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Studies on the efficacy of some biorational insecticides against the banana weevil *cosmopolites sordidus (*Germar) (Coleoptera: Curculionidae)

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Abstract

Biorational insecticides obtained from tobacco, ash, urine, pepper and a concoction (mixture) were tested for their effect on adult weevil mortality, repellence and oviposition. Weevil oviposition on corms treated with tobacco, urine and the concoction was significantly reduced compared to oviposition on those treated with ash and pepper and on control corms. Similarly, the mean number of weevils settling on corms treated with the concoction compared to controls was statistically different for all the periods of the study. The mean number of weevils settling on corms treated with concoctions stored for four weeks was significantly lower than to those settling on corms treated with concoctions used either immediately or stored for one to two weeks. The concoction showed limited residual activity.

Key words: Banana weevil, biorational insecticide, concoction, *Cosmopolites sordidus*, residual activity, toxicity.

Introduction

The banana weevil *Cosmopolites sordidus* (Germar) (Coleoptera: Curculionidae) is one of the major constraints to banana production especially in small scale farming systems (Bujulu *et al.*, 1983; Stover & Simmonds, 1987; Sikora *et al.*, 1989). The weevil has been implicated (in association with low soil fertility and diseases) in the decline of banana productivity in many parts of the country (Gold *et al.*, 1999a). The female weevil lays its eggs singly at the bases of the banana pseudostems less than 25 cm above the soil in holes perforated by the ovipositing female (Abera *et al.*, 2000). Egg production is low with oviposition estimated from 1 to 3 eggs per week (Gold 1998). After hatching, the larvae tunnel into the corm and pseudostem of the plant resulting into stunting, delayed maturation, reduced bunch sizes, snapping and sometimes premature death of the affected plants (Gold, 1998). The pest can therefore cause high yield loss and shortened plantation life span if not controlled (Rukazambuga *et al.*, 1998).

Currently, control options available to the farmers in Uganda include pesticides and cultural methods (Gold, 1998). Chemical control is regarded by farmers as easy to manage, fast acting and effective (Gold *et al.*, 1993). The chemicals if not properly used are harmful, costly and are thus not affordable by resource poor farmers in Uganda. Additionally, weevil resistance to these chemicals has recently been reported in some countries (Wright, 1977 Collins *et al.*, 1991; Gold *et al.*, 1999b). Cultural control practices currently in use include crop sanitation and trapping using pseudostem but are of limited application (Gold, 1998). Currently, alternative control methods especially those that are ecologically sound, less expensive and not harmful to non-target species are being sought. Use of biorational insecticides from materials such as tobacco, ash, urine and pepper may therefore provide a plausible alternative.

The term 'biorational insecticide' was first coined by Djerrasi *et al* (1974) who in his definition gave examples of natural materials characterized by low toxicity to non-target organisms in contrast to broad-spectrum chemical insecticides. In his definition, biorationals insecticides included extracts of waste materials such as of tobacco trash, wood ash, pepper and urine. These biorationals have been reported to suppress insect pest populations through affecting their orientation and reproductive behaviour (Mostafa *et al.*, 1996; Liu & Stansly, 1995). Some of biorationals have been tested against storage beetles, *Callosobruchus chinensis* (Khaire et *al.*, 1992). However, no similar work has been carried out with *C. sordidus* although the materials are known to be cheap, safe and readily available to the farmers in Uganda and hence the thrust of initiating this study.

The objectives of this study were (1) to assess the mortality of *C. sordidus* adults from contact with biorationals under laboratory conditions and (2) to evaluate oviposition deterrence and repellency effects of biorationals to adults of *C. sordidus*.

Materials and methods

The tests were conducted under ambient conditions in a protected roofed-in area at Kawanda Agricultural Research Institute (00.25N, 32 32E, 1195m). The site has two rainy seasons (March-May and September-November) with average precipitation of 1180 mm per year. Average daily temperatures range between 16 °C and 29 °C.

Insects

Weevils collected from fields at Kawanda Agricultural Research Institute using pseudostem traps (Mitchell 1978) were used. They were maintained in the laboratory at ambient temperature in 10 litre plastic buckets (24 cm diameter and 26 cm depth) and provided with corm pieces as food. Weevil sexes were determined according to Longoria (1968). Female weevils were first kept for three days in all cases on a non-laying substrate to deter them from early oviposition and hence reserve the eggs for the oviposition tests. Each individual was used only once during the experiment to avoid contamination.

