II

* Weighted mean for 5% and 10% aqueous extracts.
** Class 0 = <0.1; class 1 = 0.1 – 20%; class II = 20.1– 40%; class III = 40.1 – 60%; class IV = 60.1 – 80%; class V = 80.1 – 100% (Dales 1996).

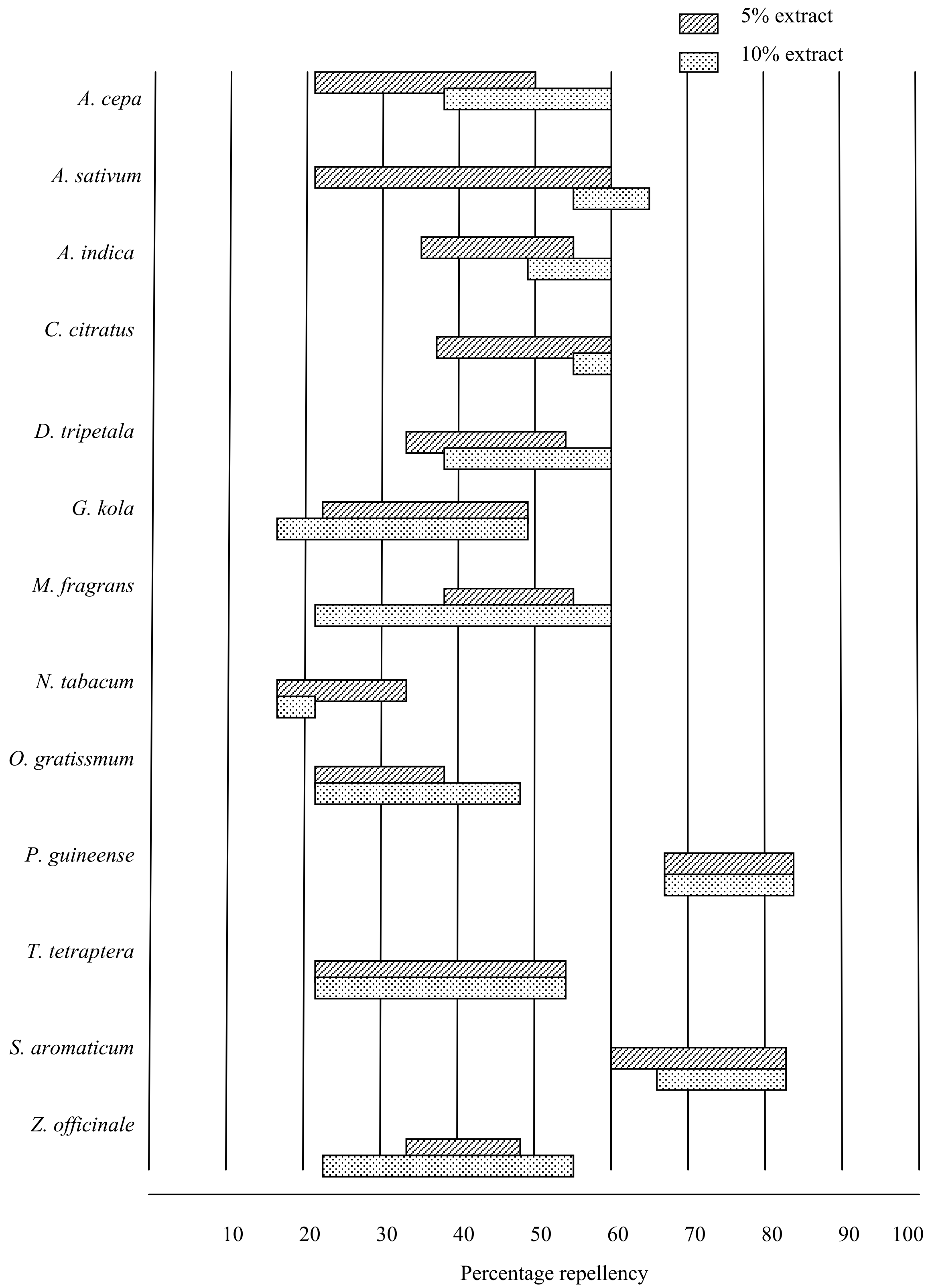

Figure 1. Approximate ranges of percentage repellencies of aqueous extracts of 13 plants against the banana weevil on filter paper bioassay.