Biorational extracts

In toxicity tests, tobacco (*Nicotiana tobacum*) and ash single components were made by adding 100 ml of tap water to 50g of the material in plastic bowels while only pure cow urine was used. The concoction was prepared by mixing 50g of ash, 50g of crashed tobacco, 150 ml of cow urine and 1 litre of water. Clear solutions of the biorationals (filtrate) were obtained by filtering using a sieve (mesh size 106mm).

In the experiments to test weevil oviposition deterrence, repellence and residual activity effects of the biorationals, ash and tobacco single components were prepared by mixing 5 kg of either material with 10 litres of water. A pepper (*Capsicum sp*) solution was prepared by mixing 0.5 kg ground pepper to 1 litre of water, while urine was used as a pure component. The concoction was prepared by mixing 10 litres of cow urine, 5 kg of crashed tobacco, 5 kg of ash, 1 kg pepper and 10 litres of water and incubated for two weeks (except where mentioned otherwise) before being used in the tests.

Toxicity of biorationals to adult weevils

During this experiment, weevils were inoculated by putting two drops of filtrate of each solution to the abdomen of each weevil placed in 9 mm petri dishes where the treated weevils were allowed to bath in the materials for about 2 hours. Ten petri dishes (replicates) each containing 10 weevils was used for each treatment (tobacco, ash, urine, concoction and distilled water). The weevils were then transferred to fresh petri dishes lined with moist tissue so as to monitor mortality. Dishes were checked for dead weevils at 5-day interval.

Effect of biorationals on weevil oviposition

In the choice tests (where the weevils were free to move inside the container and lay eggs on a corm of their choice), six corm pieces (0.5-1kg) each treated with a biorational were placed equidistant from each other in a 30-litre basin (52 cm diameter and 24 cm depth) (Figure 1). Control corms were sprayed with distilled water. Twenty female weevils were placed at the centre of the basin. The basins were then covered with black polythene sheets that were perforated to provide adequate ventilation. The corm pieces were removed after three days and dissected by peeling off thin layers of tissue to expose eggs, which were counted. Each treatment was replicated 10 times.

In the no-choice tests, clean pared banana corms (1-2 kg) were treated by immersion in solutions of biorationals and one corm piece was placed in individual 10l buckets. Control corms were immersed in distilled water and placed in different 10 buckets. Ten female weevils were released to each bucket that was then covered by perforated lids. The corm pieces were removed after three days and dissected by peeling off thin layers of tissue to expose eggs, which were counted. Each treatment was replicated 10 times.

Weevil repellence by biorationals

Six corm pieces (0.5-1 kg) each treated with one of the biorationals was placed in the 30-litre basin at equidistant positions (Figure 1). Control corm pieces were sprayed with distilled water. Twenty weevils were placed at the centre of the basin and the basins covered with black polythene papers. The numbers of weevils settling on treated and control corms were recorded after 1, 2, 4, 24 and 48 hours. This experiment was replicated 10 times. The repellence factor was measured by the formula of Leonard and Ehrman (1976) as:

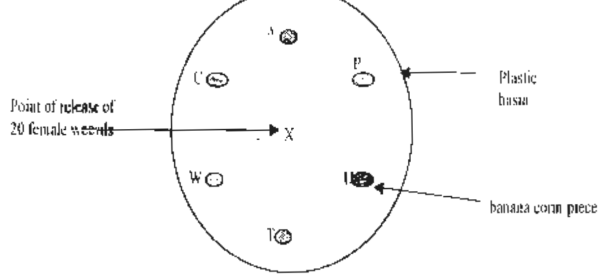
$$R = \frac{NC - NB}{NI} \cdot 100$$

Where:
R = repellency (-) or attractancy (+)
NC = number of insects on the treated corm
NB = number of insects on the control corm
NI = total number of insects on both corms

Effect of the storage period of the concoction on weevil repellence

In this experiment, only the concoction prepared as described above was used. It was selected basing on the results of the previous experiments in which it showed significant oviposition deterrence and repellency to *C. sordidus* compared to other biorationals that were tested. There were four treatments (i.e solution used immediately (0 weeks), after 1, 2 and 4 weeks of storage). Five corm pieces, four treated with the concoction of different storage period (each corm receiving a treatment) and the other sprayed with distilled water were placed in the 30-litre basin (52 cm diameter and 24 cm depth) at equidistant positions in an arrangement similar to the one indicated in figure 1. Thirty weevils were placed at the centre of the basins and covered with perforated black polythene sheets. The numbers of weevils settling on treated and untreated corms were recorded after 1, 2, 4, 24 and 48 hours. The treatments were replicated ten times.