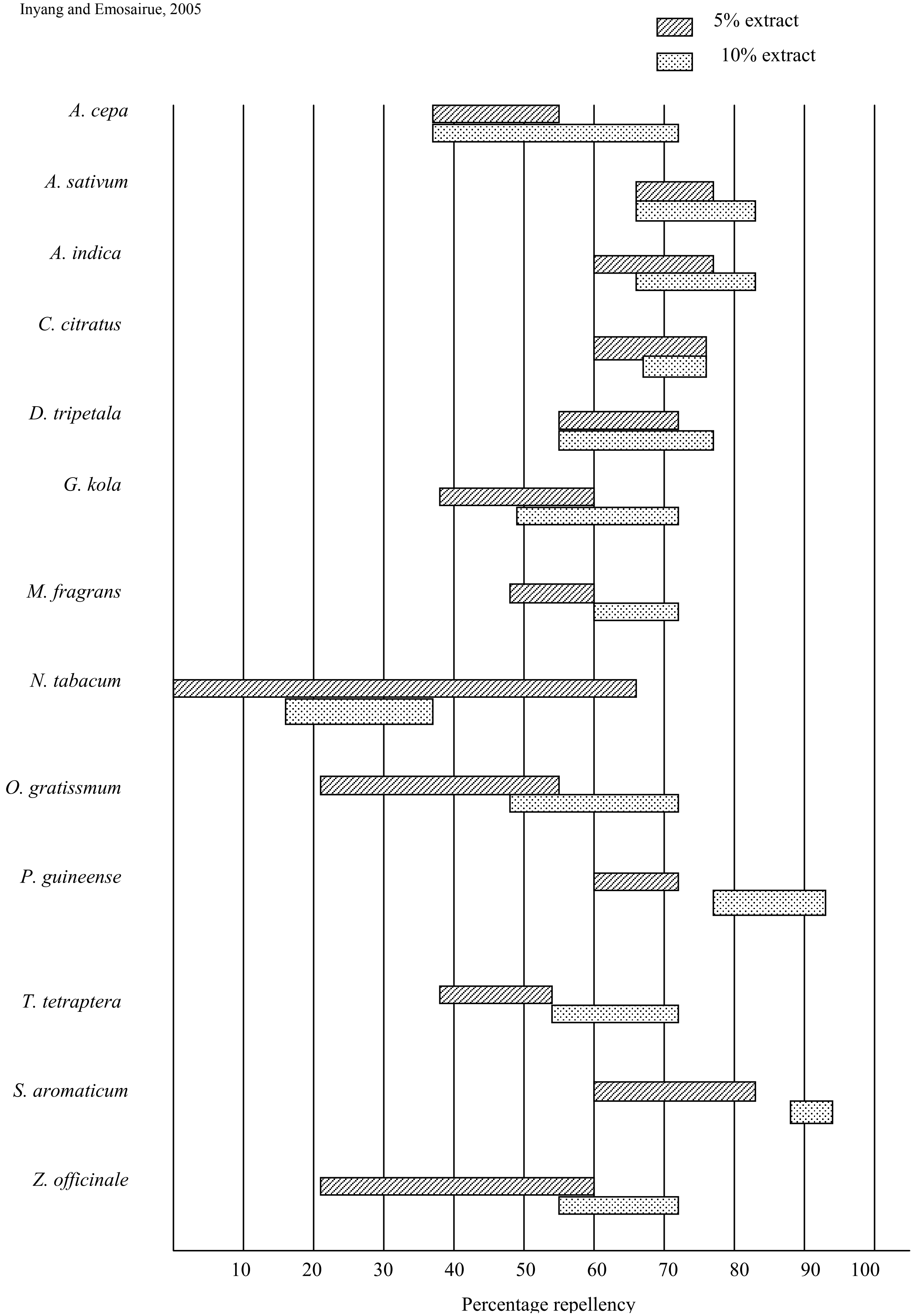

Figure 2. Approximate ranges of percentage repellencies of aqueous extracts of 13 plants against the banana weevil on feeding material bioassay.

DISCUSSION

The type of responses by insects to the effects of active materials in their environments are known to vary amongst different insect species. However in some instances, different insect species respond similarly to a common stimulus. Extracts of the plant species and the parts selected for this study have been reported to inhibit the bioactivity of one or more insect species. All the thirteen plant extracts caused some degree of restraint on the orientation and feeding of the banana weevil under laboratory condition. Results suggest that if the weevils had choice, they would avoid materials treated with the extracts. Generally, percent repellency values for all the extracts were higher on feeding materials than on filter paper. Obeng-ofori et al (1998) cited other workers who reported that filter papers have polar surfaces to which some toxicants when applied may be bound to reduce volatilisation and therefore become less effective than non-polar surfaces.

The feeding deterrency effect of all the extracts was low. This was probably because the insects were already starved for 48 hours before exposure to the treated materials. They would therefore naturally feed on the only source available. Tuncer and Aliniazee (1998) proffered similar explanation to the weak anti feedant effect of extracts of neem seeds, margosan-o, on the filbert aphid, *Myzocallis coryli*, a severe pest of hazelnuts. It is thought that under natural freedom, the insects would have dispersed to more palatable sources of food right from the first day of exposure when all the materials showed deterrent effects. *T. tetraptera* showed the highest deterrency value.

It would appear that the repellent and antifeedant properties of the plant extracts under discussion resulted from the effects of the active constituents of these plants. Okonkwo and Okoye (1996) reported that *P. guineense* contains the active materials Piperine and Chavicine which are insecticidal. These are the likely constituents of this plant, which inhibited the banana weevil. According to Lale and Alaga (1998), the seed oil of the plant was strongly repellent to another curculionid *Tribolium casteneum* Herbst and evoked a class V (80.1 – 100%) repellency on 200mg/30cm^2 filter paper.

S. aromaticum is highly pungent and contains eugenol a sesquiterpene, and caryophiline. The restraint of the banana weevil by extracts of this plant is attributable to high level of pungency elicited by it. This suggests a fumigant mode of action against the insect. The oil extract (10.38mg/cm^3) applied on filter paper showed 70% (class IV) repellency against another curculionid *T. casteneum* (Dales, 1996).

Adedire and Ajayi (1998) attributed the insecticidal activity of *A. cepa* against *Sitophilus zeamais* to fumigant mode of action. This is the likely factor which also repelled *C. sordidus.* Stoll (1988); Oparaeke and Dike (1996) and Dales (1996) have all reported of the pesticidal properties of *A. sativum* as a repellent, antifeedant, bactericide, fungicide and nematicide. The active constituent in the plant is allicin, and this, most probably inhibited the banana weevil.

A. indica is globally acclaimed as insecticidal (Ivbijaro, 1983a; 1983b, 1990; Tanzubil 1991; Jackai et al 1992; Shin-foon, 1992; Umeh, 1994; Das, 1995; Dales (1996). Dipping of suckers in a 20% seed solution of *A. Indica* at planting protected young suckers from weevil attack by reducing oviposition through its repellent effect on adult weevils (Gold and Messiaen 2000). Active constituents in the seed/fruit of *A. indica* include Azadirachtin and Nimolinone (Prakash and Rao, 1997). These constituents appeared to have repelled the banana weevil.