Figure 1



Effect of residual activity of concoctions on weevil oviposition

The concoction prepared as described above was used in this experiment. Forty clean pared suckers (corms) were treated by immersing in the concoction and removed them immediately. Forty other clean pared corms were sprayed with distilled water. All corms were replanted in 10 litre buckets half filled with soil after treatment. Ten female weevils were released to 10 of the buckets immediately after treatment. The buckets were covered tightly with perforated lids and kept in a shade house at ambient temperature. Watering whenever necessary was done to maintain moisture in the containers. Release of weevils to other treated corms was done after 1, 2, 4 weeks. For each treatment (incubation period), uprooting and checking for eggs was done after three days of releasing weevils. At each occasion, treated corms were compared with corms sprayed with distilled water and there were 10 replicates of each treatment.

Data analysis

All data was analysed using Minitab statistics package. The data was subjected to analysis of variance (ANOVA) and means were separated by Fisher's pair wise comparisons. Differences at the 5% level were considered significant. The Percentage larvae reduction was calculated as the number of eggs recovered from treated corms relative to the number recovered from control corms.

Results and discussions

The weevils treated with the concoction appeared dead in the first 15-30 minutes after introduction to materials and continued to be inactive and paralysed while lying on their backs during the period of exposure. The weevils from ash treatment were active though weak compared to those from tobacco treatment and those exposed to concoction. It was interesting to observe that most of the weevils from all treatments recovered slowly and on the forth day after treatment were active again. The results indicate that biorationals tested had limited toxicity to *C. sordidus*. As in previous reports, biorationals such as of tobacco trash, wood ash, pepper and urine have limited insecticidal properties but may suppress insect pest populations through affecting their orientation and reproductive behavior (Mgenzi, 1999; Mostafa *et al.*, 1996; Liu & Stansly, 1995).

The mean numbers of weevil eggs recovered from corms treated with biorationals were significantly lower ($p < 0.05$) than eggs laid on control corms in the choice tests (Table 2). Weevil oviposition on corms treated with tobacco, urine and the mixture were significantly ($p < 0.05$) reduced compared to oviposition on control corms and those treated with ash and pepper in no choice tests. The mean number of eggs recovered from corms treated with pepper and ash were however not statistically different from those recovered from control corms.

All biorationals that were used in this study acted as repellants to *C. sordidus* (Table 3). The concoction was the most effective repellant biorational, with the highest repellency rate at all periods of examination while ash showed the lowest repellency throughout the examination period. The degree of repellence of biorationals with exception of the mixture decreased with time after treatment. The data indicates that single components of the biorationals have limited potential effect on *C. sordidus* through repellence compared to the concoction.

The mean number of weevils settling on corms treated with the concoction incubated for 4 weeks was significantly ($p < 0.05$) fewer than the mean number of weevils settling on corms treated with the concoction incubated for 0, 1, and 2 weeks (Table 4). The mean number of weevils settling after 48 hours on corms treated with the concoction of different incubation periods were however not significantly different ($p > 0.05$). The mean numbers of weevils settling on corms treated with concoctions incubated for 0, 1, and 2 weeks were not statistically different ($p > 0.05$).

The mean numbers of eggs recovered from corms treated with the concoction at same time but weevils released to them at different periods after treatment were not statistically different ($p>0.05$) (Table 5). Percentage

Table 1: Mean percentage mortality of weevils at different periods after treatment

Treatment	% mortality (n =10, ± S. E)	
	14 days	30 days
Ash	1.2 ± 0.7	2.0 ± 0.5
Urine	1.2 ± 0.7	7.0 ± 4.3
Tobacco	1.7 ± 0.8	7.0 ± 3.2
Mixture	1.2 ± 0.7	15.0 ± 7.2
Control	0.0 ± 0.0	1.7 ± 0.8

Table 2: Mean number of eggs laid on treated and untreated corms in both no-choice and choice tests

Treatment	Mean Number of eggs/corm	
	No-choice (n=10)	Choice (n=10)
Control	3.00a	33.4a
Pepper	2.38ab	19.7b
Ash	1.25ab	22.1b
Tobacco	0.62b	19.4b
Urine	0.62b	21.9b
Mixture	0.62b	18.6b

Table 3: Mean number of weevils settling at corm pieces at different times after treatment with concoctions

Treatment	Hours after treatment									
	1		2		4		24		48	
	Mean No. of Repellence of weevil factor		Mean No. of Repellence of weevil factor		Mean No. of Repellence of weevil factor		Mean No. of Repellence of weevil factor		Mean No. of Repellence of weevil	
Pepper	1.9bc	54.8	2.4bc	46.7	1.9bc	59.1	4.0ab	14.9	3.6ab	12.2
Ash	5.4ab	9.2	5.5ab	9.1	5.1ab	18.4	4.6a	8.0	4.0ab	7.0
Tobacco	3.0bc	35.3	3.3bc	33.3	2.9bc	43.6	0.8bc	9.6	0.9bc	9.0
Urine	2.3bc	47.7	2.1bc	51.7	2.3bc	52.6	1.6bc	54.3	1.6bc	48.4
Mixture	0.5c	85.7	0.5c	85.9	0.4c	89.7	0.5bc	83.0	0.3c	87.8
Control	6.5a		6.6a		7.4a		5.4a		4.6a	

In a column, means with the same letter are not significantly different (n=10, P=0.05); using Fisher's pair wise comparisons of Minitab.

Table 4: Mean number of weevils on corms treated with the mixture incubated for different periods

Weeks of incubation	Number of weevils settling on corms at different hours after release (n=10, ± S.E)				
incubation	1	2	4	24	48
0	3.4 ± 1.0	3.4 ± 1.0	3.6 ± 1.1	3.3 ± 0.7	2.3 ± 0.2
1	4.5 ± 1.0	5.6 ± 1.1	4.4 ± 0.8	3.1 ± 0.6	3.1 ± 0.6
2	4.9 ± 1.1	4.2 ± 1.3	4.0 ± 1.1	3.9 ± 1.2	4.5 ± 1.0
4	2.1 ± 0.7	1.1 ± 0.4	1.0 ± 0.3	2.0 ± 0.5	3.3 ± 0.7
Control	14.9 ± 1.0	15.9 ± 1.0	15.9 ± 1.1	14.2 ± 0.9	13.9 ± 0.8

Table 5: Effect of concoctions' residual activity on weevil oviposition

Period after treatment (in weeks)	Mean number of eggs/corm (n=10, ± S. E)	Reduction % of control
0	5.7±0.6	55.0
1	4.9±0.8	30.9
2	3.8±1.2	30.9
4	4.1±1.2	16.3

reduction of oviposition was lowest (16.3%) on the corms where weevils were exposed four weeks of treatment with the concoction as compared to oviposition reduction (55.0%) on corms where weevils were exposed immediately after treatment. The results indicate that the concoction has limited residual activity.

Concoctions have been reported by some banana farmers in Uganda to control the banana weevil (Ssennyonga *et al*, 1999). On the other hand, reports indicate that some of the biorationals known to control the weevil may have a nutritive effect that may induce the exposed bananas to grow vigorously and tolerate weevil damage (Bosch *et al*., 1995). The results of this study indicate that concoction has a potential to reduce weevil damage by repelling them from the banana plant and deterring oviposition. The effect of the concoction treatment may only work for less than a month for a single treatment as it showed limited efficacy after four weeks. This would therefore imply that the dose and frequency of application could influence management of *C. sordidus* through oviposition deterrence. Increasing the amounts and frequency of application would make the method labour intensive and costly for the subsistence farmer. Future studies should provide further information on how the concoction can reduce the banana weevil damage through affecting oviposition and settling responses under field conditions; and determine the appropriate dose and frequency of application of the concoctions.

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