Oparaeke and Dike (1996) found that *C. citratus* was more effective than *A. sativum* in the control of cowpea bruchid *Callosobruchus maculatus* F. Adedire and Ajayi (1996) also found it effective against *S. zeamais*. Members of the genus *Cymbopogon* are rich in geraniol content to which insecticidal property is attributable. An application of 0.5ml of 1% oil of *Cymbopogon* sp. to filter paper in repellency trials against *T. casteneum* and *C. chinensis* was reported to have repelled the insects for 52 hours (Dales, 1996). Purseglove (1972) had reported of a constituent, citral, which is highly pungent and might repel insects. Olaifa et al. (1987) used extracts of this plant in the control of *Dysdercus superstitiosus*, *Ootheca mutabilis* and *Riptortus dentipes*. The effects of geraniol and citral appeared to have restrained the banana weevil.

The high efficacy of *D. tripetala* in the control of *C. maculatus* and *S. zeamais* has also been documented (Okonkwo and Okoye, 1996). Pessu and Williams (1998) also documented the very effective insecticidal properties of the seed powder of this plant against *S. zeamais*, *T. casteneum, Oryzaephilus mercator* and *Rhizopertha dominica*. Results showed 100% mortality of all adult insects within 24 – 96 hours of exposure. Faster results were achieved under airtight conditions even when the insects made no direct contacts with the powder. This suggests a fumigant mode of action which might have caused the repellent/ anti- feedant effect against *C. sordidus.*

Extracts of *M. myristica* was effective in controlling *Podagrica* spp. on fields of Okra. (Emosairue and Uguru, 2001). It is also reported to be effective against *C. maculatus* (Dales 1996). Myristicin is a poisonous constituent found in nutmegs (Cobley, 1976). Dales (1996) listed other constituents to include charicol, thymol and a-pinene. These might constitute repellent and/or antifeedant factors which inhibited *C. sordidus.*

T. tetraptera is strongly pungent to the extent of repelling snakes (Dupriez and De Leener, 1989). This attribute might have repelled the banana weevil from materials treated with its extracts. This plant was highly deterrent to feeding by the weevil. Its mode of action appeared to be fumigant.

G. kola is not strikingly pungent but it is known to repel snakes in the traditional circles of southeastern Nigeria. The seeds are chewed as stimulants and for various medicinal purposes. It was found effective in inhibiting *S. zeamais* (Adedire and Ajayi, 1998). It is most probably that the unidentified factor which repels snakes also repelled the weevil. *N. tabacum* possesses respiratory poisoning property attributed to the active constituent nicotine (Stoll, 1988). This effect probably inhibited *C. sordidus*

Ocimum spp. are known to be important sources of repellents and toxicants against many insect pests (Bekele et al, 1996). Two active materials namely camphor and eugenol, elicit repellent effects against insects. Obeng-ofori *et al* (1998) reported repellency of class V (80-100%) against *S. granarium*, *S. zeamais*, *T. casteneum* and *Prostephanus truncatus* by camphor, the major component of the genus, while Bekele *et al* (1996) cited Hassanah *et al* (1990) as reporting that eugenol was effective repellent in laboratory bioassays against *S. zeamais*. *O. gratissimum* is rich in camphor and is most likely the factor responsible for repelling *C. sordidus.*

Z. officinale contains a sesquiterpene, zingerone. The pungent principle Zingerone ($C_{11}H_{14}O_3$) (Purseglove, 1972) appears responsible for its inhibition effect against the banana weevil.

Much work on the above discussed plants is done on storage insect pests. The experience in the Philippines and Ecuador where herbal concoctions are used in soil pest inhibition might be useful in controlling the banana weevil. Results obtained from this laboratory study demonstrate attractive potentials for field trials. It is noteworthy that all the plants used in this study are not only consumed by man and therefore very safe in the homestead farms of the predominantly peasant growers of plantain/banana, but are abundantly available in the agroecology of the study area, a major plantain/banana producing area of the humid rainforest zone.

CONCLUSION

This study conceptualises that a programmed application of the extracts of the plants on plantain/banana stools might reduce infestation and damage by the banana weevils.

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